International and Intergenerational Aspects of Capital Income Taxation in an Endogenously Growing World Economy*

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Abstract

This paper discusses how capital income taxation affects economic growth and welfare in an endogenously growing world economy with perfect capital mobility and worldwide externalities. Worldwide externalities provide a mechanism for equalizing national growth rates even with different capital income tax rates. The welfare of future generations is more influenced by a change in the growth rate than by the international spillover effect which has been the primary concern of the previous studies. Moreover, our model finds intergenerational conflicts arising from the change in the growth rate caused by a change in the source tax rate of the foreign country.

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1 Introduction

In the era of the highly integrated world capital market, we have to take into account the international spillover effects of capital taxation even when discussing domestic tax policy. Most studies of tax policy in a two country model with perfect capital mobility - including Ihori (1991), Sibert (1990) and Sorensen (1990) - show international conflicts created by a source tax reform. A source tax makes investment in a foreign country more attractive. Therefore, the capital stock shifts from the home country to the foreign country (we call this a "capital allocation effect"). The source tax also lowers the total capital stock of the world economy (we call this a "capital formation effect") because the two countries, when aggregated, can be regarded as a closed economy when viewing tax effects on the world wide equilibrium. When the foreign country raises the source tax rate, the capital inflow due to the capital allocation effect dominates a decrease in capital due to the capital formation effect (Ihori, 1991, Sorensen, 1990). Therefore an increase in the source tax rate decreases the capital stock in the home country and increases it in the foreign country. The welfare effect of source taxes is positive on the foreign country and negative on the home country (Sibert, 1990).[1]

In the present paper, we will tell a different story by examining an overlapping generations model which allows that the growth rate is determined endogenously. We claim that the tax effects previously known in the exogenous growth models are actually divided into the growth rate effect and the level effect once the long run growth rate is endogenized.

The capital formation effect in the endogenous growth model appears as a decline of the growth rate of the economy, thus it is a growth rate effect. In contrast, the capital allocation effect is a level effect. In endogenous growth models, the capital allocation effect will be dominated by the capital formation effect in the long run, because the latter is growing over time. Therefore, economic effects and welfare consequences differ from the case of

[1] This result holds when the current accounts of the two countries are balanced initially. Sibert (1990) stresses that the existence of large initial current account imbalances may reverse these welfare implications.

exogenous growth, where the capital allocation effect is always dominant.

Considering an overlapping generation model, this paper sheds light on the *intergenerational* conflicts of capital income tax reforms. In exogenous growth models, residence and source taxes show a sharp contrast in regard to the international spillover effect on welfare. In our endogenous growth model, these tax changes affect the national growth rate. Therefore, their effect on welfare is amplified as time goes on. The capital allocation effect of source tax favors the foreign country, as Ihori (1991) and Sorensen (1990) show. At the time of a source tax reform, this effect is dominant in the foreign country. However, this welfare improvement of the foreign country will be dominated later by the harmful welfare effect caused by the growth rate reduction. The welfare of foreign country will therefore decline in the long run. This is a story of intergenerational conflicts of capital income tax reforms; an increase in the source tax rate makes the foreign country's agents better off in the short-run, but it reduces the welfare of future generations in both countries.

In this paper we build the simplest possible model to feature the above story. The world economy consists of identical two countries. Each generation lives for two periods. There are Arrow (1962) - Romer (1986) style knowledge spillovers across borders. The presence of a particular kind of knowledge spillover makes endogenous growth possible and eliminates transition dynamics. In this setting we examine the effects of residence and source taxes on the growth rate and capital stock of each country. The welfare of all future generations is also calculated.

2 The Model

There are two countries, which are identical except for taxes. We call one the home country and the other the foreign country. In order to avoid duplicating descriptions we show equations only for the home country. An asterisk is added to the foreign counterparts. There is no population growth, and the size of the population is normalized to 1 in each country.

2.1 *Production*

One of the mechanisms of endogenous growth is represented by the Arrow (1962) - Romer (1986) type "knowledge spillover" model. A typical setting of the aggregate production function in this type of models is

$$Y_t = F(K_t, K_t N), \tag{1}$$

where K and $N(= 1)$ represent capital stock and labor in the country, respectively. Here the efficiency of labor is improved by "learning-by-doing" work, which is assumed to be related to the firm's physical capital stock. Knowledge prevails among the firms within the country without any cost. An implicit assumption here is that the knowledge does not spill over across countries at all. However, in reality the country boarder might not be crucial to determine the area where the knowledge can prevail. When the production externalities are assumed to work across borders, the production function is then specified as

$$Y_t = F(K_t, \bar{K}_t N), \tag{2}$$

where $\bar{K}$ represents the world wide capital stock $(= K + K^*)$.[2] Assuming that this production function is homogeneous of degree one with respect to K and $\bar{K}N$, we can rewrite (2) as

$$Y_t = F(K_t/\bar{K}_t N, 1)\bar{K}_t N = F(K_t/\bar{K}_t, 1)\bar{K}_t \equiv f(\alpha_t)\bar{K}_t, \tag{3}$$

where $\alpha_t \equiv K_t/\bar{K}_t$. As (3) shows, output of one country is written as a function of the world-wide capital rather than the capital stock installed in the country. This formula will be helpful when we focus on the dynamics of the world economy.

Perfect competition in factor markets implies

$$r_t = (1 - \sigma)f'(\alpha_t) \tag{4}$$

$$w_t = f(\alpha_t)\bar{K}_t - f'(\alpha_t)K_t, \tag{5}$$

where σ, r and w are the source tax rate, the interest rate and the wage, respectively.

[2]The world wide capital stock is regarded as exogenous by firms in both countries.

2.2 *Households*

The consumption behavior is the same as the standard overlapping generations model. Homogenous households in each of the two countries live for two periods. In the first period they supply a fixed unit of labor and, in the second period, they retire. The utility function of generation t in the home country is represented as

$$U^t = u(c_t^t, c_{t+1}^t) + \frac{e_{t+1}}{1+\delta}, \tag{6}$$

where c_t^s stands for the consumption of generation s in period t, e_{t+1} is the level of public goods at the old and δ is a discount rate. Moreover, u is assumed to be homothetic. Households take the supply of public goods as exogenous. The budget constraint is

$$c_t^t + K_{t+1} + B_{t+1} = w_t \tag{7}$$

$$c_{t+1}^t = [1 + (1-\rho)r_{t+1}]K_{t+1} + [1 + (1-\rho)r_{t+1}^*]B_{t+1}, \tag{8}$$

where B is the foreign asset, ρ the residence tax rate of the home country, respectively.

