Dynamic Tax Competition, Home Bias and the gain from Non-preferential Taxation Regimes: A case for unilateral commitment*

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Abstract

In a dynamic two-period model of tax competition between two symmetric countries, where an investor has home bias for the country where he/she invests in the initial period, we show that a country has an incentive to unilaterally commit to a non-preferential taxation regime even when the competitor follows a preferential taxation strategy. When one country commits to a non-preferential taxation regime and the other adopts a preferential taxation strategy, the tax revenue of the country which commits to a non-preferential taxation regime is higher than what it can obtain when both countries jointly adopt non-preferential taxation regimes. The tax revenue of the country which adopts a preferential taxation strategy is equal to what it obtains when both countries jointly adopt non-preferential taxation regimes.

JEL classification: F21; H21; H25; H87

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1 Introduction

This paper is a contribution to the significant theoretical literature that has focused on the comparison of tax revenues generated under capital tax competition between two countries under a preferential regime (where countries set

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discriminatory taxes based on mobility, nationality etc.) and a non-preferential regime, under which a country is restricted not to set discriminatory tax rates. In recent years, concerned by the perceived "harmful effects" of such preferential measures adopted by large number of countries, several international agreements and non-binding resolutions have been adopted by the European Union (EU)[1] and Organization for Economic Cooperation and Development (OECD)[2] in order to impose restrictions on preferential taxation among member countries and to take joint action against continuation of preferential tax regimes by non-member countries. The primary "harmful effect" motivating such agreements appears to be the erosion of tax revenues and the loss of economic efficiency due to movement of capital between jurisdictions solely to evade tax payments.

There is a vast literature on tax competition[3] and the effects of coordinated adoption of non-preferential regimes on tax revenues of competing countries[4]. But the literature is not conclusive whether a preferential or a non-preferential regime generates higher tax revenues. Keen (2001) analyzes a symmetric game of tax competition between two countries that compete over two exogenous capital bases and shows that if the elasticity of investment flow with respect to tax differential is not too high, then tax revenues generated in Nash equilibrium are higher under preferential taxation regimes relative to non-preferential taxation regimes. Non-preferential regimes distort tax rates (as optimal tax rates are different for capital bases with different elasticity) and spread competition from more elastic tax bases to less elastic tax bases as well, resulting in lower tax revenues for competing countries. While in Keen (2001), both capital bases are imperfectly mobile, Wilson (2005) looks at a scenario where one of the capital bases is perfectly mobile, and the other is imperfectly mobile. He finds that a preferential regime generates higher tax revenues compared a non-preferential regime[5]. Bucovetsky and Haufler (2007) extends the main result of Keen (2001) for the case when competing countries are asymmetric.

[1] Main emphasis in the meeting of Council of Economics and Finance Ministers (1997) was to formalize "a design to detect such tax measures which unduly affect the location of business activity in the Community by being targeted merely at non-residents and by providing them with a more favorable tax treatment than that which is generally available in the Member State concerned. In 1998 EU Group established to identify harmful tax measures. By Nov 1999, Group identified 66 harmful tax measures".

[2] In 1998, the OECD adopted its "Guideline on Harmful Preferential Tax Regimes" (see, OECD, 1998). OECD(2000) Committee on Harmful Tax Practices identified 47 preferential tax regimes. In its progress report, OECD (2004) mentions that, 18 of these abolished, 14 amended and 13 were not found to be harmful on further analysis. OECD (2006) report states "The Committee considers that this part of the project has fully achieved its initial aims. Future work in this area will focus on monitoring any continuing and newly introduced preferential tax regimes identified by member countries".

[3] See for example Janeba (1998), Zodrow and Mieszkowski (1986), Janeba and Keen (1996), Zodrow (2010), Bucovetsky (1991), Baldwin and Krugman (2004), Bucovetsky and Haufler (2007), Burbidge, Cuff and Leach (2006), Davies and Eckel (2010), Oshima (2010), Hong and Smart (2010), Konrad and Kovenock (2009), Bucovetsky and Haufler (2008), Zodrow and Mieszkowski (1986), Janeba (1998).

[4] See Wilson (1999) and more recently Keen and Konard (2013) for a review of the tax competition literature.

[5] See proposition 2 in Wilson (2005).

The literature has identified rationales for having non-preferential regimes. Haupt and Peters (2005) introduced "home bias" in a model similar to Keen (2001) and find that a non-preferential taxation scheme generates higher tax revenue compared to preferential taxation scheme. Janeba and peters (1999) show that if competing countries differ in size (capital base) a non-preferential regime generates a higher tax revenue compared to a preferential tax regime. Janeba and Smart (2003) show that a non-preferential taxation is desirable when tax bases are on average highly responsive to a coordinated increase in tax rates by all governments, and when tax bases with large domestic elasticities are also more mobile internationally. Mongrain and Wilson (2015) provide a microfoundations for "home bias" in terms of different cost of relocation and find that a non-preferential regime generates higher tax revenue compared to a preferential regime. Thus, the results depend on composition of tax bases and how tax competition is modeled.

While papers discussed above are static in nature, I consider a dynamic two-period model of tax competition. Two identical countries compete for foreign investments over two periods, where, in each period, an investor is willing to invest in one of the competing countries. An investor who invests in a particular country during an initial period incurs a discrete cost of relocation (home bias effect) if he relocates to the competing country in a later period. In Haupt and Peters (2005) and Mongrain and Wilson (2015) investors are small with different cost of relocation, while in our paper, investors are large and have a discrete cost of relocation ("home bias). Haupt and Peters (2005) and Mongrain and Wilson (2015) consider competition over two capital bases where both capital bases are imperfectly mobile between two countries. Wilson (2005) looks at a scenario where one of the capital bases is perfectly mobile, and the other capital base is imperfectly mobile. While in Wilson (2005) imperfectly mobile investors are small, we consider a scenario with large investors.

The literature on tax competition compares payoffs of competing countries when competing countries commit to non-preferential taxation regimes jointly with a scenario where competing countries non-cooperatively adopt preferential taxation regimes. Many countries have adopted non-preferential taxation regimes. At the same time, there are many countries who are not inclined to adopt non-preferential taxation regimes. That is perhaps the reason why there is a shift in focus from preferential regimes to tax heavens[6]. The 2001 Progress Report also shows a shift in focus from preferential regimes to tax havens. With respect to tax havens, the OECD focused on transparency and exchange of information as the criteria for defining an uncooperative tax haven. Thus a jurisdiction would not be considered uncooperative if it committed to transparency and effective exchange of information. This raises a question whether a country has an incentive to unilaterally commit to a non-preferential taxation strategy even when its competitors adopt preferential taxation strategy. Janeba and Peters (1999) consider a model where in the initial stage competing countries choose whether to commit to a preferential (discriminatory) taxation regime or

[6] See OECD (2001) progress report " "The OECD's Project on Harmful Tax Practices".

a non-preferential taxation strategy (non-discriminatory) taxation regime and in the later stage they compete with taxes. They find that discriminatory taxation of foreign capital is a dominant strategy. On the contrary, we show that discrimination is not a dominant strategy. When one country adopts a preferential taxation strategy, the competing country has an incentive to commit to a non-preferential taxation regime unilaterally.

Major contributions of this paper are following. First, we show that when two symmetric countries compete to attract foreign investments, a country has an incentive to unilaterally commit to a non-preferential taxation regime[7]. The combined tax revenues of competing countries are higher when one country commits to a non-preferential taxation regime and the other adopts a preferential taxation regime. Second, we extend the result of Haupt and Peters (2005) and Mongrain and Wilson (2015) in a dynamic setting when investors are large. In Haupt and Peters (2005) both capital bases have home bias. In our paper, only one of the capital bases have home bias. Therefore, we extend the result of Haupt and Peters for a scenario where only one of the capital bases has home bias. This paper also captures a scenario when the capital bases are infinitely elastic. While Wilson (2005) shows that when one of the capital bases is perfectly mobile, and the another capital base is imperfectly mobile, a preferential regime generates higher tax revenue compared to a non-preferential taxation regime. We show that the result is opposite when investors are large; a non-preferential regime generates higher tax revenue compared to a preferential regime. We also show that, a non-preferential taxation scheme not only generate higher tax revenue in the later period, it also reduces tax subsidies provided to investors during the initial period.

