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International Enforcement Cooperation and Leadership Against Profit Shifting

Xuyang Chen* and Jean Hindriks†

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Abstract

Market asymmetry between large and small countries induces tax gap that triggers profit shifting and base erosion from multinationals. Tax enforcement is the alternative to tax coordination to limit profit shifting. However, the lack of enforcement coordination makes the fight against profit shifting less effective. We consider a game in which countries differ in market size and enforcement productivity (enforcement elasticity of tax revenue). Countries seek to maximize welfare (tax revenue net of enforcement cost), choosing first their enforcement levels to limit profit shifting before competing in taxes. We find that enforcement leadership Pareto dominates simultaneous enforcement choices, and that the low-enforcement productivity country would be the leader. In line with the OECD/G20 BEPS project, we analyze the scope for international enforcement cooperation. We establish that Nash bargaining over enforcements (with countries competing in taxes) induces higher enforcement, tax and revenue for each country, and that the benefit of enforcement cooperation is larger for the low-enforcement productivity country. We then analyze the minimum tax reform, showing that it achieves a Pareto improvement under both cooperative and non-cooperative enforcement.

JEL classification: H30, H87, C72

Keywords: Leadership, Tax enforcement, Profit shifting, Minimum tax

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1 Introduction

With the prosperity of multinational enterprises (MNEs) in recent years, international tax issue on MNEs has taken center stage in public debates and policy circles. International tax-rate differentials provide MNEs with opportunities to shift profits between foreign subsidiaries in order to reduce their tax obligations. Overwhelming evidence shows that base erosion and profit shifting (BEPS) exist and cause considerable loss of tax revenue for both OECD and developing countries.[1] The impacts of BEPS on tax administrations worldwide are twofold. Firstly, induced by the profit shifting, countries compete with each other in corporation taxes so as to attract more mobile profits of MNEs, which results in substantial falls in corporate tax rates (see Devereux et al., 2008; Huizinga and Laeven, 2008; Overesch and Rincke, 2011).[2] Secondly and more importantly, more and more countries realize the severity of BEPS and strengthen their tax enforcement to combat this problem[3], which limits MNEs' profit shifting behavior (see Beer and Loeprick, 2015; Riedel et al., 2015; Dharmapala, 2019). Some recent empirical works further show that in addition to tax rates, countries may use tax enforcement as policy instrument to secure tax revenues, and find evidence of strategic interaction in tax enforcement among governments (e.g., Zinn et al., 2014; Durán-Cabré et al., 2015). In view of the above studies, Hindriks and Nishimura (2021) build a fiscal competition model where countries compete in tax enforcements simultaneously, and analyze the viability of enforcement cooperation. In their framework, however, the assumption of countries'

[1] For instance, Huizinga and Laeven (2008) points out that international profit shifting by multinationals causes Germany to lose significant tax revenues. Clausing (2016) finds that more than half of the foreign profits of US multinationals are booked in low-tax countries, which causes US tax revenue loss between \$77 billion and \$111 billion by 2012. Cristea and Nguyen (2016) shows that transfer price manipulation of physical good exports by multinationals reduces Danish government's corporate tax revenues by approximately 3.24%. Crivelli et al. (2016) argues that developing countries suffer from the problem of BEPS to a greater extent than OECD countries. Bilicka (2019) reveals that foreign multinational subsidiaries in the UK underreport taxable profits by about 50 percent relative to (comparable) domestic companies. See also OECD (2015)'s final reports.

[2] In 1980, corporate tax rates around the world averaged 40.11 percent, and 46.52 percent when weighted by GDP. In 2020, the average is 23.85 percent, and 25.85 when weighted by GDP (see Tax Foundation, "Corporate Tax Rates around the World, 2020," Dec. 9, 2020, https://taxfoundation.org/corporate-tax-rates-around-the-world-2020/).

[3] In particular, G20 and OECD launch a BEPS package which provides 15 action plans against tax avoidance by multinationals (see OECD, 2015). OECD and G20 countries along with an increasing number of developing countries actively participate in the development of this OECD/G20 BEPS project, and make unparalleled efforts to tackle BEPS. The measures that countries often take to enhance tax enforcement include designing effective Controlled Foreign Company (CFC) rules, tightening transfer pricing regulations and increasing the auditing probability (see e.g., Buettner and Wamser, 2013; Durán-Cabré et al., 2015; Riedel et al., 2015).

simultaneous moves in choosing enforcement levels is questionable. Indeed, evidence suggests that countries' decisions on enhancing tax enforcement are not made simultaneously. For instance, as early as 2011, Chile changed tax-enforcement policy on MNEs. It strongly increased reporting requirements for multinationals, increased the number of specialized tax auditors and created a specialized unit to monitor transfer pricing (see Bustos et al., 2019). Besides, in response to the OECD/G20 BEPS project, the progresses of enforcement reforms are also different among the participating countries. For instance, responding to interest deductions (Action 4) in the OECD/G20 BEPS package, Finland tightened the interest deductibility limits as early as 2013, while a draft Financial Bill including similar rules was proposed in France until 2018. Regarding transfer pricing documentation (Action 13), a law introducing the country-by-country (CbC) reporting requirement took effect in Italy in January, 2016. In contrast, Czech Republic implemented the CbC reporting requirements nearly two years later.[4] These facts naturally raise the following questions: how does the sequence of enforcement decisions affect countries' tax revenues? Which countries are likely to lead in tax enforcement competition if the timing of enforcement is taken into account, and what is the determinant of the enforcement leadership? To the best of our knowledge, there is no study on the tax enforcement leadership.

In this paper, we build upon Hindriks and Nishimura (2021)'s model by endogenizing the timing of countries' enforcement decisions. To this end, we introduce a timing game at the pre-play stage, as proposed by Hamilton and Slutsky (1990), in which two countries commit themselves to move early or late in choosing tax enforcements.[5] At the next stage, two countries choose non-cooperatively their enforcement levels, based on their timing decisions at the pre-play stage. Through this approach, we stipulate an "enforcement leadership game" to analyze the emergence of the enforcement leadership. Another contribution of this paper is to consider asymmetric enforcement productivity among countries.[6] Using a

[4] The information on countries' action developments in response to the OECD/G20 BEPS project is compiled from Ernst & Young's survey (more details available at: https://www.ey.com/en_gl/beps-tracker).

[5] The game with endogenous timing of moves, which is also called "commitment game", has been well developed in tax competition model to analyze the leadership of tax decisions. See, for instance, Kempf and Rota-Graziosi (2010), Hindriks and Nishimura (2015, 2017) for the analysis of leadership among countries in setting tax rates. In our base model, the tax leadership is absent: we exogenously assume that two countries set tax rates simultaneously so as to focus on the enforcement leadership. However, as demonstrated in Subsection 4.2, incorporating the tax leadership into our framework does not change the main results obtained in the base model.

[6] Various forms of country asymmetries have been studied in the fiscal competition literature, including

Cobb-Douglas enforcement technology, we represent the enforcement productivity as the (constant) enforcement elasticity of tax revenue.[7] This is related to Keen and Slemrod (2017), who propose the concept "enforcement elasticity of tax revenue" to capture the productivity of the administrative interventions (i.e., enforcement). Throughout the paper, we refer to the country with a high enforcement elasticity of tax revenue as the country with a high enforcement productivity.[8] Given the super-modularity of the Cobb-Douglas function, following Amir and Stepanova (2006), we find that the Subgame Perfect Equilibria (SPEs) of the enforcement leadership game consist of two Stackelberg equilibria in which countries set their enforcement levels sequentially. Both countries are better off under Stackelberg equilibria than under simultaneous Nash equilibrium. Then we solve the subsequent equilibrium selection problem by resorting to the Pareto-dominance and the risk-dominance criteria (see Harsanyi and Selten, 1988).

Although both countries are better off by choosing enforcements sequentially, we show that there is still scope for mutually beneficial cooperation on tax enforcements. Unlike Hindriks and Nishimura (2021), in which cooperation maximizes joint welfare (with the risk that the low-tax country may lose from such cooperation in the absence of compensating transfers), we study international enforcement cooperation as a Nash bargaining problem.[9] Some recent literature on profit shifting also involves Nash bargaining, such as bargaining between the MNE and labor union, between the headquarter and supplier (Riedel, 2011; Bauer and Langenmayr, 2013). Becker and Davies (2014) provide a "negotiation model" in which the high-tax country and low-tax country bargain over the multinational's transfer price, but tax competition is absent in their analysis. In contrast, our paper analyzes bargaining over enforcement levels with tax competition, and shows that bargaining outcome

the asymmetries in endowments, market size and capital ownership (see Bucovetsky, 1991; Peralta and van Ypersele, 2005; Hindriks and Nishimura, 2015, 2017, 2021).

[7] Several concepts concerning tax evasion issues have been developed in the previous literature, e.g., concealment technology, tax avoidance technology and tax collection technology. see Slemrod and Yitzhaki (2002) for a comprehensive review of this field. In our paper, the enforcement technology transforms countries' enforcement efforts into the cost of profit shifting for multinationals.

[8] Hindriks and Nishimura (2021) assume that the enforcement technology is a symmetric CES function with the symmetric Cobb-Douglas as a special case. The asymmetry of enforcement productivity is therefore ruled out in their model. We discuss further the specification of the enforcement technology in Subsection 2.3.

[9] Hindriks and Nishimura (2021) show that such cooperation may not benefit the low-tax country if the market-size asymmetry is too large. In contrast, the Nash bargaining outcome will necessarily make both countries better off compared to the non-cooperative outcome.

leads to higher enforcements, taxes and welfare for each country relative to the Stackelberg outcomes. We then consider the minimum tax reform, showing that (binding) minimum taxation raises enforcement and tax revenue of each country. Our results are also shown to be robust to the sequential choices of taxes (tax leadership).

Our paper highlights the key role of enforcement productivity. First, the unequal enforcement productivity (but not the unequal market size) drives the enforcement leadership. The low enforcement productivity country is the enforcement leader. Second, the low-enforcement productivity country benefits (relatively) more from enforcement cooperation. Third, the welfare effect of the market-size asymmetry is affected by the enforcement productivity. In particular, increasing market-size disparity can harm the large country if its enforcement productivity is sufficiently low.

The paper is organized as follows. Section 2 presents the model and the non-cooperative equilibrium with endogenous enforcement leadership. Section 3 investigates enforcement cooperation under Nash bargaining. Section 4 extends the base model to analyze minimum tax and tax leadership. Section 5 concludes. All the proofs are in the Appendix.