Perfect capital mobility implies

$$(1-\rho)r_{t+1} = (1-\rho)r_{t+1}^*,$$

so that we have

$$r_{t+1} = r_{t+1}^*. \tag{9}$$

From (6)-(9) and the homotheticity of u, we obtain the following saving function:

$$S_t \equiv w_t - c_t^t = s(\beta_{t+1})w_t, \tag{10}$$

where $s(\beta_{t+1})$ is the propensity to save with respect to life time income and β is the after-tax interest rate defined as

$$\beta_{t+1} = (1-\rho)(1-\sigma)f'(\alpha_{t+1}). \tag{11}$$

We assume here that the sign of $s'(\beta)$ is positive, because it carries the same implications as the standard Ramsey type model.

2.3 *The Government*

The home government taxes capital income in each period and spends the total tax revenues on public goods, which give benefits for the old generation in the home country. Thus, the public policy is neutral to intergenerational income distribution. The government budget is assumed to be always balanced. With (4), (7), (10) and (11), the government budget constraint is

$$e_{t+1} = \rho r_{t+1} S_t + \frac{\sigma}{1-\sigma} r_{t+1} K_{t+1} = \rho r_{t+1} B_{t+1} + [f'(\alpha_{t+1}) - \beta_{t+1}] K_{t+1} \equiv e\bar{K}_t, \tag{12}$$

where

$$e \equiv \rho (1-\sigma) f'(\alpha) \{ s(\beta) [f(\alpha) - f'(\alpha)\alpha] - \alpha(1+g) \} + [f'(\alpha) - \beta] \alpha (1+g). \tag{13}$$

2.4 *Market Equilibrium*

The world market equilibrium condition is given by

$$K_{t+1} + K^*_{t+1} = S_t + S^*_t, \tag{14}$$

because $B + B^* = 0$.

2.5 *The Dynamics of the Model*

Next consider the dynamics of the model. Substituting (4) into (9) yields

$$(1-\sigma) f'(\alpha_t) = (1-\sigma^*) f'(\alpha^*_t). \tag{15}$$

The following equation obviously holds from the definitions of α and $\bar{K}$:

$$\alpha_t + \alpha^*_t = 1. \tag{16}$$

(15) and (16) determine unique values of α and α^* for given σ and σ^*. Note that if σ and σ^* remain constant over time, then the values of α and α^* also remain unchanged, and, thus, the (before-resident-tax) interest rate is kept constant. From (11) and the fact that α is a function of σ and σ^*,

we observe that the after-tax interest rate, β, is determined solely by ρ, σ and σ^*. When all tax rates are constant, β is also kept constant. Like the AK production technology, the after-tax interest rate is independent of the amount of saving. Furthermore, from (5) and the definition of $\bar{K}$, the wage, w, can be represented as

$$w_t = [f(\alpha) - f'(\alpha)\alpha]\,\bar{K}_t, \tag{17}$$

which implies that the wage is proportional to $\bar{K}$.

Substituting (17) into (10) gives the home country saving function:

$$S_t = s(\beta)[f(\alpha) - f'(\alpha)\alpha]\bar{K}_t. \tag{18}$$

The foreign counterpart is obtained similarly. From (14) and (18) and the definition of $\bar{K}$, the dynamics of the world capital stock will be represented as

$$\bar{K}_{t+1} = \{s(\beta)[f(\alpha) - f'(\alpha)\alpha] + s(\beta^*)[f(\alpha^*) - f'(\alpha^*)\alpha^*]\}\,\bar{K}_t \equiv (1+g)\bar{K}_t, \tag{19}$$

where g is the growth rate of the world capital stock. The dynamics of foreign asset holdings, B, is given by

$$B_{t+1} = S_t - \alpha\bar{K}_{t+1} \equiv b\bar{K}_t, \tag{20}$$

where

$$b \equiv s(\beta)[f(\alpha) - f'(\alpha)\alpha] - \alpha\,(1+g)\,. \tag{21}$$

Therefore, the dynamics of the world capital and foreign assets are linear and one dimensional.

Like other endogenous growth models, some assumption is needed for the growth of the world economy to be sustainable, so we assume $g > 0$. Intuitively speaking, in order for the capital stock to grow, the propensity to save for future consumption has to be sufficiently large in our model, where the life-cycle saving of households constitutes the capital stock.

2.6 *The Effects of Taxation on Interest Rates*

Table 1 summarizes how capital income taxes affect the location of capital and the before- and after-tax interest rates. Since residence tax is designed to be neutral to investor's decisions on the location of capital, it does not affect the location of capital on the before-tax interest rate. From (11), the residence tax just lowers the after-tax interest rate faced by residents. The residence tax in the foreign country has no effect on the interest rate in the home country.

Table 1: Tax Effects on Capital Allocation and Interest Rates

	Residence-based tax		Source-based tax	
	Home	Foreign	Home	Foreign
Allocation of capital (α)	0	0	$\frac{f'(\alpha)}{2f''(\alpha)} < 0$	$-\frac{f'(\alpha)}{2f''(\alpha)} > 0$
Before-tax interest rate ($f'(\alpha)$)	0	0	$\frac{f'(\alpha)}{2} > 0$	$-\frac{f'(\alpha)}{2} < 0$
After-tax interest rate (β)	$-f'(\alpha) < 0$	0	$-\frac{f'(\alpha)}{2} < 0$	$-\frac{f'(\alpha)}{2} < 0$

A source tax distorts the allocation of capital. An increase in the source tax rate shifts the capital stock from the home country to the foreign country, because the capital in the home country must earn a higher return due to the source tax. The before-tax interest rate, or the marginal productivity of capital, in the home country is increased in the home country and decreased in the foreign country.

The after-tax interest rate is decreased in both countries. Since the burden of source tax spreads over two countries, the derivative of the domestic after-tax interest rate with respect to the source tax rate is exactly half of that with respect to the residence tax rate.

3 Capital Income Taxation and Growth Rate and Income Differentials

This section analyzes the effects of international differences in capital income tax rates on growth rate and income level differentials.