2 Model

There are two identical countries/jurisdictions indexed by $i \in \{A, B\}$, who compete to attract capital from the outside their jurisdictions. The economy lasts for two periods, 1 and 2. In the beginning of period 1 competing countries have no domestic capital. In each period, a single investor enters the market (who owns a unit of capital), who wishes to invest either in country A or country B. For simplicity we assume that outside the two competing countries the return on capital is equal to 0. Once capital is invested in country A (country B) the return on capital is equal to 1 in each period. If the investor invests in country A (country B) in period 1, it has "home bias" for country A (country B). Home bias is captured by the term $1 \geq F \geq 0$. Home bias can also be considered as the cost of relocation. If the investor invests in country A (country B) in period 1, then if country B (country A) wish to attract the investor in period 2, it has to undercut the tax rate set by country A (country B) by a margin of F. We assume that competing countries cannot commit to future tax rates. In the beginning of each period, competing countries announce tax rates applicable

[7] See Kishore and Roy (2014) and Kishore (2016) for a scenario when a single country wishes to attract heterogeneous foreign investors.

for that period. In the beginning of period 1, competing countries announce tax rates applicable for period 1. The investor observes tax rates and decides whether to make an investment in country A (country B), or stay outside. In the beginning of period 2, both governments announce tax rates applicable in period 2. The investor residing outside the two competing countries decides whether to invest in country A or country B. The investor who is already invested either in country A (country B) decides whether to relocate to country B (country A) or remain invested in the initial location. If an investor had invested in country A (country B) in period 1 and decide to relocate to country B (country A), he incurs a cost F.

We analyze this two-period dynamic tax competition game when in the beginning of period 1 competing countries can either commit to a non-preferential taxation strategy or a preferential taxation strategy. Under a preferential taxation scheme, a government is free to set different tax rates for domestic and foreign capital. Under a non-preferential taxation scheme, a government is restricted to set an equal tax rate for domestic and foreign capital. In the present scenario competing countries has no domestic capital in the beginning of period 1. Hence, preferential and non-preferential taxation scheme have different implications only in period 2. If a country receives an investment in period 1, then in period 2, it cannot set different tax rates for the investor who invested in period 1 and the new investor in period 2 under a non-preferential taxation scheme. We assume that governments wish to maximize tax revenue and investors maximize their net return on capital after tax payments. For simplicity, we assume that governments and investors do not discount future income.

The dynamic game we analyze can be described in three stages:

Stage one: Both countries simultaneously decide whether to commit to a non-preferential regime or a preferential regime.

Stage two: In the beginning of period 1, both countries simultaneously announce tax rates applicable for period 1. The investor observes the tax rates and decide whether to make an investment in country A or country B. Governments receive taxes at the end of period 1.

Stage three: In the beginning of period 2, both countries simultaneously announce tax rates applicable for period 2. The country which commits to a preferential taxation regime announces the tax rate applicable on domestic capital (investment from period 1) and the tax rate applicable on foreign capital. The country which commits to a non-preferential taxation regime announces a single tax rate which is applicable for domestic (the investor who previously invested in the country) and foreign capital (the potential new investor). Both investors observe tax rates and make investment decision. The new investor decides whether to make an investment in country A or country B. The investor who has previously invested in country A (country B) decides whether to relocate to country B (country A) or remain invested in the initial location. Government receive taxes at the end of period 2.

The equilibrium concept is subgame-perfect Nash equilibrium. In the next section we consider a scenario when both competing countries adopt preferential taxation regime.

3 Preferential Taxation

Under a preferential taxation scheme, a country is free to set different tax rates for domestic and foreign capital. First, we look at the outcome in period 2.

3.1 Tax Competition in Period 2 under Preferential Taxation

Without loss of generality, suppose the investor invests in country A in period 1. Under a preferential taxation scheme, country A sets different tax rates for the domestic investor (the investor who previously invested in period 1) and foreign capital (the new investor who enters the market in period 2). Because country B has no domestic capital, it sets a tax rate for foreign capital. Because the new investor has no cost of relocation to either country, competition between two countries drives down the tax rate to zero. Country A sets the tax rate equal to F on the investor from the earlier period. It is not beneficial for country B to set a tax rate lower than 0 to attract the investor from country A. Therefore, country A retains the investor from period 1 and obtains tax revenues equal to F. Because the tax rate on the new investor is equal to 0, country B does not receive a positive tax revenue in period 2. Proposition 1 states this result formally.

Proposition 1 *The equilibrium tax revenues of country A (where the investor invests in period* 1*) and country B in period* 2 *are* F *and* 0*, respectively. In a unique pure strategy Nash equilibrium, country A sets the tax rates* F *and* 0 *respectively, on the investors from period* 1 *and period* 2*. Country B sets the tax rate equal to* 0 *on both investors.*

3.2 Tax Competition in Period 1 under Preferential Taxation

From Proposition 1 it is clear that a country which is able to attract the investor in period 1 also receives a positive tax revenue in period 2. On the other hand a country which fails to attract the investor in period 1 receives 0 as tax revenue in period 2. Hence, competing countries offer tax subsidy equal to the possible gain in period 2 from attracting the investor in period 1. Proposition 2 states the result and the proof is obvious.

Proposition 2 *Competing countries offer a tax subsidy equal to* F *in period* 1*. The tax revenue of competing countries is equal to* 0*.*

4 Non-preferential Taxation

In this section we analyze the game under a non-preferential taxation scheme. Under a non-preferential regime, competing countries are restricted to set an

equal tax rate on the investor from period 1 and the new investor in period 2. First, we look at the outcome in period 2.

4.1 Tax Competition in Period 2 under Non-preferential Taxation

Under a non-preferential taxation regime, if a country competes to attract the new investor in period 2 it has to offer a lower tax rate to the new investor and the investor who previously invested in period 1. This makes the country which receives an investment in period 1 less competitive in period 2. Similarly, a higher value for F (home bias) reduces competition in period 2. A country which receives an investment in period 1 can set a high tax rate and receive taxes only from the investor from period 1, while the country which does not receive an investment in period 1 is more willing to compete for the new investor. As F decreases, competition is more intense in period 2 because the country which does not receive an investment in period 1 is willing to undercut its competitor to attract the investor from period 1 as well. Here, one of the capital bases (investment from period 1) is imperfectly mobile, while the other tax base (investor in period 2) is perfectly mobile between two countries. Wilson (2005) also considers tax competition over two tax bases where one of the capital bases is perfectly mobile and the other is imperfectly mobile. Haupt and Peters (2005) and Mongrain and Wilson (2015) consider competition over two tax bases where both capital bases are imperfectly mobile between two competing countries. Wilson (2005), Haupt and Peters (2005) and Mongrain and Wilson (2015) consider a scenario with continuum of investors with heterogeneous cost of mobility (home bias). In this paper, we have large investors with an equal and discrete cost of mobility. This scenario is important because a majority of foreign direct investments (FDI) is done by large multinationals. Below, we analyze this game of tax competition in period 2.

