Inter-jurisdictional Information Sharing and Capital Tax Game Under Imperfect Capital Mobility

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Dans cet article nous étudions les incitants à la transmission d’information sur les revenus du capital obtenus par les non-résidents, à l’aide d’un modèle de concurrence fiscale internationale dans lequel le capital est imparfaitement mobile. La transmission d’information entre juridictions et la concurrence fiscale sont modélisées sous des hypothèses alternatives quant au système fiscal international, au moyen d’un jeu à deux étapes avec information complète et imparfaite. L’équilibre parfait de ce jeu est utilisé pour examiner comment les raisons stratégiques des gouvernements à transmettre de l’information peuvent dépendre du type de système de taxation et quels éléments ont les effets les plus importants sur les résultats.

The purpose of this paper is to analyse the incentives for jurisdictions to share information about foreign investment of non-residents with other jurisdictions in a model of international capital income tax competition and when capital is internationally imperfectly mobile. The inter-jurisdictional information transmission and capital tax competition are modelled under alternative systems of international taxation by means of a two stage game of complete and imperfect information. The subgame perfect equilibria of this game is analysed to examine how the government strategic reasons for information transmission may depend on the type of international tax system and which features have the largest impact on the results.

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1. Introduction

The structure of taxation has important implication for the distortionary effects of taxes on the international allocation of investment. Two polar principles of international income taxation are often examined in the literature. The residence principle and the source principle. According to the latter, income originating in one jurisdiction is uniformly taxed regardless of the place of residence of the recipients of income, making the tax system neutral as to capital import. Then residents are not domestically taxed on their foreign-source income while non-residents are taxed as residents on income originating in that country. By contrast, and according to the residence principle, households and firms are uniformly taxed on their world-wide income without taking into account the source of their income, while non-residents are not taxed on income originating in the country. The residence principle is often argued in the literature as an efficient instrument enabling governments not only to preserve national tax sovereignty but also to minimise the distortionary effects created by international capital mobility, (see, for example, GIOVANNINI and HINES 1990). For that reason, that principle has been suggested as a second best measure to the full international co-ordination of capital tax policies.

A basic requirement however for the residence principle to work is that tax authorities have full information regarding the world-wide investments made by its residents. In GERARD and HADHRI (1994) we set forth that full information transmission is required for the residence principle to be effective. In theory, a government is able under the residence principle to tax capital income of residents earned abroad. However, in practice, it is too difficult for one jurisdiction to monitor foreign savings of its residents. This is due in particular to the lack of exchange of information between different tax authorities. To solve that problem of tax evasion, a co-operative policy between jurisdictions and financial intermediaries is necessary in terms of information transmission about foreign investment, (see also GORDON, 1990).

The purpose of this work is to analyse the incentives for governments to exchange information about investment by non-residents domestically invested when they behave in a non co-operative way. Two important questions are addressed here: First, is it welfare improving for one jurisdiction to share information about foreign investment with the other competing jurisdictions? Second,
what are the implications of the government's informational behaviour on the international allocation of investment, on private consumption, and on the provision of public services and social welfare?

The inter-jurisdictional information transmission and capital tax competition are examined under the presence of international imperfect capital mobility by means of a two stage game of complete and imperfect information. The first stage of this game is formulated as a situation where jurisdictions compete between each other for the amount of information to transmit abroad in order to maximise welfare of residents. The second stage of this game is characterised by the inter-jurisdictional competition in capital income tax rates. Jurisdictions are the players of this game and payoffs are social welfare of each country. The subgame perfect equilibria is studied under alternative systems of international taxation to examine how the government strategic reasons for information transmission may depend on the type of international tax system and which features have the largest impact on the results.

To the best of our knowledge, there has been no attempt in the literature on public economics focusing on the modelling of competition among jurisdictions in information sharing and capital income tax rates except the contribution of BACCHETTA and ESPINOSA (1995) which was an important reference for the present work. They have investigated the incentives for jurisdictions to share information about foreign investment with other jurisdictions using a highly simplified framework. Their model suggests that the informational government behaviour is crucial and should be taken into account when designing the optimal international tax system. They show that under some features of the tax system there will be no information sharing, while there are institutional arrangements under which government will transmit partial information for strategic purposes.

As said in their conclusion, the model used in their work is highly stylised and rests on some strongly simplifying assumptions. In particular the modelling of the production sector should be incorporated in a more realistic manner; the behaviour of tax payers (and tax evaders) could be specified in more detail; and some of the institutional features of their model could be endogenously determined. One may investigate if the strategic reasons for information transmission are robust to these modifications of their model.
Several extensions have been examined in our work. First, the modelling of international imperfect capital mobility which has been improved by incorporating the preference of household for domestic investment. Such a preference has been justified by BOVENBERG and GOULDING (1989), THALMANN, DELORME, and GOULDING (1996) and WINCOOP (1992). Second, the modelling of the production side using capital and labour. The incorporation of the constant returns to scale technology is a way to capture the impact of information sharing on the level of employment demanded by firms, on net labour earning of households, and on the government labour income revenue. Finally, strategic reasons for information transmission have been examined under the discriminatory tax system where jurisdictions can discriminate between income of residents and non-residents.

This paper is organised as follows. The main features of the model are analysed in section 2. The inter-jurisdictional information sharing and capital tax competition are investigated in section 3. Summary and concluding remarks are provided at the end of the article.

2. The Model

We use a two-period and two-country model with one private good produced by domestic firms in the second period. Technology is described as a constant returns to scale production function. Domestic output is produced using locally available capital and labour supplied by residents. Labour is immobile across countries while capital is internationally imperfectly mobile.

It is a two-jurisdiction model: the world economy consists of two countries linked by imperfect capital mobility. There is no lump-sum tax nor lump-sum subsidy. To maximise social welfare of the representative household, each government is assumed to levy taxes and to determine the amount of information it transmits to the other country about foreign investment of non-residents. Labour income tax rate is regarded, for simplicity, as exogenously fixed.

The utility function of household is specified as a function of private consumption and the level of public services supplied by the government in the second period. The individual is assumed to live two periods, and to have per-
fect foresight. He receives in the first period a fixed endowment $S^H$, and he has to determine how much he invests at home and how much he invests abroad in order to maximise his private utility. Public services are assumed to be financed by tax revenues levied on both capital and labour income in such a way that the government budget is balanced. The household is assumed to take as given the public spending of the government when he maximises his utility.

