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Economic Integration and Agglomeration of Multinational Production with Transfer Pricing*

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Abstract

Do low corporate taxes always favor multinational production in the course of economic integration? We propose a two-country model in which multinationals choose the locations of production plants and foreign distribution affiliates and shift profits between home plants and foreign affiliates by manipulating transfer prices in intra-firm trade. We show that when trade costs are high, plants are concentrated in the low-tax country, but surprisingly this location pattern reverses when they are low. Unlike existing models with single-plant firms, the impact of economic integration is non-monotonic, which we empirically confirm: a fall in trade costs first decreases and then increases the share of plants in the high-tax country. We also analyze tax competition and find that allowing for transfer pricing makes competition tougher, indicating a possibility of international coordination on transfer-pricing regulation making the world better off.

Keywords: Profit shifting; Multinational firms; Intra-firm trade; Trade costs; Foreign direct investment (FDI).

JEL classification: F12; F23; H25; H26.

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1 Introduction

Progressive economic integration in the last few decades brought more international mobility to multinational enterprises (MNEs), allowing them to diversify activities across subsidiaries in different countries. Considering the complexity of multinational activities, governments today need to carefully design policies to attract MNEs. Among many factors, corporate taxation is one of the essential determinants of foreign direct investment (FDI) (Navaretti and Venables, 2004, Chapter 6; Blonigen and Piger, 2014).[1] One naturally expects that countries with a low corporate tax rate would succeed in hosting more FDI inflow than those with a high tax rate. Earlier empirical studies confirmed this using data on FDI in *all sectors* (e.g., Bénassy-Quéré et al., 2005; Egger et al., 2009).

However, the type of activities of multinationals that operate in such low-tax countries is not obvious. Governments reduce taxes to attract production plants, which contribute to local employment and tax revenues.[2] Contrary to host governments' expectations, MNEs may establish affiliates in low-tax countries just to save taxes and may not engage in production (Horner and Aoyama, 2009).[3] As economic integration has dismantled barriers to goods' and factors' mobility in recent years, MNEs may put more emphasis on other barriers such as high taxes when choosing a location.

The point that countries with lower taxes do not necessarily attract more multinational production can be illustrated using Fig. 1. In Fig. 1(a), we take 23 Organisation for Economic Co-operation and Development (OECD) countries and draw the relationship between each country's average corporate tax rate from 2008 to 2016 and the average number of foreign affiliates in all sectors coming from the other OECD countries in the same periods.[4] To control for the host country's size, the average number of affiliates is divided by the average GDP of the host country. The fitted line with a clear downward slope tells us that countries with a

[1]As other determinants of MNEs' location decision, recent studies highlight agglomeration economies arising from affiliates (Mayer et al., 2010) and financial development in the host country (Bilir et al., 2019).

[2]The Irish government, for example, has explicitly stated its commitment to the low corporate tax rate to attract FDI. See the 2013 Financial Statement by the Minister for Finance: `http://www.budget.gov.ie/Budgets/2013/FinancialStatement.aspx`, accessed on 25 November 2020.

[3]Horner and Aoyama (2009) provide a list of Ireland-based MNEs' relocations. There are several examples where some MNEs moved production from Ireland abroad while maintaining non-production activities such as service centers and marketing in Ireland.

[4]The sample countries do not include four European countries identified as tax havens by Zucman (2014), i.e., Ireland, Luxembourg, the Netherlands, and Switzerland. The patterns laid out in Fig. 1 are unchanged if we include these four countries.

lower tax rate tend to attract more MNEs. Fig. 1(b) shows the type of MNEs' activities by plotting the share of affiliates in manufacturing sectors out of those in all sectors. The fitted line has little explanatory power with R-squared being 0.088, suggesting that multinationals locating in low-tax countries do not necessarily engage in production.

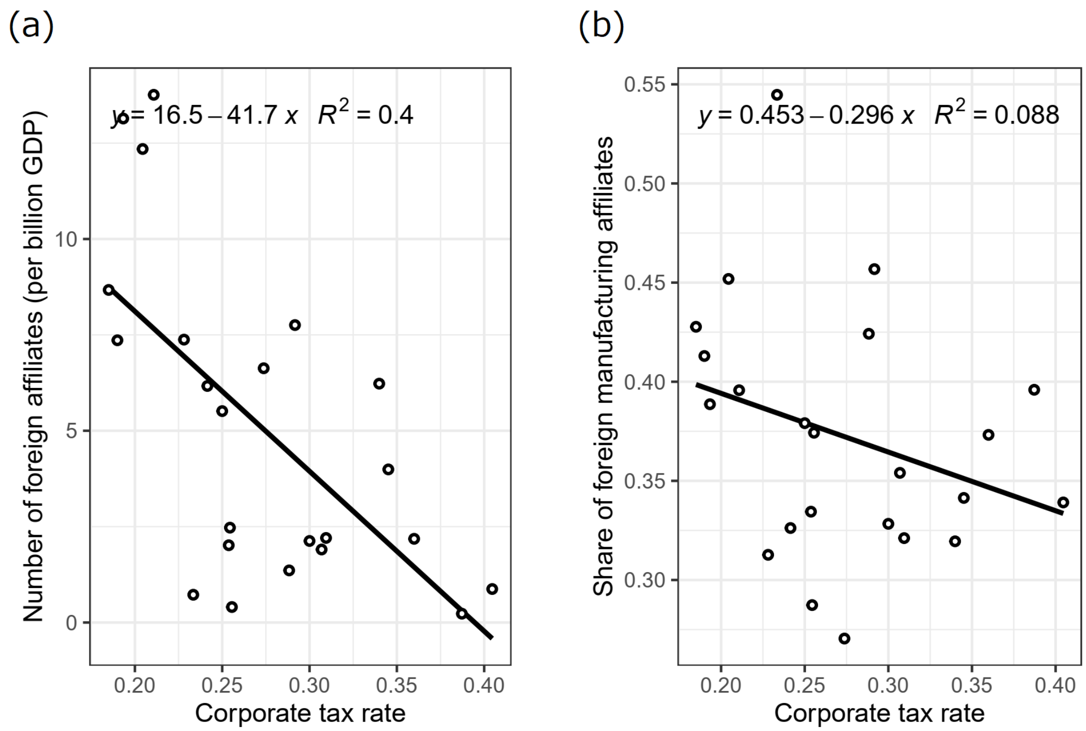

Fig. 1. Corporate tax rates and foreign affiliates in 2008 to 2016

Sources: Centre for Business Taxation Tax Database 2017 (Habu, 2017); Corporate Outward activity of multinationals by country of location–ISIC Rev 4. In OECD Statistics: `https://stats.oecd.org/`
Notes: The horizontal axis is the average statutory corporate tax rate of a country in 2008 to 2016. In panel (a), the vertical axis is the average number of foreign affiliates in all sectors (per USD 1 billion GDP of the host country) coming from the other sample countries in 2008 to 2016. In panel (b), it is the average share of foreign manufacturing affiliates out of those in all sectors. Foreign affiliates in 2008 to 2016. See also Appendix 1 for details.

The fact that low taxes do not necessarily attract multinational production can be explained by profit shifting of MNEs. MNEs allocate their activities between low-tax and high-tax countries and transfer profits by controlling prices for intra-firm trade, known as *transfer prices*.[5] For example, headquarters in high-tax countries make profits by selling

[5] Empirical evidence on transfer pricing can be found in many studies. See Swenson (2001); Bartelsman and Beetsma (2003); Clausing (2003); Bernard et al. (2006); Cristea and Nguyen (2016); Gumpert et al. (2016); Guvenen et al. (2017); Bruner et al. (2018); and Davies et al. (2018).

goods to affiliates in low-tax countries by setting low transfer prices to inflate the affiliates' profits. Such profit shifting through intra-firm trade has been made easy by the recent proliferation of trade liberalization and the advancement of transportation technology.

When profits can be transferable between countries with different tax rates, it is no longer clear where MNEs optimally set up their plants and affiliates. To answer the question, we extend a two-country spatial model developed by Pflüger (2004) to incorporate MNEs with profit-shifting motives.

Specifically, we investigate in which country–the low-tax or the high-tax one–multinational production is agglomerated and how the location pattern changes as trade costs fall. There is a fixed mass of monopolistically competitive MNEs in the world, each of which locates a plant (or the headquarters) for production in one country and an affiliate for distribution in the other. The MNE engages in intra-firm trade by exporting the output produced in home country to the affiliate in foreign country. It can use the transfer price of the output for profit shifting. However, due to trade costs, shipping goods from one country to another will be costly. Trade costs change the volume of intra-firm trade and thus affect the effectiveness of profit shifting, which in turn affects the choice of MNEs' location.

Based on this setting, we obtain the following results. With a low level of economic integration marked by high trade costs, the low-tax country attracts a higher share of multinational production than the high-tax country. When high trade costs hamper intra-firm trade, thereby limiting the profit shifting opportunity, MNEs can sell little to their foreign affiliate. As most of the profits are made in the country where goods are produced, they simply prefer to locate production in the low-tax country.

With a high level of economic integration marked by low trade costs, however, this location pattern reverses: production plants agglomerate in the high-tax country. This result seems surprising, but it is indeed consistent with MNEs' optimal location choice. The MNE with production in the high-tax country *lowers* the transfer price to shift its home plant's profits to its foreign affiliate in the low-tax country. The lowered transfer price reduces the affiliate's marginal cost, which allows it to lower the price of goods and gain competitiveness against local plants. Conversely, the MNE with production in the low-tax country *raises* the transfer price to shift profits from its foreign affiliate in the high-tax country back to its home plant. Due to the high transfer price, the affiliate sells goods at a high price and loses competitiveness against local plants. Thus, transfer pricing favors the MNE with production in the high-tax country in a way such that makes them competitive in both home and foreign markets. When trade costs are so low that this effect is significant, all MNEs strategically choose to locate production in the high-tax country.

Moreover, the location pattern of multinational production is indeed non-monotonic. That is, a fall in trade costs first decreases and then increases the share of production plants in the high-tax country. A simple intuition that production is agglomerated in the low-tax country to save both taxes and trade costs holds under high trade costs, but it does not apply under low trade costs where transfer pricing crucially affects the strategic location choice of MNEs that seek price competitiveness.

These results may explain the fact that low-tax countries do not necessarily attract manufacturing affiliates compared with high-tax countries, as Fig. 1 suggests. In addition, Overesch (2009) provides empirical evidence that multinationals in high-tax Germany increase real investments as the cross-country corporate tax difference between their home country and Germany is larger. Our own empirical exercise using the same data as those in Fig. 1 also confirms the non-monotonic impact of economic integration on the distribution of multinational production.

As a result of transfer pricing, the high-tax country attracts more multinational production but does not enjoy greater tax revenues than it would without transfer pricing. The opposite is true for the low-tax country. In fact, allowing for transfer pricing lowers global tax revenues. Amid growing concerns about tax base erosion, the OECD recently reported that the estimated revenue losses from MNEs' tax avoidance are about 10% of global corporate income tax revenues.[6] Our finding may justify the concern about low-tax countries attracting affiliates that receive shifted profits from high-tax countries.

The basic model is further extended to consider tax competition between two countries that differ in tax-administration efficiency. The main result is carried over that transfer pricing leads to production agglomeration in the high-tax country with more efficient tax administration. Contrary to existing studies telling that agglomeration generates taxable rents (Baldwin and Krugman, 2004), agglomeration in our model leads to tax-base erosion. A bigger tax difference would bring more opportunities to manipulate transfer prices, triggering greater tax-base erosion. To prevent this, the high-tax country is forced to lower its tax

[6]See `http://www.oecd.org/ctp/oecd-presents-outputs-of-oecd-g20-beps-project-for-discussion-at-g20-fi` `htm`, accessed on 25 November 2020. To tackle this issue, the OECD set up a project called "Base Erosion and Profit Shifting" (BEPS), involving over eighty countries. See `http://www.oecd.org/tax/beps`, accessed on 20 February 2019. Recent empirical studies estimate the magnitude of revenues losses from BEPS (e.g., Dharmapala, 2014; Janský and Palanský, 2019; Beer et al., 2020; Tørsløv et al., 2018), among which Blouin and Robinson (2020) caution against the possibility of overestimation due to double counting of foreign income. The estimated magnitude of revenue losses depends on how pre-tax profits respond to corporate taxes. Heckemeyer and Overesch (2017) suggest that one of the dominant channels of profit shifting is transfer pricing, which our model highlights.

rate. In addition, transfer pricing makes tax competition tougher and the countries worse off by narrowing the equilibrium tax difference. Although the governments have difficulty coordinating their tax rates, they agree on tightening transfer-pricing regulation to achieve a Pareto improvement.