2 The model

2.1 The setups

Building upon Hindriks and Nishimura (2021)'s model, we consider two countries indexed by 1 and 2 and two MNEs indexed by a and b. Each Each MNE has affiliates in both countries, and produces a homogeneous good with unit cost c_i in country i ($i = 1, 2$). The output of MNE k ($k = a, b$) in country i is denoted by q_i^k, and the inverse demand function in country i is $p_i = \alpha_i - \beta(q_i^a + q_i^b)$.

Without loss of generality, we assume $\gamma_1 := \alpha_1 - c_1 > \gamma_2 := \alpha_2 - c_2$. This assumption introduces the asymmetry in market size: country 1 with greater market demand (or lower supply cost) is the large country, while country 2 is the small country. Following Hindriks and Nishimura (2021), we define $\varepsilon := \dfrac{1-(\gamma_2/\gamma_1)^2}{1+(\gamma_2/\gamma_1)^2} \in (0, 1]$ as the index of market size asymmetry.

The profit of MNE k ($k = a, b$) in country i is $\pi_i^k = (p_i - c_i)q_i^k$. Each MNE chooses the amount of profit to be shifted, so as to minimize its total tax liabilities net of the profit shifting cost. The profit shifting (concealment) cost is:

$$C\left(\pi_i^k, \tilde{\pi}_i^k\right) = \delta\left(e_1, e_2\right)\left(\pi_1^k - \tilde{\pi}_1^k\right)^2 + \delta\left(e_1, e_2\right)\left(\pi_2^k - \tilde{\pi}_2^k\right)^2 = 2\delta\left(e_1, e_2\right)\left(\pi_1^k - \tilde{\pi}_1^k\right)^2,$$

where π_i^k, $\widetilde{\pi}_i^k$ and e_i respectively represent the MNE k's actual profit, reported profit and the level of enforcement in country i.

The MNE k's overall after-tax profit is $\sum\limits_i (1-t_i)\widetilde{\pi}_i^k - C(\pi_i^k, \widetilde{\pi}_i^k)$, where t_i denotes the source-based corporate tax rate in country i.

$\delta(e_1, e_2)$ denotes the enforcement technology and represents the overall enforcement level, which transforms two countries' enforcement efforts into the cost associated with MNEs' profit shifting. We assume that $\delta(e_1, e_2)$ is strictly increasing and concave in each country's enforcement level, i.e., $\forall e_1, e_2 > 0$, $\dfrac{\partial \delta(e_i, e_j)}{\partial e_i} > 0$, $\dfrac{\partial^2 \delta(e_i, e_j)}{\partial e_i^2} \leq 0$. When one country raises its enforcement (such as setting tighter transfer pricing laws or auditing MNEs more frequently), the cost of (successful) profit shifting increases for the MNEs.

Tax enforcement is costly, as countries have to devote real resources to expand enforcement activities. We denote by $EC_i(e_i)$ the enforcement cost of country i with $EC_i'(e_i) > 0$ and $EC_i''(e_i) > 0, \forall e_i > 0$.[10] Then the welfare (i.e., the tax revenue net of the enforcement cost) of country i is:[11]

$$W_i = t_i(\widetilde{\pi}_i^a + \widetilde{\pi}_i^b) - EC_i(e_i). \tag{1}$$

2.2 Enforcement leadership

To endogenize the enforcement leadership, we introduce a timing game at stage 1 (i.e., the pre-play stage). The sequence of players' decisions is as below:

Stage 1 (pre-play stage): Countries non-cooperatively decide whether to move "Early" or "Late" in choosing their enforcement levels.

[10] The enforcement cost, which is also referred to as the administrative cost of enforcement, may result from employing tax inspectors and from the burden of examining statutory documentation provided by multinationals (see Zinn et al., 2014). Almunia and Lopez-Rodriguez (2018) also specify a strictly increasing and convex function to capture the enforcement cost when analyzing the effects of tax enforcement on firms' tax compliance and on social welfare. See also Slemrod and Yitzhaki (2002), who discussed at length the administrative cost from the perspective of information gathering.

[11] As in Hindriks and Nishimura (2021), the profit tax does not distort the productions and prices, which means that the consumer surplus is independent of the tax system. Therefore, we refer to the tax revenue net of the enforcement cost as the country's welfare throughout the paper.

Stage 2: Countries non-cooperatively choose enforcement levels to maximize their welfare, according to the timing decisions at stage 1.

Stage 3: Countries set simultaneously and non-cooperatively their tax rates to maximize their tax revenues.

Stage 4: MNEs choose outputs and reported profits in each country to maximize their after-tax profits.

There are four strategy pairs at the pre-play stage: (Early, Early), (Early, Late), (Late, Early), (Late, Late), which can generate three different games at stage 2. Specifically, a simultaneous-move game G^N is induced when two countries make the same choice (i.e., (Early, Early) or (Late, Late)). When country i moves early and the other moves late, it induces a sequential game G^i, where superscript i represents the enforcement leadership by country i.

Hereafter, the leader and follower in each sequential game are respectively denoted by superscripts L and F , while we denote by superscript N the simultaneous Nash game G^N .

2.3 The equilibrium analysis

The backward induction is applied to solve for the Subgame Perfect Equilibria (SPEs) of the game. Let $\beta = \frac{2}{9}(\gamma_1^2 + \gamma_2^2)$ such that the total profits of the two MNEs are normalized to unity. Let t_i^* and R_i^* be respectively country in i's equilibrium tax rate and revenue in the stage-3 tax subgame. Lemma 1 gives the equilibrium outcomes of stages 3 and 4 (see Equations (4), (7) and (9) in Hindriks and Nishimura (2021)).

Lemma 1. *(i)* $\pi_i^k = \dfrac{1+\mathbf{1}\varepsilon}{4}$, $\tilde{\pi}_i^k = \dfrac{1+\mathbf{1}\varepsilon}{4} - \dfrac{t_i - t_j}{4\delta(e_1, e_2)}$ $(k = a, b)$; *(ii)* $t_i^* = \dfrac{3+\mathbf{1}\varepsilon}{3}\delta(e_1, e_2)$, $R_i^* = \dfrac{(3+\mathbf{1}\varepsilon)^2}{18}\delta(e_1, e_2)$,
where $\mathbf{1}$ *is an indicator taking the value 1 for country 1 and -1 for country 2.*

Lemma 1(ii) shows that the large country (i.e., country 1) sets a higher tax than its rival in the (simultaneous) tax subgame. The equilibrium tax gap is driven by the market-size asymmetry. To see this more clearly, consider each country's tax base elasticity under uniform rate: $-\dfrac{\partial\widetilde{\pi}_1}{\partial t_1}\dfrac{t_1}{\widetilde{\pi}_1} = \dfrac{t}{(1+\varepsilon)\delta(e_1, e_2)} < -\dfrac{\partial\widetilde{\pi}_2}{\partial t_2}\dfrac{t_2}{\widetilde{\pi}_2} = \dfrac{t}{(1-\varepsilon)\delta(e_1, e_2)}$, where $\widetilde{\pi}_i = \sum_k \widetilde{\pi}_i^k$. So the small country (i.e., country 2) perceives its tax base to be more elastic and thus taxes less. Note that tax base elasticities are inversely proportional to the overall enforcement level. So, the benefit of enforcement is to enhance the fiscal capacity of each country by limiting their tax base elasticity. Interestingly, the low tax country also benefits from enforcement, even though for any given tax rates, the amount of profit shifting is decreasing with enforcement. The reason is that in response to higher enforcement, the low tax country will increase its tax to a lesser extent than the high tax country (see Lemma 1(ii)), so as to offset the impact of enforcement on profit shifting. Indeed, from Lemma 1, profit shifting is, under equilibrium taxes, independent of the overall enforcement. The implication is that both countries can benefit from higher enforcement but face the free rider incentive.

Using Lemma 1 and (1), the welfare function at stage 2 is:

$$W_i(e_1, e_2) = d_i \delta(e_1, e_2) - EC_i(e_i), \tag{2}$$

where $d_i = \dfrac{(3 + \mathbf{1}\boldsymbol{\varepsilon})^2}{18}$.

Following Amir and Stepanova (2006), the stage-1 equilibria depend on the cross partial derivative of $\delta(e_1, e_2)$. Specifically, if $\dfrac{\partial^2 \delta(e_1, e_2)}{\partial e_1 \partial e_2} > 0,\ \forall e_1, e_2 > 0$, then both (Early, Late) and (Late, Early) are the equilibria of the enforcement timing game and can lead to higher welfare for both countries than the simultaneous game. If $\dfrac{\partial^2 \delta(e_1, e_2)}{\partial e_1 \partial e_2} < 0,\ \forall e_1, e_2 > 0$, then (Early, Early) is the unique equilibrium of the enforcement timing game. Two countries are indifferent between moving early and late, and all the four strategy pairs are the equilibria if $\dfrac{\partial^2 \delta(e_1, e_2)}{\partial e_1 \partial e_2} \equiv 0,\ \forall e_1, e_2 > 0.$[12]

To further analyze the enforcement leadership, we impose some structure on the administrative cost and enforcement technology by specifying a quadratic enforcement cost function $EC_i(e_i) := \dfrac{\eta}{2} e_i^2$ ($\eta > 0$) and a Cobb-Douglas enforcement technology $\delta(e_1, e_2) := e_1^{\alpha} e_2^{1-\alpha}$ ($0 < \alpha < 1$).[13] Given (2) and the above specifications, country i's welfare function

[12]Following Amir and Stepanova (2006)'s approach, given the welfare function (2), we can establish that for each country: (i) the equilibrium welfare in the sequential game where it follows is higher (resp. lower) than in game G^N if $\frac{\partial^2 \delta(e_1, e_2)}{\partial e_1 \partial e_2} > 0, \forall e_1, e_2 > 0$ (resp. $\frac{\partial^2 \delta(e_1, e_2)}{\partial e_1 \partial e_2} < 0, \forall e_1, e_2 > 0$); (ii) the equilibrium welfare in the sequential game where it leads is always higher than in game G^N if $\frac{\partial^2 \delta(e_1, e_2)}{\partial e_1 \partial e_2} \neq 0, \forall e_1, e_2 > 0$; and (iii) its equilibrium enforcement and welfare levels are the same in games G^1, G^2 and G^N if $\frac{\partial^2 \delta(e_1, e_2)}{\partial e_1 \partial e_2} \equiv 0, \forall e_1, e_2 > 0$. These properties directly yield the stage-1 equilibria. The detailed derivations are available upon request.