We focus now on the analysis of the main features of the model. We consider a situation where domestic source income of residents is taxed only by the home jurisdiction, while capital income of residents earned abroad is partially taxed by the home jurisdiction and partially by the foreign one. Tax revenue is therefore shared between the two jurisdictions. Each government may have three different tax rates applying to interest income. It has to levy taxes on not only capital income of residents regardless of the country where it is earned, but also on source income of non-residents domestically earned.

Following MINTZ and TULKENS (1996), and RAZIN and SADKA (1991), the tax structure of the home jurisdiction is characterised by,

- $m^H_D$: Tax rate levied on residents on domestic source income;
- $m^H_A$: Effective rate of additional tax levied on residents' foreign-source income;
- $m^H_N$: Tax rate levied on income of non-residents.
- $a^H$: The rate of foreign tax credit assumed to be exogenous.

Correspondingly, the foreign jurisdiction levies similar taxes, denoted by $m^F_D$, $m^F_A$, $m^F_N$, and $a^F$. Let us define $T^{HF}$ as the effective tax rate on foreign source income of residents,

$$T^{HF} = m^H_A + (1-a^H)m_N^F \quad \text{with} \quad m^H_A \geq a^H m_N^F$$

The net rate of return on domestic savings is given by,

$$r^{HH} = r(1-m_D^H)$$

and the net return on foreign savings is,

$$r^H_I = r(1-T^{HF})$$

where $r$ is the rate of return before taxes.
2-1. Assumptions about Tax Evasion

Domestic source income of residents is assumed to be totally known and controlled by the home country, so that no tax evasion can occur therefore on domestic earnings. On the other hand, individuals do not report their foreign investment, and the home jurisdiction is assumed to have no complete information about foreign source income of its residents. Residents are domestically taxed on their foreign source income only when the foreign jurisdiction provides information to the home jurisdiction. Following BACCHETTA and ESPINOSA (1995), incentive for tax evasion is not explicitly represented in this work, and individuals are assumed, for simplicity, to be risk neutral.

We define $\lambda^F$ as the proportion of investment abroad on which the foreign government gives information, and which may be interpreted in several ways. One may consider a situation in which the foreign government gives information on a subset of investments only which represents a proportion $\lambda^F$ of all foreign investments. Another way is to assume that the foreign government has a random inspection procedure that detects evasion by foreigners with a probability $\lambda^F$.

Investment of an individual is,

\begin{equation}
S^H = S^{HH} + \lambda^F S^{HF} + (1 - \lambda^F) S^{HF} \quad \text{for } 0 \leq \lambda^F \leq 1
\end{equation}

The first term on the right hand side stands for domestic investment totally known by the home jurisdiction, the second term is the share of foreign investment of residents monitored by the two jurisdictions, and the last term is the amount of tax evasion only known by the foreign jurisdiction.

The proportion of transmitted information, $\lambda^F$ is known to the taxpayer, and there is no cost of collecting and transmitting information. The household is assumed to receive one unit of endowment, ($S^H = 1$) in the first period, and it has to determine how much to invest at home and how much to invest abroad. Future private consumption is assumed to be financed by net labour earnings and the net return derived from the three types of investment: domestic investment, foreign known investment, and foreign non-monitored investment,
\( C^H = \alpha^H \left( 1 + r^{HF} \right) + \lambda^F \left( 1 - \alpha^H \right) \left( 1 + r_T^H \right) + (1 - \lambda^F) \left( 1 - \alpha^H \right) \left( 1 + r^{HF} \right) - \eta^H \left( \alpha^H \right) + (1 - t) w L^H \)

Where \( \alpha^H \) is the share of endowment of residents domestically invested, \( \eta^H \) is the net mobility cost of investing abroad, \( L^H \) is the second period labour supply, \( t \) is the labour income tax rate, \( w \) is the gross wage rate. The first term on the right hand side of (5) is the net return from domestic investment while the second and third terms are the net return from foreign investment. The first two terms represent the net return from investment of residents known by the home jurisdiction. The next three terms stand respectively for the net return from foreign investment only controlled by the foreign jurisdiction, the net mobility cost of foreign investment, and net labour earnings.

We denote by \( r_N^{HF} \) the net rate of return from the total foreign investment,

\( r_N^{HF} = \lambda^F r_T^H + (1 - \lambda^F) r^{HF} \)

where \( r^{HF} \) is the net rate of return from the foreign non-monitored investment,

\( r^{HF} = r \left( 1 - m^F_N \right) \)

Private consumption may be rewritten in a simpler way as

\( C^H = 1 + \tilde{R}_{\alpha}^H + \tilde{R}_L^H \)

where

\( \tilde{R}_{\alpha}^H = \tilde{r}^H - \eta^H, \quad \tilde{r}^H = \alpha^H r^{HH} + (1 - \alpha^H) r_N^{HF}, \quad \text{and} \quad \tilde{R}_L^H = (1 - t) w L^H \geq 0 \)

where \( \tilde{r}^H \) is the average rate of return net of all taxes, \( \tilde{R}_{\alpha}^H \) is the net return from investment, and \( \tilde{R}_L^H \) is the net labour earnings.

2-2. The Imperfect Capital Mobility Modelling

Little attention has been devoted so far in the literature on public economics to the modelling of the international allocation of savings and investment when capital is internationally imperfectly mobile. The main justification of this as-
sumption is the suppression of all barriers to capital movement by most industrialised countries. However, estimations of the degree of capital mobility among member States of the European Union have been proposed e.g. by ARGIMON and ROLDAN (1991) who suggest that European countries might be divided into two groups, Germany, the Netherlands and the United Kingdom on the one hand, characterised by a high degree of international capital mobility, Spain, France, Denmark, Belgium and Ireland on the other hand, characterised by a low degree of international capital mobility.

The degree of international capital mobility plays a key role in dynamic open economy models. A high sensitivity of tax models' results to the capital mobility presumption has been examined and confirmed. By way of example, HADHRI and GERARD (1995) have empirically investigated how welfare gains from tax co-ordination among countries may be affected in particular by the degree of international capital mobility when countries start out together from the non co-operative equilibrium. A high sensitivity of welfare effects of tax co-ordination to the international capital mobility has been confirmed in their work. Results suggest that tax co-ordination is welfare improving for all countries as compared to the Nash equilibrium when the degree of capital mobility is high. However, under a low degree of capital mobility, tax co-ordination can generate the reverse outcome. Welfare gains are improved therefore by tax co-ordination and the size of the improvement increases with the degree of international capital mobility.