Relation to the literature. Our main contribution to the literature on transfer pricing pioneered by Copithorne (1971) and Horst (1971) is to examine the impact of economic integration on the location choice of MNEs using transfer pricing. Earlier studies in the literature points out that transfer prices are used to make affiliates competitive as well as to shift profits (Elitzur and Mintz, 1996; Schjelderup and Sørgard, 1997; Zhao, 2000; Nielsen et al., 2003).[7] The former is called a strategic effect and the latter a tax manipulation effect. They assume the fixed location of affiliates, unlike our study. In our monopolistically competitive model à la Dixit and Stiglitz (1977), optimal transfer prices themselves are not chosen strategically in the sense that they do not depend on the number of rival firms as a result of the constant elasticity of substitution between varieties. However, our model shares the strategic aspect of transfer pricing in the sense that MNEs choose their location of plants/affiliates to make them competitive in their markets. We allow for the flexible location of affiliates and show that it is in fact chosen strategically due to transfer pricing.

Although there are a number of studies examining the production location choice of MNEs with profit-shifting motives, they focus on symmetric tax rates (e.g., Haufler and Schjelderup, 2000; Kind et al., 2005; Slemrod and Wilson, 2009). Some studies highlight asymmetric tax rates resulting from tax competition between symmetric or asymmetric countries (Stöwhase, 2005, 2013; Johannesen, 2010).[8,9] Stöwhase (2013) studies tax competition between two unequal-sized countries and finds that the large country sets a higher tax rate while attracting a plant. By contrast, Stöwhase (2005) and Johannesen (2010) obtain the opposite result that low-tax countries attract more plants (or a higher capital-labor ratio) than high-tax countries.

[7] See Nielsen et al. (2008); Choe and Matsushima (2013); and Yao (2013) for subsequent development.

[8] In many studies dealing with asymmetric tax rates, country asymmetry results from difference in market size (Stöwhase, 2005, 2013). In other tax competition models without profit-shifting MNEs, countries are assumed to be asymmetric due to inequality in public infrastructure (Han et al., 2018), hub-and-spoke structure of jurisdictions (Janeba and Osterloh, 2013; Darby et al., 2014), and heterogeneous efficiency in tax administration (Han et al., 2014) as in ours.

[9] There are studies introducing a low-tax country with no production and/or no consumption, calling it a *tax haven* country (Slemrod and Wilson, 2009; Johannesen, 2010; Krautheim and Schmidt-Eisenlohr, 2011; Langenmayr et al., 2015; Hauck, 2019). Underlying channels through which profits are shifted to tax havens include royalty payments for intangible assets (Juranek et al., 2018; Choi et al., 2020b) and the financial choice between debt and equity (Fuest et al., 2005; Haufler and Runkel, 2012). However, we do not consider tax havens because our main focus is on the MNEs' production location.

These studies, however, do not consider trade costs, which is our primary interest. Trade costs are important for profit-shifting patterns among MNEs because they significantly affect intra-firm trade, one of the main channels of profits shifting (Heckemeyer and Overesch, 2017).

The location choice of MNEs' production plants is sometimes associated with the choice of their organizational form (Bauer and Langenmayr, 2013; Egger and Seidel, 2013; Keuschnigg and Devereux, 2013).[10] Specifically, firms choose whether they should undertake FDI to manufacture inputs within their firms (i.e., vertical integration), or source inputs from independent suppliers (i.e., outsourcing), known as the *make or buy* decision.[11] This type of FDI can be considered as a vertical FDI in the sense that different stages of bringing a product on to the market are organized across borders (Antràs and Helpman, 2004). Using a monopolistically competitive trade model, Egger and Seidel (2013) theoretically predict and empirically confirm that larger tax differences are more likely to encourage MNEs to engage in vertical FDI, rather than outsourcing. Bauer and Langenmayr (2013) develop a similar model with contracting frictions between headquarters and suppliers and show that vertical integration is desirable for high-productive MNEs. To highlight MNEs' organizational choices, whether vertical integration or outsourcing, these studies fix the headquarters' location, either a high-tax or a low-tax country. The location of input production is determined not only by international tax differences but also by organizational differences such as bargaining positions of headquarters and suppliers. By contrast, we isolate the pure effect of taxes on MNEs' location choice by fixing their organization form, i.e., vertical integration only.[12] Moreover, we emphasize the role of economic integration, which is not explored by the aforementioned studies. Furthermore, we extend the basic model to incorporate a flexible choice of organizational form and confirm the robustness of our main results (see Section 4.2).

Among studies on internationally mobile MNEs with profit-shifting motives, Peralta et al. (2006); and Ma and Raimondos (2015) are the closest to ours in that they allow for both trade costs and asymmetric tax rates. In a tax-competition game over a *single* MNE with a plant and an affiliate, Peralta et al. (2006) show the possibility that the large, high-tax

[10]See also Amerighi and Peralta (2010); Behrens et al. (2014); Bond and Gresik (2020); and Choi et al. (2020a) for related studies on organizational choice of MNEs with profit-shifting motives. As in studies cited above, they only deal with a single MNE and/or do not consider trade costs, unlike our model. Our companion study investigates the location of input production within the boundaries of MNEs (Kato and Okoshi, 2019).

[11]For quantitative studies on MNEs and taxes but without transfer pricing, see Shen (2018); and Wang (2020).

[12]Strictly speaking, the function of foreign affiliate in our model is the distribution of final goods, while that in the aforementioned models is the production of intermediate good. Nonetheless our model shares the vertical nature of FDI with the aforementioned models in that different stages of value-added processes are located across borders.

country wins the MNE's plant when trade costs are *high*, which is similar to but different from our findings. Moreover, the mechanism crucially differs from ours because in their model countries use regulation policy on transfer pricing as well as corporate taxation.[13] Despite its higher tax rate, the large country can attract the plant by adopting a loose regulation policy and thus its *effective tax rate* is lower. Ma and Raimondos (2015) also consider tax competition for a *single* MNE and obtain similar results. The crucial difference of our model from theirs is that we consider a *continuum* of MNEs and allow them to compete in the final good's market. In doing so, we can shed light on the strategic aspect of transfer pricing, which cannot be captured by the aforementioned models with a single MNE. In our model, MNEs strategically choose the location of their plants/affiliates such that transfer pricing contributes to competitiveness as well as to tax saving, leading to the non-monotonic impact of economic integration on MNEs' plant share. This new finding in the literature is indeed empirically confirmed (see Section 3.3) and helps understand the fact shown in Fig. 1 that low-tax countries do not necessarily attract a higher share of multinational production.

We also contribute to the literature on new economic geography (NEG) that examines the impact of economic integration on firm location (Fujita et al., 1999). To our knowledge, our study is the first to introduce transfer pricing into a NEG model, specifically one developed by Martin and Rogers (1995) and Pflüger (2004). An important insight from NEG models is that countries with large home market hosts a greater share of firms than their market-size share for *all levels* of trade costs except for prohibitive and zero levels, known as the *home market effect* (Helpman and Krugman, 1985). Our model also inherits this effect in the sense that the low-tax country offers a greater profit potential for MNEs than the high-tax country. Indeed, the low-tax country attracts a higher plant share when trade costs are *high*. By contrast, when trade costs are *low* making profit shifting through intra-firm trade effective, the home-market effect is no longer dominant so that the location pattern reverses (Propositions 1 and 2).

In the analysis of tax competition using NEG models, the home-market effect allows the country where firms are agglomerated to set a higher tax rate without losing firms (Baldwin and Krugman, 2004; Borck and Pflüger, 2006).[14,15] Introducing transfer pricing does not

[13]Some studies analyze competition for capital between governments using both taxes and other policy instruments such as public infrastructure (Hindriks et al., 2008; Han et al., 2014), though they do not consider MNEs with profit-shifting motives.

[14]See also Kind et al. (2000); Ludema and Wooton (2000); Andersson and Forslid (2003); and Ottaviano and van Ypersele (2005) for earlier contributions. Recent studies in the literature allow for heterogeneity among firms (Davies and Eckel, 2010; Haufler and Stähler, 2013; Baldwin and Okubo, 2014), forward looking behavior of governments (Han et al., 2014; Kato, 2015). See also Keen and Konrad (2013, Section 3.5.3).

[15]This result is in contrast with that of perfectly competitive models of tax competition between asym-

alter this location pattern, but drastically changes the implication of agglomeration. That is, agglomeration of production plants in the high-tax country does not bring such taxable rents, but, on the contrary, induces tax-base erosion and thus puts a downward pressure on its tax rate (Proposition 3).

The rest of the paper is organized as follows. The next section develops the model. Section 3 characterizes the equilibrium plant distribution when taxes are given. It shows how allowing for transfer pricing changes the plant distribution. Section 4 discusses several extensions of the basic model. Section 5 deals with tax competition between two countries and examines how the results change with and without profit shifting. The final section concludes.

2 Basic setting

We consider an economy with two countries (country 1 and 2), two goods (homogeneous and differentiated goods), and two factors of production (labor and capital). Letting L be the world population, there are $L_1 = s_1 L$ of population in country 1 and $L_2 = s_2 L = (1 - s_1)L$ in country 2, where $s_1 \in (0, 1)$ is country 1's world share. Likewise, the amount K of world capital is distributed such that country 1 (or country 2) is endowed with $K_1 = s_1 K$ (or $K_2 = s_2 K = (1 - s_1)K$). An individual in each country owns one unit of labor and two units of capital, implying that $K = 2L$. To highlight corporate tax difference, we assume away the difference in market size, i.e., $s_1 = 1/2$, throughout the paper except for Section 4.3. There are two types of MNEs, one with a production plant (the headquarters) in country 1 and a foreign distribution affiliate in country 2; and the other with a production plant (the headquarters) in country 2 and a foreign distribution affiliate in country 1. MNEs use labor and capital supplied by individuals. The government in each country taxes on operating profits, sales minus labor/input costs, of plants and affiliates there. We interpret capital as equity and assume that capital costs are non-deductible, while labor costs are deductible.[16] In this and the next sections, we fix the tax rates of countries and assume that country 1's tax rate is higher than that of country 2, $t_1 > t_2$, without loss of generality.

The timing of actions proceeds as follows. First, each MNE chooses in which country

metric countries (Bucovetsky, 1991; Wilson, 1991; Stöwhase, 2005). In these models, diminishing returns to marginal capital investment imply that smaller countries face a higher outflow of capital when raising their tax rate than larger countries, unlike NEG models. As a result, smaller countries set a lower tax rate and achieve a higher capital-labor ratio.

[16] We thank two referees for pointing this out.

to locate a production plant and in which country to locate a foreign distribution affiliate, endogenously determining the share of plants n_1. Second, the MNE chooses transfer prices, g_i. Third, production plants and distribution affiliates set selling prices, p_{ij}. Finally, production and consumption take place. We solve the game in a backward fashion. For convenience, we refer to the results with fixed capital allocation as a *short-run equilibrium* and refer to the results in the endogenous case as a *long-run equilibrium*.