[13]Empirical evidence indicates that countries strengthen their transfer pricing regulations in response to others' tighter policies against profit shifting (see Zinn et al., 2014; Riedel et al., 2015). This supports the specification of a super-modular enforcement technology with $\frac{\partial^2 (e_1^{\alpha} e_2^{1-\alpha})}{\partial e_1 \partial e_2} > 0, \forall e_1, e_2 > 0$, since in our model strategic complementarity (resp. substitutability) of tax enforcements corresponds to the super-modularity (resp. sub-modularity) of $\delta(e_1, e_2)$. The related derivations are available upon request.

at stage 2 is:

$$W_i(e_1, e_2) = d_i e_1^{\alpha} e_2^{1-\alpha} - \frac{\eta}{2} e_i^2. \tag{3}$$

The Cobb-Douglas enforcement technology implies constant enforcement elasticity of tax revenue in each country, based on which we can introduce the asymmetry in countries' enforcement productivity.[14] Specifically, parameters α and $1-\alpha$ respectively represent the enforcement elasticity of tax revenue in country 1 and in country 2. In line with Keen and Slemrod (2017), we say that enforcement productivity is higher (resp. lower) in country 1 than in country 2 if $\alpha > \frac{1}{2}$ (resp. $\alpha < \frac{1}{2}$).[15] Hence, our model involves two types of asymmetry: the asymmetry in market size and the asymmetry in enforcement productivity.[16]

To secure interior solutions in the tax subgame, we assume that the enforcement cost parameter η is sufficiently large with $\eta \geq \frac{8}{3}$. Given (3), the equilibrium enforcement and welfare levels associated with games G^N, G^1 and G^2 are displayed in Table 1:

Table 1: Equilibrium enforcement and welfare in games G^N, G^1 and G^2

	G^N	G^1	G^2
Country 1			
e_1	$\frac{(1-\alpha)^{\frac{1-\alpha}{2}} \alpha^{\frac{1+\alpha}{2}} d_1^{\frac{1+\alpha}{2}} d_2^{\frac{1-\alpha}{2}}}{\eta}$	$\frac{(1-\alpha)^{\frac{1-\alpha}{2}} \left(\frac{2\alpha}{1+\alpha}\right)^{\frac{1+\alpha}{2}} d_1^{\frac{1+\alpha}{2}} d_2^{\frac{1-\alpha}{2}}}{\eta}$	$\frac{\left(\frac{2-2\alpha}{2-\alpha}\right)^{\frac{1-\alpha}{2}} \alpha^{\frac{1+\alpha}{2}} d_1^{\frac{1+\alpha}{2}} d_2^{\frac{1-\alpha}{2}}}{\eta}$
W_1	$\frac{(2-\alpha)\alpha^{\alpha}(1-\alpha)^{1-\alpha} d_1^{1+\alpha} d_2^{1-\alpha}}{2\eta}$	$\frac{(2\alpha)^{\alpha}(1-\alpha)^{1-\alpha}(1+\alpha)^{-1-\alpha} d_1^{1+\alpha} d_2^{1-\alpha}}{\eta}$	$\frac{\left(\frac{\alpha}{2}\right)^{\alpha}(1-\alpha)^{1-\alpha}(2-\alpha)^{\alpha} d_1^{1+\alpha} d_2^{1-\alpha}}{\eta}$
Country 2			
e_2	$\frac{(1-\alpha)^{\frac{2-\alpha}{2}} \alpha^{\frac{\alpha}{2}} d_1^{\frac{\alpha}{2}} d_2^{\frac{2-\alpha}{2}}}{\eta}$	$\frac{(1-\alpha)^{\frac{2-\alpha}{2}} \left(\frac{2\alpha}{1+\alpha}\right)^{\frac{\alpha}{2}} d_1^{\frac{\alpha}{2}} d_2^{\frac{2-\alpha}{2}}}{\eta}$	$\frac{\left(\frac{2-2\alpha}{2-\alpha}\right)^{\frac{2-\alpha}{2}} \alpha^{\frac{\alpha}{2}} d_1^{\frac{\alpha}{2}} d_2^{\frac{2-\alpha}{2}}}{\eta}$
W_2	$\frac{(1+\alpha)\alpha^{\alpha}(1-\alpha)^{1-\alpha} d_1^{\alpha} d_2^{2-\alpha}}{2\eta}$	$\frac{2^{\alpha-1}\alpha^{\alpha}(1-\alpha)^{1-\alpha}(1+\alpha)^{1-\alpha} d_1^{\alpha} d_2^{2-\alpha}}{\eta}$	$\frac{2^{1-\alpha}\alpha^{\alpha}(1-\alpha)^{1-\alpha}(2-\alpha)^{\alpha-2} d_1^{\alpha} d_2^{2-\alpha}}{\eta}$

[14] Note that under the Cobb-Douglas enforcement technology, the alternative timing in which countries simultaneously choose enforcements and taxes would lead to trivial solutions, i.e., $\widetilde{e}_1 = \widetilde{e}_2 = 0$ and $\widetilde{t}_1 = \widetilde{t}_2 = 0$ (detailed derivations are available on request). The reason is that with Cobb-Douglas technology, both countries' participation in tax enforcement is required to secure effective enforcement. Each country has an incentive to tax less than the other and to set its enforcement to zero, so as to capture all the profits of the MNEs. This extreme "race to the bottom" outcome obviously does not fit the reality. Moreover, enforcement levels, usually determined by monitoring policies and transfer pricing rules, are long-term policy variables and less alterable than tax rates. Therefore, it is reasonable to assume that countries pre-commit on enforcements before setting their taxes. See Peralta et al. (2006) and Hindriks and Nishimura (2021) for similar setups.

[15] Suppose that each country unilaterally increases its enforcement level by one percent. Then country 1 can raise its revenue by a larger percentage than country 2 iff $\alpha > \frac{1}{2}$.

[16] For simplicity, throughout the paper we focus on the Cobb-Douglas function that is homogeneous of degree 1, such that the sum of enforcement productivities is normalized to unity. All the results in our paper remain qualitatively unchanged under a more general Cobb-Douglas enforcement technology: $\delta(e_1, e_2) := e_1^{\alpha} e_2^{\beta}$ with $\alpha, \beta > 0$ and $0 < \alpha + \beta \leq 1$. Under this general form, country 1 displays a higher enforcement productivity iff $\alpha > \beta$.

From Table 1, we can compare the equilibrium enforcement and welfare levels under three games:

$$\forall \alpha \in (0,1), \quad e_i^L > e_i^F > e_i^N \quad \text{and} \quad W_i^F > W_i^L > W_i^N, \tag{4}$$

where $W_i^L := W_i(e_i^L, e_j^F)$, $W_i^F := W_i(e_i^F, e_j^L)$ and $W_i^N := W_i(e_i^N, e_j^N)$ respectively represent the equilibrium payoffs of country i in games G^i, G^j and G^N $(i, j = 1, 2;\ i \neq j)$.

Compared to the Nash equilibrium, Stackelberg equilibria induce higher enforcement levels in both countries. Indeed, consider a small increase in the leader's enforcement relative to the Nash equilibrium. By strategic complementarity, this raises the follower's enforcement, which in turn benefits the leader because of the positive enforcement externality (higher enforcement reduces the tax base elasticity of two countries, enabling them to tax more).

Given the welfare ranking in (4), each country prefers to follow than to lead (second-mover advantage), but at the same time both countries prefer sequential choice to simultaneous move. As a result, the two Stackelberg equilibria in which each country can either lead or follow constitute the SPEs of the timing game.

To solve the coordination problem caused by multiple equilibria, we use the Pareto-dominance and risk dominance refinement (see Harsanyi and Selten, 1988).[17] The equilibrium (Early, Late) risk dominates (Late, Early) iff:

$$\Pi := (W_1^L - W_1^N)(W_2^F - W_2^N) - (W_1^F - W_1^N)(W_2^L - W_2^N) > 0.$$

Then, we establish the following:

Proposition 1. *(i) The enforcement leadership by country 1 (resp. country 2) is risk-dominant iff* $0 < \alpha < \dfrac{1}{2}$ *(resp.* $\dfrac{1}{2} < \alpha < 1$*). If* $\alpha = \dfrac{1}{2}$*, there is no risk-dominant enforcement leadership. (ii) Neither of the Stackelberg equilibria Pareto-dominates the other.*

Proof. See the Appendix.

This proposition contrasts with the tax leadership derived from the market-size asymmetry (see Kempf and Rota-Graziosi, 2010; Hindriks and Nishimura, 2015, 2017). In our model, the enforcement leadership is driven by the enforcement strategic complementarity

[17] Even if neither of the two SPEs is Pareto-dominant (i.e., Proposition 1(ii)), the risk-dominant equilibrium is often selected in the coordination game. This is because it is perceived as a safer choice when players face strategic uncertainty about rivals' moves (see Van Huyck et al., 1990; Amir and Stepanova, 2006).

together with the positive externality of enforcement. Indeed, from lemma 1, we see that even the low-tax country benefits from higher enforcements, because in equilibrium it will increase its tax to a lesser extent than the high-tax country so as to maintain its tax base unchanged. This is different from usual analysis of tax enforcement in which taxes are fixed. In our model, enforcement enables countries to scale up their tax. The enforcement leadership is taken by the low-enforcement productivity country. The reason is that the positive externality induced by the follower's enforcement response is larger when the follower is the high-enforcement productivity country. To see this, we present country i's ($i = 1, 2$) reaction function $e_i^N(e_j) := arg\,\underset{e_i}{max}\, W_i(e_i, e_j)$ in game G^N:

$$\begin{cases} e_1^N(e_2) = \left(\dfrac{\alpha d_1}{\eta}\right)^{\frac{1}{2-\alpha}} e_2^{\frac{1-\alpha}{2-\alpha}}, \\ e_2^N(e_1) = \left[\dfrac{(1-\alpha)d_2}{\eta}\right]^{\frac{1}{1+\alpha}} e_1^{\frac{\alpha}{1+\alpha}}. \end{cases} \tag{5}$$

As footnote (13) states, the super-modularity of the enforcement technology implies that enforcements are strategic complements: $\dfrac{\partial e_i^N(e_j)}{\partial e_j} > 0$.