One possible way to model the imperfect capital mobility across jurisdictions is to use the "net mobility cost" function of investing abroad. We refer to the net mobility cost as in PERSSON and TABELLINI (1992) and HADHRI (1996b) as the extra complication that foreign direct investment requires as compared to domestic investment. It can represent for example, the cost of gathering extra information about legal issues or about marketing.

\[ \eta^H = \left( \frac{\mu}{2} \right) \left( \alpha_0^H - \alpha^H \right)^2 \]

The parameter \( \mu \) measures the size of mobility costs. The cost function is specified in such a way that international capital tax difference is not the only reason for households to invest abroad. The household has to hold a positive fraction of his endowment abroad, even if tax rates are equal in the two coun-
tries. He is assumed to exhibit a stronger preference for domestic investment, \( \alpha_0^H \),

\[ \alpha_0^H \geq 1/2 \]

Such strong preference for home country has been justified by BOVENBERG and GOULDIER (1989), and THALMANN, DELORME, and GOULDIER (1996). As argued in WINCOOP (1992), there is a very limited international portfolio diversification, e.g. at the end of 1989 US investors held 94% of their equity portfolio in US stock and the Japanese held 98% of their equity portfolio in Japanese stock. The fact that investors are not attempting to reap the benefits of diversification available from holding a global portfolio can be explained by the exchange rate risk argument, the tax differences, the risk of expropriation associated with investing abroad, and the cost of transactions which may be large when investing in foreign markets.

2-3. Portfolio Choice

Utility of the household is specified as a function of the private and public consumption. He is assumed to live two periods, and to have perfect foresight. As mentioned above, the individual receives a fixed endowment of 1 in the first period, and he has to determine how much to invest at home, \( \alpha^H \), and how much to invest abroad in order to maximise his utility function written in a general form as,

\[ U(C^H, G^H) = C^H + \gamma^H G^H \text{ with } \gamma^H \geq 0 \]

where \( C^H \) is the private consumption in period 2 defined by equation 5 and \( G^H \) is the level of public services. The individual is assumed to take as given the supply of public services. He does not take into account the impact of his tax evasion decision on public consumption.

The first order derivative of \( C^H \) with respect to

\[ \alpha^H = (-r/\mu)m_H^H + (\lambda^F r/\mu)m_A^H + (1-\lambda^F a^H)(r/\mu)m_F^H + \alpha_0^H \]

The share of portfolio domestically invested, \( \alpha^H \) is a function of the capital
tax rates, the rate of foreign tax credit, \( a^H \), the degree of information transmitted by the foreign government, \( \lambda^F \), and the household's preference for domestic investment, \( \alpha^H \). It depends positively on \( m^H_A \), \( m^F_N \), and \( \lambda^F \), and negatively on \( m^H_D \). An increase in \( \lambda^F \) makes tax evasion less attractive from the home jurisdiction and enhances therefore the share of portfolio of residents domestically invested.

2-4. Production

On the production side, technology is described by constant returns to scale activities. Domestic output is produced in the second period using locally available capital, \( K^H_i \) and labour supplied by residents,

\[
L^H = \sigma(w)K^H \quad \text{with} \quad K^H = \alpha^H + 1 - \alpha^F
\]

\( \sigma(w) \) is the labour-capital ratio parameter standing for the level of employment demanded by domestic firms per unit of capital stock. The incorporation of that relationship into the model is important since it permits one to analyze the impact of information transmission of the home jurisdiction on the level of employment demanded by domestic firms, on net labour earnings of the household, and on the labour income revenue of the government.

2-5. Public Consumption

The analysis of competition in information and capital tax rates needs the modelling of government behaviour. Public good is supplied in the second period by the government, and financed with the various tax revenues as,

\[
G^H = rm^H_D \alpha^H + \lambda^F r (1 - \alpha^F) \left( m^H_A - \alpha^H m^F_N \right) + rm^H_N \left( 1 - \alpha^F \right) + nw \sigma(w) K^H
\]

The first two terms stand for the government tax revenue obtained from taxing residents respectively on their domestic and foreign known investment. The third term reflects tax revenue levied on non-residents on their investment originated in the home jurisdiction while the last term is the labour income tax revenue. The type of public good used here is known in the literature as, public good with zero income effects, (or "Ziff public good") which means that the
marginal rate of substitution is independent of the private consumption, (COWEL and GORDON, 1988). We shall investigate how public welfare may be affected by the tax evasion behaviour of the household on the one hand, and by the government incentives for information transmission on the other.\footnote{The optimal provision of public goods with tax evasion has always been important, and presently is attracting increasing attention. Two key questions have been addressed in the literature. First, how tax evasion decisions of individuals affect the public good provision? Second, does the optimal provision of public good influence the individual tax evasion behaviour?, [see, e.g., COWEL and GORDON (1988), GIOVANNINI (1988), FALKINGER (1988, 1991)]. As an example, FALKINGER (1991) has shown that tax evasion has no impact on the optimal level of public good provision. By using an additive utility specifications, he showed also that tax evasion may lead to either a less or to a higher optimal level of public good provision.}

3. Subgame Perfect Equilibria Under Alternative Tax Systems

Little attention has been focused in the literature on the modelling of information transmission about foreign investment as a strategic behaviour of the government. Our aim is to acquire a better understanding of the relationship that may exist between information sharing and capital income tax competition among jurisdictions.

Competition in information and capital tax rates has been analysed by means of a two stage game of complete and imperfect information, in which governments are assumed to choose their actions independently and simultaneously at each stage. Governments are the true players of the game, and payoffs are the social welfare of each country. Fiscal equilibria are solved by backwards induction. At the first stage each jurisdiction has to choose the degree of information to transmit to the foreign jurisdiction, in order to maximise welfare of its residents, taking as given the degree of information transmitted by the foreign country.

At the second stage, tax competition works as follows: Each jurisdiction has to determine capital income tax rates, in order to maximise welfare of its residents, taking as given the tax rates chosen by the other government, and the degree of information transmitted at the first stage. The second stage Nash equilibrium is characterised by capital income tax rates in the two countries, which in turn are functions of the degree of information sharing determined at the first stage.
3.1. An Initial Source Tax System

Under that system, capital income of residents is taxed at the same rate by the home tax authority regardless of the country in which it is invested, and non-residents are taxed by the home jurisdiction at the same rate as residents. This involves,

\[ m_D^H = m_A^H = m_N^H = m^H \quad \text{and} \quad T^{HF} = m^H + (1 - a^H)m^F \]

That system is used by a lot of countries for foreign direct investment by multinationals. Residents still pay a uniform tax on their monitored income directly to their government, but foreign investment is also taxed initially by the foreign government at the uniform foreign tax rate, \( m^F \). This system is typically applied to multinationals when they pay the foreign corporate tax rate on profit from their foreign subsidiaries but receive only a partial tax credit.