Consumers. Following Pflüger (2004), each consumer has an identical quasi-linear utility function with a constant-elasticity-of-substitution (CES) subutility. Consumers in country 1 solve the following maximization problem:

$$\max_{\tilde{q}_{11}(\omega),\tilde{q}_{21}(\omega),q_1^O} \quad u_1 = \mu \ln Q_1 + q_1^O,$$
$$\text{where} \quad Q_1 \equiv \left[\sum_{i=1}^{2} \int_{\omega\in\Omega_i} \tilde{q}_{i1}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega\right]^{\frac{\sigma}{\sigma-1}},$$

subject to the budget constraint:

$$\sum_{i=1}^{2} \int_{\omega\in\Omega_i} p_{i1}(\omega)\tilde{q}_{i1}(\omega) d\omega + q_1^O = w_1 + \overline{q}_1^O.$$

$\mu > 0$ captures the intensity of the preference for the differentiated goods. q_1^O and $\overline{q}_1^O$ are respectively the individual demand for the homogeneous good and its initial endowment. We assume that $\overline{q}_1^O$ is large enough for the homogeneous good to be consumed. w_1 is the wage rate. $\tilde{q}_{i1}(\omega)$ is the individual demand from consumers in country 1 for the variety $\omega \in \Omega_i$, where Ω_i is the set of varieties produced in country $i \in \{1, 2\}$. Q_1 is the CES aggregator of differentiated varieties with $\sigma > 1$ being the elasticity of substitution over them.

Solving the above problem gives the aggregate demand for the variety ω produced in country $i \in \{1, 2\}$ and consumed in country 1:

$$q_{i1}(\omega) \equiv L_1\tilde{q}_{i1}(\omega) = \left(\frac{p_{i1}(\omega)}{P_1}\right)^{-\sigma} \frac{\mu L_1}{P_1}, \tag{1}$$
$$\text{where} \quad P_1 \equiv \left[\sum_{i=1}^{2} \int_{\omega\in\Omega_i} p_{i1}(\omega)^{1-\sigma} d\omega\right]^{\frac{1}{1-\sigma}}.$$

P_1 is a price index of the varieties. Although we will mainly present the results for country 1 in the following, analogous expressions hold for country 2. As firms are symmetric, we will suppress the variety index ω for notational brevity.

Homogeneous good sector. The homogeneous good sector uses a constant-returns-to-scale technology. That is, one unit of labor produces one unit of the good. The technology leads to perfect competition, making the good's price equal to its production cost, or the wage rate. Letting w_i be the wage rate of country $i \in \{1, 2\}$, the costless trade of the homogeneous good equalizes the wage rates between countries; that is $w_1 = w_2$.[17] We choose the good as the numéraire such that $w_1 = w_2 = 1$.

Differentiated goods sector. The differentiated goods sector uses an increasing-returns-to-scale technology. Each MNE needs one unit of capital for a production plant serving as the headquarters in one country and another unit for a foreign affiliate in the other.[18] Once established, the plant needs a units of labor to produce one unit of variety. Since the world amount of capital is $K = 2L$, the mass of (the headquarters of) MNEs in the world is $K/2 = L$. We denote the mass of production plants located in country 1 by $N_1 = n_1 L$ and that in country 2 by $N_2 = n_2 L = (1 - n_1)L$, where $n_1 \in [0, 1]$. There are $100 \cdot n_1\%$ of all plants in the world in country 1, while the remaining $100 \cdot (1-n_1)\%$ of plants are in country 2. The symmetric organization structure of MNEs implies that there are N_2 (or N_1) distribution affiliates in country 1 (or country 2). Put differently, $100 \cdot n_1\%$ of all establishments in country 1 are the production plant, while the remaining $100 \cdot (1 - n_1)\%$ establishments in country 1 are the distribution affiliate.

Consider a MNE with production plant (i.e., the headquarters) in country 1. The plant produces quantities q_{11} using aq_{11} units of labor and sells them at a price p_{11} to home consumers. In addition, it produces quantities q_{12} and exports them at a transfer price g_1 to its distribution affiliate in country 2. When exporting, due to iceberg trade costs $\tau > 1$, $1/\tau < 1$ units of quantities melt away, so the plant has to produce τ units to deliver one unit to the affiliate. The affiliate sells the imported goods to consumers in country 2 at a price p_{12}.

MNEs have decentralized decision making following previous studies on transfer pricing (Zhao, 2000; Nielsen et al., 2003, 2008; Kind et al., 2005). In other words, the headquarters (i.e., the production plant) of the MNE sets the transfer price to maximize global post-tax

[17] We assume the costless trade of the homogeneous good to highlight the role of differentiated sector while cutting the complicated general-equilibrium channel of wages. This is common in the NEG models, but is not totally innocuous. See, for example, Fujita et al. (1999, Chapter 7) for more on this point.

[18] Similar specifications in the context of transfer pricing can be found in Kind et al. (2005); and Matsui (2012), although they fix the location of plants and affiliates.

profits, while the foreign affiliate sets the retail price to maximize its own profits. In practice, it is sensible to delegate decisions to local managers who are familiar with their local business environments. In many cases, a company's acquisition of a rival often involves the latter receiving divisional autonomy (e.g., Volkswagen's acquisition of Audi, Ford's acquisition of Volvo, and GM's acquisition of Saab).[19] We examine the case of centralized decision making in Appendix 9 and confirm the robustness of our results.

2.1 Short-run equilibrium

Let us derive the optimal prices given the location of plants and affiliates (see Appendix 2 for detailed derivations). The initial share of production plants is assumed to be equal to that of capital share, i.e., $n_1 = s_1 = 1/2$.[20] The MNE with production in country 1 makes profits from a home plant and a foreign distribution affiliate in country 2. The pre-tax operating profits of the plant, π_{11}, and that of the affiliate, π_{12}, are respectively,

$$\begin{aligned}
\pi_{11} &= \underbrace{(p_{11} - a)q_{11}}_{\text{Domestic profits}} + \underbrace{(g_1 - \tau a)q_{12}}_{\text{Shifted profits}} - \underbrace{\delta|g_1 - \tau a|q_{12}}_{\text{Concealment cost}}, \\
\pi_{12} &= \underbrace{(p_{12} - g_1)q_{12}}_{\text{Foreign profits}} \\
&= (p_{12} - \tau a)q_{12} \underbrace{-(g_1 - \tau a)q_{12}}_{\text{Shifted profits}},
\end{aligned}$$

where q_{11} is given by Eq. (1), q_{12} is defined analogously, a is the unit-labor requirement, and R_1 is the reward to capital invested in the MNE. The second term in π_{11} represents the profits from intra-firm trade subject to trade costs τ. The MNE may choose the transfer price differently than the true marginal cost: $g_i \neq \tau a$. For profits to move from high-tax country 1 to low-tax country 2, the second term must be negative: $(g_1 - \tau a)q_{12} < 0$ or $g_1 < \tau a$, which we will see shortly. This term captures profit shifting within MNEs, appearing in π_{12} with the opposite sign. The third term in π_{11} is a concealment cost associated with the deviation of the transfer price from the true marginal cost (Haufler and Schjelderup, 2000; Kind et al., 2005). As the deviation is larger, it is more costly for MNEs to conceal the transfer pricing activity from tax authorities. High δ makes profit shifting more costly, implying that δ can be interpreted as the stringency of transfer price regulation.

[19] See Ziss (2007) for more on this issue.
[20] As we shall see, the allocation of plants does not affect optimal selling prices or transfer prices.

At the third stage of the game, the production plant and the foreign affiliate choose their prices to maximize their own profits. The optimal prices are

$$p_{11} = \frac{\sigma a}{\sigma - 1}, \qquad p_{12} = \frac{\sigma g_1}{\sigma - 1}. \tag{2}$$

At the second stage, the MNE with a plant in the high-tax country 1 sets the transfer price to maximize the following global post-tax profits Π_1:

$$\Pi_1 \equiv (1 - t_1)\pi_{11} + (1 - t_2)\pi_{12} - 2R_1, \tag{3}$$

where $t_i \in [0, 1]$ is the tax rate of country $i \in \{1, 2\}$. We again note that labor/input costs are deductible, while capital costs are non-deductible. Suppose that the MNE with production in country 1 tries to shift profits of its home plant to its foreign affiliate in the low-tax country 2, i.e., $(g_1 - \tau a)q_{12} < 0$, where the concealment cost is given by $\delta|g_1 - \tau a|q_{12} = -\delta(g_1 - \tau a)q_{12} > 0$. It chooses the transfer price to maximize the post-tax profit, Eq. (3):

$$g_1 = \frac{(1 + \delta)\sigma\tau a}{\sigma - \Delta t_1 + \delta(\sigma - 1)}, \qquad \text{where} \ \ \Delta t_1 \equiv \frac{t_2 - t_1}{1 - t_1} < 0, \tag{4-1}$$

where g_1 decreases with t_1, while it increases with t_2, implying that a greater tax difference leads to a more aggressive transfer-pricing behavior.[21] Similarly, supposing that the MNE with production in country 2 tries to shift profits from its foreign affiliate in country 1 back to its home plant, it incurs the concealment cost of $\delta|g_2 - \tau a|q_{21} = \delta(g_2 - \tau a)q_{21} > 0$. The optimal transfer price maximizing the MNE's post-tax profit is

$$g_2 = \frac{(1 - \delta)\sigma\tau a}{\sigma - \Delta t_2 - \delta(\sigma - 1)}, \qquad \text{where} \ \ \Delta t_2 \equiv \frac{t_1 - t_2}{1 - t_2} > 0, \tag{4-2}$$

where g_2 decreases with t_2, while it increases with t_1. The optimal transfer prices g_i do not depend on the plant share n_i because of the constant elasticity of substitution σ, implying that g_is entail only tax-saving motives, not strategic ones. As will be clear in the next section, however, MNEs make a strategic location choice such that they use g_is to make their affiliates competitive.

For the optimal transfer prices to be consistent with the direction of profit shifting, the optimal transfer price from country 1 to 2 (or from country 2 to 1) must be set lower (or

[21] The result that a larger tax difference leads to a lower export price from the high-tax to low-tax country is in line with empirical findings by Clausing (2003).

higher) than the true marginal cost:

$$g_1 < \tau a \ \rightarrow \ \delta < \frac{t_1 - t_2}{1 - t_1},$$
$$g_2 > \tau a \ \rightarrow \ \delta < \frac{t_1 - t_2}{1 - t_2}.$$

These conditions reduce to $\delta < (t_1 - t_2)/(1 - t_2) = \overline{\delta}$, which also satisfies the second-order condition for maximization ($\delta < 1$). Under $\delta < \overline{\delta}$, profits net of concealment cost shifted from country 1 to 2 are negative: $(1+\delta)(g_1 - \tau a)q_{12} < 0$, while those shifted from country 2 to 1 are positive: $(1-\delta)(g_2 - \tau a)q_{21} > 0$. If the tax difference is too large, the total pre-tax profits of the plant in country 1 could be negative: $\pi_{11} < 0$ (see Appendix 3 for details). To exclude this possibility, we further assume $(t_2 <)t_1 < 1/2$, which is plausible considering the highest corporate tax rate being 0.4076 in 23 OECD countries in 2010 to 2016 (Japan in 2010 to 2012).