In game G^i, denoted by $e_j^F(e_i)$ follower j's best response function. Then, leader i's tax revenue function is $R_i(e_i, e_j^F(e_i)) = d_i \delta(e_i, e_j^F(e_i))$, from which we can derive the leader's enforcement elasticity of tax revenue in game G^i:[18]

$$\frac{dR_i/R_i}{de_i/e_i} = \underbrace{\frac{\partial R_i/R_i}{\partial e_i/e_i}}_{\text{enforcement productivity}} + \underbrace{\frac{\partial R_i/R_i}{\partial e_j^F/e_j} \cdot \frac{de_j^F/e_j}{de_i/e_i}}_{\text{interaction effect}}. \tag{6}$$

Suppose that country i in game G^i increases its enforcement level by one percent from the Nash level e_j^N. This triggers country j to raise its enforcement by $\dfrac{de_j^F/e_j}{de_i/e_i}$ percent. From (6), the strategic response of country j can raise country i's revenue by $\dfrac{\partial R_i/R_i}{\partial e_j^F/e_j} \cdot \dfrac{de_j^F/e_j}{de_i/e_i}$ percent. We refer to it as the "interaction effect" on leader i's revenue in game G^i. As shown by (6), the effect of the leader's enforcement on its own revenue in the Stackelberg game can be decomposed into two parts. The first part is its enforcement productivity, and the second

[18] The strategic complementarity of tax enforcements produces a gap between the exogenous enforcement productivity and the endogenous enforcement elasticity of tax revenue under enforcement leadership.

part is the interaction effect, which measures the enforcement externality from the follower's strategic response.

Notice that follower j is on its best response function in Stackelberg game G^i , which means that $e_j^F(e_i) \equiv e_j^N(e_i)$. Then given (5) and (6), the interaction effects in games G^1 and G^2 are $\dfrac{\alpha(1-\alpha)}{1+\alpha}$ and $\dfrac{\alpha(1-\alpha)}{2-\alpha}$, respectively. Comparing the two values, we see that the interaction effect in game G^1 is larger (resp. smaller) than in game G^2 if $0 < \alpha < \dfrac{1}{2}$ (resp. $\dfrac{1}{2} < \alpha < 1$). Therefore, when $0 < \alpha < \dfrac{1}{2}$, country 1 gains more as a leader from country 2's enforcement response, than the other way round. In other words, country 1 loses more than country 2 by reverting to simultaneous moves instead of being the enforcement leader. This triggers country 1 (the low enforcement productivity country) to take the lead in the enforcement competition. The opposite reasoning holds for $\dfrac{1}{2} < \alpha < 1$, where a switch of the relative enforcement productivity induces a switch of enforcement leadership.

3 Cooperative enforcement

3.1 Nash bargaining over enforcement

Thus far, we assume that enforcement levels are set non-cooperatively, and our findings reveal that both countries are better off by setting enforcements sequentially instead of simultaneously. Nevertheless, there is still scope for efficiency gains from enforcement coordination, as indicated by Lemma 2:

Lemma 2. *For any $\alpha \in (0, 1)$, a small equi-proportional increase of both countries' enforcements from the Stackelberg levels is strictly Pareto-improving.*

Proof. See the Appendix.

This lemma points out the inefficiency of the two Stackelberg equilibria, as both countries can be better off by slightly increasing their enforcements from the Stackelberg levels. As mentioned before, the enforcement leadership increases both countries' enforcement levels compared to the simultaneous Nash game. Nevertheless, the positive externality of enforcement cannot be fully internalized in the Stackelberg games. When choosing its enforcement, each country does not take into account the positive effect of its enforcement on the other (to enhance its tax capacity). As a result, the Stackelberg equilibria involve suboptimal enforcement levels.

This inefficiency provides scope for international enforcement cooperation. In contrast with the marginal enforcement reform indicated by Lemma 2 (Pareto improvement), a more practical policy is to negotiate over enforcement to achieve the best possible outcome (Pareto efficiency). In the following, we consider enforcement cooperation as a Nash bargaining problem. Specifically, two countries negotiate over enforcement levels to maximize the product of their welfare gains relative to the disagreement outcomes. In case the negotiation breaks down, they choose enforcement levels according to the enforcement leadership game.[19]

Formally, based on Proposition 1, the Nash bargaining problem to be solved is:[20]

$$\begin{gathered}\max_{\{e_1,e_2\}} \left(W_1\left(e_1,e_2\right)-W_1^u\right)\left(W_2\left(e_1,e_2\right)-W_2^v\right), \\ \text{subject to:}\quad e_1\geq 0,\ e_2\geq 0,\ W_1(e_1,e_2)\geq W_1^u,\ W_2(e_1,e_2)\geq W_2^v,\end{gathered} \tag{7}$$

where $(u,v)=\begin{cases}(L,F) & if \quad \alpha\in\left(0,\dfrac{1}{2}\right)\\ (F,L) & if \quad \alpha\in\left(\dfrac{1}{2},1\right)\end{cases}.$

The strict concavity of the welfare functions guarantees that the feasible set is convex and the Nash product is strictly quasi-concave, which together with the compact feasible set ensure the existence and uniqueness of the solution to Problem (7).[21] Hereafter, we use superscript B to denote the Nash bargaining solution for each country.

[19] Hindriks and Nishimura (2021) treat enforcement cooperation in a different way. They consider enforcement cooperation as maximization of the joint welfare. In the absence of (lump sum) compensating transfers, enforcement cooperation is beneficial for both countries only if the market-size asymmetry is small enough, otherwise the small (low-tax) country will lose from the cooperation. By contrast, Nash bargaining solution rules out the possible disagreement against cooperation, since both countries are necessarily better off at this solution compared to non-cooperation. Another difference from Hindriks and Nishimura (2021) is that the disagreement outcome in our model is the Stackelberg equilibrium and not the simultaneous Nash equilibrium.

[20] Here, two countries are supposed to possess equal bargaining power. The assumption is reasonable. Indeed, each country can still secure Stackelberg outcomes without participating in enforcement cooperation. Neither country will have a superior bargaining position to the other in the negotiation.

[21] The detailed proofs are available on request to the authors.

3.2 Bargaining solution

We can compare the equilibrium outcomes under Nash bargaining and enforcement leadership game.

Proposition 2. *The equilibrium enforcement levels, tax rates, and welfare levels of both countries are strictly higher under Nash bargaining than in the (non-cooperative) enforcement leadership game.*

Proof. See the Appendix.

Although both countries can enhance enforcement levels by moving sequentially instead of simultaneously, their enforcements can be further increased to efficient levels under Nash Bargaining. The fundamental mechanism behind this result is twofold. First, the positive enforcement externality $\dfrac{\partial W_i(e_i, e_j)}{\partial e_j} > 0$ $(i, j = 1, 2;\ i \neq j)$ is internalized under Nash bargaining, since both countries are maximizing the product of their welfare gain (relative to the disagreement outcomes) instead of their own welfare. When bargaining over the enforcement, each country takes into account the positive externality of its enforcement on the other country. Thus, both countries have incentives to exert more enforcement efforts, which enables them to raise taxes (without changing their tax base). Second, due to the super-modularity of the enforcement technology $\dfrac{\partial^2 \delta(e_i, e_j)}{\partial e_i \partial e_j} > 0$ $(i, j = 1, 2;\ i \neq j)$, higher enforcement by one country increases the marginal welfare of enforcement for the other country. Therefore, the other country has an incentive to enhance enforcement, too. The two forces act in the same direction to raise enforcement levels compared to the Stackelberg levels.[22] The increased enforcements limit profit shifting, reduce the tax base elasticity and induce higher taxes under Nash bargaining.

We now analyze the cooperative welfare under Nash bargaining. The following proposition states which country gains (relatively) more from enforcement cooperation.

Proposition 3. *Compared to (Stackelberg) disagreement outcomes, under enforcement cooperation the leader's welfare gain (in percentage) is larger than the follower's welfare*

[22] Proposition 2 always holds for a super-modular enforcement technology, i.e., $\forall e_1, e_2 > 0$, $\frac{\partial^2 \delta(e_i, e_j)}{\partial e_i \partial e_j} > 0$. See Appendix A.3 for a proof without specifying the functional form of $\delta(e_1, e_2)$.

gain, i.e., $\begin{cases} \dfrac{W_1^B}{W_1^L} > \dfrac{W_2^B}{W_2^F} & if \quad \alpha \in \left(0, \dfrac{1}{2}\right) \\ \dfrac{W_2^B}{W_2^L} > \dfrac{W_1^B}{W_1^F} & if \quad \alpha \in \left(\dfrac{1}{2}, 1\right) \end{cases}.$

Proof. See the Appendix.

Although two countries have the same bargaining power, their welfare levels do not increase in the same proportion. The explanation is as follows. Enforcement cooperation leads both countries to raise enforcements above the Stackelberg levels. Recall that each country's revenue function is $R_i = d_i e_1^{\alpha} e_2^{1-\alpha}$, which yields $\dfrac{\partial R_1/R_1}{\partial e_2/e_2} = 1-\alpha$ and $\dfrac{\partial R_2/R_2}{\partial e_1/e_1} = \alpha$. Hence, the positive enforcement externality (in percentage) on one country is equal to the enforcement productivity of the other country. This means that the enforcement externality is larger on the country with a lower enforcement productivity. Therefore, relative to the Stackelberg outcome, the low-enforcement productivity country (i.e., the enforcement leader) benefits more from enforcement cooperation.

Proposition 3 also implies that the distribution of the efficiency gains from cooperation is twisted in favor of the enforcement leader. To see this, we rewrite the expression in Proposition 3 as below:

$$\begin{cases} \dfrac{W_1^B}{W_1^B + W_2^B} > \dfrac{W_1^L}{W_1^L + W_2^F} \\ \dfrac{W_2^B}{W_1^B + W_2^B} < \dfrac{W_2^F}{W_1^L + W_2^F} \end{cases} if \quad 0 < \alpha < \frac{1}{2}, \text{ and } \begin{cases} \dfrac{W_1^B}{W_1^B + W_2^B} < \dfrac{W_1^F}{W_1^F + W_2^L} \\ \dfrac{W_2^B}{W_1^B + W_2^B} > \dfrac{W_2^L}{W_1^F + W_2^L} \end{cases} if \quad \frac{1}{2} < \alpha < 1.$$

This shows that compared to the Stackelberg equilibrium, cooperation increases the enforcement leader's share in the total welfare. To sum up, the enforcement leader benefits more from cooperation than the follower.

Our next result shows how the market-size asymmetry affects each country's equilibrium welfare.