From (12), the optimal portfolio choice is then such that,

\[ \alpha^H = \left( \frac{r}{\mu} \right) (\lambda^F - 1) m^H + \left( 1 - \lambda^F a^H \right) \left( \frac{r}{\mu} \right) m^F + \alpha_0^H \]

One can easily show that,

\[ \alpha^H \geq \alpha_0^H \quad \text{if} \quad m^H \leq \left( \frac{1 - \lambda^F a^H}{1 - \lambda^F} \right) m^F \]

Public consumption is then,

\[ G^H = rm^H \alpha^H + rm^H (1 - \alpha^F) + \lambda^F r (1 - \alpha^H)(m^H - a^H m^F) + tw\sigma(w)k^H \]

The timing of the fiscal game is as follows: First, governments have to determine simultaneously and independently the degree of information transmission about foreign investments, \( \lambda^H \) and \( \lambda^F \). Second, both countries observe the degree of information transmission, and choose simultaneously and independently capital tax rates, \( m^F \) and \( m^H \). Third, payoffs are social welfare of each country, \( W_i^i(\lambda^H, \lambda^F, m^H, m^F) \) for \( i = H, F \).

The government problem at the second stage is,

\[ \max \quad C^H + \gamma^H G^H \]

\[ < m^H > \]
subject to (8), (15), (16), and (18). The reaction function of the home jurisdiction is then,

\[ m^H = b^H_1(\lambda^H)m^F + b^H_0(\lambda^H) \quad \text{and} \quad \lambda = (\lambda^H, \lambda^F) \]

(20)

and the reaction function of the foreign jurisdiction is,

\[ m^F = b^F_1(\lambda^F)m^H + b^F_0(\lambda^F) \]

(21)

Nash equilibrium in capital tax rates is given by,

\[ m^H(\lambda^H, \lambda^F) = \frac{b^H_1b^F_0 + b^H_0}{1 - b^H_1b^F_1} \geq 0, \quad \text{and} \quad m^F(\lambda^H, \lambda^F) = \frac{b^F_1b^H_0 + b^F_0}{1 - b^H_1b^F_1} \geq 0 \]

where \( b_1 \) and \( b_0 \) are defined in the appendix.

At the first stage, the home jurisdiction has to choose the degree of information to transmit abroad, \( \lambda^H \), so as to maximise welfare of its residents, taking as given the amount of information provided by the foreign jurisdiction, \( \lambda^F \). The social welfare function is implicitly written for the sake of implicitly as a function of the degree of information provided by the two jurisdictions on the one hand, and the capital tax rates equilibria determined at the first stage on the other hand. Then the problem of the home jurisdiction is,

\[ \text{Max } W^H[\lambda^H, \lambda^F, m^H(\lambda^H, \lambda^F), m^F(\lambda^H, \lambda^F)] \]

(23)

\[ <\lambda^H > \]

The first order condition of that maximisation w.r.t. \( \lambda^H \) can be stated in the general form,

\[ \frac{\partial W^H}{\partial \lambda^H} + \frac{\partial W^H}{\partial m^H} \frac{\partial m^H}{\partial \lambda^H} + \frac{\partial W^H}{\partial m^F} \frac{\partial m^F}{\partial \lambda^H} = 0 \]

(24)

The first term stands for the direct welfare effect of information stemming from the impact of \( \lambda^H \), at the initial value of the foreign tax rate, \( m^F \). That effect is negative, since providing information to the foreign jurisdiction makes foreign investment of non-residents less attractive, and generates therefore a negative effect on the home country's national investment, the level of employment, and a cut in government tax revenue from both savings and labour. The second term is equal to zero from the second stage optimisation. The last term represents the strategic welfare effect of information which may be interpreted as the indirect welfare effect originating from the impact of \( \lambda^H \) on \( m^F \).
Two cases are to be considered: First, if the strategic effect is negative, then providing information abroad generates a harmful welfare effect, and there would be no incentive for information transmission, and \( \lambda^H = \lambda^F = 0 \). Second, if the strategic effect is positive, then an increase of \( \lambda^H \) induces non-residents to invest more in their own country. Tax evasion from the foreign jurisdiction becomes less attractive allowing the foreign jurisdiction to impose a higher capital tax rate, \( m^F \) to raise more revenue (capital and labour). Now, since residents are taxed by the foreign jurisdiction at the same rate as non-residents on their foreign source income, a higher capital tax \( m^F \) is expected to induce residents to hold domestically a larger fraction of their wealth and to reduce tax evasion from the home country. The home jurisdiction is deemed to set a higher capital tax rate in order to earn a larger revenue.

To analyse these effects, we proceed as follows:

3.1.1. Direct Effects

The direct welfare effect of information transmission is decomposed as follows:

\[
\frac{\partial W^H}{\partial \lambda^H} = \left( \frac{\partial \tilde{R}_K^H}{\partial \lambda^H} + \frac{\partial \tilde{R}_L^H}{\partial \lambda^H} \right) + \gamma^H \left( \frac{\partial R_K^H}{\partial \lambda^H} + \frac{\partial R_L^H}{\partial \lambda^H} + \frac{\partial R^H}{\partial \lambda^H} \right) \leq 0
\]

where

\[
R_K^H = rm^H K^H, \quad R_L^H = \lambda^F r (1 - \alpha^H) (m^H - a^H m^F), \quad \text{and} \quad R^H = tw\sigma(w)K^H
\]

The first expression on the right hand side stands for the direct consumption effect stemming from the impact of \( \lambda^H \) on private consumption; it is equal to the direct portfolio effect and the direct employment effect. The direct portfolio effect is equal to zero since residents are totally indifferent to the degree of information transmitted by their jurisdiction when they decide to allocate their investments. Providing information by the one government has no direct impact on the portfolio choice of the residents. The second term is the direct employment effect: transmitting information to the foreign jurisdiction reduces the amount of investment produced in the home country through the decline in foreign investment of non-residents, which in turn decreases employment and hence the net labour earning of residents. Thus, the direct consumption effect is always non-positive. It depends positively on the labour capital ratio parameter and negatively on the labour tax rate and the size of capital mobility cost.
The second expression stands for the direct revenue effect originated from the impact of information sharing on the government tax revenue obtained from taxing both capital and labour income. It is equal to the direct capital revenue effect and the direct labour revenue effect. The first two terms represent the direct capital revenue effect. Communicating information to the foreign tax authority reduces capital revenue via the decline in the foreign investment of non-residents. That effect consists of two terms. The first one represents the negative impact of transmitting information on the government revenue stemming from taxing both residents and non-residents on their capital income earned domestically. The second one is the impact of exchanging information on government revenue stemming from taxing residents on their foreign known investment, and it is equal to zero. The last term is the direct labour revenue effect.