Using the demand function, Eq. (1), and optimal prices, Eqs. (2) and (4), we rearrange the post-tax profit, Eq. (3), as

$$\begin{aligned}
\Pi_1 &= (1-t_1)\pi_{11} + (1-t_2)\pi_{12} - 2R_1 \\
&= (1-t_1)\Bigg[\underbrace{\frac{\mu L_1}{\sigma(N_1 + \phi\gamma_2 N_2)}}_{\text{Domestic profits}} + \underbrace{\frac{(\sigma-1)(\Delta t_1 + \delta)}{\sigma} \cdot \frac{\phi\gamma_1\mu L_2}{\sigma(\phi\gamma_1 N_1 + N_2)}}_{\text{Shifted profits (net of concealment cost) } <0}\Bigg] \\
&\quad + (1-t_2) \cdot \underbrace{\frac{\phi\gamma_1\mu L_2}{\sigma(\phi\gamma_1 N_1 + N_2)}}_{\text{Foreign profits}} - 2R_1,
\end{aligned} \tag{5-1}$$

$$\begin{aligned}
\Pi_2 &= (1-t_1)\pi_{21} + (1-t_2)\pi_{22} - 2R_2 \\
&= (1-t_1) \cdot \underbrace{\frac{\phi\gamma_2\mu L_1}{\sigma(N_1 + \phi\gamma_2 N_2)}}_{\text{Foreign profits}} \\
&\quad + (1-t_2)\Bigg[\underbrace{\frac{\mu L_2}{\sigma(\phi\gamma_1 N_1 + N_2)}}_{\text{Domestic profits}} + \underbrace{\frac{(\sigma-1)(\Delta t_2 - \delta)}{\sigma} \cdot \frac{\phi\gamma_2\mu L_1}{\sigma(N_1 + \phi\gamma_2 N_2)}}_{\text{Shifted profits (net of concealment cost) } >0}\Bigg] - 2R_2,
\end{aligned} \tag{5-2}$$

$$\text{where} \ \ \phi \equiv \tau^{1-\sigma}, \quad \Delta t_i \equiv \frac{t_j - t_i}{1 - t_i}, \quad i \neq j \in \{1, 2\},$$
$$\gamma_1 \equiv \left(\frac{\sigma(1+\delta)}{\sigma - \Delta t_1 + \delta(\sigma - 1)}\right)^{1-\sigma}, \quad \gamma_2 \equiv \left(\frac{\sigma(1-\delta)}{\sigma - \Delta t_2 - \delta(\sigma - 1)}\right)^{1-\sigma}.$$

The first and second terms in the square brackets in Π_1 and Π_2 are respectively the profit from domestic market and the profit shifted through transfer pricing. $\phi = \tau^{1-\sigma} \in [0, 1]$ is an inverse measure of trade costs, or the openness of trade. $\phi = 0$ (i.e., $\tau = \infty$) corresponds to a prohibitively high level of trade costs, while $\phi = 1$ (i.e., $\tau = 1$) indicates zero trade costs.

We assume as in standard NEG models the free entry and exit of potential MNEs (or equivalently the arbitrage behavior of capital owners), so that excess profits are driven to zero. This zero profit condition implies that, for given MNEs' locations, the return to capital, R_i, is determined at the point where $\Pi_i = 0$ holds. In the short-run equilibrium where capital is immobile, the return to capital in general differs between countries. The capital-return differential generates a relocation incentive which guides us to analyze the long-run equilibrium where capital is mobile.

3 Long-run equilibrium

To highlight the role of tax difference, we assume that the two countries are of equal size ($s_1 = 1/2$). When the difference in the capital return is positive: $R_1 - R_2 > 0$ (or negative: $R_1 - R_2 < 0$), capital owners invest in the MNE with production in country 1 (or the MNE with production in country 2). In the long-run equilibrium, the return differential is zero where no capital owners change their investment behavior. This also means that no MNEs are willing to change their location of plants/affiliates. By solving the long-run equilibrium condition ($R_1 - R_2 = 0$) for the share of production plants in country 1, we obtain interior equilibria $n_1 \in (0, 1)$. If $R_1 - R_2 = 0$ does not have interior solutions, then we obtain corner equilibria in which all multinational production takes place in one country, i.e., $n_1 \in \{0, 1\}$.

3.1 Plant distribution and the non-monotonic impact of economic integration

Location incentives of MNEs depend on the ease of intra-firm trade, which is subject to trade costs. A high level of trade costs τ (or lower trade openness ϕ) does not allow for much intra-firm trade, leaving little room for profit shifting.[22] As the MNEs earn profits mostly from home production plants, they prefer to locate them in the low-tax country 2. The low-tax country offers a greater profit potential for MNEs and thus it can be considered as a country with a large home market. The concentration of production in country 2 results

[22] In Eqs. (5-1) and (5-2), the profits from intra-firm trade and those from the foreign affiliate disappear if $\phi = 0$.

from the well-known home-market effect common in NEG models (Helpman and Krugman, 1985). We note that there is a small but positive share of plants in the high-tax country 1, i.e., $n_1|_{\phi=0} \in (0, 1/2)$. Since competition in the domestic market works as a dispersion force, the corner distribution where all plants are in the low-tax country 2 cannot be an equilibrium, i.e., $(n_1|_{\phi=0} \neq 0$.

By contrast, smaller τ (or higher ϕ) allows MNEs to engage in intra-firm trade fully, making effective profit shifting through transfer pricing.[23] Transfer pricing does not just shift profits between home plants and foreign affiliates, but also affects the competitiveness of the affiliates. As we showed, MNEs with production in the high-tax country 1 set a low transfer price to shift profits to their affiliates in the low-tax country 2 (see Eq. (4-1)). Due to the low input cost, the affiliates can sell at a low price and become competitive against local plants. Conversely, MNEs with production in country 2 set a high transfer price (see (4-2)), which makes their affiliates in country 1 less competitive against local plants. MNEs with production in country 1 have a competitive advantage in both the domestic and foreign markets against MNEs with production in country 2. Therefore, MNEs prefer to locate production in the high-tax country 1 so that transfer-pricing makes their affiliates competitive. In fact, if ϕ is sufficiently high such that $\phi > \phi^S$, which we call an agglomeration threshold, all production plants are located in country 1.[24]

Assuming away transfer-pricing regulation ($\delta = 0$), we can formally prove the following proposition by applying Taylor approximations at zero tax difference.

[23] We can confirm that given the plant share n_1, the shifted profit increases with ϕ; that is, $\partial(|g_i - \tau a|q_{ij})/\partial\phi > 0$ for $i \neq j \in \{1, 2\}$.

[24] The agglomeration threshold is called the sustain point in the literature in the sense that full agglomeration is sustainable when trade openness is higher than the point (Fujita et al., 1999). It can be checked that ϕ^S decreases with $t_1 - t_2$ (see Appendix 4). A larger tax difference offers more room for profit shifting and thus leads to more aggressive transfer pricing (very low g_1 or very high g_2). This strengthens the competitiveness of MNEs with production in country 1 against MNEs in both the domestic and foreign markets. Consequently, the larger tax difference lowers ϕ^S, making full production agglomeration in country 1 more likely.

Proposition 1 (Plant distribution). *Assume that two countries are of equal size ($s_1 = 1/2$) and that country 1 has a higher corporate tax rate than country 2 ($t_2 < t_1 < 1/2$), but that the tax difference is small enough ($t_1 - t_2 \approx 0$), and that there is no transfer-pricing regulation ($\delta = 0$). The equilibrium allocation of production plants is as follows:*

(i). With high trade costs such that $\phi \in [0, \phi^\dagger)$, the high-tax country 1 hosts a smaller share of plants than the low-tax country 2, i.e., $n_1 < 1/2$.

(ii). With low trade costs such that $\phi \in (\phi^\dagger, 1]$, the high-tax country 1 hosts a greater share of plants, i.e., $n_1 > 1/2$.

(ii-a). With sufficiently low trade costs such that $\phi \in [\phi^S, 1]$ where $\phi^S (> \phi^\dagger)$ is the agglomeration threshold, all production plants are located in the high-tax country , i.e., $n_1 = 1$.

At $\phi = \phi^\dagger$, the two countries have an equal share of plants, i.e., $n_1 = 1/2$.

We do not report here the lengthy expressions of $\phi^\dagger$ and ϕ^S, which are implicitly defined as $\phi^\dagger \equiv \arg_\phi\{n_1 = 1/2\}$ and $\phi^S \equiv \min \arg_\phi\{n_1 = 1\}$, respectively. See Appendix 4 for the proof.

It is worth noting that full production agglomeration in country 1 occurs even at zero trade costs ($\tau = 1$ or $\phi = 1$). In the case without transfer pricing, MNEs are indifferent to the location of plants at $\phi = 1$. The selling price for the foreign market is equal to that for the home market, i.e., $p_{ij} = p_{ii} = \sigma a/(\sigma - 1)$, so that MNEs make the same profits from the two markets. They cannot avoid high taxes in country 1 by changing the location of plants/affiliates and thus do not have a strong location preference. In the transfer-pricing case, however, the selling prices for the two markets are not equalized even at $\phi = 1$, i.e., $p_{ij} \neq p_{ii}$, because they reflect transfer prices that are not equal to the true marginal cost ($g_i \neq \tau a$) but are dependent on the tax difference (see Eqs. (4-1) and (4-2)). To fully utilize transfer pricing for saving taxes and enhancing competitiveness, MNEs have a strong preference for production location even at $\phi = 1$.

Fig. 2 shows a representative pattern of long-run equilibrium plant share for different levels of trade openness ϕ (solid curve), along with the long-run equilibrium plant share in the case without transfer pricing (dashed curve).[25] As ϕ increases from zero, the share of

[25] For clarity, $\phi^\dagger$ is not shown in Fig. 2, at which $n_1 = 1/2$ holds. Parameter values are given in Appendix 12. Specifically, we set the elasticity of substitution σ to five, which is the lower bound of the range estimated by Lai and Trefler (2002). We set tax rates to $(t_1, t_2) = (0.3, 0.2)$, which seem plausible considering the fact

plants in the high-tax country 1 decreases in both cases with and without profit shifting. When high trade costs prevent exporting, MNEs make profits mostly from their home plants and thus prefer to locate them in the low-tax country. Along with a further increase in ϕ from $\phi^{\#}$, however, the high-tax country 1 increases plants in the case with profit shifting, whereas it continues to decrease plants in the case without profit shifting. Sufficiently low trade costs expand intra-firm trade and thus increase the opportunities for profit shifting, leading to a sharp contrast in location patterns.

This finding is summarized in the following proposition:

Proposition 2 (Non-monotonic impact of economic integration). *Under the same assumptions as in Proposition 1, the impact of economic integration on the plant share in the high-tax country 1, n_1, is non-monotonic. That is, a fall in trade costs first decreases and then increases the plant share, i.e., $dn_1/d\phi \leq 0$ for $\phi \in [0, \phi^{\#})$ and $dn_1/d\phi > 0$ for $\phi \in (\phi^{\#}, 1]$.*

The exact expression of $\phi^{\#}$ and the proof are given in Appendix 5.

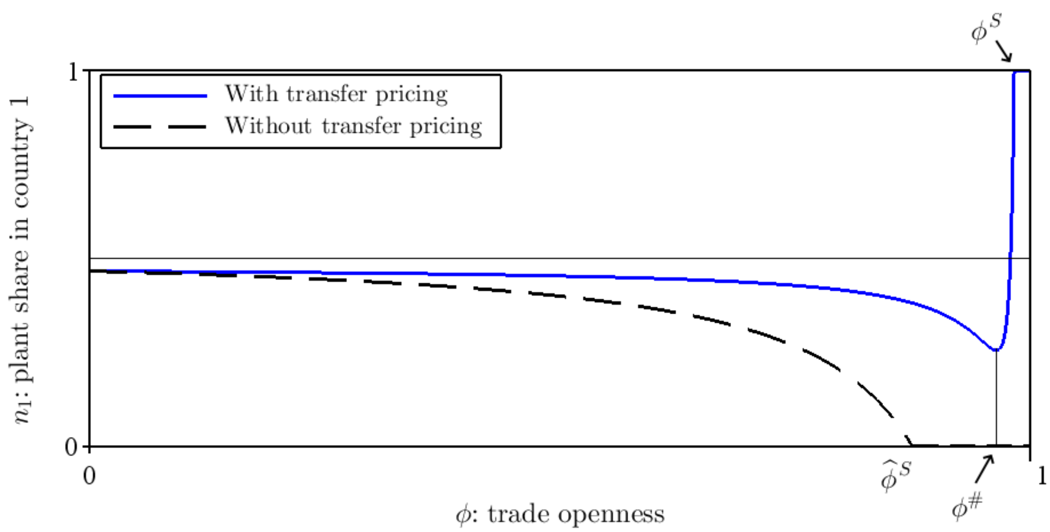

Fig. 2. Share of production plants in the high-tax country 1

that the average tax rate is 0.274 and the average tax difference is 0.077 in our sample of 23 OECD countries in 2008 to 2016. We experimented with different values of σ and t_is and obtained similar patterns to those in Fig. 2. In the special case where σ is extremely low, it is possible that as trade costs fall, full production agglomeration in country 2 occurs before full production agglomeration in country 1 is achieved. But our qualitative results are unchanged in this special case.