Proposition 4. *In all non-cooperative games G^1, G^2, and G^N and under Nash bargaining, the large country 1's equilibrium welfare is strictly increasing (resp. decreasing) in ε iff $\alpha > \dfrac{\varepsilon}{3}$ (resp. $\alpha < \dfrac{\varepsilon}{3}$). The small country 2's equilibrium welfare is strictly decreasing in ε for all parameter values.*

Proof. See the Appendix.

Reducing the market size of the small country reduces its tax base and increases its tax base elasticity.[23] As a result, the low tax country will tax less and enforce less in equilibrium. On the contrary, increasing the market size of the large country increases its tax base, while the welfare effect is ambiguous because of the lower enforcement level from the small country. To understand this, keeping the overall enforcement level $\delta(e_1, e_2)$ unchanged, the marginal rate of substitution is $-\frac{de_1/e_1}{de_2/e_2} = \frac{1-\alpha}{\alpha}$. Hence, as α decreases, country 1 needs to increase its enforcement to a greater extent to offset the enforcement cut of country 2. As Proposition 4 reveals, when α is very small relative to the market asymmetry (i.e., $\alpha < \frac{\varepsilon}{3}$), it becomes too costly for country 1 to offset the enforcement cut of country 2. In this case, increasing the market-size asymmetry also hams the large country.

4 Extensions

We have so far analyzed enforcement leadership and Nash bargaining over enforcements. In this section, we extend our analysis to investigate minimum tax and tax leadership, and show the robustness of our main results.

4.1 Minimum tax

In practice, countries are usually unable to agree on full tax harmonization. However, it is possible that countries agree on a uniform tax band within which tax rates can be set freely. One example of such partial cooperation is minimum tax. Kanbur and Keen (1993) firstly explore the minimum tax in a commodity tax competition model with cross-border shopping (and without enforcement issues). More recently, some economists have proposed to impose a minimum tax constraint on corporate tax rate to complement the OECD/G20 BEPS project dealing with aggressive tax planning (see, e.g., Laffitte et al., 2020).[24] We

[23]According to the definition of ε, an increase in the market-size asymmetry (i.e., a larger value of ε) means an increase (resp. decrease) in country 1's (resp. country 2's) market size.

[24]In their arguments, minimum tax rate stands for the effective rate on multinationals' affiliates. Here, we consider a simpler proposal in which minimum tax rate is the minimum statutory corporate tax rate that each country should obey. In the mean time, 131 countries and jurisdictions have joined a new two-pillar plan to tackle BEPS, which suggests a global minimum corporate income tax with a minimum rate of at least 15% (see OECD, "Statement on a Two-Pillar Solution to Address the Tax Challenges Arising From the Digitalization of the Economy," July 1, 2021, https://www.oecd.org/tax/beps/statement-on-a-two-pillar-solution-to-address-the-tax-challenges-arising-from-the-digitalisation-of-the-economy-july-2021.htm).

now investigate, in the settings of enforcement and tax competition, how the imposition of a minimum tax affects countries' enforcement, tax and welfare levels.

Consider a lower bound $\underline{t}$ on the corporate tax rates. Following Kanbur and Keen (1993) and Keen and Konrad (2013), we focus on the case where the minimum tax rate lies between two countries' unconstrained Nash equilibrium tax rates, and denote the minimum tax $\underline{t}$ as the weighted average of the unconstrained equilibrium taxes:

$$\underline{t} = \lambda t_1^* + (1-\lambda)t_2^*, \tag{8}$$

where $\lambda \in (0,1)$ and $t_i^* = \dfrac{1+\mathbf{1}\varepsilon}{3}\delta(e_1,e_2)$ as in Lemma 1(ii).

Keeping the rest of the base model unchanged, country i is now subject to $t_i \geq \underline{t}$ when setting its tax at stage 3.

Denote respectively by t_i^m and R_i^m the stage-3 equilibrium tax rate and revenue of country i under the minimum tax constraint $t_i \geq \underline{t}$. We get the following:

Lemma 3. *In stage-3 tax subgame, for any $\varepsilon \in (0,1]$,*

(i) the equilibrium tax rates under a minimum tax as in (8) are $\begin{cases} t_1^m = \dfrac{(1+\varepsilon)\delta(e_1,e_2)}{2} + \dfrac{\underline{t}}{2} \\ t_2^m = \underline{t} \end{cases}$;

(ii) the equilibrium tax revenues are $\begin{cases} R_1^m = \dfrac{(3+\varepsilon+\varepsilon\lambda)^2\delta(e_1,e_2)}{18}, \\ R_2^m = \dfrac{(3-\varepsilon-\varepsilon\lambda)(3-\varepsilon+2\varepsilon\lambda)\delta(e_1,e_2)}{18} \end{cases}$, *which are strictly higher than the unconstrained Nash equilibrium revenues.*

Proof. See the Appendix.

Lemma 3 is similar to Kanbur and Keen (1993, pp. 887-888), whereas our findings are established in the context of corporate tax competition with MNEs' profit shifting. Given two countries' enforcement levels, Lemma 3(i) reveals that imposing a minimum tax constraint can induce the small country to raise its tax to this minimum rate. As a result, the large country also increases its tax (due to strategic complementarity in tax rates). Lemma 3(ii) shows that for given enforcement levels, both the low-tax and the high-tax countries can reach unanimous agreement on a minimum tax proposal, as they can extract more tax revenues from the MNEs. Note that when $\varepsilon = 1$, the small country is a tax haven with no production and actual profit (i.e., $\pi_2^a = \pi_2^b = 0$). Therefore, imposing a minimum tax is also attractive to tax havens.

Now we analyze the equilibrium enforcement choice under the minimum tax constraint. Given (3) and Lemma 3(ii), under the minimum tax each country's welfare function at stage 2 is:

$$W_i^m(e_i, e_j) = d_i^m e_1^\alpha e_2^{1-\alpha} - \frac{\eta}{2} e_i^2, \tag{9}$$

where $d_1^m = \dfrac{(3+\varepsilon+\varepsilon\lambda)^2}{18}$ and $d_2^m = \dfrac{(3-\varepsilon-\varepsilon\lambda)(3-\varepsilon+2\varepsilon\lambda)}{18}$ with $d_i^m > d_i$.

Notice that (9) has the same structure as (3), except for the value of coefficient d_i^m. So all the reasoning in the base model can be applied to solve the enforcement leadership game and Nash bargaining problem under minimum tax, which means that Propositions 1, 2 and 3 still hold. On the other hand, according to (A-19)[25] , each country's equilibrium enforcement and welfare levels under Stackelberg games G^1 , G^2 and under bargaining are strictly increasing in d_1 and d_2. So, we can establish the following:

Proposition 5. *Suppose a minimum tax as in (8). The results on enforcement leadership and Nash bargaining still hold, as in Propositions 1-3. Furthermore, imposing the minimum tax constraint strictly increases equilibrium enforcement, tax and welfare of each country under both enforcement leadership and Nash bargaining.*

Proposition 5 states that the minimum tax is beneficial to both countries. Introducing a minimum tax constraint improves their welfare not only in the non-cooperative enforcement competition but also in the Nash bargaining over enforcements. The reason is that given enforcement levels, the minimum tax raises equilibrium taxes and reduces tax dispersion.[26] In turn given the higher taxes at stake, each country has stronger incentives for enforcement under both enforcement leadership and Nash bargaining. As a result, the minimum tax leads to higher enforcements, taxes and welfare for each country.

4.2 Tax leadership

Tax leadership can be considered within our framework without many analytical difficulties. To this end, we keep the rest of the base model unchanged, and replace stage

[25] See Appendix A.5.

[26] From Lemma 1(ii) and Lemma 3(i), we can derive: $(t_1^m - t_2^m) - (t_1^* - t_2^*) = \frac{3-\varepsilon}{6}\delta(e_1, e_2) - \frac{\underline{t}}{2} < 0$, where the last inequality holds since $\underline{t} > t_2^* = \frac{3-\varepsilon}{3}\delta(e_1, e_2)$.

3 by another timing game concerning tax decisions: two countries decide whether to move "Early" or "Late" in choosing tax rates; then according to their commitments, two countries non-cooperatively set taxes to maximize their own tax revenues.

The stage 4 equilibrium outcomes are as in Lemma 1(i). Proceeding backward, the tax timing game at stage 3 is solved by computing each country's equilibrium revenue with different tax leaderships, which is given by:

$$\begin{cases} R_1^{TL} = \dfrac{(3+\varepsilon)^2}{16}\delta(e_1, e_2) \\ R_2^{TF} = \dfrac{(5-\varepsilon)^2}{32}\delta(e_1, e_2) \end{cases} \quad \text{and} \quad \begin{cases} R_1^{TF} = \dfrac{(5+\varepsilon)^2}{32}\delta(e_1, e_2) \\ R_2^{TL} = \dfrac{(3-\varepsilon)^2}{16}\delta(e_1, e_2) \end{cases},$$

where superscripts TL and TF respectively denote the tax leader and follower in each sequential game at stage 3.

Thus, we have the following ranking of countries' tax revenues at stage 3:

$$\forall \varepsilon \in (0, 1], \quad R_i^{TF} > R_i^{TL} > R_i^*, \quad i = 1, 2, \tag{10}$$

where $R_i^* = \dfrac{(3 + \mathbf{1}\varepsilon)^2}{18}\delta(e_1, e_2)$ as in Lemma 1(ii).

It directly follows from (10) that the tax leadership by either country 1 or country 2 is the stage-3 equilibria and that there is a second-mover advantage for taxes as well as for enforcements. Moreover, the tax leadership by country 1 (i.e., the large country) risk dominates.[27] At stage 2, countries' welfare functions under country 1's tax leadership are:

$$W_i(e_1, e_2) = \widetilde{d}_i e_1^{\alpha} e_2^{1-\alpha} - \frac{\eta}{2} e_i^2, \tag{11}$$

where $\widetilde{d}_1 = \dfrac{(3+\varepsilon)^2}{16}$ and $\widetilde{d}_2 = \dfrac{(5-\varepsilon)^2}{32}$ with $\widetilde{d}_i > d_i$.

