Competition for FDI with vintage investment and agglomeration advantages: A revisit

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November 25, 2022

Abstract

In a dynamic two-period tax competition game where two competing countries choose whether to adopt a preferential or a non-preferential regime during the initial stage, we analyze taxation regimes that may emerge when the country that attracts investments during the initial period gains agglomeration advantages during the later period. Whether a country adopts a non-preferential or a preferential regime during the initial stage depends critically on agglomeration effects. When competing countries choose taxation regimes simultaneously, either non-preferential or mixed taxation regime emerges for relatively small agglomeration effects. A mixed taxation regime is the only subgame perfect equilibrium when the agglomeration effect is in the intermediate range. Preferential, non-preferential, or mixed taxation regimes can emerge when the agglomeration effect is considerably large. We also discuss equilibrium outcomes when competing countries choose taxation regimes sequentially rather than simultaneously. Taxation regimes that emerge depend on agglomeration advantages. The tax revenue of the first mover is weakly greater than that of the second mover.

JEL classification: F21, H21, H25, H87

Keywords: Preferential Taxation, Non-preferential Taxation, Dynamic Tax Competition, Tax Holidays.

*"Competing interests: The authors declare no competing interests." I am thankful to the participants at the department seminar IISER Bhopal and the Public Economic Theory conference (PET 2022) for their valuable comments and suggestions. I am extremely thankful for the valuable suggestions from anonymous referees that helped me improve the paper. All remaining errors are mine. Email: kaushal@iiserb.ac.in Ph: +91 7496088192

1 Introduction

Countries across the world compete to attract footloose foreign capital. With economic integration and increasing mobility of human resources and capital, large multinationals often choose their location based on tax rebates offered by different governments [1]. Authors and policymakers argue that governments across the world are willing to lower tax rates to attract foreign investments. Competition for foreign capital results in very low tax rates on many forms of income, and that in the literature on "tax competition" is termed as the "race to the bottom" effect. At the same time, many countries do set relatively high tax rates on mobile capital. Authors have provided justification for such high tax rates using agglomeration effects and imperfect capital mobility[2].

In a seminal paper on economic geography and fiscal competition, Baldwin and Krugman (2004) look at tax competition between two asymmetric countries in the presence of trade costs and agglomeration effects. The relation between the agglomeration effect and the tax rate is non-monotone. The tax rate increases initially with economic integration in the region with agglomeration advantages, followed by a decrease in the tax rate with further economic integration. The agglomeration advantage is maximum when the trade cost is in the intermediate range. All firms move to the region with agglomeration advantages. Therefore, we can say that the tax rate increases with an increase in agglomeration advantages. In a similar model, Hayato and Hirofumi (2019) introduce profit shifting mechanism where a firm can shift profit to a low-tax country through transfer pricing. They show that during the initial level of economic integration, the low-tax country attracts more production plants than the high-tax country because the cost of intra-firm trade is high enough. Further economic integration makes intra-firm transactions less costly, and the high-tax country with agglomeration advantages becomes a more attractive destination for firms. Ludema and Wooton (2000) also find a similar result where regional integration reduces tax competition. Ferret and Gravino (2020) look at the competition between symmetric countries for a multinational enterprise (MNEs) where one of the competing countries also hosts a domestic firm that gains from foreign investments through knowledge transfer if the government can attract the MNE. In the absence of fiscal competition, the MNE locates in the country with no domestic firm to avoid knowledge transfer to the less efficient domestic firm. When countries compete to attract the MNE through fiscal incentives, the MNE locates in the country with a domestic firm. One can consider agglomeration advantages described in Baldwin and Krugman (2004) as a two-way knowledge transfer where the rent from agglomeration advantages increases for domestic as well as foreign entrepreneurs. Ferret and Gravino

[1] OECD. 1997, Model Tax Convention on Income and Capital (Paris: OECD Committee on Fiscal Affairs)

[2] For a survey on capital mobility and tax competition, see Zodrow (2018). For the literature on economic geography and tax competition, see Baldwin and Krugman (2004), Ledema and Wooton (2000), Ferret and Gravino (2020), and Hayato and Hirofumi (2019). Also see Bretschger and Hettich (2002) for empirical evidence of the effect of agglomeration advantages on tax competition.

(2020) consider a one-way transfer from the MNE to the domestic firm.

In the literature discussed above, one region has agglomeration advantages compared to the other, and that is determined exogenously. Moreover, they consider the case where competing countries set an equal tax rate for all investors. Ours is a two-period dynamic model where the country that attracts investments during the initial period gains agglomeration advantages during the later period. During the later period, the investor's cost of moving to the country with a larger domestic capital base is smaller compared to the other country. In other words, the return on investments is greater in the country with a larger domestic capital base. Unlike Ferret and Gravino (2020), we can interpret this as knowledge transfer from the domestic firm to the MNE. Our results are similar to the findings of the literature discussed above. When the agglomeration effect is relatively small, both countries attract investments with a strictly positive probability irrespective of taxation regimes they choose at the start of the game. On the other hand, all investors invest in one country when the agglomeration effect is greater than a critical level. Although all investments occur in one country, that does not lead to higher tax revenues. We find a different relation between the tax rate and agglomeration advantages. The tax rate is a decreasing function of the agglomeration effect as long as the agglomeration effect is not very large. The tax rate is an increasing function of the agglomeration effect when it is greater than a critical level. In Baldwin and Krugman (2004), the tax rate increases with an increase in agglomeration advantages that reaches its maximum when the trade cost is in the intermediate range.

The paper closely relates to various policy measures initiated through supranational agencies such as Organization for Economic Co-operation and Development (OECD) to promote cooperation on international taxation[3]. Policymakers argue that countries are increasingly adopting discriminating preferential taxation strategies to attract foreign investments. Governments offer lower tax rates to mobile investors while setting a relatively higher tax rates for immobile domestic investors. Discrimination can also be based on nationality, origin, sectors, or vintages of investments. Competition for foreign investments result in very low tax rates on many forms of capital. In order to reduce competition, policymakers encourage countries to adopt non-preferential taxation regimes. Under a non-preferential regime, a government is restricted from setting different tax rates for different capital bases. The reason behind such policy recommendation is that a non-preferential regime increases the cost of lowering tax rates and that should reduce competition for foreign investments. But the debate is far from over whether a non-preferential or a preferential regime generates higher tax revenues. The results depend on the composition of capital bases and how "tax competition" is modelled.

Authors compare tax revenues of competing countries under two different taxation regimes: (i) all competing countries adopt non-preferential taxation regimes that restrict them from setting different tax rates based on different

[3]See OECD (2004): The OECD's project on harmful tax practices.

mobility, vintages, nationality, etc., and (ii) all competing countries adopt preferential taxation regimes where they are free to set different tax rates for different capital bases[4]. Keen (2001) analyzes a symmetric game of tax competition between two symmetric countries over two exogenous capital bases. He shows that if the elasticity of investments flow with respect to tax differentials is not too high, tax revenues generated in Nash equilibrium are actually higher under preferential regimes compared to non-preferential regimes. Non-preferential regimes distorts tax rates (as optimal tax rates are different for capital bases with different elasticity) and spread competition for more elastic to less elastic tax base, resulting in lower tax revenues. Authors find that "home bias" and asymmetric capital bases provide rational for competing countries adopting non-preferential regimes[5]. In a model similar to Keen (2001), Haupt and Peters (2005) introduce "home bias". They show that equilibrium tax revenues are higher when competing countries adopt non-preferential regimes. In this paper, countries compete over two independent tax bases. One of the capital bases has a home bias for one country, and the other capital base has a home bias for the competing country. When a capital base has a home bias for one country, more than half of the capital is invested in that country when competing countries set an equal tax rate. Under preferential regimes, competition for one capital base is independent of the other capital base. This leads to stiff competition because the smaller country is more willing to lower the tax rate to attract foreign capital. In this scenario, non-preferential regimes bring symmetry between two countries, and that reduces competition and increases equilibrium tax revenues. Bucovetsky and Haufler (2007) show that when countries differ in the size of domestic capital bases, non-preferential regimes generate greater tax revenues. The larger country obtains equal tax revenues under two regimes, while the smaller country obtains greater tax revenues under non-preferential regimes. Therefore, the combined tax revenue of the two countries is greater. The cost of lowering the tax rate is higher for the country with a larger domestic capital base, and that allows the smaller country to set a relatively higher tax rate and yet attract mobile capital[6]. Janeba and Peters (1999) look at the competition between two countries for the internationally mobile capital base, while each country also owns a domestic immobile capital base. Competing countries either commit to a non-preferential or preferential taxation regime for the entire duration of the game during the initial stage. They find that a scenario where both countries adopt non-preferential regimes is difficult to sustain. When countries are asymmetric, a mixed taxation regime may arise in equilibrium where the smaller (the country with a smaller immobile capital base) gains if the larger of the larger country adopts a non-preferential regime. Marceau,

[4]See for example; Haupt and Krieger (2020), Haupt and Peters (2005), Janeba and Peters (1999), Janeba and Smart (2003), Keen (2001), Kishore (2019), Mongrain and Wilson (2018), Wilson (2005), Bucovetsky and Haufler (2007), Merceau, Mongrain, and Wilson (2010).