3.2 Tax revenues

The tax base in country 1, denoted by TB_1, consists of profits of both home production plants and foreign distribution affiliates. Using Eqs. (5-1) and (5-2), we can rewrite TB_1 as

$$
\begin{aligned}
TB_1 &= \underbrace{N_1\pi_{11}}_{\text{Profits of home plants}} + \underbrace{N_2\pi_{21}}_{\text{Profits of foreign affiliates}} \\
&= \Big[\underbrace{N_1(p_{11}-a)q_{11}}_{\text{Domestic profits of home plants}} + \underbrace{N_1(1+\delta)(g_1-\tau a)q_{12}}_{\text{Shifted profits of home plants (net of concealment cost) } <0}\Big] \\
&\quad + \Big[\underbrace{N_2(p_{21}-\tau a)q_{21}}_{\text{Domestic profits of foreign affiliates}} + \underbrace{N_2(\tau a-g_2)q_{21}}_{\text{Shifted profits of foreign affiliates } <0}\Big] \\
&= \left[N_1\frac{\mu L_1}{\sigma(N_1+\phi\gamma_2 N_2)} + N_1\frac{(\sigma-1)(\Delta t_1+\delta)}{\sigma}\frac{\phi\gamma_1\mu L_2}{\sigma(\phi\gamma_1 N_1+N_2)}\right] \\
&\quad + \left[N_2\frac{\phi\gamma_2\mu L_1}{\sigma(N_1+\phi\gamma_2 N_2)}\left\{1+\frac{(\sigma-1)(\Delta t_2-\delta)}{\sigma(1-\delta)}\right\} - N_2\frac{(\sigma-1)(\Delta t_2-\delta)}{\sigma(1-\delta)}\frac{\phi\gamma_2\mu L_1}{\sigma(N_1+\phi\gamma_2 N_2)}\right] \\
&= \frac{\mu L}{2\sigma} + \underbrace{N_1\frac{(\sigma-1)(\Delta t_1+\delta)}{\sigma}\frac{\phi\gamma_1\mu L}{2\sigma(\phi\gamma_1 N_1+N_2)}}_{\text{Shifted profits of home plants (net of concealment cost) } <0}, \qquad (6\text{-}1)
\end{aligned}
$$

where $L_1 = L_2 = L/2$; $\Delta t_1 + \delta < 0$; and $\Delta t_2 - \delta > 0$. Tax revenues are then given by $TR_1 \equiv t_1 \cdot TB_1$. The first term of the last line, $\mu L/(2\sigma)$, is the total profits made in country 1 and turns out to be the tax base in the no-transfer-pricing case. The constant first term corresponds to the tax base in the case without transfer pricing (see Section 5.1 for more details). It is clear from the second negative term of the last line, the shifted profits of home plants, that allowing for transfer pricing always reduces tax revenues in country 1.

As shown in the second and third lines, there are two types of shifted profits, one by the plants of MNEs headquartered in country 1 (i.e., home plants) and the other by the affiliates of MNEs headquartered in country 2 (i.e., foreign affiliates). It turns out, however, that the shifted profits of foreign affiliates do not explicitly show up in the last line. This is because the lost tax base is compensated by an increase in domestic profits of home plants and is implicitly included in the first term of the last line: $\mu L/(2\sigma)$. More specifically, foreign affiliates in the high-tax country 1 pay a high input/transfer price g_2 for moving profits to their plants in the low-tax country 2. They pass on the high-input price to the selling price p_{21}, raising the price index (higher $P_1 = (\sum_{i=1}^{2} N_i p_{i1}^{1-\sigma})^{\frac{1}{1-\sigma}}$) and thus the demand for all varieties in country 1 (larger $q_{i1} = p_{i1}^{-\sigma} P_1^{\sigma-1}\mu L_1$). Home plants increase their domestic profits such that the loss from profit shifting is cancelled out.

Similarly, the tax base in country 2 is

$$
\begin{aligned}
TB_2 = & \underbrace{N_2\pi_{22}}_{\text{Profits of home plants}} + \underbrace{N_1\pi_{12}}_{\text{Profits of foreign affiliates}} \\
= & \Big[\underbrace{N_2(p_{22}-a)q_{22}}_{\text{Domestic profits of home plants}} + \underbrace{N_2(1-\delta)(g_2-\tau a)q_{21}}_{\text{Shifted profits of home plants (net of concealment cost) } >0} \Big] \\
& + \Big[\underbrace{N_1(p_{12}-\tau a)q_{12}}_{\text{Domestic profits of foreign affiliates}} + \underbrace{N_1(\tau a - g_1)q_{12}}_{\text{Shifted profits of foreign affiliates } >0} \Big] \\
= & \left[N_2 \frac{\mu L_2}{\sigma(\phi\gamma_1 N_1 + N_2)} + N_2 \frac{(\sigma-1)(\Delta t_2 - \delta)}{\sigma} \frac{\phi\gamma_2\mu L_1}{\sigma(N_1+\phi\gamma_2 N_2)} \right] \\
& + \left[N_1 \frac{\phi\gamma_1\mu L_2}{\sigma(\phi\gamma_1 N_1 + N_2)} \left\{ 1 + \frac{(\sigma-1)(\Delta t_1+\delta)}{\sigma(1+\delta)} \right\} - N_1 \frac{(\sigma-1)(\Delta t_1+\delta)}{\sigma(1+\delta)} \frac{\phi\gamma_1\mu L_2}{\sigma(\phi\gamma_1 N_1+N_2)} \right] \\
= & \frac{\mu L}{2\sigma} + \underbrace{N_2 \frac{(\sigma-1)(\Delta t_2-\delta)}{\sigma} \frac{\phi\gamma_2\mu L}{2\sigma(N_1+\phi\gamma_2 N_2)}}_{\text{Shifted profits of home plants (net of concealment cost) } >0}, \qquad \text{(6-2)}
\end{aligned}
$$

noting that $\Delta t_2 - \delta > 0$. Due to the inflow of profits made in the high-tax country 1 (i.e., the second positive term of the last line), tax revenues, defined by $TR_2 \equiv t_2 \cdot TB_2$, are higher in the transfer-pricing case than those in the no-transfer-pricing case except when $\phi = 0$. As in the case of TB_1, the shifted profits of foreign affiliates do not explicitly enter the last line. By sourcing inputs at a low transfer price g_1, foreign affiliates in country 2 set a low selling price p_{12} and thus push the price index there P_2 downward. The lowered price index reduces the domestic profits of home plants, eroding the tax-base inflow that foreign affiliates bring.

These findings are summarized as follows.

Lemma 1 (Tax revenues). *Under the same assumptions as in Proposition 1, tax revenues in the high-tax country 1 (or the low-tax country 2) in the transfer-pricing case are always lower than or equal to (or higher than or equal to) those than in the no-transfer-pricing case.*

Fig. 3(a) illustrates the total profits shifted from the high-tax country 1 to the low-tax country 2, $N_1(\tau a - g_1)q_{12} + N_2(g_2 - \tau a)q_{21}$, for different levels of trade openness ϕ.[26] The dashed horizontal lines are the corresponding values in the no-transfer-pricing case. Naturally, more profits are transferred as trade gets more open. Tax revenues in each country are drawn in Fig. 3(b). It is worth noting that both curves exhibit an inverted-U shape when ϕ is high.

[26] Parameter values are the same as those in Fig. 2. See Appendix 12 for details.

This can be explained from the U-shaped relationship between ϕ and country 1's plant share n_1. As Fig. 2 and Proposition 2 suggest, a rise in ϕ below $\phi^{\#}(< \phi^S)$ decreases n_1 and increases $n_2 = 1 - n_1$. This change in the plant share is likely to suppress the tax-base outflow from country 1 (smaller $N_1(\tau a - g_1)q_{12}$) and encourage the tax-base inflow to country 2 (larger $N_2(g_2 - \tau a)q_{21}$), contributing to greater tax revenues in both countries.[27] Conversely, a rise in ϕ above $\phi^{\#}$ increases n_1 and decreases $n_2 = 1 - n_1$, changing tax revenues in the opposite direction to the one before.

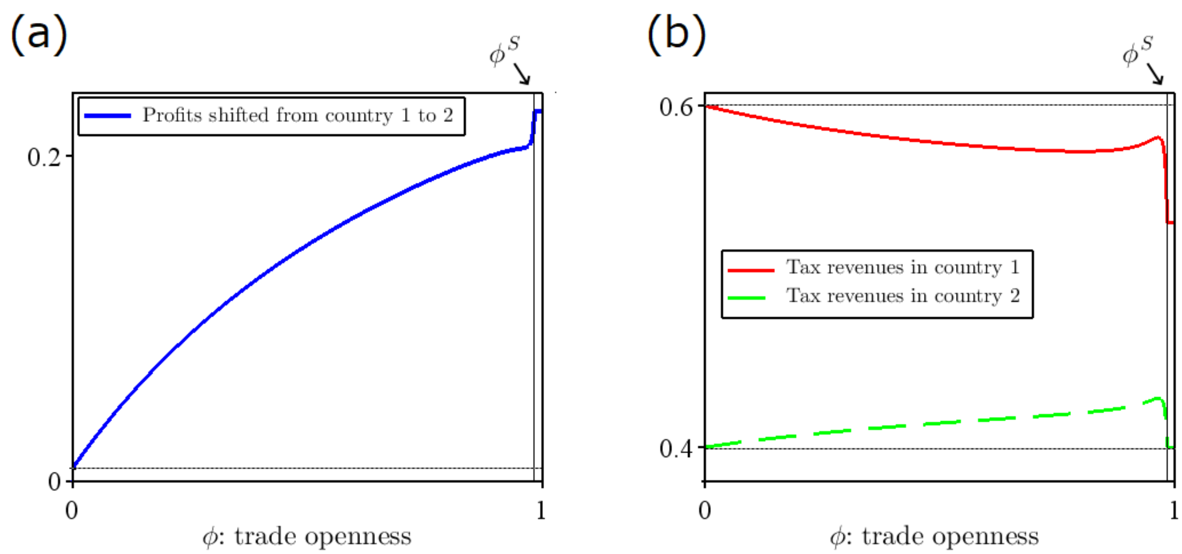

Fig. 3. Shifted profits (a) and tax revenues (b)

3.3 Empirical evidence

Proposition 2 gives an empirical implication on the relationship between bilateral FDI flows, tax differential and trade openness. That is, given the tax differential between two countries, there is a non-monotonic effect of economic integration on the share of manufacturing multinationals out of multinationals in all sectors. To empirically test this prediction, we can think of the following regression:

$$(\text{Manufacturing-affiliate share})_{h,s} = \beta_1 \Delta TAX_{h,s} \cdot \phi_{h,s} + \beta_2 \Delta TAX_{h,s} \cdot \phi_{h,s}^2 + \boldsymbol{x}'_{\boldsymbol{h,s}} \boldsymbol{\beta} + \varepsilon_{h,s},$$

[27] It can be readily verified that $\partial[N_1(\tau a - g_1)q_{12}]/\partial n_1 > 0$ and $\partial[N_2(g_2 - \tau a)q_{21}]/\partial n_1 < 0$.

where the variables are defined as

$(\text{Manufacturing-affiliates share})_{h,s}$:

the share of manufacturing affiliates out of all affiliates in country h from country s,

$\Delta TAX_{h,s} = TAX_h - TAX_s$: corporate tax rate differential between h and s,

$\phi_{h,s}$: trade openness,

$\boldsymbol{x}_{h,s}$: vector of control variables,

$\varepsilon_{h,s}$: error term,

and where the time subscript is omitted for brevity. Supposing that the host country h sets a higher tax rate than the source country s, i.e., $\Delta TAX_{h,s} > 0$, the theory predicts

$$\frac{\partial(\text{Manufacturing-affiliate share})_{h,s}}{\partial \phi_{h,s}} = \underbrace{\Delta TAX_{h,s}}_{+} \cdot (\beta_1 + \beta_2 \underbrace{\phi_{h,s}}_{+}) \begin{cases} < 0 & \text{if } \phi_{h,s} < -\beta_1/\beta_2 \\ > 0 & \text{if } \phi_{h,s} > -\beta_1/\beta_2 \end{cases},$$

which states that an increase in trade openness has a negative (or positive) effect on the manufacturing-affiliate share in country h coming from country s if trade openness is low (or high). The sign of the derivative flips in the case of $\Delta TAX_{h,s} < 0$. Because $\phi_{h,s}$ takes positive values, the theory-consistent signs are $\beta_1 < 0$ and $\beta_2 > 0$.