The direct welfare effect of information sharing is larger in this model than in BACCHETTA and ESPINOSA (1995), since we add a direct employment effect and a direct labour revenue effect. This effect is negative and is likely to increase with the labour capital ratio parameter and the preference of jurisdiction devoted to public consumption. Results show that household’s preference for domestic investment has no impact on the direct welfare effect of information transmission which is negatively affected by the size of the capital mobility cost and positively influenced by the labour income tax rate, especially when jurisdictions exhibit a high preference for public expenditure.

3.1.2. Strategic Effects

The strategic welfare effect can be decomposed as follows:

\[
\frac{\partial W^H}{\partial m^F} \frac{dm^F}{d\lambda^H} = \left( \frac{\partial \tilde{R}_a^H}{\partial m^F} \frac{dm^F}{d\lambda^H} + \frac{\partial \tilde{R}_l^H}{\partial m^F} \frac{dm^F}{d\lambda^H} \right) + \eta^H \left( \frac{\partial R^H_K}{\partial m^F} \frac{dm^F}{d\lambda^H} + \frac{\partial R^H_l}{\partial m^F} \frac{dm^F}{d\lambda^H} + \frac{\partial R^H_l}{\partial m^F} \frac{dm^F}{d\lambda^H} \right)
\]

The first two terms on the right hand side represent the strategic consumption effect originating from the indirect impact of \(\lambda^H\) on private consumption of residents through the positive response of the foreign tax rate \(m^F\) to an increase in the amount of information transmission. The first term stands for the negative strategic portfolio effect: higher taxes abroad mean a higher tax burden. The strategic portfolio effect is a decreasing function of the household’s preference for domestic savings.
The second term is the strategic employment effect. Providing information abroad attracts capital to the home country. A higher capital tax rate in the foreign jurisdiction induces both residents and non-residents to invest more in the home country, which in turn creates employment and, consequently, net labour earnings of residents. That effect is positive, it increases with the labour capital ratio parameter, and it depends negatively on both the size of the mobility cost and the labour income tax rate.

An increase in information transmission is likely to improve private consumption of residents when the strategic portfolio effect is dominated by the strategic employment effect. The strategic consumption effect is positive for a high value of the labour capital ratio parameter, of the preference of the household for domestic investment, and the preference of the jurisdiction for public expenditure. That effect may be negative for a high mobility cost and labour income tax rate. The strategic consumption effect of information transmission is always non-positive in BACCHETTA and ESPINOSA (1995), a higher capital tax in the foreign country reduces the net return of residents on investing abroad but has no effect on the net labour earnings of the household as the strategic employment effect is not considered in their work. By contrast, the present model shows that the strategic consumption effect is positive if the loss of net return is compensated by the gain of net labour earning, (strategic employment effect).

The last three terms of (26) represent the positive strategic revenue effect. It is equal to the direct capital revenue effect and the direct labour revenue one. The first term is the indirect effect of information transmission on the capital revenue of the government stemming from taxing residents and non-residents on their investment domestically produced. That effect is positive and negatively affected by the capital mobility cost. The second term is the indirect effect of information sharing on the government revenue obtained from taxing residents on their foreign known investment. The sign of that effect is non-positive, it depends negatively on the capital mobility cost and the household's preference for its own country, and it is equal to zero for \( \lambda^H = \lambda^f = 0 \). The last term reflects the strategic labour revenue resulting from the indirect effect of providing information on the government revenue obtained from taxing labour income of residents. The strategic labour revenue is positive and depends negatively on the capital mobility cost and positively on both the labour capital ratio parameter and labour tax rate.
To have a positive value in equilibrium for $\lambda^H$ and $\lambda^F$, it is sufficient therefore to show that under some conditions,

\[
\frac{dW^H}{d\lambda^H}_{\lambda^H=\lambda^F=0} = l_0^H + l_1^H \frac{dm^*_F}{d\lambda^H}_{\lambda^H=\lambda^F=0} > 0.
\]

Results (see Appendix) show that the strategic welfare effect of information sharing has a positive sign when the jurisdiction's degree of preference for public services is large. It depends negatively on the size of the capital mobility cost, and labour income tax rate. It depends positively on the labour capital ratio parameter and the preference of household for domestic investment. That effect might be large to compensate the direct effect, (negative).

3-2. A Discriminatory Tax System

Under that system, investment income of residents is domestically taxed at the same rate irrespective of the country in which it is produced,

\[
m_H^A = m^H
\]

In addition, the home tax authority is assumed to discriminate between residents and non-residents which means that endowment of residents and non-residents domestically invested are taxed at a different rate by the home jurisdiction.

Solving the portfolio choice problem involves,

\[
\alpha^H = (\lambda^F - 1)(r / \mu)m^H + (1 - \lambda^F a^H)(r / \mu)m_N^F + \alpha_0^H
\]

The government problem at the second stage is stated as,

\[
\text{Max } C^H + \gamma g^H G^H
\]

subject to (8), (14), (28), and (29). Solving that problem involves the two reaction functions,

\[
m^H* = b^H_1(\lambda^F)m^F* + b^H_0(\lambda^F) \quad \text{and} \quad m_{N^*}^H = d^H_1(\lambda^H)m^F* + d^H_0(\lambda^H)
\]
The reaction functions of the other country are written,

\[ m^F = b_1^F (\lambda^H) m^H_N + b_0^F (\lambda^H) \quad \text{and} \quad m^F_N = d_1^F (\lambda^F) m^H + d_0^F (\lambda^F) \]

where \( b_0, b_1, d_0, \) and \( d_1 \) are defined in the appendix. Nash equilibrium in capital tax rates is therefore,

\[ m^H_N (\lambda^F) = \frac{b_1^F d_0^H + b_0^H}{1 - b_1^H d_1^H} \geq 0 \quad , \quad m^H_N (\lambda^H) = \frac{d_1^H b_0^H + d_0^H}{1 - d_1^H b_1^H} \geq 0 \]

and

\[ m^F (\lambda^F) = \frac{b_1^F d_0^H + b_0^H}{1 - b_1^F d_1^H} \geq 0 \quad , \quad m^F_N (\lambda^F) = \frac{d_1^F b_0^H + d_0^H}{1 - d_1^F b_1^H} \geq 0 \]

At the first stage, the home country has to choose the degree of information to transmit abroad, \( \lambda^H \), so as to maximise the welfare of its residents, taking into account the direct welfare effect of \( \lambda^H \), and the strategic welfare effect through the Nash equilibrium in capital tax rates, determined at the second stage.