Without loss of generality, suppose the investor invests in country A in period 1. Under a non-preferential taxation scheme, country A is restricted to set an equal tax rate on the investor who previously invested in period 1 and the new investor. Suppose in the beginning of period 2, country A and country B set the tax rates t_{A2} and t_{B2}, respectively. The tax revenue of country A in period 2 (TR_{A2}) is:

$$TR_{A2} = \begin{cases} 0 & if\ t_{A2} > t_{B2} + F \\ t_{A2} & if\ t_{B2} < t_{A2} \leq t_{B2} + F \\ 2t_{A2} & if\ t_{A2} \leq t_{B2} \end{cases} . \tag{1}$$

If country A sets the tax rate $t_{A2} > t_{B2} + F$ then country B is able to attract the new investor as well as the investor from country A. If country A sets t_{A2} such that $t_{B2} < t_{A2} \leq t_{B2} + F$, country B receives new investment in period 2 but country A is able to keep its domestic investor because of home bias. When $t_{A2} \leq t_{B2}$, country A is also able to attract new investment as well. Similarly,

the tax revenue of country B in period 2 (TR_{B2}) is:

$$TR_{B2} = \begin{cases} 0 & if\ t_{A2} \leq t_{B2} \\ t_{B2} & if\ t_{B2} - F \leq t_{A2} < t_{B2} \\ 2t_{B2} & if\ t_{B2} < t_{A2} - F \end{cases} . \tag{2}$$

Note that country B is more aggressive competitor in period 2. Country B has to undercut the tax rate of country A by a small margin to attract the new investor. Country B can also undercut country A by a margin of F to attract the investor from country A. Proposition $3-6$ describes the equilibrium of this game.

Proposition 3 *There is no pure strategy Nash equilibrium of this game when* $F > 0$. *When* $F = 0$, *there is a unique symmetric pure strategy Nash equilibrium where both countries set the tax rate equal to* 0.

Proof. Suppose there is a symmetric pure strategy Nash equilibrium where both competing countries set an equal tax rate t. Note that t should be greater than 0 because, country A can receive a positive tax revenue by setting a higher tax rate and receive taxes only from its domestic investor. When $t > 0$, country B would like to lower its tax rate and receive foreign investment. Hence, there is no possibility of a symmetric Nash equilibrium. Suppose there is an asymmetric pure strategy Nash equilibrium where country A sets t_A and country B sets t_B such that $t_A > t_B$. In this case country B will receive foreign investment but it has incentive to increase the tax rate. Similarly, there is no possibility of a Nash equilibrium where $t_A < t_B$. The proof is complete. ■

Given a pure strategy Nash equilibrium does not exist for $F > 0$, we analyze a mixed strategy Nash equilibrium. Wilson (2005) also didn't find a pure strategy Nash equilibrium when one of the capital bases is imperfectly mobile and the other capital base is perfectly mobile. Given we don't have a pure strategy Nash equilibrium, we analyze a mixed strategy Nash equilibrium[8]. Proposition 4 describes a mixed strategy Nash equilibrium when home bias is relatively large, *i.e.*, $F \geq \frac{2}{3}$.

Proposition 4 *If* $\frac{2}{3} \leq F$, *in a mixed strategy Nash equilibrium country A and country B receives* 1 *and* $\frac{1}{2}$ *respectively, as tax revenue. The support of the mixed strategy Nash equilibrium is* $\left(\frac{1}{2},\ 1\right)$ *with country A having a probability mass of* $\frac{1}{2}$ *at* 1. *Distribution of taxes of country A* $(\mathcal{F}_A(t_{A2}))$ *and country B* $(\mathcal{F}_B(t_{B2}))$ *over the support are*

$$\mathcal{F}_A(t_{A2}) = \begin{cases} 1 - \frac{1}{2t_{A2}} & for\ t_{A2} \in \left[\frac{1}{2},\ 1\right] \\ 0 & for\ t_{A2} \notin \left[\frac{1}{2},\ 1\right] \end{cases} \tag{3}$$

$$\mathcal{F}_B(t_{B2}) = \begin{cases} 2 - \frac{1}{t_{B2}} & for\ t_{B2} \in \left[\frac{1}{2},\ 1\right] \\ 0 & for\ t_{B2} \notin \left[\frac{1}{2},\ 1\right] \end{cases} . \tag{4}$$

[8] Also see Wang (2004) for a mixed strategy Nash equilibrium in tax competition game.

Proof. From (3) and (4) state that country A has probability mass of $\frac{1}{2}$ at the supremum of the support. Country B has no probability mass anywhere on the support. In step 1 we will show that competing country's expected tax revenue is same everywhere on the support. In step 2 we will show that no country can do strictly better by unilateral deviation.

Step 1 : If country A (country B) sets a tax rate $t \in \left[\frac{1}{2},\ 1\right]$, their expected tax revenue can be represented as

$$TR_{A2} = t + t\left[1 - \mathcal{F}_B(t)\right] = t + t\left[1 - \left(2 - \frac{1}{t}\right)\right] = 1 \tag{5}$$

$$TR_{B2} = t\left[1 - \mathcal{F}_A(t)\right] = t\left[1 - \left(1 - \frac{1}{2t}\right)\right] = \frac{1}{2}. \tag{6}$$

Equality in (5) and (6) follow from (3) and (4).

Step 2 : Note that no country can set a tax rate higher than 1, because in that case the investor will not make an investment. It is easy to observe that country A cannot gain from setting a tax rate lower than $\frac{1}{2}$, as tax revenue is strictly less than 1. If country B sets a tax rate sets a tax rate such that $t \leq 1 - F$ its tax revenue will be strictly less than $\frac{1}{2}$. Only thing remains to be checked is that if country B can do strictly better by setting a tax rate less than or equal to $1 - F$. When country B sets a tax rate lower than $\frac{1}{2}$, its tax revenue jumps discontinuously at $1 - F$.

$$(1 - F) + \frac{1}{2}(1 - F) > \frac{1}{2} \Rightarrow F < \frac{2}{3}. \tag{7}$$

From (7) it is clear that country B cannot do better by setting the tax rate equal to $1 - F$. If country B sets the tax rate lower than $1 - F$ then we have $\frac{\partial TR_{B2}}{\partial t} = \frac{F}{2(t+F)^2} > 0$. Hence, its tax revenue decreases if the tax rate is reduced. Hence, the proof is complete. ■

Proposition 4 states that when home bias is large enough, in period 2, competing countries receive strictly positive tax revenues. Equilibrium tax revenues of competing countries do not depend on home bias. When F is large $\left(F \geq \frac{2}{3}\right)$, the mixed strategy Nash equilibrium is similar to Varian (1980) and Narasimhan (1988). When $F = 1$, the mixed strategy Nash equilibrium is exactly similar to Narasimhan (1988). Country A can receive tax revenue equal to 1 by setting the tax rate equal to 1 on the investor from period 1 and forgo the new investor. Hence, the minimum tax rate country A sets is equal to $\frac{1}{2}$ because even if country A is able to attract the new investor with probability 1 at a tax rate lower than $\frac{1}{2}$, its tax revenue is lower than 1. Note that as long as $\frac{2}{3} \leq F$, the mixed strategy Nash equilibrium remains the same because country B has to set a tax rate lower than $1 - F$ to attract the investor from country A which is too low to be beneficial. The interesting feature of this equilibrium is that both countries receive the new investor with a positive probability and country A is able to retain the investor who previously invested in period 1. Proposition 5 describes the outcome when F is relatively smaller.