We test this using the same affiliate data as those used in Fig. 1. To construct the trade openness, $\phi_{h,s} \in (0, 1)$, we take the inverse of the log of the bilateral distance measure constructed by Mayer and Zignago (2011). Besides the two interaction terms of our interest, we include as control variables ($\boldsymbol{x}_{h,s}$) a simple tax differential; a common-language dummy; a colony dummy; a host country-year dummy; and a source country-year dummy, following the empirical literature on the determinants of FDI (e.g., Egger et al., 2009; Choi et al., 2020c).[28] In addition to the statutory tax rates, we use as a robustness check the effective average tax rates (Devereux and Griffith, 1998), which are calculated from data on profits and investment. The sample is an unbalanced panel of 23 OECD countries, covering the period of 2008-2016. We exclude observations with missing values and/or zero affiliates from the sample. See Appendix 1 for details.

The regression results are summarized in Table 1. In columns (1) and (2) the statutory tax rates are used, while in columns (3) and (4) the effective average tax rates are used. In

[28]We cannot include variables varying only in host/source country-year level such as host/source country GDP because their effects are absorbed by the host/source country-year dummy.

columns (2) and (4), the tax differential is lagged by one year. The theoretical prediction that $\beta_1 < 0$ and $\beta_2 > 0$ is strongly supported with a 1% significance in all columns. We can also confirm that the infection point of trade openness is actually in between zero and one (e.g., in column (1): $74/270 \simeq 0.27$).

Table 1
Non-monotonic effect of economic integration on multinational production
Dependent variable: (foreign manufacturing affiliates)/(foreign affiliates in all sectors)

	Statutory tax rate		Effective tax rate	
	(1)	(2)	(3)	(4)
$\Delta TAX_{h,s,t} \cdot \phi_{h,s}$	-71.93^{***}		-83.86^{***}	
	(23.07)		(25.09)	
$\Delta TAX_{h,s,t} \cdot \phi^2_{h,s}$	259.43^{***}		305.51^{***}	
	(82.38)		(90.16)	
$\Delta TAX_{h,s,t-1} \cdot \phi_{h,s}$		-71.70^{***}		-83.14^{***}
		(24.87)		(26.45)
$\Delta TAX_{h,s,t-1} \cdot \phi^2_{h,s}$		267.32^{***}		315.41^{***}
		(88.65)		(94.29)
Control variables	Yes	Yes	Yes	Yes
Observations	1,845	1,596	1,845	1,596
R^2	0.516	0.491	0.516	0.491

Notes: The dependent variable is the share of foreign manufacturing affiliates out of those in all sectors in a host country. All regressions include a host country-year dummy; a source country-year dummy; and other control variables mentioned in the text. Robust-standard errors in parentheses are clustered at the host country-year level. ***Significant at the 1% level; **Significant at the 5% level; *Significant at the 10% level.

Supporting evidence can also be found in existing studies such as Overesch (2009) and Goldbach et al. (2019). Using firm-level panel data of German inward FDI from 1996 to 2005, Overesch (2009) finds that domestic investment by foreign affiliates located in Germany increases as the corporate tax difference between Germany and their source country gets higher. Goldbach et al. (2019) also employ similar data of German outward FDI and find that the complementarity between domestic and foreign investment by German-based MNEs is higher as the tax difference between Germany and their destination country gets wider. Considering the fact that important source/destination countries of German FDI are Germany's neighboring ones such as France and Austria, their empirical results are consistent with our prediction that the high-tax country attracts multinational production from the low-tax country when the bilateral trade openness is high.[29]

4 Extensions

This section discusses four extensions of our main model.

4.1 Transfer-pricing regulation

We established Propositions 1 and 2 under no transfer-pricing regulation, i.e., $\delta = 0$. A tighter regulation (higher δ) limits the effectiveness of profit shifting in a way such that makes smaller the deviation of the transfer price from the true marginal cost. Thus, MNEs find less profitable to move to country 1, where there is a higher tax rate but little scope for transferring profits. In fact, we can numerically confirm in Fig. 4 that higher δ makes less likely the concentration of production in the high-tax country 1.[30] When δ is sufficiently high such that $\delta = (t_1 - t_2)/(1 - t_1) = (0.3 - 0.2)/(1 - 0.3) = 0.143$ (dashed curve), there is no room for profit shifting ($g_i = \tau a$) so that the plant share in country 1 coincides with that in the case without transfer pricing (dashed curve in Figure 2) and never exceeds one-half.

[29]Strictly speaking, Overesch (2009) and Goldbach et al. (2019) consider a different mechanism than ours in that they consider incremental investment by a representative MNE, while we consider discrete investment by a continuum of MNEs. In the theoretical model of Overesch (2009), the amount of shifted profits is assumed to be related to that of capital invested by the affiliate. Profit shifting from an affiliate in high-tax Germany to its parent in a low-tax source country reduces the required rate of return to the affiliate, leading to an increase in investment by the affiliate. Goldbach et al. (2019) apply the same argument to the case of German-based parents.

[30]Parameter values are the same as those in Figs. 2 and 3 except for δ. See Appendix 12.

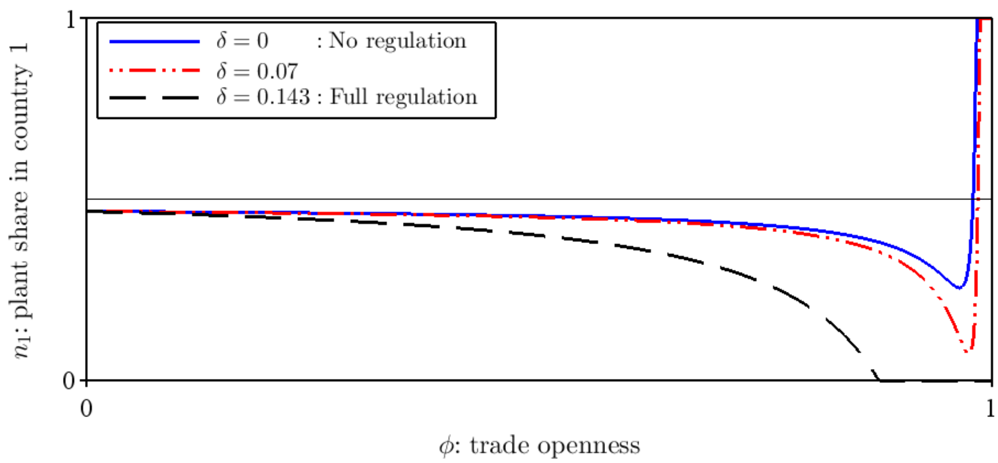

Fig. 4. Impact of transfer-pricing regulation

4.2 Pure exporters

In the main analysis, we excluded the possibility of pure exporters, who export varieties without using distribution affiliates. However, one may expect that it would be profitable for production plants in the low-tax country to serve the high-tax country by exporting directly to consumers, rather than via distribution affiliates. Exporting while locating production in the low-tax country would save taxes and avoid the negative aspect of strategic transfer pricing. To consider this, we endogenize whether each firm becomes a MNE or a pure exporter. The MNE establishes a plant in one country and a distribution affiliate in the other, as in the main model. The pure exporter locates two plants in the same country, one for the home market and the other for the foreign market. Specifically, the timing of actions is modified as follows. Firms first decide the location of a plant for the home market and then choose their organization form, either a MNE or a pure exporter. The subsequent actions proceed as in the main analysis.

We also assume that MNEs face a lower level of trade cost than pure exporters. The ease of communication within a MNE reduces costs related to intra-firm trade. In fact, Ramondo and Rodríguez-Clare (2013) report that what they call multinational production costs, which are similar to intra-firm trade costs here, are more sensitive to changes in distance than arm's length trade costs. Let τ^M and τ^E be intra-firm trade costs and arm's-length trade costs respectively. The corresponding measures of openness are denoted by $\phi^M \equiv (\tau^M)^{1-\sigma}$ and $\phi^E \equiv (\tau^E)^{1-\sigma}$, where $\eta \equiv \phi^E/\phi^M \in [0, 1]$ represents the (inverse of) difficulty of arm's length trade relative to intra-firm trade.

This extended model is fully analyzed in Appendix 6, where we confirm the aforementioned expectation; given the location of production (i.e., first plant), firms in the high-tax country 1 always become MNEs, while firms in the low-tax country 2 always become pure exporters. Given production in the high-tax country, there is no point becoming pure exporters because in doing so firms would dismiss the opportunities of profit-shifting. Conversely, given production in the low-tax country, it makes no sense becoming MNEs because their distribution affiliates are imposed on high-taxes and are less competitive due to a higher transfer price of inputs.

Considering these decisions of organization form, firms choose production location. Fig. 5 shows the world share of MNEs with production in country 1 in the long-run equilibrium, denoted by $n_1 \in [0, 1]$, for different levels of intra-firm trade openness ϕ^M.[31] We note that the remaining share, $1 - n_1$, represents the world share of pure exporters in country 2. There are three ηs, each of which has different ϕ^E/ϕ^M. All n_1s decrease with ϕ^M for low ϕ^M, but they behave differently for high ϕ^M. When arm's length trade is about as open as intra-firm trade ($\phi^E/\phi^M = 0.882$: the bottom dashed curve), most firms choose the low-tax country 2 for production and become pure exporters, i.e., $n_1 \simeq 0$. When arm's length trade is subject to more difficulties than intra-firm trade ($\phi^E/\phi^M = 0.88135, 0.88$: the dotted and solid curves), more firms become MNEs and seek to utilize transfer pricing. Thus the location patterns are similar to those in the basic model (see Fig. 2). In sum, if we allow for the pure export solution, our main results of (i) agglomeration of MNEs' production plant in the high-tax country (Proposition 1) and (ii) the non-monotonic impact of economic integration on the plant share (Proposition 2) are unchanged as long as intra-firm trade costs are sufficiently lower than arm's length trade costs.

[31] Parameter values are the same as those in Figs. 2 and 3 except for $\phi^E/\phi^M = \eta$. See Appendix 12 for details.