[5]Kishore and Roy (2014) analyze whether a single country facing dynamic inconsistency and the hold-up problem has an incentive to commit to a non-preferential regime. A similar problem is analyzed in Kishore (2017) when investors are strategic.

[6]Wilson (2005) also obtains a similar result when one capital base is imperfectly mobile, and the other is perfectly mobile.

Mongrain, and Wilson (2010) look at a similar problem while considering more than two countries. They also consider a scenario where countries set their tax rate sequentially. They also find that equilibrium tax revenues are higher when competing countries adopt non-preferential regimes. Mongrain and Wilson (2018) look at the competition between two countries for two imperfectly mobile capital bases. They find that a preferential regime generates higher tax revenues when a large fraction of the capital base has a relatively small cost of moving to the other jurisdiction. On the other hand, a non-preferential regime generates higher tax revenues when more firms have high moving costs. In this paper, governments not only care for tax revenues but also care for private sector incomes. The gains from non-preferential regimes are higher when governments only care for tax revenues. A mixed taxation regime can also arise when competing countries are sufficiently asymmetric.

While many countries have adopted non-preferential regimes, some countries are not willing to do so. Therefore, it is imperative to understand the kind of taxation regimes that emerge when countries non-cooperatively adopt non-preferential or preferential regimes at the start of the game and whether the rent from agglomeration effects has a bearing on the outcome. This question has not been addressed in the literature discussed above. It is also important to analyze this question to understand the feasibility of cooperation on taxation regimes in the presence of agglomeration effects. In this paper, we look at a two-period dynamic model where a single investor having one unit of indivisible capital enters the economy in each period. At the start of the game, competing countries simultaneously choose whether to commit to a non-preferential or a preferential regime for the entire duration of the game. The capital is fully sunk once invested, and the country that attracts the investor during the initial period gains agglomeration advantages during the later period. Similar to Konrad and Kovenock (2009), countries compete over two capital bases during the later period where one of the capital bases is perfectly immobile (investments from the earlier period), and the new investor that enters the market in period two faces different costs of moving. The cost of moving to the country with agglomeration advantages is zero, and the cost of relocation to the other country is positive. Konrad and Kovenock (2009) look at the competition for foreign capital when two competing countries adopt non-preferential regimes for the entire duration of the game. In this paper, we allow competing countries to commit to a non-preferential or preferential regime simultaneously for the entire duration of the game at the beginning of the game. We analyze whether agglomeration effects have an impact on the taxation regime that will emerge from three possible regimes: (i) Non-preferential regimes where both countries commit to non-preferential regimes, (ii) Mixed taxation regimes where one country adopts a non-preferential and the other adopts a preferential regime, and (iii) Preferential regimes where both countries adopt preferential regimes. We show that Non-preferential regimes and Mixed taxation regimes are subgame perfect equilibria of the game when the agglomeration effect is relatively small. In this scenario, both countries attract investments with a strictly positive probability and receive positive tax revenues. The result relates to the existing literature

on tax competition discussed above. This paper extends the result of Haupt and Peters (2005) in a dynamic setting for the scenario where "home bias" is endogenously determined and one of the capital bases is infinitely elastic. The result also shows that even though competing countries are ex-ante symmetric, non-preferential regimes generate higher tax revenues, i.e., asymmetry of capital bases is not necessary for this result. A mixed taxation regime is the only subgame perfect equilibrium of the game when the agglomeration effects are in intermediate range. Investments are fully agglomerated in the country that adopts a preferential taxation regime. Non-preferential, Preferential, and Mixed taxation regimes are subgame perfect equilibria of the game when the agglomeration effects are very large. Investments are fully agglomerated in one country and that does not depend on whether a country adopts a preferential or a non-preferential taxation regime.

Lastly, the paper is also related to the literature on "switching cost", and competition between firms in the presence of loyal consumer bases. The nature of mixed strategy Nash equilibrium that arises during the later period has been previously studied in Bertrand-type competition between firms with loyal customers (See Narasimhan (1988)), or when customers have switching costs (Farrell and Klemperer (2007)).

2 Model

We consider two identical countries/jurisdictions indexed by $i \in (A, B)$. Economy lasts for two periods, 1 and 2. Countries (A, B) compete to attract investments from outside their jurisdictions. Competing countries have no domestic capital at the beginning of period 1. At the beginning of period 1, a single investor (who owns one unit of capital) enters the market. At the beginning of period 2, a new investor with one units of capital enters the market. For simplicity, we assume that outside the two competing countries, the return on invested capital is equal to 0. The return on investments in countries A and B is 1 in each period. We assume that investments in country A (country B) are fully sunk. At the beginning of period 1, the investor can move to country A (country B) without incurring any cost. At the beginning of period 2, the new investor can move to the country with a domestic capital base (investments from period 1) without incurring a cost. On the other hand, the investor incurs the cost of F to move to the country without having a domestic capital base, where $0 \leq F \leq 1$. Konrad and Kovenock (2009) also similarly capture agglomeration advantage. In other words, the country that receives investments during the initial period gains agglomeration advantages. We assume that competing countries cannot commit to future tax rates. Therefore, at the beginning of each period, competing countries announce tax rates applicable for that period. We analyze this dynamic tax competition between two symmetric countries when at the beginning of the game, countries simultaneously commit to a non-preferential or preferential regime. If a country commits to a non-preferential taxation regime, it cannot set discriminating tax rates depending on the ori-

gin of the capital (domestic and foreign) or capital bases of different vintages (old investments and potential new investments). Under a preferential taxation regime, a country is free to set different tax rates for different capital bases. We assume that governments maximize tax revenues, and investors maximize net returns on investments after-tax payments. We further assume that neither governments nor investors discount future income. The timing of the game is described below.

Stage 1: Competing countries simultaneously decide whether to adopt a non-preferential or a preferential taxation regime for the entire duration of the game. The same is observed by governments and investors. We consider equilibria in pure strategies at this stage of the game. In section (7) we analyze the case when competing countries choose taxation regimes sequentially.

Stage 2: At the beginning of period 1, competing countries simultaneously announce the tax rates applicable in period 1. Even if a country adopts a preferential taxation regime, it sets a single tax rate because there is no domestic capital base. The investors observe the prevailing tax rates and taxation regimes and make an investment in country A or country B.

Stage 3: At the beginning of period 2, competing countries announce tax rates applicable for period 2. If a country has domestic capital (investments from period 1) and has adopted a preferential taxation regime, it sets tax rates for the domestic and foreign capital bases. A country sets a single tax rate when it has no domestic capital (no investments during the initial period), or when it has adopted a non-preferential taxation regime at the initial stage. The new investor observes prevailing tax rates and invests in country A or country B. Governments receive taxes at the end of period 2.

We look at the subgame-perfect Nash equilibrium of this three-stage dynamic game.