3.1 *Growth Rate Differentials*

As Rebelo (1991) and Buiter and Kletzer (1991, 1993) argue, differences in residence tax rates across countries have been regarded as one of the most important factors for international growth rate differentials. However, this does not hold in our model. Even if there are asymmetries in residence tax rates (and source tax rates) across countries, the growth rate of each country is always equalized. Let us verify this point.

From (3), the home and foreign countries' GDP, Y and Y^*, are given by

$$Y = f(\alpha)\bar{K} \tag{22}$$

$$Y^* = f(\alpha^*)\bar{K}. \tag{23}$$

These reduced form production functions resemble Rebelo's (1991) AK technology, since α is constant. Due to the international knowledge spillover, the total capital stock of the world economy becomes a determinant of the production activities for each country. Since a country which invests less capital can enjoy the spillover from the investment by the other country, less investment in a jurisdiction is no longer a handicap for growth. This is a very different implication from Rebelo (1991), while his and our model both belong to a class of AK technology. In Rebelo (1991), where there is no international spillover at all, the GDP in each country depends in turn on the capital stock in each country. Thus, a lower rate of capital accumulation leads to a lower growth rate of GDP.

The capital allocation across borders in Rebelo's (1991) AK model is on a knife-edge: the country with the highest return of capital attracts all capital in the world. This somewhat unrealistic phenomenon does not emerge in our

model, because our specification exhibits a property of "decreasing return" to the amount of capital relative to the world-wide capital stock.

Buiter and Kletzer (1991, 1993) construct a two-country model in which the growth rates are not equalized even under perfect capital mobility. Their results differ from ours because their model introduces human capital, which is immobile across countries. The accumulation of human capital in the home country raises only the marginal productivity of capital in the home country, because human capital has no external effects to the other country's productivity. In our model, however, the externalities in production raise the marginal productivities of capital in both countries.

3.2 *The Growth Rate Effect of Taxation*

We next examine the effects of capital income taxation on the growth rate of the world economy. Our policy experiments consider permanent increases in tax rates in period 1. This change is announced before the generation born in period 0 (the first generation affected by the policy change) plans their consumption schedule,[3] so that they or their offsprings are not forced to revise their plan in the middle of their lifetime. In other words, our policy exercise is an anticipated permanent change in tax rates. Therefore, a given K_0 and (19) determine the dynamics of K under the new tax rate. Because our one dimensional dynamic model does not have any transitional processes, the economy then goes on a new balanced growth path.

A closer look at generational consequences of the policy change is in order. Responding to a change in the after-tax interest rate, the generation born in period 0 makes a different saving plan from the previous generations. The resulting change in capital accumulation affects the wage earned by the generation born in period 1. Thus the policy change affects the generations born in period 1 or later through a change in the wage and the after-tax interest rates.

Tax policy affects the common growth rate of the two countries. From

[3]How early this announcement is does not matter, because the preceeding generations, without intergenerational linkages, are not affected by the policy change.

(19), the growth rate can be represented as a function of the after-tax interest rate and the allocation of capital:

$$1+g=s\left(\beta\right)\left[f\left(\alpha\right)-f'\left(\alpha\right)\alpha\right]+s\left(\beta^{*}\right)\left[f\left(\alpha^{*}\right)-f'\left(\alpha^{*}\right)\alpha^{*}\right], \qquad (24)$$

which implies that the capital tax affects the growth rate of the world economy through the effects on α and β. If two countries are initially symmetric, a change in the allocation of capital between countries has a null effect on the growth rate, because the marginal increase in output of one country is exactly offset by the marginal decrease in output of the other country. Therefore, we can focus only on the tax effect on the after-tax interest rate when examining the growth effect. When the saving increases with the interest rate, a drop in the after-tax interest rate lowers the growth rate through a reduction of the amount of saving.

The residence tax lowers the saving of only the home country, because it does not affect the after-tax interest rate faced by the households in the foreign country. While the source tax lowers the saving of both countries, its impact on each country is a half as large as the effect of residence tax, as shown in Table 1. It implies that the total growth effect is equal between residence and source tax. This equivalence is not surprising because, in the world economy, where total saving equals total investment, there is no difference in the effect on the interest rate between residence (saving) tax and source (investment) tax; the world economy behaves like a closed economy for this exercise.

A formal derivation of growth effects is obtained by differentiating (24) with respect to tax rates at the no tax state:

$$\frac{d(1+g)}{d\rho}=\frac{d(1+g)}{d\rho^{*}}=\frac{d(1+g)}{d\sigma}=\frac{d(1+g)}{d\sigma^{*}}=-s'(\beta)[f(\alpha)-f'(\alpha)\alpha]f'(\alpha)<0. \qquad (25)$$

3.3 *The Effects of Taxation on the GDP and GNI Level Differentials*

Tax policy may be a source of income level differentials. Let us examine the tax effects on income on a steady growth path. From (16), (22) and (23) the GDP ratio between the two countries depends on the allocation of capital:

$$\frac{Y^*}{Y} = \frac{f(\alpha^*)}{f(\alpha)} = \frac{f(1-\alpha)}{f(\alpha)}.$$

Since, as shown in Table 1, an increase in the source tax rate shifts capital stock to the foreign country, a lower home GDP, relative to the foreign GDP, is associated with a higher home source tax rate. On the other hand, residence tax does not create any international differences in GDP, because residence tax does not affect α.

We next consider the effects of taxation on the GNI (Gross National Income) ratio between the two countries. GNI, which was formerly called GNP in the old System of National Accounts, is the sum of GDP and the interest receipts from (or payments to) the other country :

$$Y + rB = \left[f(\alpha) + (1-\sigma) f'(\alpha) \frac{b}{1+g} \right] \bar{K}. \tag{26}$$

Since residence tax does not affect GDP, its effect on GNI comes from changes in the net foreign asset. Residence tax lowers the saving of residents, and thus GNI of the home country will decline. Moreover, since the world GDP is not affected by residence tax given the world wide capital stock, a decline in GNI in one country leads to a rise of GNI in the other country.

The case of source tax is more complicated, because both GDP and the net foreign asset are affected. Differentiating the bracket term in (26) with respect to σ at the zero tax state yields

$$f'(\alpha)\frac{d\alpha}{d\sigma} + \frac{f'(\alpha)}{1+g}\frac{db}{d\sigma}.$$

The effect of source tax on the net foreign asset can be decomposed into three parts. The first effect is through the change in the after-tax interest rate.