The government problem is stated therefore,

\[ \text{Max } W^H [\lambda^H, \lambda^F, s^H (\lambda^H, \lambda^F), s^F (\lambda^H, \lambda^F)] \]

\[ \text{< } \lambda^H \text{> } \]

where

\[ s^H (\lambda^H, \lambda^F) = (m^H, m^H_N) \quad \text{and} \quad s^F (\lambda^H, \lambda^F) = (m^F, m^F_N) \]

The first order derivative of that maximisation with respect to \( \lambda^H \) may be written as,

\[ \frac{dW^H}{d\lambda^H} + \frac{dW^H}{dm^F} \frac{dm^F_N}{d\lambda^H} + \frac{\partial W^H}{\partial m^F} \frac{dm^F_N}{d\lambda^H} = 0 \]

The first term is the \textit{direct} welfare effect of \( \lambda^H \) at the initial values of the foreign tax rates, \( m^F \) and \( m^F_N \), the second term is equal to zero as \( m^F_N \) is not influenced by \( \lambda^H \), and the last term is the \textit{strategic welfare} effect of \( \lambda^H \).

Three points are of particular interest. First, the direct portfolio effect is equal to zero as in the previous case and the direct employment effect is negative : the level of employment goes down when \( \lambda^H \) increases through the decline in foreign investment of non-residents. On the other hand, capital and labour revenue
effects are both negative. The direct welfare effect of $\lambda^H$ is therefore non-positive, and there is no direct welfare gain from information transmission. Second, there is no strategic welfare effect through an increase in the foreign tax rate. Providing information to the foreign country has no strategic effect on allocation of investment of residents since the foreign tax rate, $m^F_N$, is not influenced by $\lambda^H$.

Third, the only strategic effect occurs through investment of non-residents originating in the home country. An increase of the degree of information transmitted abroad, $\lambda^H$, induces the foreign jurisdiction to impose a higher capital tax rate, $m^F$, so as to raise more revenue (capital and labour). This makes tax evasion from the foreign country more attractive and induces non-residents to hold a larger fraction of their wealth in the home country. Then that allows the home jurisdiction to set a higher capital tax rate, $m^H_N$, in order to earn a larger revenue. To have in equilibrium a positive value for $\lambda^H$ and $\lambda^F$, the direct effect should be largely dominated by the strategic consumption effect and the strategic revenue effect which are positive. Strategic reasons for information transmission are less present under the discriminatory tax system as compared to the initial source tax. This is due in particular to the absence of the strategic effect through foreign investment of residents.

3.3. A Fixed Withholding Tax

According to that principle, domestic and foreign sources income of residents are taxed by the home jurisdiction at the same rate, but residents are assumed to pay abroad a predetermined withholding tax $\tilde{m}$ on their capital income earned there. So that,

\begin{equation}
(37) \quad m^H_D = m^H_A = m^H \quad \text{and} \quad m^H_N = m^F_N = \tilde{m}
\end{equation}

The portfolio choice is given by

\begin{equation}
(38) \quad \alpha^H = (\lambda^F - 1)(r / \mu)m^H + (1 - \lambda^F \alpha^H)(r / \mu)\tilde{m} + \alpha^H_0
\end{equation}

Nash equilibrium in capital tax rates is now,\(^3\)

\(^3\) See Appendix.
\[ m^H(\lambda^H) = -\frac{f_0^H + e_0^H}{f_1^H + e_1^H} \geq 0 \quad , \quad m^F(\lambda^F) = -\frac{f_0^F + e_0^F}{f_1^F + e_1^F} \geq 0 \]

The direct welfare effect is negative, there is no strategic effect through foreign investment of residents, and the strategic effect works only through foreign investment of non-residents. Governments have less strategic reasons to exchange information as compared to the discriminatory tax system, according to which, governments can discriminate between residents and non-residents.

3.4. The Pure Residence-Based System

According to the residence principle, each country taxes its households on both domestic and foreign source income. Taxes on the foreign source income of residents are fully credited by the home tax authority. Thus, foreign source income of residents is only taxed by the home jurisdiction, and foreign source income of non-residents are not taxed by the home jurisdiction and hence fully exempted. Moreover, capital income of residents is domestically taxed at the same rate regardless of the country where it is earned. This involves,

\[ a^H = 1 \quad m^H_N = 0 \quad \text{and} \quad m^H_D = m^H_A = m^H \]

That principle has been examined in the literature assuming full exchange of information by the different tax authorities and hence no tax evasion. Governments are assumed to co-ordinate their informational behaviour. One can show that social welfare function is totally independent of the degree of information transmitted by the home jurisdiction, \( \lambda^H \), and the foreign tax rate, \( m^F \). Both direct and strategic effects of information transmission are equal to zero. The level of information is therefore indeterminate.

The result of indeterminacy of \( \lambda^H \) is of considerable interest, it might not be robust to the generalisation of the model. For example, there is no incentive to attract foreign capital in this institutional setting. If there were such an incentive, governments would not share information. Moreover, we know that in a somewhat more general model the complete residence-based system is not a Nash equilibrium.\(^4\)

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\(^4\) See Mintz and Tulkens (1996).
3.5. The Pure Source-Based System

Under the source principle, residents are not domestically taxed on their foreign-source income and there is no crediting of foreign taxes, then

\[(41) \quad m_A^H = 0, \quad a^H = 0 \quad \text{and} \quad m_D^H = m_N^H = m^H\]

It is easy to show that neither \(m^H^*\) nor \(m^F^*\) depend on the level of information provided by the home government, \(\lambda^H\) and the foreign one, \(\lambda^F\). Both the direct and the strategic effects are equal to zero, and there is no need for information sharing.

4. Summary and Concluding Remarks

We have attempted to analyse the inter-jurisdictional information transmission and capital tax competition in the presence of international imperfect capital mobility. The basic interest was to examine whether the degree of information transmission may be a strategic variable in the same way as capital income tax rates when jurisdictions behave in a non-co-operative way. Two important questions have been addressed here: First, is it welfare improving for one jurisdiction to share information about foreign investment with the other competing jurisdictions? Second, what are the implications of the government’s informational behaviour on the international allocation of investment, on private consumption, and on the provision of public services and social welfare.