3 Preferential Taxation

The outcome under the preferential taxation regime is straightforward, and we omit the detailed discussion. Without a loss of generality, suppose country A attracts the investor in period 1. Country A sets different tax rates for immobile domestic capital base (investments from period 1) and new investments. It is optimal to set a tax rate of 1 on the domestic capital base. Country B has to undercut the tax rate of country B by a margin of F to attract the new investment. The lowest tax rate country B is willing to set in period 2 to attract the investor is zero. Therefore, country A sets a tax rate of F and attracts the investor with certainty. The equilibrium tax revenues of country A and country B in period 2 are $1 + F$ and 0, respectively. The gain to country A in period 2 from attracting the investor in period 1 is $1 + F$. Therefore, country A is willing to offer a tax holiday of amount $1 + F$ in period 1 to attract the investor. The tax holiday a country has to offer in period 1 to attract the investor counterbalances the revenue gains in period 2. Therefore, the equilibrium tax revenue of competing countries is equal to 0. Moreover, the country that attracts the

investor in period 1 also attracts the investor in period 2. Lemma 1 describes the outcome formally.

Lemma 1 *When both countries adopt preferential taxation regimes during the initial stage of the game, the equilibrium tax revenue of competing countries is equal to 0. The country that attracts the investor in period 1 receives a tax revenue of* $1 + F$ *in period 2, while the other country does not receive positive tax revenues. The country that attracts the investor in period 1 sets a tax rate of* 1 *and* F *on domestic the capital base and new investments in period 2 and succeeds in attracting the new investor. A country with no domestic capital base sets a tax rate of 0 on new investments. Competing countries offer a tax holiday of* $1 + F$ *in period 1.*

4 Non-preferential Regime

Let us consider the case when both countries adopt non-preferential taxation regimes. First, we look at the outcome in period 2. Without a loss of generality, we assume that country A attracts the investor in period 1.

4.1 Non-preferential Taxation: Period Two

Let t_a and t_b be tax rates set by countries A and B, respectively. Country B has to undercut the tax rate of country A by a margin of F to attract the mobile investor. The tax revenue of country A in period 2, TNP_a^2, is represented as

$$TNP_a^2 = \begin{cases} 2t_a, & \text{if } t_a \leq t_b + F \\ t_a, & \text{if } t_a > t_b + F \end{cases} \tag{1}$$

When $t_a \leq t_b + F$, country A attracts the new investor in period 2 as well. When country A sets $t_a > t_b + F$, country A does not attract the investor in period 2, and it receives taxes only from the domestic capital base. The tax revenue of country B in period 2, TNP_b^2, is represented as

$$TNP_b^2 = \begin{cases} t_b, & \text{if } t_b < t_a - F \\ 0, & \text{if } t_b \geq t_a - F \end{cases} \tag{2}$$

When country B undercuts the tax rate of country A by a margin of F, it attracts the new investor and receives t_b in tax revenues. When country sets $t_b > t_a - F$ then the new investor also invests in country A. Country B does not receive positive tax revenues in this case.

Lemma 2 *When both countries adopt non-preferential taxation regimes during the initial stage of the game and* $F \geq 1/2$*, a pure strategy Nash equilibrium exists. In equilibrium, countries* A *and* B *set tax rates of* F *and 0, respectively.*

The equilibrium tax revenues of countries A and B are 2F and 0, respectively.

When $F < 1$, country B can undercut the tax rate of country A by a margin of F to attract the new investor when country A sets a tax rate greater than F. In response, country A lowers the tax rate. Let t_a^{min} be the minimum tax rate country A is willing to set to attract the investor in period 2. If country set t_a^{min} and attracts the new investor, its tax revenue is $(2t_a^{min})$. Country A can set a tax rate of 1 and extract maximum tax revenue of 1 from the domestic capital base. Therefore, the following equality holds $2t_a^{min} = 1$. From the equality we obtain

$$t_a^{min} = \frac{1}{2}. \tag{3}$$

When $F < 1/2$, country B can undercut the tax rate of country A when country A sets t_a^{min}. Therefore, when $F \geq 1/2$, country A sets $t_a = 1 - F$ and attracts the new investor. The finding is in line with existing results in the literature on economic geography and fiscal competition in the presence of agglomeration effects (See Baldwin and Krugman (2004))[7]. All firms locate in the advantageous region when the agglomeration effect is substantial. Next, we consider the case when $F < 1/2$.

Lemma 3 *When both countries adopt non-preferential taxation regimes during the initial stage of the game, a pure strategy Nash equilibrium does not exist when $F < 1/2$.*
Proof. See Appendix.

The argument is simple. Country A lowers the tax rate to attract the new investor as long as the tax rate of country B is large enough. When the tax rate of country B is very small, it is not beneficial for country A to further reduce the tax rate. In this scenario, country A sets the tax rate of 1 and receives taxes only from the immobile domestic capital base. Given a pure strategy Nash equilibrium does not exist, we analyze mixed strategy Nash equilibrium.

We propose a candidate for mixed strategy Nash equilibrium where the equilibrium tax revenues of countries A and B are 1 and $\frac{1}{2} - F$, respectively. Countries A and B randomize over the sets $[\frac{1}{2}, 1]$ and $[\frac{1}{2} - F, 1 - F)$. Let F_a and F_b denote distributions of taxes over the supports of countries A and B. Suppose country A sets the tax, $t_a \in (\frac{1}{2}, 1)$. With a probability of $[1 - F_b(t_a - F)]$, it attracts the new investor as well and receives tax revenues of $2t_a[1-F_b(t_a-F)]$. With a probability of $F_b(t_a-F)$ it only receives tax revenues from the immobile domestic capital base. The total tax revenue is $2t_a[1-F_b(t_a-F)]+t_aF_b(t_a-F)$. A country receives equal tax revenue everywhere over the support. Therefore, the following equality holds.

$$2t_a[1 - F_b(t_a - F)] + t_aF_b(t_a - F) = 1 \tag{4}$$

[7]Here, we interpret the cost of relocation (F) as an excess return to the entrepreneur from investing in the country that has a larger domestic capital base.

Solving (4) for $F_b(t_a - F)$ and substituting $t = t_a - F$, we obtain the distribution of taxes over the support of country B, $F_b(t)$.

$$F_b(t) = 2 - \frac{1}{t+F},\ t \in [\frac{1}{2} - F, 1 - F) \tag{5}$$

Note that $F_b(\frac{1}{2} - F) = 0$, and $F_b(1 - F) = 1$. Therefore, there is no probability mass over the support of country B. Now, suppose country B sets the tax $t_b \in (\frac{1}{2} - F, 1 - F)$. With a probability of $[1 - F_a(t_b + F)]$, it attracts the investor and receives tax revenues of $t_b[1 - F_a(t_b + F)]$. The equilibrium tax revenue of country B is $\frac{1}{2} - F$. Therefore, the following equality holds.

$$t_b[1 - F_a(t_b + F)] = \frac{1}{2} - F \tag{6}$$

Solving the above equality and substituting $t = t_b + F$, we obtain the distribution of taxes over the support of country A, $F_a(t)$.

$$F_a(t) = 1 - \frac{1}{t - F}(\frac{1}{2} - F),\ t \in [\frac{1}{2}, 1] \tag{7}$$

Note that $F_a(1) = \frac{1}{2(1-F)} < 1$ when $F < \frac{1}{2}$. Therefore, there is a probability mass of m_a at the *supremum* of the support of country A, where $m_a = 1 - F_a(1)$. After simple manipulation we obtain

$$m_a = \frac{1 - 2F}{2(1 - F)} \tag{8}$$

When country B sets the tax rate of $\frac{1}{2} - F$ it attracts the new investor with probability one. Therefore, country B cannot gain from lowering the tax rate. Similarly, if country B sets a tax rate greater than $1 - F$, it does not attract investments with a positive probability. Therefore, country B cannot gain from unilateral deviation. If country A sets a tax rate below $\frac{1}{2}$, the tax revenue is less than 1 even when it attracts the new investor with probability one. Therefore, we conclude that proposed strategies constitute a mixed strategy Nash equilibrium. Proposition 1 describes the mixed strategy Nash equilibrium formally when $F < 1/2$.

Proposition 1 *When competing countries adopt non-preferential taxation regimes during the initial stage of the game, a unique mixed strategy Nash equilibrium exists when $F < 1/2$. The equilibrium tax revenues of countries A and B are 1 and $(\frac{1}{2} - F)$, respectively. Countries A and B randomize over the sets $[\frac{1}{2}, 1]$ and $[\frac{1}{2} - F, 1 - F)$. The distributions of taxes over the supports of country A (F_a), and B (F_b) are described by (7), (8), and (5).*

Proof. See Appendix for proof of uniqueness.