Since it depresses the saving of both countries equally, net asset positions are not changed. The second effect comes directly from the capital allocation effect. The capital outflow due to source tax results in an increase in the net foreign asset. Since the capital outflow also decreases GDP, however, the combined effects of capital inflow on GNI is neutral. The remaining effect, which ultimately changes GNI, comes from a change in the wage rate caused by the capital outflow. When the home country raises the source tax rate, a lower share of the country's capital stock in the world economy has a negative effect on wage income and, consequently, on GNI.

A formal derivation of the above argument is as follows. Differentiating the bracket term in (26) with respect to σ and substituting results presented in table 1 and (25) into it yields:

$$f'(\alpha)\frac{d\alpha}{d\sigma} + \frac{f'(\alpha)}{1+g}\left\{s'(\beta)\frac{d\beta}{d\sigma}[f(\alpha) - f'(\alpha)\alpha] - sf''(\alpha)\frac{d\alpha}{d\sigma} - \frac{d\alpha}{d\sigma}(1+g) + \alpha\frac{d(1+g)}{d\sigma}\right\}$$
$$= -\frac{f'^2}{4} < 0. \tag{27}$$

The foreign counterpart of the bracket term in (26) is increased by a change in the source tax rate, because the world GNI is unchanged by the source tax reform. Thus an increase in source tax lowers GNI of the home country and raises that of the foreign country through the capital allocation effect.

4 Welfare Analysis

Finally, we analyze the welfare implications of capital tax reform. The effects on the welfare are slightly different from those on GNI, because GNI aggregates the incomes of different generations. The welfare of each generation depends on wage income, the after-tax interest rate and the supply of public goods.

We calculate the welfare change of each generation after the reform. This sort of analysis can be cumbersome in most overlapping generation models. Since the dynamic path of our model immediately exhibits a balanced growth, the welfare of each generation will increase with the constant growth rate.

By virtue of this property we will obtain the tax effect on each generation with a single equation.

4.1 *Welfare Effects of an Increase in the Residence Tax Rate*

The indirect utility function is useful to evaluate the welfare effect. Noticing from (12) that public goods grow at the same rate as capital (g), we can obtain the indirect utility function of generation t as:

$$V^t(\frac{1}{1+\beta}, w_t)+\frac{e_{t+1}}{1+\delta} = V^t(\frac{1}{1+\beta}, [f(\alpha) - f'(\alpha)\alpha](1+g)^t\bar{K}_0)+\frac{e(1+g)^t\bar{K}_0}{1+\delta}. \tag{28}$$

An increase in the residence tax rate affects the utility level through a lower g, a lower β and a higher e. The decline in the growth rate lowers the welfare of the subsequent generations. An important fact is that this negative effect on welfare is magnified as time goes on since later generations suffer more from declines in wages caused by the decrease in the economic growth rate in all the proceeding periods. In exogenous growth models, the capital formation effect results in a lower capital-labor ratio, which is not multiplicative on time. The transform from the level effect under an exogenous growth to the growth rate effect under an endogenous growth does not alter the qualitative implications of the welfare effect of residence tax. However, it will play an important role in deriving a story about source tax reform, as shown in the next subsection.

Tax reform also affects the welfare through a decrease in the after-tax interest rate and an increase in the supply of public goods. They reflects the marginal costs and benefits of public goods. Since these parts of policy effects are not relevant directly to our focus, we ignore them in the current analysis. Appendix 1 verifies that if the tax revenues are assumed to be refunded to the older generations with a lump-sum fashion, these two effects cancel each other.

Appendix 1 also shows that the welfare effects of residence tax under an

additional assumption is given by

$$\frac{dV^t/d\rho}{V_2(1+g)^{t-1}\bar{K}_0} + \frac{de_{t+1}/d\rho}{V_2\left(1+g\right)^{t-1}\bar{K}_0} = \left[f\left(\alpha\right) - f'\left(\alpha\right)\alpha\right]\frac{\partial g}{\partial \rho}t \tag{29}$$

$$\frac{dV^t/d\rho^*}{V_2(1+g)^{t-1}\bar{K}_0} = \left[f\left(\alpha\right) - f'\left(\alpha\right)\alpha\right]\frac{\partial g}{\partial \rho^*}t, \tag{30}$$

where V_2 is the marginal utility of lifetime income. (29) and (30) confirm the narrative analysis shown above.

4.2 *Welfare Effects of an Increase in the Source Tax Rate*

The welfare effects of changes in the source tax rates comes from two channels: the capital formation effect and the capital allocation effect. The capital allocation effect represents that source tax decreases the capital stock in the home country. As suggested in the standard argument of dynamic efficiency, if the interest rate is greater than the growth rate, the decrease in capital stock leads to a lower welfare level. This is why source tax hurts home households. The households of the foreign country are made better off due to the capital inflow from the home country. The welfare effects caused by the capital shift are opposite across the borders.

The higher source tax rate also lowers the growth rate of the world economy, and thus, the welfare level of later generations is reduced by the tax reform. The capital formation effect grows over time like the case of residence tax. Therefore, source tax hurts both countries in the long-run. International conflicts, caused by the capital allocation effect and stressed in the exogenous growth context, fade away in our model.

A combination of the growth rate effect and the level effect creates intergenerational conflicts, along with short-run international conflicts, in source tax reforms. Figure 1 illustrates total effects of source tax reform on the welfare level of foreign households. The horizontal axes are the index of cohorts. Since (28) implies that the utility of each cohort is governed by the wage, the welfare level grows with the rate of g. In order to depict the welfare level over

time as a straight line, the vertical axis measures the natural logarithm of utility. The magnitude of welfare gain due to capital inflows is proportional to the world capital stock. Panel (a) shows that an increase in the tax rate shifts the utility line upward. The capital formation effect makes the utility line flatter, as shown in Panel (b).

Combining these two effects, Panel (c) shows the total change in welfare, which is measured by the horizontal axis. In a typical case, early generations are made better off because the capital allocation effect dominates, but later generations are hurt because the growing capital formation effect becomes sufficiently large. The break-even point varies with the underlying parameters of the model, although we do not give an explicit analysis.