Proposition 5 *When* $0.543\,69 < F < \frac{2}{3}$*, in a mixed strategy Nash equilibrium, country* A *and country* B *receive* $\frac{\phi}{1-\phi}$ *and* ϕ *respectively as tax revenue. Country* A *randomizes between* $(\phi,\ 1)$ *and country* 2 *randomizes between* $\left[\left(\frac{\phi}{1-\phi} - F,\ 1 - F\right),\ \left(\phi,\ \frac{\phi}{1-\phi}\right)\right]$*. Country* A *has a positive probability mass of* m *at the supremum of its support. Distribution of taxes of country* A $(\mathcal{F}_A(t_{A2}))$ *and country* B $(\mathcal{F}_B(t_{B2}))$ *are*

$$\mathcal{F}_A(t_{A2}) = \begin{cases} \frac{2(t_{A2}-F)-\phi}{t_{A2}-F} & for\ t_{A2} \in \left[\frac{\phi}{1-\phi},\ 1\right] \\ 1 - \frac{\phi}{t_{A2}} & for\ t_{A2} \in \left[\phi,\ \frac{\phi}{1-\phi}\right] \end{cases} \tag{8}$$

$$\mathcal{F}_B(t_{B2}) = \begin{cases} 2 - \frac{\phi}{(1-\phi)t_{B2}} & for\ t_{B2} \in \left[\phi,\ \frac{\phi}{1-\phi}\right] \\ \frac{(t_{B2}+F)(1-\phi)-\phi}{(t_{B2}+F)(1-\phi)} & for\ t_{B2} \in \left[\frac{\phi}{1-\phi} - F,\ 1 - F\right] \end{cases} \tag{9}$$

$$\phi = \frac{1}{2F}\left(1 + 3F - \sqrt{6F + F^2 + 1}\right)$$

$$m = \frac{\phi + F - 1}{1 - F}$$

Proof. See appendix. ■

In a mixed strategy Nash equilibrium country A randomizes over $[\phi,\ 1]$ while country B randomizes over $\left[\phi,\ \frac{\phi}{1-\phi}\right]$ and $\left[\frac{\phi}{1-\phi} - F,\ 1 - F\right]$. When country A sets the tax rate in the range $\left[\frac{\phi}{1-\phi},\ 1\right]$, it is beneficial for country B to sets its tax rate in the range $\left[\frac{\phi}{1-\phi} - F,\ 1 - F\right]$ and attract the new investor and the investor who previously invested in country A. When country A sets relatively lower tax rate in the range $\left[\phi,\ \frac{\phi}{1-\phi}\right]$, it is not beneficial for country B to undercut the tax rate of country A by a discrete margin to attract the investor from country A. In this scenario, both countries compete for the new investor. Note that when $F = 0.543\,69$ then $1 - F = \phi$. The support of the mixed strategy Nash equilibrium of country B is disjoint because country A has a probability mass at the supremum of its support. Therefore, when country B lowers its tax rate from $\frac{\phi}{1-\phi}$ to $1 - F$, it undercuts country A with a discrete positive probability. Figure 1 depicts the equilibrium tax revenues of competing countries described in Proposition 3. The red line is $\frac{\phi}{1-\phi}$, the blue line is ϕ and two green lines are F and $2F$, respectively. We can see that $2F > \frac{\phi}{1-\phi} > F$ and $0 < \phi < F$.

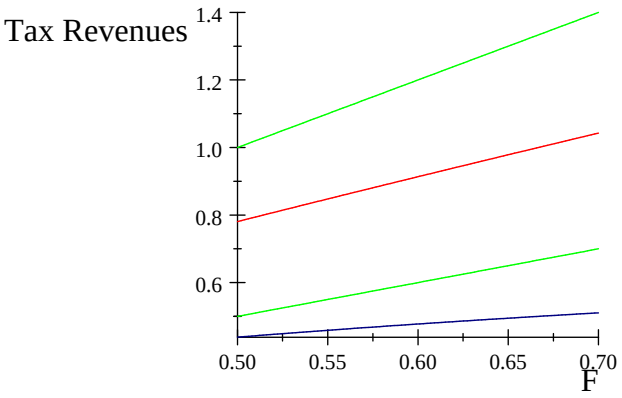

Figure 1: Equilibrium tax revenues of competing countries when $0.543\,69 \leq F \leq \frac{2}{3}$.

Below Proposition 6 describes the equilibrium outcome when F is very small, *i.e.*, $0 < F \leq 0.543\,69$. The mixed strategy Nash equilibrium described in Proposition 6 is similar to the one described in Proposition 5. Note that in Proposition 5, the support of the mixed strategy Nash equilibrium of country B is disjoint. When F is lower, the support of the mixed strategy Nash equilibrium of country B is also not disjoint. Tax rates set by both countries are relatively lower and there is no probability mass over the support of mixed strategy Nash equilibrium of country A.

Proposition 6 *When* $0 < F \leq 0.543\,69$*, in a mixed strategy Nash equilibrium country* A *and country* B *earn* $(1.54370)\,F$ *and* $(0.83929)\,F$ *respectively as tax revenue. There is no probability mass over the support. Distribution of taxes of country* A $(\mathcal{F}_A(t_{A2}))$ *and country* B $(\mathcal{F}_B(t_{B2}))$ *are:*

$$\mathcal{F}_{A2}(t_{A2}) = \begin{cases} 2 - \frac{(0.83929)F}{t_{2A}-F} & for\ t_{2A} \in [(1.54370)\,F,\ (1.83929)\,F] \\ 1 - \frac{(0.83929)F}{t_{2A}} & for\ t_{2A} \in [(0.83929)\,F,\ (1.54370)\,F] \end{cases} \tag{10}$$

$$\mathcal{F}_{B2}(t_{B2}) = \begin{cases} 1 - \frac{(1.54370)F}{t_{B2}+F} & for\ t_{B2} \in [(0.54370)\,F,\ (0.83929)\,F] \\ 2 - \frac{(1.54370)F}{t_{B2}} & for\ t_{B2} \in [(0.83929)\,F,\ (1.54370)\,F] \end{cases} \tag{11}$$

Proof. See appendix. ■

Intuition behind the mixed strategy Nash equilibrium described in Proposition 6 is similar to the one already described in Proposition 5. When country A sets relatively high tax rate in the range $[(1.54370)\,F,\ (1.83929)\,F]$, it is beneficial for country B to undercut by a discrete margin to attract the investor from country A and the new investor. When country A sets a lower tax rate in the range $[(0.83929)\,F,\ (1.54370)\,F]$ then it is not beneficial for country B to undercut by a discrete margin to attract the investor who had previously invested in country A. In this scenario both countries compete for the new investor. Note

that there is no probability mass anywhere on the supports of either country. Tax revenue of both countries decreases as F decreases.

Proposition 7 describes the outcomes of Proposition $3-6$. Note that from Proposition 4, when $F \geq \frac{2}{3}$, country A receives 1 and country B receives $\frac{1}{2}$ as tax revenues.

Proposition 7 *Under a non-preferential taxation scheme, in period* 2*, tax revenue of competing countries decreases as* F *decreases when* $F < \frac{2}{3}$*. When* $F \geq \frac{2}{3}$*, tax revenues of competing countries are independent of* F*.*

4.2 Tax Competition in Period 1 under Non-preferential Taxation

As evident from Proposition 3−6 the country which is able to attract the investor in period 1 also receives a higher tax revenue in period 2. Note that country which does not receive investment in period 1 also receives strictly positive tax revenue in period 2 when $F > 0$. Without loss of generality suppose country A receives an investment in period 1. Depending on F, suppose that the tax revenue of country A and country B in period 2 is TR_{A2} and TR_{B2}, respectively. Given $\partial = TR_{A2} - TR_{B2} \geq 0$, countries compete to attract the only investor in period 1. Because ∂ is equal to the gain in period 2 when the country attracts the investor in period 1, the maximum tax subsidy competing countries offer is equal to $\partial \geq 0$ in period 1. Hence, in equilibrium, the tax revenue of competing countries is equal to what a country receives in period 2 when it does not attract the investor in period 1. Proposition 8 describes the outcome of period 1.