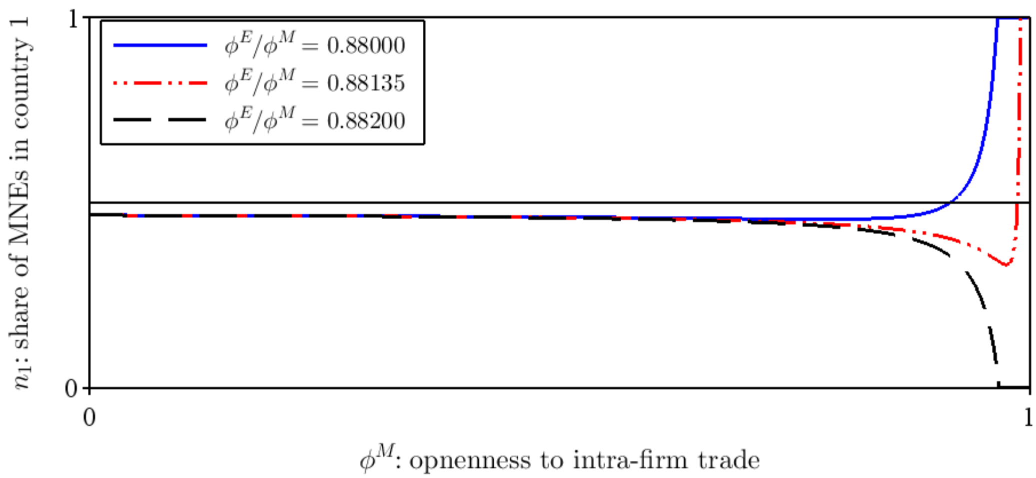

Fig. 5. MNEs vs. pure exporters

4.3 Asymmetric country size

The result of the high-tax country 1 attracting more multinational production for low trade costs, in general, does not depend on the assumption of symmetric market size. Our model inherits a common feature of NEG models that firms try to locate in large countries to save trade costs when exporting. Thus, if country 1 is larger ($s_1 > 1/2$), the larger market size strengthens the incentive of MNEs to locate production there. If country 1 is smaller ($s_1 < 1/2$), MNEs have less incentive to choose it for production. Even in this case, however, the small high-tax country 1 may achieve full production agglomeration for low trade costs, where the trade-cost-saving motive is weak. In Appendix 7, we confirm that production plants are always agglomerated in the high-tax country 1 at zero trade costs except in the case where country 1 is extremely large.[32]

4.4 Centralized decision making

We assumed that MNEs have decentralized decision making, where foreign affiliates choose prices to maximize their own profits. Our main result holds true if MNEs have centralized decision making, in which the MNE chooses all prices to maximize global profits. Note that the direction of profit shifting does not change depending on the decision making style. That

[32] In the special case where $s_1 > \bar{s}_1 \equiv \sigma/(2\sigma - \Delta t_2)$, full production agglomeration in the large, high-tax country 1 does not occur, because the transferable profits, which depend on the sales of distribution affiliates in country 2, are very small. This exceptional case implies that the very small, low-tax country, which can be roughly considered as a tax-haven, may host a greater share of plant than its market-size share: $n_2 > s_2$.

is, foreign affiliates source goods from production plants by paying high (or low) transfer prices if they are in the low-tax country (or the high-tax country). By locating in the low-tax country, foreign affiliates enjoy a higher price-cost margin than those located in the high-tax country ($p_{12} - g_1 > p_{21} - g_2$) and earn larger profits. As in the decentralized decision making case, profit shifting affects the profitability of foreign affiliates asymmetrically, leading to agglomeration of production plants in the high-tax country. See Appendix 8 for details.

5 Tax competition

We here allow countries to choose their tax rate non-cooperatively and compare the results of tax competition in the case with and without transfer pricing. Throughout this section except for Section 5.3, we cast aside transfer-pricing regulation, i.e., $\delta = 0$. The timing of actions is modified such that the government in each country sets its tax rate before all the actions of multinationals and individuals. The objective function of government $i \in \{1, 2\}$ takes the form of

$$\begin{aligned} G_i &= TR_i - \frac{\alpha_i t_i}{1 - t_i}, \\ \text{where } \ TR_i &\equiv t_i \cdot TB_i, \\ TB_i &\equiv N_i \pi_{ii} + N_j \pi_{ji}, \qquad i \neq j \in \{1, 2\}, \end{aligned}$$

As we saw in Section 3.2, the tax base for government i, TB_i, consists of profits of home production plants, $N_i \pi_{ii}$, and those of foreign distribution affiliates, $N_j \pi_{ji}$. The second term is a tax administration cost, where $\alpha_i > 0$ captures its inefficiency. We assume that government 1 is more efficient in tax administration than government 2: $\alpha_1 < \alpha_2$.[33] The two governments simultaneously and non-cooperatively decide their tax rates before the location MNEs' decision.

[33] Tax administration cost is well recognized as an important determinant of raising revenues (OECD, 2017; Profeta and Scabrosetti, 2017). OECD (2017) states that "Even small increases in compliance rates or compliance costs can have significant impacts on government revenues and the wider economy." (p.5) In addition, this objective function in general captures the fundamental conflicts governments face: they attempt to raise tax revenues while maintaining a low tax rate, which is deemed a reduced-form objective that either selfish or benevolent government adopts (Baldwin and Krugman, 2004). See also Borck and Pflüger (2006); Han et al. (2014); and Kato (2015) for similar specifications.

5.1 No-transfer-pricing case

As a benchmark, we derive the equilibrium tax rates when transfer pricing is not allowed. The inability to manipulate transfer prices implies that the transfer price must be equal to the true marginal cost: $g_i = \tau a$, in which case $\gamma_i = 1$ holds. This leads to zero profits from intra-firm trade: $(g_i - \tau a)q_{ij} = 0$ for $i \neq j \in \{1, 2\}$. Combining these results with Eq. (6-1) yield tax revenues for government 1:

$$
\begin{aligned}
TR_1 &= t_1 TB_1 \\
&= t_1[N_1\pi_{11} + N_2\pi_{21}] \\
&= t_1\left[N_1 \cdot \frac{\mu L_1}{\sigma(N_1 + \phi N_2)} + N_2 \cdot \frac{\phi\mu L_1}{\sigma(N_1 + \phi N_2)}\right] \\
&= t_1 \cdot \frac{\mu L_1(N_1 + \phi N_2)}{\sigma(N_1 + \phi N_2)} \\
&= t_1 \cdot \frac{\mu L}{2\sigma},
\end{aligned}
$$

where $L_1 = L_2 = L/2$. Using Eq. (6-2), we can analogously derive tax revenues for government 2 as $TR_2 = t_2 TB_2 = t_2\mu L/(2\sigma)$. It is worth noting that TB_1 depends on neither the share of plants (n_i), trade openness (ϕ), nor taxes (t_is). The tax base independent of n_i, ϕ and t_is can be explained by the two facts.[34] First, the total mass of plants and affiliates generating country 1's tax base is constant and is given by $N_1 + N_2 = n_1 L + (1 - n_1)L = L$. Second, the transferable profits of foreign affiliates depend on their sales in country 1 and are thus limited by its residents' expenditure on manufacturing goods ($\sum_{i=1}^{2} N_i p_{i1} q_{i1} = \mu L_1$). The constant tax base then implies that governments do not benefit from full agglomeration of plants. Put differently, the concentration of multinational production in a country does not generate taxable agglomeration rents there, which sharply contrasts with the implication of the existing NEG models (Baldwin and Krugman, 2004).

Government i thus maximizes

$$
G_i = \frac{\mu L t_i}{2\sigma} - \frac{\alpha_i t_i}{1 - t_i}.
$$

[34] The constant tax base does not result from the quasi-linear utility function with constant expenditure on manufacturing goods: $\sum_{i=1}^{2} N_i p_{ij} q_{ij} = \mu L_j$. In Appendix 12, we confirm that the Cobb-Douglas utility function also yields a constant tax base.

Solving the first-order condition gives the equilibrium tax rate in country i:

$$\widehat{t}_i = 1 - \sqrt{\frac{2\alpha_i \sigma}{\mu L}}, \tag{7}$$

where we use $\widehat{x}$ to represent the equilibrium value of x in tax competition without transfer pricing. We can check that the government payoff is positive: $G_i(t_i = \widehat{t}_i) = [\mu L/(2\sigma) - \alpha_i]^2 > 0$. The equilibrium tax rate decreases with α_i, reflecting the fact that a government with an inefficient tax-administration finds it costly to raise taxes. In fact, government 1 sets a lower tax rate than government 2, i.e., $\widehat{t}_1 > \widehat{t}_2$, because more efficient tax administration allows government 1 to do so. Because the government objective functions depend on neither the plant share (n_i) nor trade openness (ϕ), the equilibrium tax rates given in Eq. (7) are unique for any n_i and ϕ. A too high (or low) α_1 makes the equilibrium tax rate too low (or high). To ensure $\widehat{t}_i \in (0, 1/2)$, we will assume $\alpha_i \in (\mu L/(3\sigma), \mu L/(2\sigma))$.

Without transfer pricing, the higher tax rate of a country discourages production plants to locate there, as discussed in Section 3. This tendency is more pronounced when trade costs are low, or equivalently, trade openness is high. In particular, when the level of trade openness is smaller than the agglomeration threshold ($\phi > \widehat{\phi}^S$), all plants are located in the low-tax country 2:

$$\widehat{\phi}^S = \frac{1 - \widehat{t}_1}{1 - \widehat{t}_2} \in (0, 1), \tag{8}$$

The situation of full production agglomeration in country 2 ($\widehat{n}_1 = 0$) is shown in Fig. 6 (dashed line).[35] We note that MNEs are indifferent to production location at zero trade costs ($\widehat{n}_1 \in [0, 1]$) because they cannot differentiate selling prices for home and foreign markets to save taxes (see Section 3.1).

These results are summarized as follows (see Appendix 9 for the proof).

Lemma 2 (Tax competition without transfer pricing). *Assume that two countries are of equal size ($s_1 = 1/2$) and that government 1 has a more efficient tax administration than government 2: $\alpha_1 < \alpha_2$, where $\alpha_i \in (\mu L/(3\sigma), \mu L/(2\sigma))$. As a result of tax competition without transfer pricing, government 1 always sets a higher tax rate than government 2 ($\widehat{t}_1 > \widehat{t}_2$, given in Eq. (7)). If trade costs are small enough such that $\phi \in [\widehat{\phi}^S, 1)$, where $\widehat{\phi}^S$ is given in Eq. (8), all MNEs locate their production plants in the low-tax country 2, i.e., $\widehat{n}_1 = 0$. At zero trade costs ($\phi = 1$), all MNEs are indifferent to the location of plants, i.e.,*

[35]Parameter values are given in Appendix 12.

$\widehat{n}_1 \in [0, 1]$.

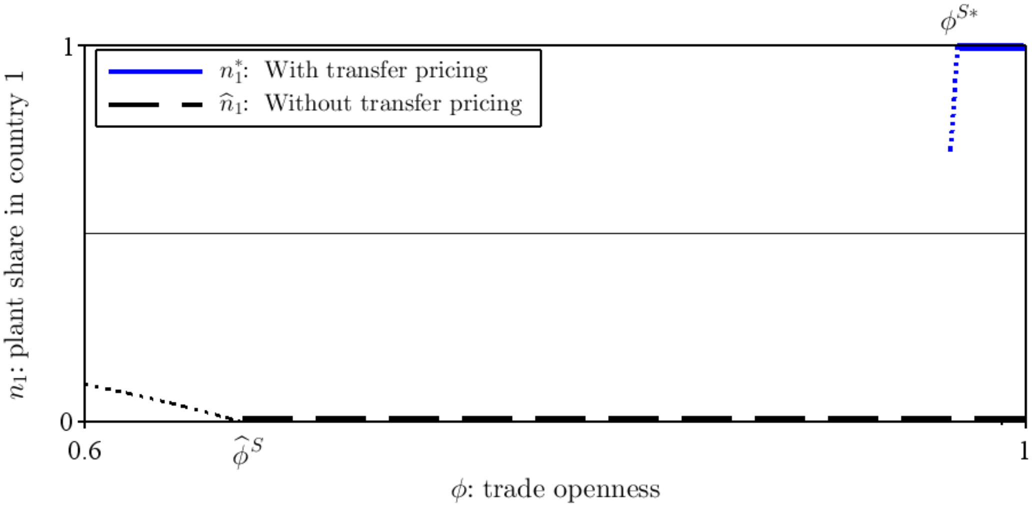

Fig. 6. Plant share under tax competition

5.2 Transfer-pricing case

We examine how the above results change if MNEs can use transfer pricing. The analyses of Section 3 indicate that when trade costs are low such that $\phi \in [\phi^S, 1]$, all production plants are agglomerated in country 1, as long as its tax rate is higher than that of country 2, even a little ($t_1 > t_2$). This situation is illustrated in Fig. 6.[36] We here derive conditions under which this situation emerges as a result of tax competition.