The exact forms of welfare effects of source taxation to generations born after period 1 are calculated as follows:

$$\frac{dV^t/d\sigma}{V_2(1+g)^{t-1}\bar{K}_0}+\frac{de_{t+1}/d\rho}{V_2\left(1+g\right)^{t-1}\bar{K}_0}=-\left(\beta-g\right)\frac{1+g}{1+\beta}\frac{f'(\alpha)\alpha}{2}+[f(\alpha)-f'(\alpha)\alpha]\frac{dg}{d\sigma}t \tag{31}$$

$$\frac{dV^t/d\sigma^*}{V_2(1+g)^{t-1}\bar{K}_0}=\left(\beta-g\right)\frac{1+g}{1+\beta}\frac{f'(\alpha)\alpha}{2}+[f(\alpha)-f'(\alpha)\alpha]\frac{dg}{d\sigma^*}t. \tag{32}$$

The welfare of generation 0 is not changed due to the following reason. As expressed in Section 3.2, the policy change does not affect their wages. In other words, the constant terms in (31) and (32) are dropped. Since they are the first generation after the new policy, they have not suffered from the growth rate effect either.

5 Discussion

Our model and analysis have been tuned up to an exposition of intergenerational conflicts caused by the source tax reform. The model exhibits several attractive features. While a constant returns to the world capital makes endogenous growth possible, decreasing returns to the relative share of capital describes realistic movements of capital across borders. The welfare effects is easily scrutinized by virtue of the one dimensional dynamics of the model.

As usual, these properties depend on several simplifying and restrictive assumptions. In this section, we discuss how alternative specifications and assumptions influence our results.

5.1 *Asymmetric case*

Many parts of the calculation benefit from the assumption that the two countries are symmetric and that there are no taxes initially. We do not defend symmetric assumptions because allowing different preference and technology between countries derives a variety of outcomes, and gives little insight into what is an essential effect of taxation.

The existing literature on international taxation like Frenkel and Razin (1989), Iwamoto and Shibata (1999), and Sibert (1990) points out that some results depend on a foreign asset position. Since we eliminate some terms in equations for the welfare effect of the source tax reform with taking $b = 0$, our result may be altered when the initial net foreign asset position is not zero. As is seen from the analysis in Appendix 2, the eliminated term has a positive effect on the welfare when the initial net foreign position asset is negative. When the home country is a net debtor, an increase in the source tax increases revenues from foreign investors. This income transfer from the foreign country benefits the households in the home country, thereby working as an offsetting effect against the reduction of wage due to the capital shift to the foreign country. If the initial debt is sufficiently large, the source tax improves the welfare of the home country and hurts the foreign country at the early stage of reform. Note, however, that since the income transfer effect is the level effect, the growth rate effect will dominate the income transfer effect and the capital allocation effect. Therefore, the long-term consequences are independent of foreign asset positions. In this case, an intergenerational conflict arises in the *home* country.

5.2 *The way to refund tax revenues*

Since we assume tax revenues are used to finance public goods, the welfare effect of public goods disturbed our welfare analysis. We simplified formulas for the welfare effects by ignoring the terms coming from the marginal benefit of public goods and the marginal utility of income at the old. This procedure is justified if these two terms are equal. This condition is not satisfied in general under the current policy rule, but it holds if tax revenues are refunded to the old with a lump-sum manner. Readers may complain that we should have started from the assumption of the lump-sum refund to immediately obtain the simplified formulas. However, this alternative way has its costs. Since the lifetime income of households under the alternative policy rule depends on the refund at the old, the counterpart of (24), which represents the growth rate, becomes very complicated, and the calculation of growth effects and subsequent analysis would become cumbersome. Moreover, even in the alternative case we can show that essentially the same results are obtained by performing nasty calculations. Hence we preferred to employ the current setting.

5.3 *Specifications of Spillovers*

The presence of cross-border knowledge spillover is crucial to our story of international conflicts. Since labor is immobile across borders in our model, it might be reasonable that the knowledge embodied into the human capital is difficult to spill over across borders. On the other hand, several studies have suggested that the knowledge can spill over across borders through patent licensing, foreign direct investment and international trade of goods. A convincing, general, specification shall be:

$$Y_t = F(K_t, (K_t + \theta K_t^*)N), \tag{33}$$

where θ represents a kind of the "distance" between the two countries, or the degree of cross-border knowledge spillovers.[4] It would be natural to assume

[4]Specifications of knowledge sipllovers have been concerned by the preceding literature on sipllovers within countries. See Grilliches (1992) for a survey on empirical issues.

that $0 \leq \theta \leq 1$. The previous literature, like Buiter and Kletzer (1991, 1993) and Razin and Yuen (1994, 1996), has not considered the cross-border spillover. Thus, they can be considered as an extreme case of the general setting presented by (1), while the present paper focuses on the other extreme case, $\theta = 1$.

In this general formula, the production function can be transformed as:

$$Y_t = F(\alpha, \alpha + \theta\alpha^*)\overline{K}_t.$$

As is easily seen from this reduced form production function, wage income depends on the world capital stock unless $\theta = 0$, and, hence, the convergence in growth rates occurs. Although the analysis of the general form becomes complicated, we see no particular mechanism which may fundamentally reverse our conclusions of policy effects.

Eaton and Kortum (1995, 1997) assume that technology diffuses internationally with lags. It plays an important role in describing medium-term movements of productivity, which is the focus of their papers. Since a unit of period in our model is a generation, however, we do not believe that ignoring sluggish diffusion here is a fatal drawback. By the same token, the adjustment cost of investment, which is stressed by Bernstein and Mohnen (1998), may be safely ignored.

So far we have considered a linear specification to capture international spillover of capital accumulation externalities. Alternatively, Alogoskoufis and van der Ploeg (1991) and Coe and Helpman (1995), among others, assume the level of world-wide knowledge is captured well by a geometric average of each country's capital:

$$\bar{K} = K^{\theta}K^{*1-\theta}.$$

This form with the Cobb-Douglas production function is convenient to empirical research, because taking a logarithm yields a linear equation.

It is easy to show that even in this setting, we can analyze the effects of capital income taxation in a similar way to that in Section 2. Now we can rewrite the production function as:

$$Y = F(K/\bar{K}N, 1)\bar{K}N \equiv f(\gamma)\bar{K}, \tag{34}$$

where γ is defined as:

$$\gamma \equiv K/\bar{K} = (K/K^*)^{1-\theta}.$$

Because γ is a geometric average, instead of the sum of each country's capital, we have the following relation between γ and γ^* :

$$\gamma\gamma^* = 1. \tag{35}$$

Since we can determine unique constant values of γ and γ^* in a similar way to that in Section 2, the social production function, (34), is again reduced to an AK technology. The effects of source tax changes on the allocation of capital and before-tax rate are easily derived from (35) and the arbitrage equation.