It is easily seen that (11) has the same form as (3), except for coefficient $\widetilde{d}_i$. Hence, Propositions 1, 2 and 3 still hold with endogenous tax leadership. Compared to simultaneous tax competition in the base model, tax leadership by country 1 increases two countries'

[27]It can be shown that for any $\varepsilon \in (0, 1]$, the product of deviation losses is larger when the large country is the tax leader, that is, $(R_1^{TL} - R_1^*)(R_2^{TF} - R_2^*) > (R_1^{TF} - R_1^*)(R_2^{TL} - R_2^*)$ holds. Thus, according to the definition of risk-dominance, the tax leadership by country 1 is a risk-dominant equilibrium. Tax leadership by the large country is in line with the existing literature on tax competition (see, e.g., Hindriks and Nishimura, 2015, 2017). All the detailed derivations involved in stage-3 equilibrium are available upon request.

equilibrium enforcements, taxes and welfare in the enforcement leadership game and Nash bargaining problem. It is worth noting that the enforcement leadership is driven by the asymmetry in enforcement productivity, whereas the tax leadership is driven by the market-size asymmetry.

5 Conclusion

This paper has investigated tax enforcement leadership and cooperation in the context of international profit shifting. The benefit of tax enforcement is to raise the cost of profit shifting for multinationals, which makes tax bases less sensitive to tax rates enabling countries to sustain higher corporate taxes. We depart from Hindriks and Nishimura (2021) in which enforcement decisions are simultaneous, to allow for the possible leadership in tax enforcement. Enforcement leadership is consistent with the evidence that progresses of strengthening tax enforcements are different among countries.

To endogenize the timing of enforcement decisions, the paper considers an "enforcement leadership game" in which countries commit themselves to move early or late in choosing their enforcement levels. Our model incorporates two types of asymmetry between countries. Besides the asymmetry in market size, countries are also asymmetric in enforcement productivity (i.e., enforcement elasticities of tax revenues). The Subgame Perfect Equilibria (SPEs) of the enforcement leadership game consists of two Stackelberg equilibria at which two countries set enforcements sequentially. Both countries are better off by setting their enforcement sequentially instead of simultaneously. We then resort to the risk dominance criterion to solve for the coordination issue caused by multiple equilibria, and establish that enforcement leadership by the country with low enforcement productivity risk dominates. Therefore, our model finds a novel driving force of enforcement leadership (the asymmetric enforcement productivity), which is distinct from that of tax leadership (the asymmetric market size).

A key feature of our model is that enforcement is chosen before taxes. Enforcements act as a level playing field, before countries compete in taxes. The implication is that even the low-tax country can benefit from higher enforcement. The positive enforcement externality leads to suboptimal levels of non-cooperative enforcement. To reach Pareto efficiency, we consider enforcement cooperation as a Nash Bargaining problem. We establish that both countries' enforcement levels, taxes and welfare levels are strictly higher under Nash bargaining than under enforcement leadership. The country with a low-enforcement productivity (also the enforcement leader) benefits more from the cooperation (both in terms of welfare gain and welfare share).

We then show the robustness of our results to the minimum tax and tax leadership. Moreover, under both cooperative and non-cooperative enforcement, imposing a minimum tax constraint can increase two countries' enforcement, tax and welfare levels compared to the unconstrained equilibrium outcomes. We also confirm that in our framework the tax leadership by the large country risk dominates (as in the existing literature on tax leadership without enforcement).

A key consideration in the international taxation challenge is the enforcement decisions and cooperation. Our results suggest that the enforcement leadership and the benefit of enforcement cooperation closely relate to the asymmetry in enforcement productivity. This indicates the importance of an empirical analysis of countries' enforcement elasticities of tax revenue in the context of international profit shifting.

Appendix A Proofs

A.1 Proof of Proposition 1

Given the results in Table 1, we can compute the product of deviation losses:

$$\Pi = \frac{\alpha^{2\alpha}(1-\alpha)^{2-2\alpha}}{4\eta^2(2-\alpha)^2} d_1^{1+2\alpha} d_2^{3-2\alpha} J(\alpha),$$

where $J(\alpha) := 2^{-\alpha}\left[2^{1-\alpha}(2-\alpha)^\alpha + \alpha - 2\right]\left[2^\alpha(2-\alpha)^2(1+\alpha) - 4(2-\alpha)^\alpha\right] + (2-\alpha)^2(1+\alpha)^{-2\alpha}\left[2^\alpha - (1+\alpha)^\alpha\right]\left[2^{1+\alpha} - (2-\alpha)(1+\alpha)^{1+\alpha}\right].$

The graph of function $J(\alpha)$ over interval $[0, 1]$ is:[28]

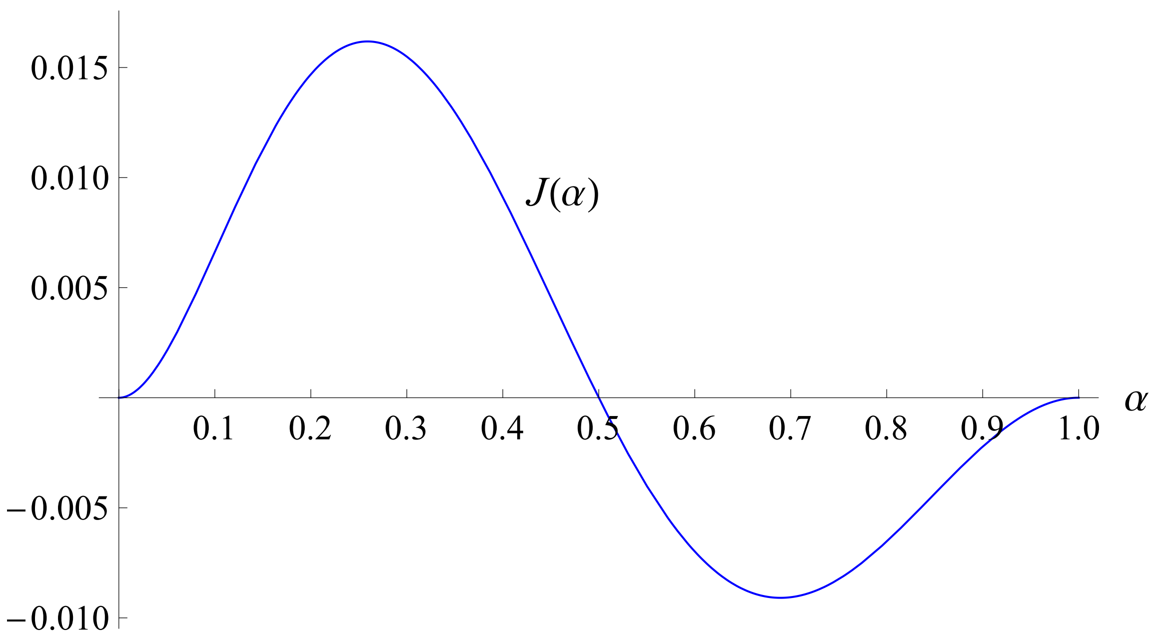

Fig. A1: The graph of $J(\alpha)$

From Fig. A1, we have: $\begin{cases} \Pi > 0, & if \quad 0 < \alpha < \frac{1}{2} \\ \Pi < 0, & if \quad \frac{1}{2} < \alpha < 1 \end{cases}$, which immediately leads to Proposition 1(i).

The second part of the proposition directly follows from (4). **Q.E.D.**

[28] Figs. A1, A2 and A3 are plotted by Wolfram Mathematica 12.1. The corresponding programs are available upon request.

A.2 Proof of Lemma 2

We analyze game G^i in which country i leads in the enforcement competition and country j follows. As for country i note that:

$$\left.\frac{\partial W_i(ke_i^L, ke_j^F)}{\partial k}\right|_{k=1} = \frac{\partial W_i(e_i^L, e_j^F)}{\partial e_i^L}e_i^L + \frac{\partial W_i(e_i^L, e_j^F)}{\partial e_j^F}e_j^F. \tag{A-1}$$

The first-order condition of country i's welfare optimization problem reads:

$$\frac{\partial W_i(e_i^L, e_j^F(e_i^L))}{\partial e_i^L} = \frac{\partial W_i(e_i^L, e_j^F)}{\partial e_i^L} + \frac{\partial W_i(e_i^L, e_j^F)}{\partial e_j^F}\frac{de_j^F(e_i^L)}{de_i^L} = 0. \tag{A-2}$$

Given (A-1), (A-2), (3) and (5), we have: $\forall \alpha \in (0,1)$

$$\left.\frac{\partial W_i(ke_i^L, ke_j^F)}{\partial k}\right|_{k=1} = \frac{\partial W_i(e_i^L, e_j^F)}{\partial e_j^F}e_j^F\left(1 - \frac{de_j^F/e_j^F}{de_i^L/e_i^L}\right) = d_i\frac{\partial \delta(e_i^L, e_j^F)}{\partial e_j^F}e_j^F(1-\varepsilon_j) > 0,$$

where $\varepsilon_j := \dfrac{de_j^F/e_j^F}{de_i^L/e_i^L} = \begin{cases} (1-\alpha)/(2-\alpha), & if \quad j=1 \\ \alpha/(1+\alpha), & if \quad j=2 \end{cases}$ represents leader i's enforcement elasticity of follower j's enforcement.

Thus, for any $\alpha \in (0,1)$ there exists some $\varepsilon_1 > 0$ such that $\forall k \in (1, 1+\varepsilon_1)$, $W_i(ke_i^L, ke_j^F) > W_i(e_i^L, e_j^F) := W_i^L$.

For country j, we have:

$$\left.\frac{\partial W_j(ke_i^L, ke_j^F)}{\partial k}\right|_{k=1} = \frac{\partial W_j(e_i^L, e_j^F)}{\partial e_i^L}e_i^L + \frac{\partial W_j(e_i^L, e_j^F)}{\partial e_j^F}e_j^F = \frac{\partial W_j(e_i^L, e_j^F)}{\partial e_i^L}e_i^L = d_j\frac{\partial \delta(e_i^L, e_j^F)}{\partial e_i^L}e_i^L > 0,$$

where the second equality derives from the first-order condition of country j's welfare optimization problem and the third equality is obtained from (3).

This implies that for any $\alpha \in (0,1)$, there exists some $\varepsilon_2 > 0$ such that $\forall k \in (1, 1+\varepsilon_2)$, $W_j(ke_i^L, ke_j^F) > W_j(e_i^L, e_j^F) := W_j^F$.

Take $\varepsilon := \min\{\varepsilon_1, \varepsilon_2\}$, then $\forall k \in (1, 1+\varepsilon)$, $\begin{cases} W_i(ke_i^L, ke_j^F) > W_i^L \\ W_j(ke_i^L, ke_j^F) > W_j^F \end{cases}$ $(i, j = 1, 2;\ i \neq j)$, i.e., increasing two countries' enforcement levels by $k-1$ percent from the Stackelberg levels can make both countries better off. **Q.E.D.**

A.3 Proof of Proposition 2

We analyze Case (i) $\alpha \in \left(0, \dfrac{1}{2}\right)$ and Case (ii) $\alpha \in \left(\dfrac{1}{2}, 1\right)$, separately.