We have assumed that country A attracts the investor in period 1. The probability mass, m_a, at the *supremum* of the support of country A decreases when F increases. When F increases, country B competes more aggressively to

attract the new investor. In response country A also lowers its tax rate. The mixed strategy Nash equilibrium described in Lemma 3 has equivalents in the literature. One can think of a Bertrand type competition between two firms. A fraction of consumers is fully loyal to one firm, and a fraction of consumers is partially loyal to the same firm. The other firm has no loyal consumers. This problem is analyzed in Narasimhan (1988). In the literature on tax competition, the equilibrium has a similarity with the mixed strategy analyzed by Konrad and Kovenock (2009).

It is worthwhile to compare the outcomes of Proposition 1 with a scenario when both countries have preferential regimes. Lemma 1 describes the outcome when both countries adopt preferential regimes. When both countries have preferential regimes, the country with a larger domestic capital base receives $1 + F$ in tax revenues, while the smaller country does not receive positive tax revenue. Under non-preferential regimes, the large country receives 1 in tax revenues, while the small country receives $\frac{1}{2} - F$. Therefore, the larger country loses when both adopt non-preferential regimes, while the smaller country gains. The competition between two asymmetric countries for a perfectly mobile capital base has been extensively analyzed. We have a similar scenario when $F = 0$. Bucovetsky and Haufler (2007) find that the small country gains while the tax revenues of the large country remain unchanged when both countries move to non-preferential regimes from preferential regimes. Janeba and Peters (1999) also find a similar result. Our results show that cooperation on Non-preferential regimes is likely to be difficult when the mobile capital base receives a positive agglomeration rent from making an investment in the larger country. Haupt and Peters (2005) show that competing countries earn higher tax revenues under non-preferential regimes when one capital base has home bias for one country and the other capital has home bias for the competing country. Our result show that the same is not true when one capital base has infinite home bias for one country while the other capital base has a positive home bias for the same country.

The expected tax payments of an investor in period 2 depends on F_a. Given we know the distribution function, F_a, the density function is $f_a \equiv \frac{1-2F}{2(t-F)^2}$. The expected tax rate in period 2 when the investor invests in country A in period 1 is $E_a \equiv \int_{1/2}^{1} t f_a(dt) + m_a$, where m_a is the probability mass at 1. Substituting for f_a and m_a we obtain

$$E_a = \frac{1}{2} + (\frac{1}{2} - F) log(\frac{2(1-F)}{1-2F}). \tag{9}$$

Figure (1) depicts E_a as a function of the agglomeration effects, F. The expected tax rate in period 2 is a decreasing function of agglomeration effects, F as long as $F < \frac{1}{2}$. For any given tax rate, t, differentiating the distribution function (7) with respect to F we obtain, $\frac{\delta}{\delta F} F_a(t) \equiv \frac{2t-1}{2(t-F)^2}$. This is positive as long as $t > \frac{1}{2}$. Country A randomizes over the set $[\frac{1}{2}, 1]$. Therefore, for any $t \in (\frac{1}{2}, 1)$, country A sets a tax rate lower than t with a greater probability when F increases. Country B has to undercut the tax rate of country A by a discrete

margin F to attract the new investor. Therefore, to increase the probability of attracting the investor, country B sets very low tax rate when F increases. This is evident once we observe that for any t, $\frac{\delta}{\delta F}(F_b(t)) \equiv \frac{1}{(t+F)^2} > 0$. This prompts country A also to lowers its tax rate. Note that when $F \geq \frac{1}{2}$, we have a pure strategy Nash equilibrium where country A sets the tax rate of F with probability 1. This is an important observation, and Lemma 4 describes this observation formally.

Lemma 4 *When both competing countries adopt non-preferential regimes during the initial stage of the game, the expected tax payment in period 2, E_a, is a non-monotone function of the agglomeration effects, F. Starting from no agglomeration effects, E_a decreases when F increase as long as $F \leq \frac{1}{2}$. When $F \geq \frac{1}{2}$, the tax is equal to the agglomeration effect, F.*

Baldwin and Krugman (2004) find that when the capital is fully agglomerated in one region then economic integration leads to an increase in tax rates before it decreases with further economic integration. Borck and Pfl¨uger (2006) also find a similar result. The result of this model is markedly different. The expected tax rate decreases when the agglomeration effect increases followed by an increase when the agglomeration effect is greater than a critical level. Unlike Baldwin and Krugman and Borck and Pfl¨uger (2006), the return of domestic firm is independent of the agglomeration effect. Moreover, the new investor finds the country with a domestic capital base more attractive. Because of this asymmetry, competition to attract the new investor is more intense in the presence of agglomerate on effects as long as the effect is not very large, i.e., $F \leq \frac{1}{2}$. This leads to an overall low tax rate. When the agglomeration effect is very large ($F \geq \frac{1}{2}$) the other country cannot compete for the new investor, and this allows the country with agglomeration advantages to attract the new investor while setting a high tax rate.

4.2 Non-preferential Taxation: Period One

We know that when a country attracts the investor in period 1 then the tax revenue depends on the agglomeration advantage F. The equilibrium tax revenue of country i in period 2, TNP_i^2, when it attracts the investor in period 1 is

$$TNP_i^2 = \begin{cases} 2F, & \text{if } F \geq \frac{1}{2} \\ 1, & \text{if } F \leq \frac{1}{2} \end{cases} \tag{10}$$

On the other hand, the equilibrium tax revenue of the country that does not attract the investor in period 1 is

$$TNP_i^2 = \begin{cases} 0, & \text{if } F \geq \frac{1}{2} \\ \frac{1}{2} - F, & \text{if } F \leq \frac{1}{2} \end{cases} \tag{11}$$

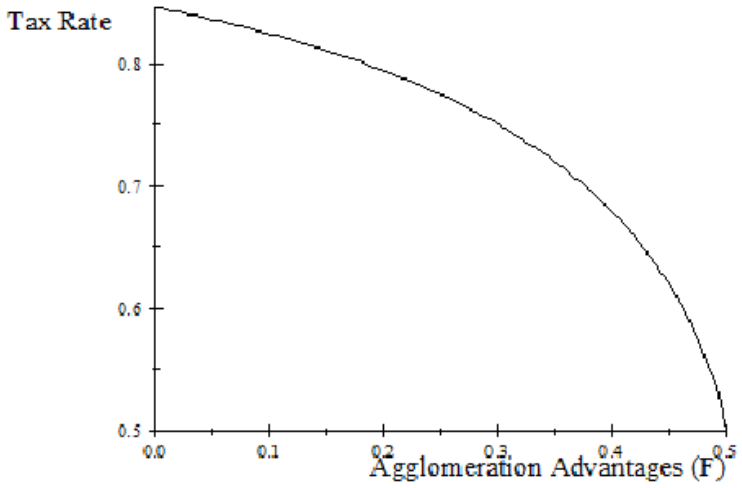

Figure 1: The expected tax payments in period 2 (Tax) for an investor from period 1 as a function of F (agglomeration advantage)

The difference in the equilibrium tax revenues of competing countries in period 2 when it attracts the investor in period 1 compared to the case when it does not attract the investor is $2F$ when $F \geq \frac{1}{2}$. Therefore, the minimum tax rate a country is willing to set in period 1 is $-2F$ when $F \geq \frac{1}{2}$. The tax holiday a country has to offer in period 1 to attract the investor counterbalances the gains in period 2. Therefore, the sum of tax revenues over two periods is 0 when $F \geq \frac{1}{2}$.

The difference in tax revenues of a country when it attracts the investor in period 1 compared to the case when it does not attract the investor is equal to $\frac{1}{2} + F$ when $F \leq \frac{1}{2}$. Therefore, the minimum tax rate a country is willing to set in period 1 is $-(\frac{1}{2} + F)$. The sum of tax revenues over two periods is equal to $\frac{1}{2} - F$. Lemma 5 describes the outcome in period 1 formally.