Moreover, it is easy to show that the dynamics of world capital under this modified model are derived as

$$\begin{aligned} K_{t+1} + K^*_{t+1} &= (1 + \gamma^{\frac{1}{\theta-1}})K_{t+1} \\ &= \left[s(\beta)[[f(\gamma) - f'(\gamma)\gamma]\gamma^{-1} + s(\beta^*)[f(\gamma^*) - f'(\gamma^*)\gamma^*]\gamma^{\frac{\theta}{\theta-1}}\right] K_t. \end{aligned}$$

Assuming symmetry of the two countries, we can analyze the growth rate and welfare effects of capital income taxation by using this difference equation.

6 Relations to the Existing Literature

6.1 *International Taxation in Exogenous Growth Models*

Theoretical literature on international taxation has contrasted the effects of residence-based taxation and source-based taxation. Using small open economy models, Bovenberg (1992), Iwamoto and Shibata (1991), Nielsen and Sorensen (1991) and Summers (1988) emphasize that these principles are related to the different implications for tax incidence on savings and on investment.[5] Using a two-country exogenous growth model with the perfect

[5]See, for example, Sinn (1987, pp. 195-197) for more detail of the residence and source principles.

capital mobility but no labor mobility, Bovenberg (1989), Christensen and Nielsen (1995), Frenkel and Razin (1989), Ihori (1991), Nielsen (1992), Sibert (1990) and Sorensen (1990) have studied the international spillover effects of taxation. The most closely related studies to our focus are Ihori (1991), Sibert (1990) and Sorensen (1990), which highlight the effects of residence and source taxes in an overlapping generations model. They also show international conflicts created by a source tax reform. While an increase in the home residence tax rate decreases the capital stock in both countries, an increase in the source tax rate decreases the capital stock in the home country, but increases it in the foreign country (Ihori, 1991, Sorensen, 1990). When the current accounts of the two countries are balanced initially, residence taxes lower the welfare of both countries. However, the welfare effect of source taxes is positive on the foreign country and negative on the home country (Sibert, 1990. She actually stresses that the existence of large initial current account imbalances may reverse these welfare implications). The most crucial difference between their models and ours is that we consider an endogenously growing world economy.

6.2 *Interactions Between Taxation and Economic Growth in Open Economies*

In multi-country endogenous growth models, a country's tax policy could affect other countries' long-run growth rates. This effect on the foreign growth rates produces a new channel of international conflicts arising from tax policy, and hence, analyzing international sipillover effects of taxation in endogenous growth models is quite important. Rebelo (1991), Razin and Yuen (1994, 1996) and Buiter and Kletzer (1991, 1993, 1995) are seminal works along this line. They obtain novel, but mixed, implications.

Rebelo (1991) gives a brief sketch of the tax effects in a two-country model with AK technology and an infinite-horizon representative agent. An increase in the residence tax rate lowers the after-tax interest rate and the economic growth rate in the home country. This is because the Euler equation of the infinite horizon agent determines the positive relationship between the after-

tax interest rate and the growth rate. However, it does not have any effects on the rest of the world. The assumption of AK technology produces more striking results regarding the effects of source taxes. Production activity concentrates in the country which has the highest after-source-tax interest rate. If the countries have the same production technology, production is undertaken in the country with the lowest source tax rate. Only the lowest source tax rate in the world matters for the world economy. Its increase lowers the growth rate of all countries.

Buiter and Kletzer (1991, 1993, 1995) examine sources of growth rate differentials by employing a two-country overlapping generations model in which economic growth is driven by the accumulation of human capital. The residence-based nonhuman capital income tax makes investment in human capital relatively attractive, and more accumulation of human capital leads to a higher growth rate. The source tax raises the home country wage rate and is likely to bring a higher rate of growth. Since the human capital is non-traded, a difference in tax policies can be a cause of international growth differentials through a difference in the accumulation of country-specific human capital.

Adding the endogenous fertility feature, Razin and Yuen (1994, 1996) show a more complicated story. In their two-country model, the infinite horizon dynasty has four measures of investment: physical capital at home, physical capital abroad, quality of children (increases in human capital) and quantity of children (increase in population). The residence tax makes the latter two measures more attractive. When investment in human capital responds significantly, the residence tax brings a higher per capita growth rate of national income. However, lower population growth offsets this increase, keeping the total income growth rate unchanged. The source tax does not create any growth rate differentials across the countries, but the world growth rate falls.

Our model incorporates a different mechanism of endogenous growth, that is, Arrow (1962) - Romer (1986) style production externalities, and we have proposed another story of how tax affects the growth rates of each country. In our model, it is assumed that the output of a country is affected by the

capital stock in the foreign country (which is a proxy of knowledge in the foreign country) as well as that in the domestic country. Specifications similar to our spirit are employed in the theoretical analysis of Alogoskoufis and van der Ploeg (1991), Fukuda (1993) and Mino (1996). Like the AK models, the production technology in our model exhibits constant returns to scale with respect to nonhuman capital accumulation, and this property yields balanced growth paths. We also assume production externalities prevail across borders. Thus the productivity of capital in each country depends on the world capital stock. In this setting, a contrast to Rebelo's (1991) and Buiter and Kletzer's (1991, 1993, 1995) arguments, any differences in the tax system cannot be a source of growth rate differentials. The international conflicts through the growth rate effects disappear in the long run.

Razin and Yuen's (1994, 1996) results come from the assumption of endogenous fertility. While tax policy may affect the per-capita growth rate of income through distorting incentives to investment in human capital, the endogenously determined population growth rate offsets the movement of the per-capita growth rate, maintaining the equality of the total income growth rates. Since population is fixed in our model, the underlying growth rate equalizing mechanism is totally different from that of their model. Here, the production externalities are crucial to equalizing the growth rates of the two countries.