Proposition 8 *Under a non-preferential taxation scheme, tax revenue of competing countries is equal to* $\frac{1}{2}$ *when* $F \geq \frac{2}{3}$*,* ϕ *when* $0.543\,69 < F < \frac{2}{3}$ *and* $(0.83929)\,F$ *when* $F \leq 0.543\,69$*. When* $F \geq \frac{2}{3}$*, competing country sets the tax rate equal to* $-\frac{1}{2}$ *in period* 1*. When* $0.543\,69 < F < \frac{2}{3}$*, competing countries set the tax rate equal to* $-\frac{\phi^2}{1-\phi} < 0$ *in period* 1*. When* $F \leq 0.543\,69$*, competing countries set the tax rate equal to* $-(0.70441)\,F \leq 0$ *in period* 1*.*

Proof. The proof is obvious once we note that $\frac{\phi}{1-\phi} - \phi$ is equal to $-\frac{\phi^2}{1-\phi}$. ■

5 Preferential Vs Non-preferential Taxation

Now we compare tax revenues of competing countries under a preferential and a non-preferential regime. First, we compare outcomes in period 2 under two tax regimes under consideration. In period 2 two countries compete over two tax bases; one imperfectly mobile and other perfectly mobile between two countries. This scenario can be considered as static tax competition between two asymmetric countries. The country which attracts the investor in period 1 is the larger of the two countries with a domestic tax base which is imperfectly mobile between two countries. The country which does not receive an investment in

period 1 is smaller with no domestic capital. We state the result which is direct consequence of Proposition 1 and Proposition $3-6$.

Proposition 9 *When two competing countries jointly commit to non-preferential taxation regimes, both countries (the country with domestic capital and the country without domestic capital) earn strictly higher tax revenue compared to a scenario when both countries adopt preferential taxation strategy as long as* $F \geq 0$. *The gain from having a non-preferential taxation scheme is strictly increasing with home bias.*

Janeba and Peters (1999) show that when two asymmetric countries compete over multiple tax bases where one of the capital bases is immobile while the other capital bases is perfectly mobile, the country with a larger immobile tax base earns an equal tax revenue under a preferential and a non-preferential taxation regime. The country with a smaller immobile tax base gains from having a non-preferential tax regime. Under a non-preferential taxation regime the larger country doesn't lower the tax rate below certain level because it loses tax revenue from its large immobile tax base which benefits the smaller country. Wang (2004) finds similar results without imposing restrictions to insure the existence of pure strategy Nash equilibrium. Proposition (9) show that both countries gain from having non-preferential taxation regimes as long as $F \geq 0$. When capital is fully immobile, the tax revenue of the large country is determined by the maximum possible tax rate on immobile capital base which is equal under a preferential and a non-preferential taxation regimes. When capital is partially mobile, under a preferential taxation regime the maximum tax rate is equal to F (cost of mobility). Under a non-preferential taxation regime the larger country can set the tax rate higher than F and still keep its partially mobile capital base because the smaller country finds it beneficial to set marginally lower tax rate and obtain higher tax revenue from fully mobile capital. This increases tax revenues of both countries under non-preferential taxation regimes. Wilson (2005) shows that when one capital base is imperfectly mobile and the other is perfectly mobile, tax revenues under preferential taxation regimes is higher compared to non-preferential taxation regimes. In Wilson (2005) investors are small, therefore, the gain from undercutting is large but the cost of undercutting is small which is partially compensated by relocation of partially mobile foreign capital. Unlike our case, a country cannot increase its tax rate without losing a fraction of its partially mobile capital. While in Wilson (2005) countries are symmetric, in our case countries are asymmetric in period 2. Haupt and Peters (2005) consider competition over two tax bases where one of the capital bases has home bias in favor of one country while one capital base has home bias in favor of the competitor. Proposition (9) also extends the main result established in Haupt and Peters (2005) for a scenario when only one of the capital bases has home bias (competing countries are asymmetric) and investors are large.

Now we compare the outcomes in period 1 under two taxation regimes. From proposition 2 it is clear that under a preferential regime, competing country's tax revenue is equal to 0. Proposition 8 states that under a non-preferential

taxation regime the equilibrium tax revenue of competing countries is strictly positive when $F > 0$. Therefore, even when competing countries are ex-ante symmetric, a non-preferential regime generates higher tax revenues compared to a preferential taxation regime. In Haupt and Peters (2005) one capital base has home bias in favor of one country and one capital base has home bias for the other country. Therefore, under a preferential taxation regime the size of capital base is asymmetric between two countries. A non-preferential taxation regime reduce this asymmetry because a smaller share in one capital base is offset by a larger share in the other capital base. Reduction in asymmetry reduces competition and increases tax revenues of competing countries. In our case, ex-ante there is no such asymmetry under a preferential or a non-preferential regime. Proposition 10 states the result formally.

Proposition 10 *Competing countries earn a strictly higher tax revenue under a non-preferential taxation scheme compared to a preferential taxation scheme as long as* $F \geq 0$. *The gain from having a non-preferential taxation scheme is strictly increasing with home bias when* $F < \frac{2}{3}$ *and remains constant when* $F \geq \frac{2}{3}$.

It is also important to determine under which regime competing government offer lower tax subsidy in the initial period. This is important because a government is often credit-constraint[9] and tax subsidies offered to large multinationals often make news. From proposition 8 it is clear that under a preferential taxation scheme, in period 1, competing countries offer tax discounts equal to F. From proposition 6, when $F \geq \frac{2}{3}$, the tax discount offered in period 1 under a non-preferential regime is equal to $\frac{1}{2}$, which is strictly less than F. When $F \leq 0.543\,69$, the tax discount offered in period 1 is equal to $(0.70441)\,F$ which is strictly less than F. When $0.543\,69 < F \leq \frac{2}{3}$, the tax discount offered in period 1 is equal to $\frac{\phi^2}{1-\phi}$ which is less than F. This result is stated in proposition 11.

Proposition 11 *In period* 1*, tax subsidy offered to the investor is lower under a non-preferential regime compared to a preferential regime.*

Under a preferential taxation scheme, in period 2, the difference between the country which receives investment and the country which does not receives investment is very high. In fact, the country which does not receive an investment in period 1 is equal to zero. This asymmetry in tax revenues in period 2, make countries offer higher tax subsidy in period 1, which reduces tax revenue. On the other hand, under a non-preferential regime, even the country which does not receive investment in period 1, receives strictly positive expected tax revenue in period 2.

[9] Besley and Persson (2009), Janeba and Schjelderup (2009) for the role of state capacity to levy taxes and tax competition.

6 A Case for unilateral commitment

In section 5 we compared two scenarios: (1) when both competing countries commit to non-preferential taxation regimes, and (2) when both countries adopt preferential taxation strategies. We observed that competing countries can do strictly better by jointly adopting non-preferential taxation regimes. In this section, we analyze whether a country has an incentive to commit to a non-preferential taxation regime even when its competitor adopts a preferential taxation strategy. When one of the competing countries commits to a non-preferential regime and the other adopts a preferential taxation strategy, then in period 2, the situation is similar to the case when both commits to non-preferential taxation regimes if the country which commits to a non-preferential taxation regime is able to attract the investor in period 1. The outcome of period 2 is described in Proposition $3-6$. In this case tax revenues of both countries are strictly positive in period 2 when $F > 0$. If the country which adopts a preferential taxation strategy is able to attract the investor in period 1, then the outcome in period 2 is similar to the scenario when both countries adopts a preferential taxation strategy. The outcome of period 2 in this case is described in Proposition 1. In this case the tax revenue of country which receives an investment in period 1 is F, while the tax revenue of the other country is 0. Without loss of generality suppose country A commits to a non-preferential taxation strategy and country B adopts a preferential taxation strategy. We know the outcome of period 2 depending on which of the two countries is able to attract the investor in period 1. Proposition 12 states which of the two countries is able to attract the investor.