Lemma 5 *When competing countries jointly adopt non-preferential taxation regimes during the initial stage of the game, the equilibrium tax revenues of competing countries is 0 when $F \geq \frac{1}{2}$. In a unique pure strategy Nash equilibrium, the tax rate in period 1 is $-2F$. When $F \leq \frac{1}{2}$. the equilibrium tax revenue of competing countries is $\frac{1}{2} - F$. The tax rate in period 1 is $-(\frac{1}{2} + F)$.*

The outcome when $F \leq \frac{1}{2}$ is more interesting. The equilibrium tax revenue decreases when F increases. The tax revenue in period 2 does not depend on the agglomeration effect when a country has a domestic capital base. On the other hand, the tax revenue decrease with an increase in the agglomeration effect when a country does not have a domestic capital base. The difference in tax revenues leads to more intense competition to attract the investor in period

1. It is evident from the fact that the tax holiday on offer in period 1 increases when the agglomeration effect increases.

It is important to compare the outcomes of Lemma 1 and Lemma 5. When both countries adopt preferential regimes, the equilibrium tax revenue of competing countries is equal to zero for any level of agglomeration effects. Moreover, the country that attracts the investor during the initial period also attracts the investor during the later period with certainty. Therefore, capital is fully agglomerated in one region. When both countries adopt non-preferential regimes, the equilibrium tax revenue is equal to $\frac{1}{2} - F$ when $F < \frac{1}{2}$. Competing countries gains from adopting non-preferential regimes but the gain is decreasing in agglomeration effects. When agglomeration effects are large than a critical level ($F \geq \frac{1}{2}$), the equilibrium tax revenue under two taxation regimes is zero. If country A sets, $t_a \in (\frac{1}{2}, 1)$, it fails to attract the new investor in period 2 with a probability of $F_b(t_a - F)$. Substituting $t = t_a - F$ in (5) we obtain $F_b(t_a - F) = 2 - \frac{1}{t_a}$. Therefore, as long as agglomeration effects are not very large, i.e., $F < \frac{1}{2}$, the probability of attracting the investor does not depend on the agglomeration effect. When agglomeration effects are very large, i.e., $F \geq \frac{1}{2}$, the country with agglomeration advantages attracts the new investor with probability one. Baldwin and Krugman (2002) also find a similar result. The region with agglomeration advantages are more likely to attract mobile entrepreneurs but that need not increase tax revenues. This is an important result and Lemma 6 describes the same formally.

Lemma 6 *When both countries adopt non-preferential regimes during the initial stage of the game, both countries receive investments with a positive probability when $F \leq \frac{1}{2}$. The probability of attracting the investor in period 2 does not depend on the agglomeration effect. On the other hand, one country attracts both investors with certainty when $F \geq \frac{1}{2}$..*

5 Mixed Taxation Regime

Now, we consider a scenario where one country adopts a non-preferential, and the other adopts a preferential taxation regime. Without loss of generality suppose country A adopts a non-preferential, and country B adopts a preferential taxation regime. First, we look at the outcome in period 2.

5.1 Mixed Taxation Regime: Period Two

The outcomes in period 2 depend on whether country A or country B attracts the investor in period 1. When country A attracts the investor in period 1 then the outcomes in period 2 are similar to the case when both countries adopt non-preferential regimes. Now suppose country B attracts the investor in period 1. Country B sets different tax rates on the immobile domestic capital base, and the mobile foreign capital base. Therefore, country B sets the tax rate of

1 on the domestic capital base, and receives a tax revenue of 1. Country A has to undercut the tax rate of country B by a margin of F to attract the new investor. Therefore, country B sets a tax rate of F on the foreign capital base, and receives a tax revenue of F. Country A sets a tax rate of 0 on the foreign capital base. Lemma 5 describes the outcome formally.

Lemma 7 *When country A adopts a non-preferential and country B adopts a preferential taxation regime, and country B attracts the investor in period 1, the equilibrium tax revenues of countries A and B are 0 and* $1+F$*, respectively. Country A sets a tax rate of 0 on the foreign capital base. Country B sets 1 and* F*, respectively on the domestic and foreign capital base.*

5.2 Mixed Taxation Regime: Period One

First, we analyze the outcome in period 1 when $F \geq \frac{1}{2}$. The tax revenues of country A and country B are $2F$ and 0, respectively in period 2 when country A attracts the investor in period 1. On the other hand, the tax revenues of country A and country B are 0 and $1+F$ respectively, when country B attracts the investor in period 1. The revenue gains to country A and country B in period 2 from attracting the investor in period 1 are $2F$ and $1+F$, respectively. Moreover, if an investor invests in country A in period 1, the tax it pays in period 2 is F. On the other hand, if an investor invests in country B then the tax it pays in period 2 is 1. Therefore, country B has to undercut the tax rate of country A by a margin of $1-F$ to attract the investor. The minimum tax rate country A is willing to set to attract the investor in period 1 is $-2F$. Therefore, the tax rate country B has to set to attract the investor is $-2F-(1-F) \equiv -(1+F)$. Therefore, country A and country B set the tax rates $-2F$ and $-(1+F)$, respectively in period 1. Irrespective of whether the investor invests in country A or country B, the gains to competing countries in period 2 are completely offset by tax rebates they offer in period 1.

Lemma 8 *In a scenario where country A adopts a non-preferential and country B adopts a preferential taxation regime during the initial stage of the game, the sum of the tax revenues over two periods is 0 when* $F \geq \frac{1}{2}$*. Countries A and B set tax rates* $-2F$ *and* $-(1+F)$*, respectively in period 1. The investor is indifferent between making an investment in country A or country B. Both countries are equally likely to attract the investor in period 1. The country that attracts the investor in period 1 also attracts the new investor in period 2, i.e., capital is fully agglomerated in one country.*

From Lemma 6 and Lemma 8, it is clear that when agglomeration effects are very large ($F \geq \frac{1}{2}$), outcomes do not depend on taxation regimes adopted by competing governments. In each case, capital is fully agglomerated in one region and competing countries do not receive positive tax revenues.

Now we look at the outcomes when $F \leq \frac{1}{2}$. When country A attracts the

investor in period 1, the outcome of period 2 is described in Proposition 1. The equilibrium tax revenues of country A and country B are 1 and $(\frac{1}{2} - F)$, respectively. When country B attracts the investor in period 1 then the outcome of period 2 is described in lemma 5. The equilibrium tax revenues of country A and country B are 0 and $(1 + F)$, respectively. Therefore, the revenue gains to country A and country B in period 2 from attracting the investor in period 1 are 1 and $(\frac{1}{2} + 2F)$, respectively. Note that the revenue gain to country A is larger compared to that of country B when $F \leq \frac{1}{4}$. Moreover, if an investor invests in country A in period 1, it pays E_a in taxes in period 2, where E_a is given by (9). Therefore, country B has to undercut the tax rate of country A by a margin of $1 - E_a$ to attract the investor in period 1. The maximum tax rebates country A and country B are willing to offer in period 1 are 1 and $(2F + \frac{1}{2})$, respectively. Therefore, country A attracts the investor when $1 + 1 - E_a > 2F + \frac{1}{2}$, and country B attracts the investor when $1 + 1 - E_a < 2F + \frac{1}{2}$. Let F_{max} be the value of F such that $Dif = 0$.[8]

$$Dif \equiv E_a + 2F - \frac{3}{2} = 0. \tag{12}$$

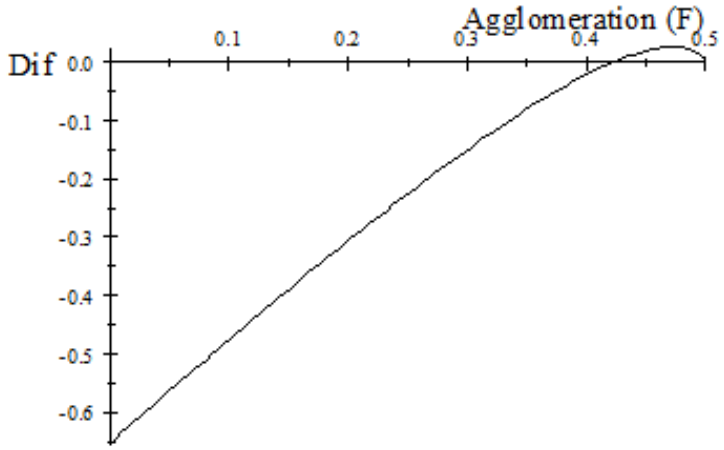

Figure 2: The function "Dif" as a function of F (agglomeration advantage)

From figure (2), it is clear that $Dif > 0$ for F is close to $\frac{1}{2}$. Now we consider two different scenarios: (i) $F \leq F_{max}$, (ii) $F \geq F_{max}$.