Our result shows that the tax effect on growth rate differentials varies with the specification of the model. One cannot determine it by theory, *per se*. In Grossman and Helpman's (1991, chapters 7 and 8) model, where the knowledge is accumulated by R&D expenditures, the international spillover of knowledge is crucial to the growth rate differentials. While the growth rate of each country does not converge in the absence of international spillover of knowledge, it ultimately shares the same growth rate with the presence of spillover. Without labor mobility across borders, the international spillover seems to be more difficult to justify than that within a country. Since the literature has pointed out that patent licensing or international trade contributes to the spillover of knowledge, however, labor immobility cannot

preclude the international spillover. The international knowledge spillovers through licensing and trade have been empirically confirmed by recent studies including Bayoumi, Coe and Helpman (1999), Bernstein and Mohnen (1998), Branstetter (2001), Coe and Helpman (1995), Coe, Helpman and Hoffmaister (1997), Eaton and Kortum (1996, 1997, 1999) and Keller (2002).[6]

6.3 *Intergenerational Considerations*

Closed economy models of endogenous growth with overlapping generations are developed by several authors, such as Saint-Paul (1992) and Grossman and Yanagawa (1993). They show that welfare properties of overlapping generations models are significantly modified once the long-run growth rate has been endogenized. For example, introduction of a pay-as-you-go type public pension reduces the long-run growth rate, and, thereby, *always* decreases the welfare levels of sufficiently distant future generations.

Pioneering works of multi-country endogenous growth models with overlapping generations are Alogoskoufis and van der Ploeg (1991) and Buiter and Kletzer (1991, 1993). Alogoskoufis and van der Ploeg (1991) investigate the effects of budgetary policy on the growth rate and the current account, while Buiter and Kletzer (1991, 1993) examine the effects of taxation on the growth rate. However, neither of them are concerned with the intergenerational equity issue partially because, we guess, the presence of a transition path makes the analysis intractable. Since the world economy in our model converges immediately to a new steady growth path as in other AK models, the welfare of each generation grows at a constant rate. This property makes it possible for us to obtain the tax effects on each generation's welfare with a single equation.

Building a two-country continuous-time overlapping generations model with exogenous growth, Christensen and Nielsen (1995) focus on different generational consequences of source tax reform. They point out that a higher source tax in the domestic country hurts the foreign households at the time of a policy change, whereas it will make future foreign households better off.

[6]Keller (2004) and Aghion and Howitt (1998, chapter 11) survey the issue.

Although both their paper and ours contrast the welfare effects of different generations in the foreign country, their direction is opposite due to a difference in underlying mechanisms. An increase in the domestic source tax rate raises the wage in the foreign country because the capital stock flows into the foreign country. In an exogenous growth model like Christensen and Nielsen (1995), future generations benefit from this wage increase. However, in the short run, older generations, who have already accumulated large capital, suffer from a reduction of capital income, because the inflow of capital stock lowers the interest rate. By considering a continuous-time overlapping generations model where young generations are roughly a labor income owner and older generations rely on capital income, Christensen and Nielsen (1995) reveal a kind of class conflict, which two-period overlapping generations models have dismissed. Nielsen (1992) provides a similar point in examining a residence tax and an investment tax credit. Since our model is a two-period overlapping generations model, a reasoning of intergenerational conflicts comes from a different place: a distinction between the level effect and the growth rate.

7 Conclusion

Using a two-country overlapping generations model with endogenous growth and perfect capital mobility, this paper has studied the international and intergenerational aspects of capital income taxation. The effects of capital income taxation on the welfare of each generation in each country have been particularly focused on. The international production externalities equalize the growth rates of the two countries. Therefore, the differences in tax systems cannot cause any growth rate differentials, unlike in Rebelo's (1991) AK model without externalities.

The fact that countries with different tax rates share the same growth rate produces novel implications for the spillover effect of tax policy. The source tax shifts the capital stock from the home country to the foreign country. This effect works to raise the welfare of the foreign country. However, the

increase in the source tax rate lowers the growth rate of the world economy. As a result, later generations will be damaged, while earlier generations benefit from the tax reform. Thus, the foreign country faces intergenerational conflicts, which have not been seen in previous exogenous growth models. Since both countries suffer from the lower economic growth rate caused by the taxes, we do not see, in the long-run, the international conflict which the literature on exogenous growth has stressed.

This finding suggests that the underlying structure of the model may be important in identifying the sources of divergent growth among countries (However, the tax policy creates the income level differences on the balanced growth path). More theoretical and empirical works are called for to determine whether there is a force to converge the growth rates of countries. In the present paper, we have provided a case where this line of research is of importance to policy debates.

Appendices

A 1: Welfare Effect of Residence Tax

From Roy's identity and (17), we have

$$\frac{V_1}{V_2} = (1+\beta)\, s(\beta)[f(\alpha) - f'(\alpha)\alpha]\bar{K}_t, \tag{A1}$$

where V_i is the partial derivative of V with respect to its i-th argument.

Next consider the change in public goods associated with a tax policy change. Differentiating (13) with respect to tax rates and evaluating it at the zero tax rate yields

$$\frac{de}{d\rho} = \frac{de}{d\sigma} = f'(\alpha)(1+g)\alpha \tag{A2}$$

$$\frac{de}{d\rho^*} = \frac{de}{d\sigma^*} = 0. \tag{A3}$$

From these results we can derive the welfare effect of capital income taxation.

Differentiating the indirect utility function with respect to ρ yields

$$\frac{dV^t}{d\rho} = V_1 \frac{\partial \frac{1}{1+\beta}}{\partial \beta}\frac{d\beta}{d\rho} + V_2 \left\{ [f(\alpha) - f'(\alpha)\alpha] \frac{\partial (1+g)^t}{\partial g}\frac{dg}{d\rho}\bar{K}_0 \right\}. \tag{A4}$$

Dividing (A4) by V_2 and substituting (A1) in it yields

$$\frac{dV^t/d\rho}{V_2} = -\frac{s(\beta)[f(\alpha) - f'(\alpha)\alpha](1+g)^t \bar{K}_0 f'(\alpha)}{1+\beta} + \left\{ [f(\alpha) - f'(\alpha)\alpha] t (1+g)^{t-1} \frac{\partial g}{\partial \rho}\bar{K}_0 \right\}. \tag{A5}$$

With (A2) and (A5), the total effects on the welfare is evaluated as

$$\begin{aligned} &\frac{dV^t/d\rho}{V_2(1+g)^{t-1}\bar{K}_0} + \frac{de_{t+1}/d\rho}{V_2(1+g)^{t-1}\bar{K}_0} \\ &= -\frac{f'(\alpha)\, s(\beta)[f(\alpha) - f'(\alpha)\alpha](1+g)}{1+\beta} + \frac{f'(\alpha)\alpha(1+g)^2}{V_2(1+\delta)} + [f(\alpha) - f'(\alpha)\alpha]\frac{\partial g}{\partial \rho} t. \end{aligned} \tag{A6}$$