Proposition 12 *In a scenario where one country commits to a non-preferential taxation regime and the other adopts a preferential taxation regime, the country which adopts a non-preferential taxation strategy is able to attract the investor in period* 1.

Proof. When $1 > F > 0$ and country B attract the investor, country B receives F in period 2 while country A receives 0. When $F \geq \frac{2}{3}$ and country A attract the investor, country A receives 1 and country B receives $\frac{1}{2}$. Therefore, the maximum tax subsidy country B will offer in period 1 is $F - \frac{1}{2} > 0$. Country A can offer a tax subsidy higher than $F - \frac{1}{2}$ in period 1 and attract the investor. If the investor receives the tax subsidy of $F - \frac{1}{2}$ and invests in country B, he pays F in period 2. The total tax payment is equal to $F - \left(F - \frac{1}{2}\right) = \frac{1}{2}$. If country A is able to attract the investor in period 1 then its expected tax revenue in period 2 is 1. Therefore, country A will offer a tax subsidy to the investor in period 1 which is greater than $F - \frac{1}{2}$ such that the expected the total expected tax payment by the investor is less than $\frac{1}{2}$. For example, country A can offer a subsidy of $1 - \varepsilon$ where $\varepsilon > 0$. Hence, the investor will make an investment in country A. The argument when $F < \frac{2}{3}$ is similar. ■

The outcome described in Proposition 12 is important. Because the country which commits to a non-preferential taxation regime is able to attract the

investor in period 1, it is clear that the outcome in period 2 does not change compared to the scenario when both countries jointly adopt non-preferential taxation regimes. Proposition 13 describes the outcome in period 1.

Proposition 13 *The tax subsidy offered in period* 1 *is lower when one country commits to a non-preferential taxation regime and the other adopts a preferential taxation regime compared to a scenario when both countries jointly adopt non-preferential taxation regimes.*

Proof. See appendix. ■

When both countries jointly commit to non-preferential taxation regime, the country which is able to attract the investor is period 1 receives higher tax revenues in period 2 compared to the other country. This prompts competing countries to offer large tax subsidy in period 1 to attract the investor. At the same time, the country which does not attract the investor also receives positive tax revenue which is relatively close to F. The country which adopts a preferential taxation strategy will get F in period 2. If the same country does not attract the investor, the tax revenue is lower than F but the difference is not large. This reduces the incentive to offer a large tax subsidy in period 1. Therefore, the country which commits to a non-preferential taxation regime is able to attract the investor by offering a smaller tax subsidy compared to the scenario when both countries commit to non-preferential taxation strategy. Proposition 14 describes the main result of this paper. The outcome is direct consequence of Proposition 12 and Proposition 13.

Proposition 14 *Compared to a scenario where both countries commit to non-preferential taxation regimes, combined tax revenues of competing countries is higher when one country commits to a non-preferential taxation regime and other adopts a preferential taxation regime. Moreover, the country which adopts preferential taxation strategy has no incentive to adopt a non-preferential taxation strategy if its competitor has committed to a non-preferential taxation strategy. Hence a scenario where one of the competing countries commits to a non-preferential taxation regime and the other adopts a preferential taxation strategy is a subgame-perfect Nash equilibrium.*

From Proposition 12 it is clear that the outcome in period 2 is similar to the case when both countries jointly adopt non-preferential taxation regimes. Proposition 7 states that when both countries commits to non-preferential taxation regimes, the total tax revenue is equal to what a country gets in period 2 when it does not attract the investor in period 1. Therefore, the country which adopts a preferential taxation strategy cannot do better by committing to a non-preferential taxation regime when the competitor adopts a non-preferential taxation regime. Proposition 13 states that the country which commits to a non-preferential taxation strategy is able to attract the investor in period 1 by offering a smaller tax subsidy compared to the scenario when both countries

jointly adopt non-preferential taxation regimes. Therefore, no country can do better by a unilateral deviation. Proposition 14 provides a novel result. Literature on tax competition compare the equilibrium tax revenue of competing countries under two different regimes; when competing countries commit to a non-preferential regime or when competing countries adopt a preferential taxation strategy. Proposition 14 states that a country has an incentive to unilaterally commit to a non-preferential regime. In the absence of competition, kishore (2014) shows that a country has an incentive to commit to a non-preferential agreement if it cannot commit to future tax rates. Proposition 14 shows that even when two countries are competing to attract investors, a country has an incentive to commit to a non-preferential regime unilaterally.

7 Conclusion

In a dynamic two-period model of tax competition between two symmetric countries, where an investor has home bias for the country where he/she invests in the initial period, we show that a country has an incentive to commit to a non-preferential taxation regime even when its competitor adopts a preferential taxation strategy. Tax revenues is higher when competing countries jointly adopt non-preferential taxation regimes compared to the scenario when countries adopt preferential taxation strategy. Competing countries do even better when one country commits to a non-preferential taxation regime and the other adopts a preferential taxation strategy. A non-preferential taxation scheme not only increases tax revenue in the later period, it also reduces competition in the initial period. The fact that a non-preferential agreement reduces tax incentives provided to investors in the initial period is very important. A credit-constraint government may prefer having a non-preferential agreement. The gain from having a non-preferential regime is strictly increasing in home bias as long as home bias is not large enough. When home bias is above a critical level, the gain from having a non-preferential agreement is independent of home bias. While the literature on tax competition has identified that "home bias" can make non-preferential taxation preferable to a preferential regime when investors are small with heterogeneous home bias, we show that even when investors are large with a discrete home bias, a non-preferential regime generates higher tax revenue compared to a preferential regime. Moreover, we show that even when only one of the capital bases has home bias, a non-preferential regime generates higher tax revenue compared to a preferential regime. This paper also quantifies the gain from a non-preferential regime with a parameter which captures home bias and provide clear comparative statics. This result is significant and a future study should analyze, if a country has an incentive to commit to a non-preferential regime when competition for FDI is between asymmetric countries.

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8 Appendix

Proof of Proposition 5: We need to show that strategy profile given by (8) and (9) constitute a mixed strategy Nash equilibrium. First, we will show that the distribution of taxes over the support are continuous. From (9), we must have $\mathcal{F}_B(\phi) = \mathcal{F}_B(1-F)$.

$$\lim_{\in \to 0} \mathcal{F}_B(\phi+\varepsilon) = 2 - \frac{\phi}{(1-\phi)\phi} = \frac{1-2\phi}{1-\phi}. \tag{12}$$

$$\lim_{\varepsilon \to 0} \mathcal{F}_B(1-F-\varepsilon) = \frac{(1-F+F)(1-\phi)-\phi}{(1-F+F)(1-\phi)} = \frac{1-2\phi}{1-\phi}. \tag{13}$$

From (12) and (13) it is clear that the distribution of taxes over the support of country B is continuous. Similarly, we must have $\lim_{\varepsilon\to 0}\mathcal{F}_A\left(\frac{\phi}{1-\phi}-\varepsilon\right) = \lim_{\varepsilon\to 0}\mathcal{F}_B\left(\frac{\phi}{1-\phi}+\varepsilon\right)$. From (8), we have

$$\lim_{\varepsilon \to 0} \mathcal{F}_A\left(\frac{\phi}{1-\phi}+\varepsilon\right) = 2 - \frac{\phi}{\frac{\phi}{1-\phi}-F} \tag{14}$$

$$\lim_{\varepsilon \to 0} \mathcal{F}_A\left(\frac{\phi}{1-\phi}-\varepsilon\right) = 1 - \frac{\phi}{\frac{\phi}{1-\phi}} \tag{15}$$

From (14) and (15) we have

$$2 - \frac{\phi}{1-\frac{1-2\phi}{1-\phi}-F} = 1 - \frac{\phi}{1-\frac{1-2\phi}{1-\phi}}. \tag{16}$$

Solving (16) for ϕ we get

$$\phi = \frac{1}{2F}\left(1 + 3F - \sqrt{6F + F^2 + 1}\right). \tag{17}$$

From (17) it is clear that the distribution of taxes over the support of country A is also continuous. The remaining part of the proof we will show in two steps. In step 1, We will show that competing countries earn an equal tax revenues everywhere on the support. In step 2, we will show that a country cannot do better from unilateral deviation.