The inter-jurisdictional information sharing and tax competition has been modelled under several types of international taxation design by means of a two-stage game of complete and imperfect information. Jurisdictions are the players of this game and payoffs are social welfare of each country. Competition in information transmission was formulated at the first stage of the game while competition in capital income tax rate was assumed to take place at the second stage.

Little attention has been given in the literature to the modelling of competition among jurisdictions in information sharing and capital income tax rates. Notable exceptions BACCHETTA and ESPINOSA (1995) have been an impor-
tant reference for the present work. They have investigated the incentives for jur-
risdictions to share information about foreign investment with other jurisdictions
using a highly simplified framework. As said in their conclusion the model used in
their work is highly stylised and rests on some strongly simplifying assumptions...
In particular the modelling of the production sector should be incorporated in a
more realistic manner. An excellent survey is provided in HADHRI (1996c) re-
garding the alternative approaches to fiscal game modelling.

Several interesting extensions have been examined in the present paper. First,
the modelling of international imperfect capital mobility has been improved by
incorporating the strong preference of households for domestic investment. Sec-
ond, we model the production side using capital and labour. The incorporation
of the constant returns to scale technology was a way to capture the impact of
information sharing on the level of employment demanded by firms, on net
labour earnings of households, and on the government labour income revenue.
Finally, strategic reasons for information transmission have been examined un-
der the discriminatory tax system, where jurisdictions can discriminate between
income of residents and non-residents.

Results show that the direct effect of information transmission is negative,
whatever the tax system. No gain can be directly generated for one country from
transmitting information abroad. In fact, providing information to the foreign
jurisdiction makes investment of non-residents less attractive, and reduces there-
fore the home country national investment, the level of employment, and gener-
ates a cut in the government tax revenue from both savings and labour.

Two strategic effects are to be considered. The first one occurs through for-
eign investment of residents, an increase in the degree of information transmis-
sion induces the foreign jurisdiction to impose a higher capital tax rate. This
makes tax evasion less attractive from the home jurisdiction and induces resi-
dents to domestically hold a larger fraction of their wealth. The second effect
works through investment of non-residents in the home jurisdiction. The strate-
gic welfare effect of information is equal to the strategic consumption effect and
the strategic revenue effect. The first effect is positive when the strategic portfo-
lio effect, (negative) is dominated by the strategic employment effect (positive).
The sign of the strategic revenue effect is ambiguous and depends on the impli-
cations of information transmission on the government’s income tax revenue.
The important insight is that governments may have an incentive to share information even when they behave in a non co-operative way. The degree of information transmission is mainly affected by the jurisdiction degree of preference for public services, the degree of capital mobility cost, the level of employment generated by domestic firms per unit of capital stock, and the household's preference for domestic investment. The incentives for governments to transmit information abroad are also likely to depend on the type of international tax system and they are more present under some tax designs like the initial source tax system. However, one should examine the incentives for jurisdictions to provide information when they co-operate in information but not in taxes, this is an indirect way to investigate whether full information sharing between countries is optimal when they behave in a co-operative way.

(October 11, 1996)
APPENDIX: THE SUBGAME PERFECT EQUILIBRIA

A1. An Initial Source Tax System

The capital stock in the home jurisdiction is obtained as,

\[ K^H = \theta_1^H m^H + \theta_2^H m^F + \theta_3^H \]

where

\[ \theta_1^H = B_1^H - B_2^F \leq 0, \quad \theta_2^H = B_2^H - B_1^F \geq 0, \quad \theta_3^H = \alpha_0^H + 1 - \alpha_0^F \geq 0 \]
\[ B_1^H = B_0 (1 - \lambda^F) \leq 0, \quad B_2^H = -B_0 (1 - \lambda^F a^H) \geq 0, \quad B_0 = -r / \mu \leq 0 \]
\[ B_1^F = B_0 (1 - \lambda^H) \leq 0, \quad B_2^F = -B_0 (1 - \lambda^H a^F) \geq 0 \]

The government problem at the second stage is stated as,

\[ \text{Max} \quad C^H + \gamma^H G^H \]
\[ < m^H > \]

The first order derivative of \( G^H \) with respect to \( m^H \) is,

\[ \frac{\partial G^H}{\partial m^H} = g_1^H m^H + g_2^H m^F + g_0^H \]

Where

\[ g_0^H = \lambda^F r (1 - \alpha_0^H) + r \theta_3^H + nw \sigma \theta_1^H \geq 0, \quad g_1^H = 2 r (\theta_1^H - \lambda^F B_1^H) \leq 0 \]
\[ g_2^H = r \theta_2^H + \lambda^F r (a^H B_1^H - B_2^H) \geq 0 \]

The first order derivative of \( C^H \) w.r.t. \( m^H \) is given by

\[ \frac{\partial C^H}{\partial m^H} = f_1^H m^H + f_2^H m^F + f_0^H \leq 0 \]
Where

\[ f_0^H = \mu \alpha_0^H B_1^H - \lambda^F r + (1-t)w\sigma \theta_1^H \leq 0, \quad f_1^H = \mu B_1^H \geq 0, \quad f_2^H = \mu B_1^H B_2^H \leq 0 \]

Nash equilibrium in capital tax rates is given by,

\[ m^{H*}(\lambda^H, \lambda^F) = \frac{b_1^H b_0^F + b_0^H}{1 - b_1^H b_1^F} \geq 0, \quad \text{and} \quad m^{F*}(\lambda^H, \lambda^F) = \frac{b_1^F b_0^H + b_0^F}{1 - b_1^H b_1^F} \geq 0 \]

where

\[ b_1^H(\lambda) = -\frac{f_2^H + \gamma^H g_2^H}{f_1^H + \gamma^H g_1^H} \quad \text{and} \quad b_0^H(\lambda) = -\frac{f_0^H + \gamma^H g_0^H}{f_1^H + \gamma^H g_1^H} \]

\[ g_0^F = \lambda^H r(1 - \alpha^F) + r\theta_3^F + tw\sigma \theta_1^F \geq 0, \quad g_1^F = 2r(\theta_1^F - \lambda^H B_1^F) \leq 0, \]

\[ g_2^F = r\theta_2^F + \lambda^H r(a^F B_1^F - B_2^F) \geq 0, \]

\[ f_0^F = \mu \alpha_0^F B_1^F - \lambda^H r + (1-t)w\sigma \theta_1^F \leq 0, \quad f_1^F = \mu B_1^F \geq 0, \quad f_2^F = \mu B_1^F B_2^F \leq 0 \]