When $F \leq F_{max}$, country A attracts the investor in period 1. Country A offers a tax holiday of amount T_h^a in period 1 and attracts the investor in period 1, where

$$T_h^a \equiv 2F + \frac{1}{2} - (1 - E_a) \equiv 2F + E_a - \frac{1}{2} \tag{13}$$

[8]The numerical approximation to the solution of the equality $Dif = 0$, is, $F_{max} = 0.4217$.

The equilibrium tax revenue of country A, TM_a, is equal to

$$TM_a = 1 - T_h^a = \frac{3}{2} - 2F - E_a. \tag{14}$$

The equilibrium tax revenue of country B, TM_b, is equal to $\frac{1}{2} - F$. From (12) and (14), it is evident that country A attracts the investor as long as the gain from attracting the investor in period 1 is positive. Let F^* be such that

$$TM_a = \frac{1}{2} - F \tag{15}$$

, that is, the tax revenues of country A and country B are equal. Note that $F^* < F_{max}$[9]. When $F \in (0, F^*)$, country A receives a higher tax revenue compared to that of country B. When $F \in (F^*, F_{max})$, country B receives a higher tax revenue. Lemma 9 describes the outcomes formally when $0 \leq F \leq F_{max}$.

Lemma 9 *In a mixed taxation regime where country A adopts a non-preferential taxation regime, and country B adopts a preferential taxation regime during the initial stage of the game, the equilibrium tax revenues of countries A and B are TM_a and $\frac{1}{2} - F$ when $F \leq F_{max}$. Country A offers a tax holiday of T_h^a in period 1 and attracts the investor. When $0 \leq F \leq F^*$, country A earns a higher tax revenue compared to country B. On the other hand, the equilibrium tax revenue of country B is higher when $F^* \leq F \leq F_{max}$. Both countries receives investments in period 2 with a positive probability. TM_a and T_h^a are given by (14) and (13). The parameters F_{max} and F^* are solutions of (12) and (15), respectively..*

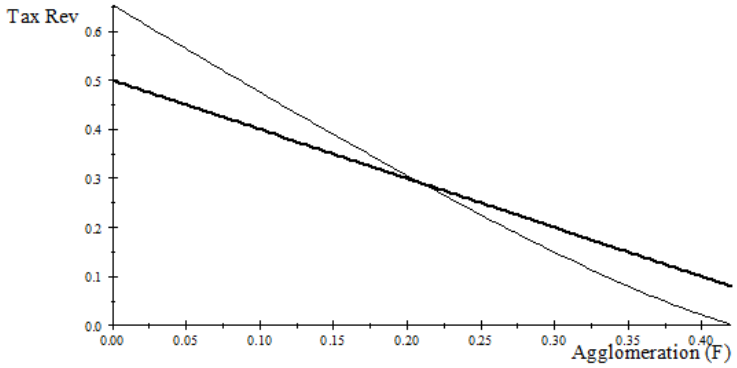

Figure 3: The tax revenues of country A (thin line) and country B as a function of F (agglomeration advantage) under a mixed taxation regime when $F \leq F_{max}$

[9]The numerical approximation to the solution of the equality, $Dif = 0$, is $F_{max} = 0.4217$. The numerical approximation to the solution of the equality, $TM_a = \frac{1}{2} - F$, is $F^* = .2090$.

Figure 3 depicts the equilibrium tax revenues of country A and country B. The tax revenues of competing countries decrease when the agglomeration advantage increases as long as $F \leq F_{max}$. It is worth taking note of the fact that for a reasonable range of values of $F \in (F^*, F_{max})$, the tax revenue of the country that does not attract the investor in period 1 is higher. If country A does not attract the investor in period 1, it does not receive a positive tax revenue in period 2. Therefore, country A is willing offer tax rebates in period 1 as long as the revenue gain from doing so is strictly positive. Moreover, the tax rebate country B is willing to offer increases when F increases. Therefore, the tax rebate country A has to offer in period 1 increases when F increases. This reduces the equilibrium tax revenue of country A.

When $F \geq F_{max}$, country B (with a preferential taxation) attracts the investor in period 1. Country B undercuts the minimum tax rate country A offers in period 1 by a margin of $(1 - E_a)$ and attracts the investor, where E_a is given by (9). As discussed before, the minimum tax rate country A is willing to set in period 1 is -1. Therefore, country B sets a tax rate of $-1 - (1 - E_a) \equiv -2 + E_a$ in period 1. The sum of tax revenues of country B over two periods is $1 + F - 2 + E_a \equiv F + E_a - 1$. Lemma 10 describes the outcome formally when $F_{max} \leq F < \frac{1}{2}$.

Lemma 10 *In a scenario where country A adopts a non-preferential and country B adopts a preferential taxation regime during the initial stage of the game, the equilibrium tax revenues of countries A and B are 0 and* $F + E_a - 1$ *when* $F_{max} \leq F < \frac{1}{2}$. *Country B offers a tax holiday of* $2 - E_a$ *in period 1 and attracts the investor, where* E_a *is given by (9). Investments are fully agglomerated in the country that adopts a preferential taxation regime during the initial stage of the game.*

The equilibrium tax revenue of country B when it attracts the investor and when it does not attract the investor are equal when $F + E_a - 1 = \frac{1}{2} - F$, or equivalently $2F + E_a - \frac{3}{2} = 0$. Equation (12) that determine the critical value of F is also the same. Therefore, the tax revenue of country B is *continuous.*The equilibrium tax revenue of country B decreases when F increases. When agglomeration effects are large enough ($F \geq F_{max}$), investments are fully agglomerated in one country. Baldwin and Krugman (2002) also find a similar result where one region attracts all investments when the agglomeration effect is substantial.

6 Comparison

We know that the equilibrium tax revenue of competing countries is equal to zero irrespective of taxation regimes adopted by competing countries during the initial stage when agglomeration effects are large[10], i.e., $F \geq \frac{1}{2}$.

[10]This follows from Lemma 1, Lemma 6, and Lemma 8

Proposition 2 *Non-preferential, Preferential, and Mixed Taxation Regimes are subgame perfect equilibria of the game when $F \geq \frac{1}{2}$. In all subgame perfect equilibria, investments are fully agglomerated in one country. Competing countries do not receive positive tax revenues.*

Now, we look at the more interesting case when $F < \frac{1}{2}$. From Lemma 5, the equilibrium tax revenue of countries is equal to $\frac{1}{2} - F$ when both countries adopt non-preferential regimes. Under mixed taxation regimes, the equilibrium tax revenues depend on whether country with a non-preferential (preferential) regime attracts the investor during the initial stage. From Lemma 9, the country with a non-preferential regime attracts the investor during the initial period when $F \leq F_{max}$, where F_{max} is defined by (12). When $F > F_{max}$, the country with a preferential taxation regime attracts the investor during the initial period. First, we find subgame-perfect Nash equilibria when $F \leq F_{max}$.

Table 1

	Non-preferential	Preferential
Non-preferential	$(\frac{1}{2} - F,\ \frac{1}{2} - F)$	$(TM_a,\ \frac{1}{2} - F)$
Preferential	$(\frac{1}{2} - F,\ TM_a)$	$(0,\ 0)$

TM_a is given by (14). We know that $TM_a \geq \frac{1}{2} - F$ when $F \leq F^*$, and $TM_a \leq \frac{1}{2} - F$ when $F \geq F^*$, where F^* is described by (15). Non-preferential taxation and mixed taxation regimes are subgame-perfect equilibria of the game. Starting from a scenario where both countries have preferential taxation regime, a country has an incentive to deviate and adopt a non-preferential taxation regime. Starting from a scenario where both countries have non-preferential regimes, a country has an incentive to convince the other country to adopt a preferential taxation regime when the agglomeration effect is not very large, i.e., $F \leq F^*$. On the other hand, starting from a scenario where both countries have non-preferential regimes, a country is worse off if the other country deviates and adopts a preferential regime when the agglomeration effect is considerably large, i.e., $F \geq F^*$. Proposition describes the comparison between taxation regimes formally.