Step 1 : First, we prove that country A gets an equal tax revenue everywhere on the support. If country A sets a tax rate $t \in \left(\phi,\ \frac{\phi}{1-\phi}\right)$. Using (9), the expected tax revenue of country A is

$$\begin{aligned} t + t\left[1 - \mathcal{F}_B(t)\right] &= t + t\left[1 - \left(2 - \frac{\phi}{(1-\phi)\,t}\right)\right] \\ &= t + t\left[\frac{\phi}{(1-\phi)\,t} - 1\right] = \frac{\phi}{1-\phi}. \end{aligned} \tag{18}$$

Similarly, if country A sets $t \in \left(\frac{\phi}{1-\phi},\ 1\right)$ then its tax revenue is

$$\begin{aligned} t\left[1 - \mathcal{F}_B(t)\right] &= t\left[1 - \left(2 - \frac{\phi}{(1-\phi)\,t}\right)\right] \\ &= t\left[\frac{\phi}{(1-\phi)\,t}\right] = \frac{\phi}{1-\phi}. \end{aligned} \tag{19}$$

Using (18) and (19), and noting the fact that distribution of taxes of country B is continuous with no probability mass anywhere over the support, it is clear that country A earns an equal tax revenue everywhere on the support. Similarly, we prove that country B earns an equal tax revenue everywhere on the support. Note that if country B sets $t \in \left(\phi,\ \frac{\phi}{1-\phi}\right)$, the distribution of taxes of country A is given by (8). Hence, tax revenues of country B over $\left(\phi,\ \frac{\phi}{1-\phi}\right)$ is

$$t\left[1 - \mathcal{F}_B(t)\right] = \phi. \tag{20}$$

Similarly, the tax revenue of country B over the interval $\left(\frac{\phi}{1-\phi} - F,\ 1 - F\right)$ is

$$t + t\left[1 - \mathcal{F}_A(t + F)\right] = \phi. \tag{21}$$

From (20) and (21) it is clear that country B earns an equal tax revenue everywhere on the interior of the support.

Step 2 : Now we prove that no country can do strictly better from unilateral deviation. Note that country B does not set a tax rate such that $1 - F < t < \phi$. Hence, if country A deviates and sets a tax rate such that $1 - F < t < \phi$ then it is not undercutting the tax rate of country B with a higher probability but still

setting a lower tax rate. Suppose country A deviates and sets a tax rate such that $\frac{\phi}{1-\phi} - F < t < 1 - F$. In this scenario country A is undercutting the tax rate of country B with a higher probability. Distribution of taxes of country B over the range $\left(\frac{\phi}{1-\phi} - F,\ 1 - F\right)$ is relevant. Hence, the tax revenue of country A is equal to

$$t + t\left[1 - \mathcal{F}_B\left(t\right)\right] = t + \frac{t}{t+F}\left(\frac{\phi}{1-\phi}\right). \tag{22}$$

Differentiating (12) with respect to t we obtain

$$1 + \left(\frac{\phi}{1-\phi}\right)\frac{F}{\left(t+F\right)^2} > 0. \tag{23}$$

From (13) it is clear that the tax revenue of country A reduces as it lowers the tax rate in the range $(1 - F - q,\ 1 - F)$. If country A sets $t = \frac{\phi}{1-\phi} - F$, it will attract receive investments from both investors with probability one and earn tax revenue equal to $2\left(\frac{\phi}{1-\phi} - F\right)$. But note that

$$2\left(1 - F - q\right) \geq \frac{\phi}{1-\phi} \Rightarrow \frac{\phi}{1-\phi} \geq 2F. \tag{24}$$

From (13) and (14) it is clear that country A cannot do strictly better from a unilateral deviation. Now, we need to show that country B has no incentive to deviate from the proposed strategy unilaterally. Following arguments similar to above, it is easy to see that country B cannot do better by setting a tax rate t such that $1 - F < t < \phi$. We have to check for $t \in \left(\frac{\phi}{1-\phi},\ 1\right)$ and $t < \frac{\phi}{1-\phi} - F$. Using (8) for $t \in \left(\frac{\phi}{1-\phi},\ 1\right)$, the tax revenue of country B is

$$t\left(\frac{\phi - t - F}{t - F}\right). \tag{25}$$

Differentiating (15) with respect to t we obtain

$$-1 - \frac{F\phi}{\left(t-F\right)^2} < 0. \tag{26}$$

If country B deviates and sets t such that $\phi - F < t < \frac{\phi}{1-\phi} - F$ its tax revenue is

$$t + t\left[1 - \mathcal{F}_A\left(t + F\right)\right].$$

From (8), the tax revenue of country B in this case is equal to

$$t + t\left(\frac{\phi}{t+F}\right). \tag{27}$$

From (16) and (17) it is clear that the tax revenue of country B is decreasing in its tax rate if the tax rate is higher than $\frac{\phi}{1-\phi}$, and the tax revenue is increasing

in its taxes when it is lower than $\frac{\phi}{1-\phi} - F$. This proves that country B cannot do better by a unilateral deviation. The proof is complete. □

Proof of Proposition 6: First, I will show that distribution of taxes of competing countries are continuous over the support. Distribution of taxes over the support of country A for taxes over the range $[(0.83929)\,F,\ (1.54370)\,F]$ and $[(1.54370)\,F,\ (1.83929)\,F]$ is given by (10).

$$\lim_{\varepsilon \to 0} \mathcal{F}_A \left[(1.54370)\,F + \varepsilon\right] = 2 - \frac{(0.83929)\,F}{(1.54370)\,F - F} = 0.4563 \tag{28}$$

$$\lim_{\varepsilon \to 0} \mathcal{F}_A \left[(1.54370)\,F - \varepsilon\right] = 1 - \frac{(0.83929)\,F}{(1.54370)\,F} = 0.4563 \tag{29}$$

From (28) and (29) we have

$$\lim_{\varepsilon \to 0} \mathcal{F}_A \left[(1.54370)\,F + \varepsilon\right] = \lim_{\varepsilon \to 0} \mathcal{F}_A \left[(1.54370)\,F - \varepsilon\right]. \tag{30}$$

Similarly, it can be shown that

$$\lim_{\varepsilon \to 0} \mathcal{F}_B \left[(0.83929)\,F + \varepsilon\right] = \lim_{\varepsilon \to 0} \mathcal{F}_B \left[(0.83929)\,F - \varepsilon\right]. \tag{31}$$

From (30) and (31) it is clear that the distributions of taxes over the support are continuous. The remaining part of the proof we show in two steps. In step 1, we show that competing countries receive equal tax revenues everywhere on the support. In step 2, we show that competing countries cannot do strictly better by unilateral deviation from the proposed strategies.