Case (i): $\alpha \in \left(0, \dfrac{1}{2}\right)$. In this case, the disagreement outcome corresponds to Stackelberg game G^1.

Lemma 2 implies that each country's welfare under Nash bargaining is strictly higher than in Stackelberg game G^1, i.e., $\begin{cases} W_1(e_1^B, e_2^B) > W_1(e_1^L, e_2^F) \\ W_2(e_1^B, e_2^B) > W_2(e_1^L, e_2^F) \end{cases}$.

Now we turn to the enforcement levels. Firstly, we show that $e_1^B > e_1^L$. The proof proceeds by contradiction.

If $e_1^L \geq e_1^B$, then $W_2(e_2^B, e_1^L) \geq W_2(e_2^B, e_1^B)$, since $W_2(e_2, e_1)$ is increasing in e_1.

On the other hand, according to the definition of the Stackelberg equilibrium of game G^1, we have: $W_2(e_2^F, e_1^L) \equiv \max\limits_{e_2} W_2(e_2, e_1^L) \geq W_2(e_2^B, e_1^L)$.

As a result, $W_2(e_2^F, e_1^L) \geq W_2(e_2^B, e_1^B)$, which violates the fact $W_2(e_2^B, e_1^B) > W_2(e_2^F, e_1^L)$.

Therefore, $e_1^B > e_1^L$ always holds.

Now we prove that $e_2^B > e_2^F$, also proceeding by contradiction.

If $e_2^F \geq e_2^B$, then the mean value theorem gives:

$$W_1(e_1^B, e_2^B) - W_1(e_1^L, e_2^F) = \frac{\partial W_1({e_1}', {e_2}')}{\partial {e_1}'}(e_1^B - e_1^L) + \frac{\partial W_1({e_1}', {e_2}')}{\partial {e_2}'}(e_2^B - e_2^F), \tag{A-3}$$

where $e_1^L < {e_1}' < e_1^B$ and $e_2^B \leq {e_2}' \leq e_2^F$.

On the other hand, notice that:

$$\frac{\partial W_1({e_1}', {e_2}')}{\partial {e_1}'} \leq \frac{\partial W_1({e_1}', e_2^F)}{\partial {e_1}'} < \frac{\partial W_1(e_1^L, e_2^F)}{\partial e_1^L} < 0, \tag{A-4}$$

where the first inequality holds since $W_1(e_1, e_2)$ is super-modular, the second holds since $W_1(e_1, e_2)$ is concave w.r.t. e_1,[29] and the last follows from the first-order condition of the welfare maximization problem for country 1 in game G^1.[30]

[29]Given (2), the super-modularity and concavity of the enforcement technology (here, it is the Cobb-Douglas function) respectively lead to the super-modularity and concavity of two countries' welfare functions.

[30]From (A-2), we have: $\frac{\partial W_1(e_1^L, e_2^F)}{\partial e_1^L} = -\underbrace{\frac{\partial W_1(e_1^L, e_2^F)}{\partial e_2^F}}_{+} \cdot \underbrace{\frac{de_2^F(e_1^L)}{de_1^L}}_{+} < 0.$

Combining (A-3) and (A-4) yields:

$$W_1(e_1^B, e_2^B) - W_1(e_1^L, e_2^F) \le \frac{\partial W_1(e_1{}', e_2{}')}{\partial e_1{}'}(e_1^B - e_1^L) < 0, \tag{A-5}$$

where the first inequality holds because of the positive externality of enforcement $\dfrac{\partial W_1(e_1{}', e_2{}')}{\partial e_2{}'} > 0$.

(A-5) breaches country 1's welfare ranking $W_1(e_1^B, e_2^B) > W_1(e_1^L, e_2^F)$.

Thus, it must be that $e_2^B > e_2^F$.

Then the comparison of tax rates immediately follows from the comparison of enforcement levels and Lemma 1(ii).

Case (ii): $\alpha \in \left(\frac{1}{2}, 1\right)$. The disagreement outcome corresponds to Stackelberg game G^2. By the similar reasoning used in Case (i), it is straightforward to show that Proposition 2 still holds. **Q.E.D.**

A.4 Proof of Proposition 3

Notice that Proposition 2 implies the interiority of the optimum solution to Problem (7), at which all the constraints in the feasible set of Problem (7) are non-binding. Therefore, we can directly give the first-order conditions of Problem (7) as follows:

$$\begin{cases} \dfrac{\partial W_1(e_1, e_2)}{\partial e_1}[W_2(e_1, e_2) - W_2^v] + \dfrac{\partial W_2(e_1, e_2)}{\partial e_1}[W_1(e_1, e_2) - W_1^u] = 0 \\ \dfrac{\partial W_1(e_1, e_2)}{\partial e_2}[W_2(e_1, e_2) - W_2^v] + \dfrac{\partial W_2(e_1, e_2)}{\partial e_2}[W_1(e_1, e_2) - W_1^u] = 0 \end{cases}. \tag{A-6}$$

From (A-6), we obtain:

$$\frac{\partial W_1(e_1, e_2)}{\partial e_1}\frac{\partial W_2(e_1, e_2)}{\partial e_2} = \frac{\partial W_1(e_1, e_2)}{\partial e_2}\frac{\partial W_2(e_1, e_2)}{\partial e_1}.$$

Given (3), the above equation can be simplified as:

$$e_1 e_2 = \frac{1}{\eta}\left[\alpha d_1 e_2 \left(\frac{e_1}{e_2}\right)^{\alpha - 1} + (1-\alpha) d_2 e_1 \left(\frac{e_1}{e_2}\right)^{\alpha}\right]. \tag{A-7}$$

Recall that the disagreement point relates to the value of α: (i) $0 < \alpha < \dfrac{1}{2}$ or (ii)

$\frac{1}{2} < \alpha < 1$. We now analyze each case separately.

Case (i): $0 < \alpha < \frac{1}{2}$. According to Proposition 1(i), country 1 leads if the negotiation collapses. In line with this, we define:

$$\begin{cases} e_1 := k e_1^L \\ e_2 := k h e_2^F \end{cases}, \tag{A-8}$$

where variables $k > 0$ and $h > 0$.

Using (A-8), we can transform (A-6) and (A-7) into equations w.r.t. k and h. Specifically, plugging (A-8) and the values of e_1^L, e_2^F shown in Table 1 into (A-7), with tedious calculations, yields the relationship of k and h:

$$k = \frac{1}{2} h^{-1-\alpha} \left[(1+\alpha) h^2 + 2 \right]. \tag{A-9}$$

Substituting (A-8) and (A-9) into (A-6), through tedious computation and simplification, we can obtain that for any $\alpha \in \left(0, \frac{1}{2}\right)$, h is the solution to the following equation:[31]

$$4 - 4h^2 - 3h^4 + 2\alpha^3 h^4 + 4h^{2\alpha}(h^2 - 1) + \alpha^2 h^2 (h^2 + 8) - 4\alpha(h^4 - h^2 + h^{2\alpha} - 2) = 0. \tag{A-10}$$

Plugging (A-9) and the values of e_1^L and e_2^F into (2), we get two countries' welfare W_i^B $(i = 1, 2)$ under Nash bargaining:

$$\begin{cases} W_1^B = \frac{1}{4} h^{-2(1+\alpha)} [(2-\alpha)(1+\alpha)^2 h^4 + 4(1-\alpha^2) h^2 - 4\alpha] W_1^L \\ W_2^B = \frac{1}{4} h^{-2\alpha} [4 + 4\alpha h^2 + (\alpha^2 - 1) h^4] W_2^F \end{cases}, \tag{A-11}$$

which yields:

$$\frac{W_1^B / W_1^L}{W_2^B / W_2^F} = -\frac{\alpha}{h^2} + \frac{2}{2 + (\alpha - 1) h^2} := g_1(\alpha). \tag{A-12}$$

Given (A-10) and (A-12), we can graph function $g_1(\alpha)$ over interval $\left[0, \frac{1}{2}\right]$ as below:

[31] For any $\alpha \in (0, \frac{1}{2})$ (resp. $\alpha \in (\frac{1}{2}, 1)$), we can show that there exists a unique h with $h > 0$ satisfying (A-10) (resp. (A-15)). Therefore, h is an implicit function of α. To save space, we omit the tedious proof of this result, which is available upon request.

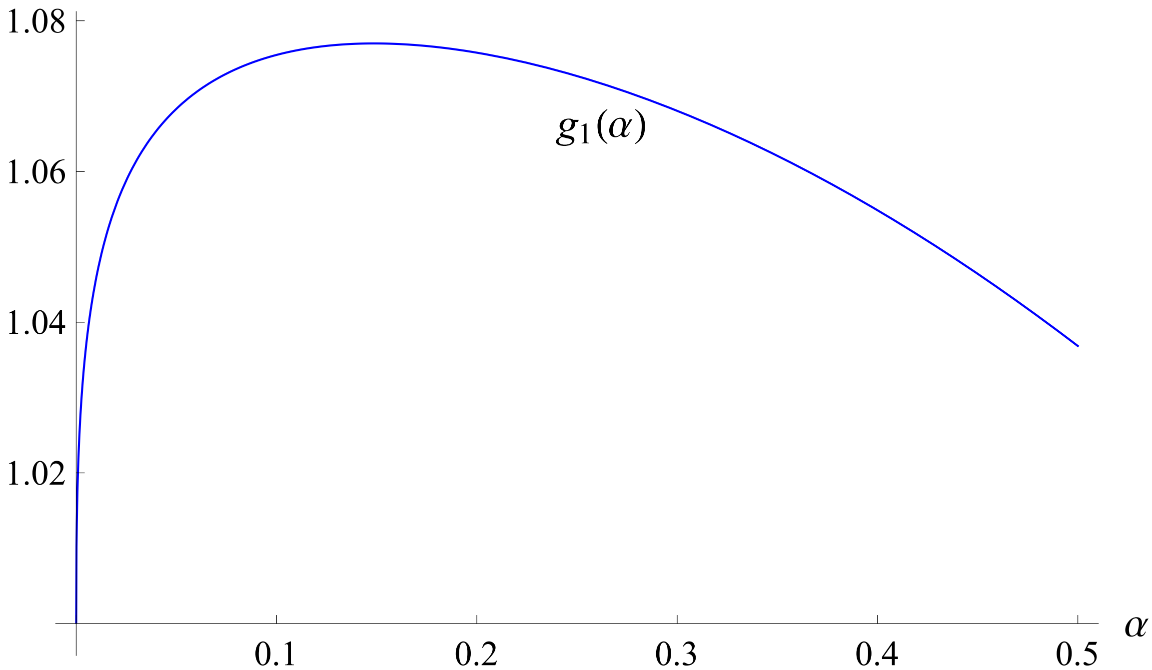

Fig. A2: The graph of $g_1(\alpha)$

According to Fig. A2, we have:

$$\forall \alpha \in \left(0, \frac{1}{2}\right), \quad \frac{W_1^B/W_1^L}{W_2^B/W_2^F} > 1. \tag{A-13}$$

Case (ii): $\frac{1}{2} < \alpha < 1$. Country 2 leads if the negotiation collapses. Then we define:

$$\begin{cases} e_1 := ke_1^F \\ e_2 := khe_2^L \end{cases}, \tag{A-14}$$

where variables $k, h > 0$.