Proposition 3 *Non-preferential taxation regime or mixed taxation regime are two subgame-perfect equilibria of the game when $F \leq F_{max}$. The equilibrium tax revenue of competing countries is equal to $\frac{1}{2} - F$ when both countries adopt non-preferential regime. Under mixed taxation regimes, the tax revenue of the country with a non-preferential regime is greater than the country with a preferential taxation regime when $0 < F \leq F^*$. The opposite is true when $F^* \leq F \leq F_{max}$.*

When $F_{max} \leq F \leq \frac{1}{2}$, the outcome of the game under different choices of taxation regimes are described in the table below.

Table 2

	Non-preferential	Preferential
Non-preferential	$(\frac{1}{2}-F,\ \frac{1}{2}-F)$	$(0,\ F+E_a-1)$
Preferential	$(F+E_a-1,\ 0)$	$(0,\ 0)$

From (12), we know that the country with a preferential regime attracts the investor when $F > F_{max} \equiv E_a + 2F - \frac{3}{2} > 0$, or equivalently $F + E_a - 1 > \frac{1}{2} - F$ when $F > F_{max}$. Therefore, a mixed taxation regime emerges as a subgame perfect Nash equilibrium where one country adopts a non-preferential and the other adopts a preferential taxation regime. The country that adopts a preferential taxation regime earns more than what it earns when both countries adopt non-preferential regimes.

Proposition 4 *A mixed taxation regime emerges as a subgame perfect Nash equilibrium where one country adopts a non-preferential while the other adopts a preferential taxation regime when $F_{max} \leq F \leq \frac{1}{2}$, where F_{max} is the solution to the equality described by (12). The tax revenue of the country that adopts a preferential taxation regime is $F + E_a - 1$. Moreover, investments are fully agglomerated in the country that adopts a preferential regime during the initial stage of the game. The country that adopts a non-preferential regime does not receive positive tax revenue.*

7 Discussion: Sequential Model

Now we analyze the outcome when countries choose taxation regimes sequentially. There is a growing literature on endogenous timing in tax competition game[11]. We ignore this issue in order to keep the discussion short. During the initial stage of the game, one of the competing countries commits to a preferential or non-preferential regime. The other country observes the taxation regime of the competitor and commits to a preferential or non-preferential regime. The rest of the game is same as before. After both countries commit to their preferred taxation regime for the entire duration of the game, they simultaneously choose tax rates in each period.

First, we analyze the case when $F \leq F_{max}$. Table 1 describes the outcome of this game for all possible taxation regimes. Without a loss of generality we assume that country A moves first and commits to a taxation regime. If country A commits to a non-preferential regime then country B receives a tax revenue of $\frac{1}{2} - F$ irrespective of whether it chooses a preferential or non-preferential regime. The equilibrium tax revenue of country A depends on the taxation regime chosen by country B. If country B adopts a non-preferential regime then country A receives $\frac{1}{2} - F$ in tax revenues. On the other hand, country A receives TM_a in tax revenue when country B adopts preferential. Note that $TM_a \geq \frac{1}{2} - F$ when

[11] See for example Kempf and Graziosi (2010), Kempf and Grazioso (2015), Ogawa (2013), and Hindriks and Nishimura (2017).

$F \leq F^*$. Staring from a scenario where country A adopts a non-preferential regime, we have two Nash equilibrium. When country A adopts a preferential regime then the optimal choice of country B is to adopt non-preferential regime. The tax revenue of country A is $\frac{1}{2} - F$. We observe that the outcome where country A chooses a preferential and country B chooses a non-preferential regime is possible if country A anticipate that when it chooses a non-preferential regime then country B chooses a non-preferential regime with certainty. We can argue that the outcome where country A chooses a preferential and country B chooses a preferential regime is not a trembling-hand perfect equilibrium. Therefore, we have two possible equilibria where country A chooses a non-preferential regime, and country B chooses a preferential or a non-preferential regime when $F \leq F^*$.

Now consider the scenario when $F^* \leq F \leq F_{max}$. Note that $TM_a \leq \frac{1}{2} - F$ when $F^* \leq F \leq F_{max}$. When country A chooses a preferential regime then it is optimal for country B to chooses a non-preferential regime. Country A receives a tax revenue of $\frac{1}{2} - F$. When country A chooses a non-preferential regime then country B is indifferent between having a preferential or non-preferential regime. The tax revenue of country A is lower when country B chooses a preferential regime. Again, we can argue that the equilibrium where country A chooses a non-preferential regime is not trembling-hand perfect equilibrium. Therefore, the stable equilibrium is where country A chooses a preferential and country B chooses a non-preferential regime. Proposition 5 describes the outcome formally.

Proposition 5. *When countries choose taxation regime sequentially and trembling-hand perfect equilibrium criterion is used to choose stable equilibria, non-preferential or mixed taxation regimes emerge when $F \leq F^*$. The first mover chooses a non-preferential and the second mover chooses a non-preferential or a preferential regime. The first mover obtains a higher tax revenues compared to the second mover. Mixed taxation regimes emerge when $F^* \leq F \leq F_{max}$. The first mover chooses a preferential and the second mover chooses a non-preferential regime. The first mover obtains a higher tax revenue than the second mover.*

Now consider the case when $F_{max} \leq F \leq \frac{1}{2}$. Table 2 describes the outcome of this game for all possible taxation regimes. When country A chooses a non-preferential regime then the optimal decision of country B is a preferential regime. Country A does not receive a positive tax revenue. When country A chooses a preferential regime then country B is indifferent between choosing a preferential or non-preferential regime. The tax revenue of country A is greater when country B chooses a non-preferential regime. Again, we can argue that the equilibrium where country A chooses a non-preferential regime is not trembling-hand perfect equilibrium. Country A obtains a higher tax revenue when country A believes that country B chooses a non-preferential regime even with a very small probability after country A chooses a preferential regime. Therefore, preferential regimes or mixed taxation regimes emerge where country A chooses a preferential regime. Competing countries do not receive a positive tax revenue when $F \geq \frac{1}{2}$. We omit the discussion for this scenario.

Proposition 6. *When countries choose taxation regime sequentially and trembling-hand perfect equilibrium criterion is used to choose stable equilibria, preferential or mixed taxation regimes emerge when* $F_{max} \leq F \leq \frac{1}{2}$. *The first mover chooses a preferential regime and the second mover chooses a preferential or non-preferential regime. The tax revenue of the first mover is weakly greater than the second mover.*

8 Conclusion

The paper addresses a pressing question of whether the rent from agglomeration effects has a bearing on taxation regimes that emerge when competing countries non-cooperatively choose taxation regimes. We show that non-preferential or mixed taxation regimes emerge as subgame perfect Nash equilibria when the agglomeration effect is relatively small. When both countries adopt non-preferential regimes, the equilibrium tax revenue is strictly positive and that decreases as the agglomeration effect increases. Under mixed taxation regimes, the tax revenue of the country with a preferential taxation regime is equal to what it gets when both countries adopt non-preferential regimes. The tax revenue of the country with a non-preferential regime depends on agglomeration effects. When the agglomeration effect is small, the country with a non-preferential regime earns a higher tax revenue compared to the country with a preferential regime. On the other hand, when the agglomeration effect is large enough, the country with a preferential regime earns a higher tax revenue. Both countries attract investments with a strictly positive probability. A country with a non-preferential regime has an incentive to convince the competitor to adopt a preferential regime when the agglomeration effect is relatively small. When the agglomeration effects is in intermediate range, a mixed taxation regime is the only equilibrium where one country adopts a preferential and the other adopts a non-preferential regime. Investments are fully agglomerated in the country with a preferential taxation regime, and the country with a non-preferential regime does not receive investments in either period. Moreover, the tax revenue of the country that adopts preferential taxation regime decreases when the agglomeration effect increases. When the agglomeration effect is large, preferential, non-preferential or mixed taxation regimes emerge in equilibrium. In all equilibria, investments are fully agglomerated in one country and that does not depend on whether a country adopts a preferential or a non-preferential regime during the initial stage. Although one country attracts investments during both periods, competing countries do not receive a positive amount in tax revenues.