Step 1 : Suppose country A sets the tax rate $t \in [(1.54370)\,F,\ (1.83929)\,F]$. The expected tax revenue is $t\left[1 - \mathcal{F}_B\left(t - F\right)\right]$. If $t \in [(1.54370)\,F,\ (1.83929)\,F]$ then $t - F \in [(0.54370)\,F,\ (0.83929)\,F]$. Using (11), the expected tax revenue of country A is

$$t\left[\frac{(1.54370)\,F}{t}\right] = (1.54370)\,F. \tag{32}$$

Similarly, if country A sets $t \in [(0.83929)\,F,\ (1.54370)\,F]$ then its tax revenue is

$$t + t\left[1 - \left(2 - \frac{(1.54370)\,F}{t}\right)\right] = (1.54370)\,F. \tag{33}$$

From (32) and (33) it is clear that country 1 receives an equal tax revenue everywhere on the support. We need to check that the same holds for country B. Suppose country B sets $t \in [(0.54370)\,F,\ (0.83929)\,F]$ then the tax revenue is equal to $t\left[1 - \mathcal{F}_A\left(t + F\right)\right]$. Note that if $t \in [(0.54370)\,F,\ (0.83929)\,F]$ then $t + F \in [(1.54370)\,F,\ (1.83929)\,F]$. Hence, the tax revenue of country B is

$$t + t\left[1 - \left(2 - \frac{(0.83929)\,F}{t + F - F}\right)\right] = (0.83929)\,F. \tag{34}$$

Similarly, if the government sets $t \in [(0.83929)\,F,\ (1.54370)\,F]$ then its tax revenue is $t\,(1-\mathcal{F}_A\,(t))$. Using (10), the tax revenue equals

$$t\left[1-\left(1-\frac{(0.83929)\,F}{t}\right)=(0.83929)\,F\right]. \tag{35}$$

From (34) and (35), it is clear that country B also receives an equal tax revenue everywhere on the support. Now in step 2, we show that no country can do strictly better from unilateral deviation.

Step 2 : First, I prove that country A do not find it beneficial to set a tax rate outside the support. Suppose country A sets a tax rate greater than $(1.83929)\,F$. Using (11), the expected tax revenue of country A at the tax rate t is equal to

$$\begin{aligned} TR_{A2} &= t\,[1-\mathcal{F}_B\,(t-F)]=\frac{t\,[TR_{A2}-(t-F)]}{t-F}=\frac{tTR_{A2}}{t-F}-t \\ \Rightarrow\quad \frac{TR_{A2}}{\partial t} &= \frac{(t-F)\,TR_{A2}-tTR'_{A2}}{(t-F)^2}=-\frac{FTR_{A2}}{(t-F)^2}-1<0. \end{aligned} \tag{36}$$

Eq (36) shows that country A cannot do better by setting a tax rate higher than $(1.83929)\,F$. Now, suppose country A sets a tax rate t which is lower than infimum of the support of mixed strategy Nash equilibrium. Note that if it sets a tax rate equal to or lower than $(0.54370)\,F$ then the maximum tax revenue it can obtain is equal to $(0.54370)\,2F$, which is less than what it obtains in mixed strategy Nash equilibrium. Hence, we only need to verify that tax revenue of country A is for $t>(0.54370)\,F$. From (11), the tax revenue of country A for $t>(0.54370)\,F$ can be written as

$$TR_{A2}=t+t\,[1-\mathcal{F}_B\,(t)]=t+t\left[\frac{TR_{A2}-t}{t}\right]=TR_{A2}. \tag{37}$$

From (36) and (37), it is clear that country A cannot do better if it sets a tax rate outside the proposed support for mixed strategy Nash equilibrium. Now, we need to show that the same is true for country B as well. Suppose country B deviates and sets a tax rate which is less then the infimum of the support. If it sets $(0.83929)\,F-F$ or less, it can attract both investors with probability 1 but we can see it will earn a negative tax revenue. Given this we concentrate on the range of taxes which is lower than infimum of the support of country B but country B also attract one investor with a positive probability. Without a loss of generality, let us suppose country B sets the tax rate equal to t. The tax revenue of country B is $t+t\,[1-\mathcal{F}_B\,(t+F)]$ which using (10) can be written as

$$TR_{B2}=t+t\left[1-\left(2-\frac{TR_{B2}}{t+F-F}\right)\right]=TR_{B2} \tag{38}$$

where TR_{B2} is the tax revenue of country B in mixed strategy Nash equilibrium. Now, if country B sets a tax rate above the supremum of the support of country A, it gets tax revenue equal to 0. Suppose country B sets a tax rate t which

is greater than the supremum of the support if country B but less than the supremum of the support of country A. The tax revenue of country B for such a tax rate is $t\left[1-\mathcal{F}_A\left(t\right)\right]$, which using (10) can be represented as

$$TR_{B2}=t\left[1-\mathcal{F}_A\left(t\right)\right]=t\left(\frac{TR_{B2}}{t}\right)=TR_{B2} \tag{39}$$

From (38) and (39), it is clear that country B cannot do strictly better by setting a tax rate outside its support for proposed mixed strategy Nash equilibrium. The proof is complete. □

Proof of Proposition 13: Consider the case when $F\geq\frac{2}{3}$. Consider the scenario when both countries jointly adopt non-preferential taxation regimes. In period 2, the country which is able to attract the investor in period 1 receives 1 and the other country receives $\frac{1}{2}$ as tax revenues. Therefore, the maximum tax subsidy a country offers in period 1 is equal to $\frac{1}{2}$. Suppose country A is attract the investor in period 1. Because the tax revenue of country A in period 2 is equal to 1, the expected tax payment by the investor (who invested in period 1) in period 2 is strictly less than 1. Therefore, the total expected payment is strictly less than $\frac{1}{2}$. Now consider the scenario when country A commits to a non-preferential taxation regime and country B adopts a preferential taxation strategy. Country B obtains $F\geq\frac{1}{2}$ in period 2 if it is able to attract the investor in period 1, else it obtains $\frac{1}{2}$. Therefore, the maximum subsidy country B offers in period 1 is equal to $F-\frac{1}{2}>0$. The total tax payment if the investor invests in country B in period 1 is equal $F-\left(F-\frac{1}{2}\right)\equiv\frac{1}{2}$. If country A offers a subsidy of $\frac{1}{2}$ in period 1 and attract the investor, the total expected tax payment by the investor is strictly less than $\frac{1}{2}$. Hence, country A can attract the investor by offering a tax subsidy which is strictly greater than $F-\frac{1}{2}$ and strictly less than $\frac{1}{2}$.

Note that $\phi<F$. Consider the scenario where both jointly commit to non-preferential taxation regimes. In this case if a country receives an investment in period 1 then its tax revenue in period 2 is $\frac{\phi}{1-\phi}$. The country which does not receive an investment in period 2 receives ϕ. Therefore, the maximum tax subsidy a country is willing to offer in period 1 is $\frac{\phi}{1-\phi}-\phi=\frac{\phi^2}{1-\phi}$. Suppose the investor who made an investment in period 1 pays $\frac{\phi}{1-\phi}$ as taxes in period 2. In this case the total payment by the investor is equal to $\frac{\phi}{1-\phi}-\frac{\phi^2}{1-\phi}$, which equals ϕ. Therefore, the expected payment by the investor is strictly less than ϕ. Now, $F-\phi<\frac{\phi^2}{1-\phi}$. Therefore, the country which commits to a non-preferential taxation regime offers tax subsidy strictly less than $\frac{\phi^2}{1-\phi}$ and is able to attract the investor in period 1.

Similarly, consider the case when $0<F\leq 0.543\,69$. The maximum tax subsidy country B offers in period 1 is equal to $(1-0.83929)=(0.160\,71)\,F$. If the investor make an investment in country A his expected tax payment in period 2 is strictly less than $(1.54370)\,F$. If country A offers a tax subsidy of $(1.54370-0.83929)\,F=(0.704\,41)\,F$ in period 1 then the total expected tax payments of the investor who makes an investment in country A in period 1 is

strictly less than $(0.83929)\,F$. Therefore, country A offers a tax subsidy strictly greater than $(0.160\,71)\,F$ and strictly less than $(0.704\,41)\,F$ and attract the investor in period 1. The proof is complete. □