Following the same steps as in Case (i), we can get the relationship between k and h in Case (ii): $k = \frac{1}{2}h^{-1-\alpha}(2 - \alpha + 2h^2)$.

For any $\alpha \in \left(\frac{1}{2}, 1\right)$, h is the solution to the following equation:

$$4 + 4\alpha - 7\alpha^2 + 2\alpha^3 - (8 - 20\alpha + 8\alpha^2)h^2 - (12 - 8\alpha)h^4 - 4h^{2\alpha}(1 + (\alpha - 2)h^2) = 0. \tag{A-15}$$

Two countries' cooperative welfare levels W_i^B $(i = 1, 2)$ are:

$$\begin{cases} W_1^B = \dfrac{1}{4} h^{-2(1+\alpha)}(\alpha - 2h^2)[\alpha - 2(1 + h^2)]W_1^F \\ W_2^B = \dfrac{1}{4} h^{-2\alpha}[4 + (\alpha - 2h^2)((\alpha - 3)\alpha - 2(\alpha - 1)h^2)]W_2^L \end{cases}, \tag{A-16}$$

which leads to:

$$\frac{W_1^B/W_1^F}{W_2^B/W_2^L} = \frac{2h^2 - \alpha}{h^2[2 + \alpha - \alpha^2 + 2(\alpha - 1)h^2]} := g_2(\alpha). \tag{A-17}$$

Likewise, given (A-15) and (A-17), we can graph function $g_2(\alpha)$ over interval $\left[\frac{1}{2}, 1\right]$:

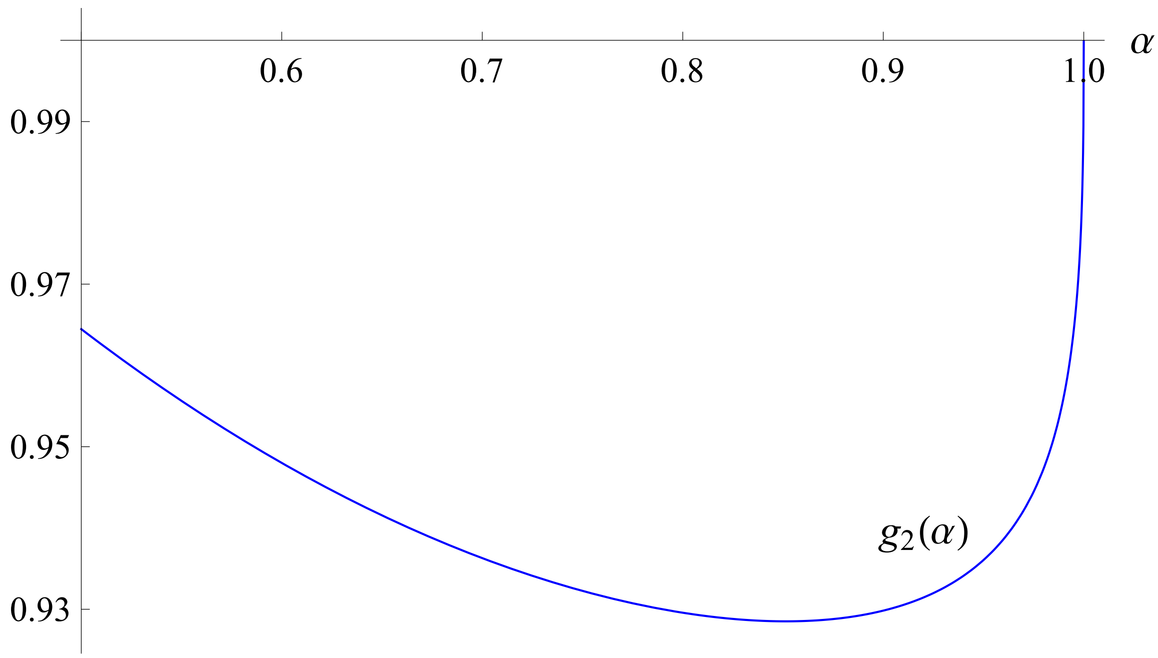

Fig. A3: The graph of $g_2(\alpha)$

From Fig. A3, we get:

$$\forall \alpha \in \left(\frac{1}{2}, 1\right), \quad \frac{W_1^B/W_1^F}{W_2^B/W_2^L} < 1. \tag{A-18}$$

Combining (A-13) and (A-18) yields Proposition 3. **Q.E.D.**

A.5 Proof of Proposition 4

Recall that h, independent of ε, is a function of α. Then given (A-8), (A-11), (A-14), (A-16) and the results shown in Table 1, two countries' equilibrium enforcement and welfare levels in games G^1, G^2, G^N and in bargaining problem display the following form:

$$\begin{cases} e_1^u = F_1^u(\alpha) d_1^{(1+\alpha)/2} d_2^{(1-\alpha)/2} \\ e_2^u = F_2^u(\alpha) d_1^{\alpha/2} d_2^{(2-\alpha)/2} \end{cases} \text{and} \quad \begin{cases} W_1^u = H_1^u(\alpha) d_1^{1+\alpha} d_2^{1-\alpha} \\ W_2^u = H_2^u(\alpha) d_1^{\alpha} d_2^{2-\alpha} \end{cases}, \tag{A-19}$$

where $u = N, L, F, B$, and $F_i^u(\alpha)$, $H_i^u(\alpha)$ $(i = 1, 2)$ are functions of α and are independent of parameter ε.

Given (A-19), the comparative static effects of ε under three non-cooperative games and under bargaining are given by:

$$\begin{cases} \dfrac{\partial W_1^u}{\partial \varepsilon} = \left(\dfrac{1+\alpha}{d_1}\dfrac{dd_1}{d\varepsilon} + \dfrac{1-\alpha}{d_2}\dfrac{dd_2}{d\varepsilon}\right) W_1^u = \dfrac{4W_1^u}{9-\varepsilon^2}(3\alpha - \varepsilon) \\ \dfrac{\partial W_2^u}{\partial \varepsilon} = \left(\dfrac{\alpha}{d_1}\dfrac{dd_1}{d\varepsilon} + \dfrac{2-\alpha}{d_2}\dfrac{dd_2}{d\varepsilon}\right) W_2^u = \dfrac{4W_2^u}{9-\varepsilon^2}(3\alpha - \varepsilon - 3) \end{cases}, \text{ where } u = N, L, F, B.$$

Then the proposition immediately follows. **Q.E.D.**

A.6 Proof of Lemma 3

At stage 3, country i, subject to the minimum tax constraint $t_i \geq \underline{t}$, chooses its tax rate to maximize the tax revenue:

$$R_i = t_i \left[\frac{1 + \mathbf{1}\varepsilon}{2} - \frac{t_i - t_j}{2\delta(e_1, e_2)}\right]. \tag{A-20}$$

Solving the first-order condition yields country i's reaction function under the minimum tax constraint:

$$t_i^m(t_j) = \max\left\{\underline{t},\ t_i^N(t_j)\right\}, \tag{A-21}$$

where $t_i^N(t_j) = \dfrac{t_j + (1+\mathbf{1}\varepsilon)\delta(e_1, e_2)}{2}$ represents country i's best response without the minimum tax constraint.

From (8) and (A-21) we get:

$$t_2^m \geq \underline{t} > t_2^*. \tag{A-22}$$

Combining (8), (A-21) and (A-22) leads to $t_1^m = t_1^m(t_2^m) \geq t_1^N(t_2^m) > t_1^N(t_2^*) = t_1^* > \underline{t}$. Thus, given (A-21), it must be that:

$$t_1^m = t_1^N(t_2^m). \tag{A-23}$$

Notice that $t_2^m \neq t_2^N(t_1^m)$. If $t_2^m = t_2^N(t_1^m)$ holds, then given (A-23) we would obtain $t_2^m = t_2^*$, which contradicts (A-22). Hence, it must be that $t_2^m = \underline{t}$. So the stage-3 equilibrium taxes have to satisfy $\begin{cases} t_1^m = t_1^N(t_2^m) \\ t_2^m = \underline{t} \end{cases}$. Moreover, we can easily verify that this tax-rate pair satisfies the definition of Nash equilibrium. This proves part (i).

We now prove part (ii). Plugging equilibrium tax rate t_i^m into (A-20) leads to the stage-3 equilibrium revenues under minimum tax constraint:

$$\begin{cases} R_1^m = \dfrac{(3+\varepsilon+\varepsilon\lambda)^2\delta\left(e_1, e_2\right)}{18} \\ R_2^m = \dfrac{(3-\varepsilon-\varepsilon\lambda)(3-\varepsilon+2\varepsilon\lambda)\delta\left(e_1, e_2\right)}{18} \end{cases}. \tag{A-24}$$

For any given enforcement levels, comparing (A-24) with the unconstrained Nash equilibrium revenues given by Lemma 1(ii) yields:

$$\begin{cases} R_1^m(\underline{t}) - R_1^* = \dfrac{\varepsilon\lambda(6+2\varepsilon+\varepsilon\lambda)\delta\left(e_1, e_2\right)}{18} > 0 \\ R_2^m(\underline{t}) - R_2^* = \dfrac{\varepsilon\lambda(3-\varepsilon-2\varepsilon\lambda)\delta\left(e_1, e_2\right)}{18} > 0 \end{cases}. \quad \textbf{Q.E.D.}$$

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