Moreover, we also analyze the game when competing countries choose taxation regimes sequentially rather than simultaneously. Non-preferential or Mixed taxation regimes emerge when the agglomeration effect is relatively small. The first mover chooses a non-preferential regime and obtains a greater tax revenue compared to the second mover when the second mover chooses a preferential regime. Therefore, the first mover has the incentive to convince the second

mover to choose a preferential regime. Mixed taxation regimes emerge when the agglomeration effect is in the intermediate range. The first mover chooses a preferential and the second mover chooses a non-preferential regime. Again, the first mover obtains a higher tax revenue. Preferential or Mixed taxation regimes emerge when the agglomeration effect is considerably large. The first mover chooses a preferential. The second mover chooses a preferential or a non-preferential regime. The second mover does not receive positive tax revenue. We observe that there is a first mover advantage irrespective of the significance of agglomeration effects.

"Data sharing is not applicable to this article as no new data were created or analyzed in this study."

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9 Appendix

Proof of Lemma 3. Suppose the tax pair (t_a, t_b) is a Nash equilibrium such that $t_a < F$. The maximum possible tax revenue of country A for a tax pair (t_a, t_b) is equal to $2F$, that is strictly less than 1. Country A can set $t_a = 1$ and obtain a tax revenue of 1. Contradicting that we have a Nash equilibrium. Similarly, suppose that the tax pair (t_a, t_b) is a Nash equilibrium such that $F < t_a < 1$. The best response of country B is to undercut the tax rate of country A by a margin of F. Therefore, the maximum possible tax revenue is t_a. Because $t_a < 1$, country A does better when it sets $t_a = 1$. Only possible Nash equilibrium is the strategy pair $(1, t_b)$, where country A sets $t_a = 1$. When $t_a = 1$, the best response of country B is $1 - F$. Because $F < \frac{1}{2}$, we have $1 - F > \frac{1}{2}$. Country A does better when it sets a tax rate arbitrary close to $1 - F$. Contradicting that we have a Nash equilibrium. This proves that a Nash equilibrium in pure strategies does not exist. *QED.*

Proof of Proposition 1. First, we show that the strategies pair (F_a, F_b) described in Lemma 3 is a mixed strategy Nash equilibrium of the game. Note that the *supremum* of the support of country A is equal to 1, that is also the maximum tax rate a country can set. Therefore, country A cannot set a tax rate greater than 1 and do better. Country A can set the tax rate equal to 1 and obtain a tax revenue of 1 with certainty. If country A sets a tax rate, t_a, lower than $\frac{1}{2}$ and attract the new investor with certainty, its tax revenue is $2t_a$, that is lower than 1 when $F \leq \frac{1}{2}$. Therefore, country A cannot deviate and do better. Similarly, we can show that country B cannot do better from a unilateral deviation.

Now we follow Narasimhan (1988) to prove the uniqueness of the mixed strategy Nash equilibrium. Let S_a^* and T_b^* be equilibrium strategy sets of country A and country B described in Lemma 3. Define the strategy set S_b^* such that $S_b^* \equiv T_b^* + F$. Now, we prove Lemma 3 in steps 1-4.

Step 1. The equilibrium strategy sets S_a^* and T_b^* are convex, or equivalently strategy sets S_a^* and S_b^* are convex.

Proof. Note that when S_b^* is convex then T_b^* is also convex.

First, we show that $T = S_a^* \cap S_b^*$ is *convex*. Let $\hat{T} = inf(T)$ and $\hat{\hat{T}} = sup(T)$. We show that there is no hole in T, that is, there is no interval $I = (T^k, T^h)$ such that, for $\hat{T} < T^k < T^h < \hat{\hat{T}}$ and for $t \in I, t \notin T$. This can happen when one of the countries have the support over T and the other does not, or neither countries has support over the interval I.

First, we show that if country A sets $t_a \in I$ with probability zero then so does country B. Let t^1 and t^2 be defined as

$$t^1 \in S_a^* \; and \; t^1 = sup(T|T < T^k)$$
$$t^2 \in S_a^* \; and \; t^2 = inf(T|T > T^k)$$
$$t_b^1 = t^1 - F$$
$$t_b^2 = t^2 - F$$

Now define Suppose country B sets a tax rate $t_b \in I$, this is equivalent to country B setting a tax rate $t_b - F \in I - F$. Therefore, the tax revenue of country B in period 2 is $t_b(1 - F_a(t_b + F))$ is increasing in t_b for $t_b - F \in I - F$. Therefore, country B is better off shifting the probability mass to t^1.

Now consider the case when neither country is randomizing over the set I. In this case country B is better off setting $t_b = t_b^2$ compared to $t_b = t_b^1$. The reason is that $t_b^2 > t_b^1$, and at the same time country A is not randomizing over the set. Therefore, the probability that country B undercuts the tax rate of country A does not change. Similarly, we can show that there is no hole in $T' = S_i^* - S_i^* \cap S_j^*$.

This proves that S_a^* and S_b^* are *convex*. When S_b^* is *convex*, T_b^* is also *convex*.

Step 2. Neither country can have a mass point anywhere other than the supremum of its support. Moreover, only one of the countries can have a mass point at the supremum of its support.

Proof. First, we show that country A cannot have a mass point at the interior of its support. Let $\hat{T}_a = inf(S_a^*)$ and $\hat{\hat{T}}_a = sup(S_a^*)$. Suppose country A sets t_a^* with a probability mass of m, where $\hat{T}_a < t_a^* < \hat{\hat{T}}_a$. Note that when t_a^* lies in the *interior* of country A's support, then $t_a^* - F$ should lie in the interior of country B's support. This is evident from *step 1*. When $t_a^* - F$ lies in the interior of country A's support then $t_a^* - F + \epsilon$ and $t_a^* - F - \epsilon$ are also in the interior of country B's support. The tax revenue of country B when it sets $t_b = t_a^* - F + \epsilon$ is

$$(t_a^* - F + \epsilon)(1 - F_a(t_a^* + \epsilon)) \tag{16}$$

The tax revenue of country B when it sets $t_b = t_a^* - F - \epsilon$ is

$$(t_a^* - F - \epsilon)(1 - F_a(t_a^* - \epsilon)) \tag{17}$$

Subtracting (16) from (17) we obtain

$$2\epsilon - \epsilon(F_a(t_a^* + \epsilon) - F_a(t_a^* - \epsilon)) + (t_a^* - F)((F_a(t_a^* + \epsilon) - F_a(t_a^* - \epsilon))) \tag{18}$$

The same can be simplified to

$$2\epsilon - \epsilon m + (t_a^* - F)m \tag{19}$$

The value described above is greater than 0 for arbitrarily small ϵ. Therefore, country B can do better. This contradicts that we have a mixed strategy Nash equilibrium. Similarly, we can show that country B cannot have a mass point at the interior of its support.

Step 3. The strategy sets S_a^* and $S_b^* \equiv T_b^* + F$ are identical when neither country has a mass point, where S_a^* and T_b^* are equilibrium strategy sets of country A and country B, respectively. When country A has a mass point at $\hat{T} \equiv sup(S_a^*)$ of its support, country B sets $\hat{T} - F$ with zero probability.

Proof. First, consider the case of no mass point. Assume to the contrary that $S_b^* \subset S_a^*$. We know from earlier discussion that interval where country B has no support will either be on the upper or the lower end. Suppose it lies to the upper end. Define $\hat{\hat{A}} = sup(S_a^*)$, and $\hat{A} = sup(S_b^*)$. Country A can move probability mass from the set $(\hat{\hat{A}}, \hat{A})$ to $\hat{\hat{A}}$ and do strictly better. This contradicts that we have a mixed strategy Nash equilibrium. Similarly, we can show a contradiction when country B does not have support to the lower end of country A's support.

step 4. $sup(S_a^*) = 1$ and $sup(T_a^*) = 1 - F$.

Proof. It is easy to argue that $sup(S_a^*) = 1$. Suppose to the contrary that $sup(S_a^*) = s$, where $s < 1$. When country A sets s, country B undercuts the tax rate of country A with probability 1. Therefore, the equilibrium tax revenue of country A is s, that is strictly less than 1. This is a contradiction. From *step 3*, we know that $sup(S_a^*) = sup(T_b^* + F)$. Therefore, $sup(T_b^*) = 1 - F$. Hence, proved. *QED.*