Welfare effect of information defined in (27) is written as follows

\[ \frac{dW^H}{d\lambda^H} \bigg|_{\lambda^H=\lambda^F=0} = l_0^H + l_1^H \frac{dm^F}{d\lambda^H} \bigg|_{\lambda^H=\lambda^F=0} > 0 \]

Where the direct effect is always negative,

\[ l_0^H = T_0^H + \gamma^H \sigma_0^H \]

where

\[ T_0^H = (1-t)w\sigma(w)c_0^H \bigg|_{\lambda^H=\lambda^F=0} \leq 0, \quad \zeta_0^H \bigg|_{\lambda^H=\lambda^F=0} = c_0^H \bigg|_{\lambda^H=\lambda^F=0} \left( rm^{H*} \bigg|_{\lambda^H=\lambda^F=0} + tw\sigma \right) < 0 \]

and

\[ c_0^H \bigg|_{\lambda^H=\lambda^F=0} = B_0 \left( m^{F*} \bigg|_{\lambda^H=\lambda^F=0} - a^F m^{F*} \bigg|_{\lambda^H=\lambda^F=0} \right) < 0 \]

The strategic welfare effect should be positive,
\[ l^H_1 = T^H_1 + \gamma^H z^H \]

where

\[ T^H_1 = -r(1 - \alpha^H_{1'}) + (2r/\mu)(1-t)w\sigma \quad \text{and} \quad z^H_1 = (2r^2/\mu)\gamma^H_{1'} \]

It turns out that,

\[ m^H = m^H_{1'	o0} \quad \text{and} \quad m^H_{1'\to0} = \frac{b^H_0 + b^H_1}{1 - b^H_0 + b^H_1} \]

where

\[ b^H_0 = \frac{\mu B_0 + 2r\gamma^H}{\mu B_0 + 4r\gamma^H} \quad \text{and} \quad b^H_1 = \frac{\mu B_0 + 2r\gamma^H + (1-t)w\sigma B_1 + \gamma^H + (1-t)w\sigma B_0}{\mu B_0 + 4r\gamma^H} \]

This involves,

\[ \frac{dm^H_{1'	o0}}{d\lambda^H_{1'	o0}} = \left( \frac{\partial b^H_0}{\partial \lambda^H} (1 - b^H_1) + b^H_0 \frac{\partial b^H_1}{\partial \lambda^H} \right) f(1 - b^H_1)^2 \]

A2. A Discriminatory Tax System

Functions defined in (31) and (32) are presented as follows,

\[ d^H_1(\lambda^H) = \frac{g^H_2}{g^H_1} \geq 0, \quad d^H_0(\lambda^H) = \frac{h^H_0 + \gamma^H g^H_0}{\gamma^H g^H_1}, \quad b^H_1(\lambda^F) = \frac{f^H_2 + \gamma^H e^H_2}{f^H_1 + \gamma^H e^H_1}, \]

\[ b^H_0(\lambda^F) = \frac{f^H_0 + \gamma^H e^H_0}{f^H_1 + \gamma^H e^H_1}, \quad g^H_0 = r(1 - \alpha^H_0) - twB^F_1, \quad g^H_1 = 2rB^F_2, \quad g^H_2 = rB^F_1 \]

\[ e^H_0 = r\alpha^H_0 + \lambda^F r(1 - \alpha^H_0) + tw\sigma B^H_1, \quad e^H_1 = 2rB^H_1(1 - \lambda^F), \quad e^H_2 = rB^H_2(1 - \lambda^F) + \lambda^F r\alpha^H_0 \]

\[ f^H_0 = \mu B^H_0 - \lambda^F r + (1-t)w\sigma B^H_1 \leq 0, \quad f^H_1 = \mu B^H_1 \geq 0, \quad f^H_2 = \mu B^H_1 B^H_2 \leq 0 \]
A3. A Fixed Withholding Tax

The first order derivative of $C^H$ with respect to $m^H$ is,

$$\frac{\partial C^H}{\partial m^H} = f_1^H m^H + \tilde{f}_0^H$$

Where

$$f_0^H = \mu B_1^H \alpha_0^H - \lambda^F r + (1-t)w\sigma B_1^H \leq 0, \quad \tilde{f}_0^H = f_2^H \bar{m} + f_0^H \leq 0$$

$$f_1^H = \mu B_1^H \geq 0, \quad f_2^H = \mu B_1^H B_2^H \leq 0$$

We turn now to the first order derivative of $G^H$ with respect to $m^H$

$$\frac{\partial C^H}{\partial m^H} = e_1^H m^H + \tilde{e}_0^H$$

Where

$$e_0^H = r\alpha_0^H + \lambda^F r\left(1 - \alpha_0^H\right) + t w\sigma B_1^H, \quad \tilde{e}_0^H = e_2^H \bar{m} + e_0^H$$

$$e_1^H = 2r B_1^H \left(1 - \lambda^F\right) \leq 0, \quad e_2^H = r B_2^H \left(1 - \lambda^F\right) + \lambda^F r a^H B_1^H$$

Nash equilibrium in tax rates is obtained as,

$$m^{H^*}(\lambda^H) = -\frac{\tilde{f}_0^H + \gamma_g e_0^H}{f_1^H + \gamma_g e_1^H} \geq 0, \quad m^{F^*}(\lambda^F) = -\frac{\tilde{f}_0^F + \gamma_g e_0^F}{f_1^F + \gamma_g e_1^F} \geq 0$$

Where

$$f_0^F = \mu B_1^F \alpha_0^F - \lambda^H r + (1-t)w\sigma B_1^F \leq 0, \quad \tilde{f}_0^F = f_2^F \bar{m} + f_0^F \leq 0$$

$$f_1^F = \mu B_1^F \geq 0, \quad f_2^F = \mu B_1^F B_2^F \leq 0$$

$$e_0^F = r\alpha_0^F + \lambda^H r\left(1 - \alpha_0^F\right) + t w\sigma B_1^F, \quad \tilde{e}_0^F = e_2^F \bar{m} + e_0^F$$

$$e_1^F = 2r B_1^F \left(1 - \lambda^H\right) \leq 0, \quad e_2^F = r B_2^F \left(1 - \lambda^H\right) + \lambda^H r a^F B_1^F$$
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