(A6) takes a nasty form because our governmental policy creates an unwanted welfare effect which is represented by the first and second terms of the right hand side. These terms appear because the benefit of the additional supply

of public goods does not equal the opportunity costs of resources devoted to the supply. This term may be positive or negative depending on the level of public goods supply. We can make these terms simpler if we assume an alternative policy assumption under which revenues from capital taxes are returned to the older generations with a lump-sum form. In this setting, marginal utility from lump-sum refund becomes $V_2/(1+\beta)$. Therefore, if

$$\frac{1}{1+\delta} = \frac{V_2}{1+\beta} \tag{A7}$$

holds, the welfare effect becomes simpler:

$$\begin{aligned}
&\frac{dV^t/d\rho}{V_2(1+g)^{t-1}\bar{K}_0} + \frac{de_{t+1}/d\rho}{V_2(1+g)^{t-1}\bar{K}_0} \\
&= -\frac{1+g}{1+\beta} f'(\alpha)\{s(\beta)[f(\alpha) - f'(\alpha)\alpha] - \alpha(1+g)\} + [f(\alpha) - f'(\alpha)\alpha]\frac{\partial g}{\partial \rho}t \\
&= [f(\alpha) - f'(\alpha)\alpha]\frac{\partial g}{\partial \rho}t.
\end{aligned} \tag{A8}$$

To obtain the third line of (A8), we have used $b = 0$ in the no-tax state for the symmetric countries. However, the final equation of (A8) is valid even when $b \neq 0$: Using $b = 0$, we have already eliminated a term in $de/d\rho$ of (A2). This term exactly chancels the first term in the second line of (A8).

The effects on the foreign households are much simpler because the residence tax does not affect the after-tax interest rate of the foreign households. Differentiating the indirect utility function with respect to ρ^* yields

$$\frac{\partial V^t}{\partial \rho^*} = V_2[f(\alpha) - f'(\alpha)\alpha]\frac{\partial (1+g)^t}{\partial g}\frac{\partial g}{\partial \rho^*}K_0, \quad \frac{dV^t/d\rho^*}{V_2(1+g)^{t-1}\bar{K}_0} = [f(\alpha) - f'(\alpha)\alpha]\frac{\partial g}{\partial \rho^*}t.$$

A 2:Welfare Effect of Source Tax

In the case of the source tax rate, a similar procedure yields

$$\begin{aligned}
\frac{\partial V^t}{\partial \sigma} &= V_1 \frac{\partial \frac{1}{1+\beta}}{\partial \beta}\frac{\partial \beta}{\partial \sigma} \\
&\quad + V_2\left\{-f''(\alpha)\frac{\partial \alpha}{\partial \sigma}(1+g)^t K_0 + [f(\alpha) - f'(\alpha)\alpha]\frac{\partial (1+g)^t}{\partial g}\frac{\partial g}{\partial \sigma}K_0\right\}.
\end{aligned} \tag{A9}$$

Adding $de_{t+1}/d\rho$ to (A9) and dividing it by $V_2(1+g)^{t-1}\bar{K}_0$ and substituting the results obtained in table 1 and (25) into it yields

$$\begin{aligned}
&\frac{dV^t/d\sigma}{V_2(1+g)^{t-1}\bar{K}_0}+\frac{de_{t+1}/d\sigma}{V_2\left(1+g\right)^{t-1}\bar{K}_0}\\
&=-\frac{1}{1+\beta}\frac{f'\left(\alpha\right)s\left(\beta\right)\left[f\left(\alpha\right)-f'\left(\alpha\right)\alpha\right]\left(1+g\right)}{2}+\frac{1}{V_2\left(1+\delta\right)}f'\left(\alpha\right)\alpha\left(1+g\right)^2 \qquad \text{(A10)}\\
&-\frac{f'(\alpha)\alpha\left(1+g\right)}{2}+\left[f(\alpha)-f'(\alpha)\alpha\right]\frac{dg}{d\sigma}t.
\end{aligned}$$

Again, substituting (A7) in (A10) yields

$$\begin{aligned}
&\frac{dV^t/d\sigma}{V_2(1+g)^{t-1}\bar{K}_0}+\frac{de_{t+1}/d\sigma}{V_2\left(1+g\right)^{t-1}\bar{K}_0}\\
&=-\frac{1+g}{1+\beta}f'\left(\alpha\right)\left\{\frac{s\left(\beta\right)\left[f\left(\alpha\right)-f'\left(\alpha\right)\alpha\right]}{2}-\alpha\left(1+g\right)\right\}-\frac{f'(\alpha)\alpha\left(1+g\right)}{2}+\left[f(\alpha)-f'(\alpha)\alpha\right]\frac{dg}{d\sigma}t\\
&=\frac{\left[\frac{1+g}{1+\beta}-1\right]f'(\alpha)\alpha\left(1+g\right)}{2}+\left[f(\alpha)-f'(\alpha)\alpha\right]\frac{dg}{d\sigma}t\\
&=-\frac{\left(\beta-g\right)\left(\frac{1+g}{1+\beta}\right)f'(\alpha)\alpha}{2}+\left[f(\alpha)-f'(\alpha)\alpha\right]\frac{dg}{d\sigma}t.
\end{aligned}$$

For the foreign households, a similar calculation makes

$$\begin{aligned}
&\frac{dV^t/d\sigma^*}{V_2(1+g)^{t-1}\bar{K}_0}\\
&=-\frac{1}{1+\beta}\frac{f'\left(\alpha\right)s\left(\beta\right)\left[f\left(\alpha\right)-f'\left(\alpha\right)\alpha\right]\left(1+g\right)}{2}+\frac{f'(\alpha)\alpha\left(1+g\right)}{2}+\left[f(\alpha)-f'(\alpha)\alpha\right]\frac{dg}{d\sigma^*}t\\
&=\frac{\left(\beta-g\right)\left(\frac{1+g}{1+\beta}\right)f'(\alpha)\alpha}{2}+\left[f(\alpha)-f'(\alpha)\alpha\right]\frac{dg}{d\sigma}t.
\end{aligned}$$

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Figure 1　The welfare effect on foreign households