Suppose that all plants are in country 1 ($n_1 = 1$). From Eq. (6-1), we derive tax revenues for government 1 as

$$\begin{aligned} TR_1 &= t_1 TB_1 \\ &= t_1 \left[\frac{\mu L}{2\sigma} + N_1 \frac{(\sigma - 1)\Delta t_1}{\sigma} \frac{\phi \gamma_1 \mu L}{2\sigma(\phi \gamma_1 N_1 + N_2)} \right] \\ &= t_1 \left[\frac{\mu L}{2\sigma} + \underbrace{\frac{(\sigma - 1)\Delta t_1}{\sigma} \frac{\mu L}{2\sigma}}_{\text{Shifted profits of home plants } <0} \right], \end{aligned}$$

[36]We obtain the agglomeration threshold ϕ^{S*} in Figure 6 by evaluating ϕ^{S*} at the equilibrium tax rate $\{t_i^*\}_{i=1}^2$, which will be discussed shortly. Parameter values are given in Appendix 12.

where $L_1 = L_2 = L/2$; $N_1 = n_1 L = L$; and $N_2 = (1-n_1)L = 0$. By contrast, tax revenues for government 2 are unchanged because there are no production plants there ($N_2 = 0$), which transfer profits. From Eq. (6-2), we obtain

$$
\begin{aligned}
TR_2 &= t_2 TB_2 \\
&= t_2 \left[\frac{\mu L}{2\sigma} + \frac{(\sigma-1)\Delta t_2}{\sigma} \frac{\phi\gamma_2 \mu L N_2}{2\sigma(N_1 + \phi\gamma_2 N_2)} \right] \\
&= t_2 \cdot \frac{\mu L}{2\sigma}.
\end{aligned}
$$

The governments' payoffs then become

$$
\begin{aligned}
G_1 &= \frac{\mu L t_1}{2\sigma} \left[1 + \frac{(\sigma-1)\Delta t_1}{\sigma} \right] - \frac{\alpha_1 t_1}{1-t_1}, \\
G_2 &= \frac{\mu L t_2}{2\sigma} - \frac{\alpha_2 t_2}{1-t_2},
\end{aligned}
$$

where G_1 now involves the tax difference due to the presence of shifted profits of home plants. To prevent this tax-base erosion, government 1 has a stronger incentive to lower its tax rate than it does in the no-transfer-pricing case. By contrast, as country 2 does not have any plants that receive shifted profits, G_2 is the same as in the no-transfer-pricing case. As noted in Section 3.2, profits shifted by foreign affiliates are included in the first term of TB_i and do not show up explicitly.

From the first-order conditions, we obtain

$$
t_1^* = 1 - \sqrt{\frac{2\alpha_1\sigma}{\mu L} + \frac{(\sigma-1)(\sqrt{2\alpha_2\sigma\mu L} - 2\alpha_1\sigma)}{\mu L(2\sigma-1)}}, \tag{8-1}
$$

$$
t_2^* = 1 - \sqrt{\frac{2\alpha_2\sigma}{\mu L}} \quad (= \widehat{t}_2), \tag{8-2}
$$

where we use x^* to represent the equilibrium value of x in tax competition with transfer pricing. t_1^* and t_2^* are in $(0, 1/2)$ under our assumptions: $\alpha_1 < \alpha_2$, where $\alpha_i \in (\mu L/(3\sigma), \mu L/(2\sigma))$. To be consistent with the full agglomeration of plants in country 1, t_1^* must be higher than t_2^*. This requires sufficiently low α_1 such that $\alpha_1 < \alpha^*$, implying that government 1 is efficient enough in tax administration (see Appendix 10). As expected, t_1^* is also lower than the equilibrium tax rate without transfer pricing $\widehat{t}_1$. Introducing profit shifting intensifies tax competition in the sense that the tax difference gets narrower.

If instead α_1 is lower than α_2 but is high enough such that $\alpha_1 \in [\alpha^*, \alpha_2)$, t_1^* is equal to or lower than t_2^* and full production agglomeration in country 1 does not occur. In this case, government 1 chooses to mimic government 2's tax rate ($t_1^* = t_2^*$) and government 2 chooses the same tax rate as it does in the no-transfer-pricing case ($t_2^* = \widehat{t}_2$), giving rise to the symmetric distribution of plants ($n_1^* = 1/2$).

Thus, our main result that profit shifting leads to production agglomeration in the high-tax country for low trade costs (Proposition 1(ii)) carries over to a tax-competition framework when countries are quite different in their efficiency in tax administration. We can formally prove the following proposition by assuming that the elasticity of substitution is slightly higher than one: $\sigma > 3/2$.

Proposition 3 (Tax competition with transfer pricing). *Assume that $s_1 = 1/2$, $\alpha_1 < \alpha_2$, where $\alpha_i \in (\mu L/(3\sigma), \mu L/(2\sigma))$ as in Lemma 2, and $\sigma > 3/2$. Consider tax competition with transfer pricing under sufficiently low trade costs such that $\phi \in [\phi^S, 1]$, where ϕ^S is the agglomeration threshold. Then there exists a unique pair of equilibrium tax rates, $\{t_i^*\}_{i=1}^2$ given in Eqs. (8-1) and (8-2), which satisfy the following:*

(i). (**Country 1's tax rate vs. country 2's**) *Country 1's tax rate is higher than country 2's ($t_1^* > t_2^*$) if the level of tax-administration efficiency of government 1 is low enough: $\alpha_1 < \alpha^*$. All production plants are located in country 1 ($n_1^* = 1$) for $\phi > \phi^{S*}$, where ϕ^{S*} is the agglomeration threshold evaluated at the equilibrium tax rates.*

(ii). (**Tax rates with and without transfer pricing**) *Assume $\alpha_1 < \alpha^*$ and $\phi > \phi^{S*}$. Compared to the no-transfer-pricing case, country 1's tax rate and payoff decrease ($t_1^* < \widehat{t}_1$; $G_1(t_1^*) < G_1(\widehat{t}_1)$), whereas country 2's tax rate and payoff are unchanged ($t_2^* = \widehat{t}_2$; $G_2(t_2^*) = G_2(\widehat{t}_2)$). That is, introducing transfer pricing makes tax competition tougher ($0 < t_1^* - t_2^* < \widehat{t}_1 - \widehat{t}_2$) and leaves the world worse off ($G_1(t_1^*) + G_2(t_2^*) < G_1(\widehat{t}_1) + G_2(\widehat{t}_2)$).*

See Appendix 10 for the proof. We note that unlike the no-transfer-pricing case full production agglomeration occurs even at zero trade costs ($\phi = 1$) because MNEs can differentiate the two selling prices using transfer prices dependent on international tax difference. In Appendix 11, we also confirm that qualitatively the same results as Proposition 3 hold when the utility function takes the Cobb-Douglas form.

The conclusion that profit shifting pushes taxes downward (Proposition 3 (ii)) can be found in Haufler and Schjelderup (2000), who employ a framework of perfect competition with symmetric countries.[37] By contrast, Stöwhase (2005, 2013) obtain the opposite result: introducing profit shifting softens tax competition by increasing the equilibrium tax rates of countries.[38] In the presence of profit shifting, governments chase the shifted profits and intensify tax competition. At the same time, MNEs' can save tax payments regardless of their locations and become less sensitive to international tax differences, thereby making tax competition less severe. In Stöwhase (2005, 2013), the latter effect dominates the former, whereas the opposite is true in our model. These differing results seem to come from the fact that while Stöwhase (2005, 2013) consider a representative firm or a monopoly firm, we consider a continuum of MNEs competing with each other. The competitive environment strengthens the tax-saving incentive and thus increases the tax-base sensitivity in the high-tax country hosting full production agglomeration.

Although the result that the high-tax country achieves full production agglomeration (Proposition 3(i)) resembles the one in Baldwin and Krugman (2004) and other NEG models, their mechanism crucially differs from ours. In Baldwin and Krugman (2004), production agglomeration generates taxable rents, which are non monotonic in terms of the degree of economic integration. A higher degree of integration may expand the rents and soften tax competition. To the contrary, in our model with profit shifting, production agglomeration is harmful to the country by inducing the erosion of tax base there. One government sets a higher tax rate than the other, not because it wants to tax agglomeration rents, but because it has a more efficient tax administration.

5.3 Coordination of transfer-pricing regulation

Based on Proposition 3(ii) stating that introducing transfer pricing leaves the world worse off, one may think that international coordination of transfer-pricing regulation would make the world better off. We show that this is indeed possible as a result of mutual agreement between the two governments. We note that international coordination of *tax rates* is difficult because both governments set the dominant-strategy equilibrium tax rate and thus do not have any incentive to change it.

[37] Agrawal and Wildasin (2020) also show that globalization, defined by a decline in relocation costs, leads to tougher tax competition in a linear spatial model where agglomeration is exogenously given.

[38] Becker and Riedel (2013) obtain a similar result, although MNEs in their model cannot shift profits for tax-saving purposes.

Adding transfer-pricing regulation δ modifies the governments' payoffs as

$$G_1 = \frac{\mu L t_1}{2\sigma}\left[1 + \frac{(\sigma-1)(\Delta t_1 + \delta)}{\sigma}\right] - \frac{\alpha_1 t_1}{1-t_1},$$
$$G_2 = \frac{\mu L_2 t_2}{\sigma} - \frac{\alpha_2 t_2}{1-t_2},$$

where government 2's payoff, G_2, is unchanged since there is no plant in country 2. The associated equilibrium tax rates are

$$t_1^{**} = 1 - \sqrt{\frac{2\alpha_1\sigma}{\mu L} + \frac{(\sigma-1)[\sqrt{2\alpha_2\sigma\mu L} - 2\alpha_1\sigma(1+\delta)]}{\mu L[2\sigma - 1 + \delta(\sigma-1)]}},$$
$$t_2^{**} = 1 - \sqrt{\frac{2\alpha_2\sigma}{\mu L}} \quad (= t_2^* = \widehat{t}_2).$$

A tighter regulation (higher δ) increases t_1^{**} and thus raises government 1's payoff. Since δ does not enter G_2, government 2 is indifferent to the degree of regulation. These observations suggest a possibility of a Pareto improvement through the coordination of transfer-pricing regulation. Both governments agree on tightening the regulation to make transfer pricing impossible, i.e., $\Delta t_1 + \delta = 0$ or $\delta = (t_1 - t_2)/(1 - t_2)$. This result is summarized as follows.

Proposition 4 (Transfer-pricing regulation). *Consider tax competition with transfer pricing, as described in Proposition 3. International coordination of regulation that prohibits transfer pricing, i.e.,* $\delta = (t_1 - t_2)/(1 - t_2)$, *makes the world better off and is possible based on mutual agreement between the two countries.*

6 Conclusion

Countries with lower corporate tax rates are expected to host more multinational production. Such a simplistic view may be challenged, however, because economic integration marked by falling trade costs allows for profit shifting and may thus change the location incentive of multinationals. To investigate this, we introduced transfer pricing into a simple two-country model of trade and geography.

With high trade costs, a low-tax country attracts more production plants than a high-tax country. With low trade costs, this pattern completely reverses and production is agglomerated in the high-tax country. When low trade costs expand intra-firm trade, MNEs can use transfer pricing as both a strategic and a profit-shifting device. To shift profits, the transfer price from the high-tax to the low-tax country is set high, whereas that from the low-tax to the high-tax country is set low. This transfer-pricing strategy lowers the input cost of distribution affiliates in the low-tax country and thus makes them competitive. In contrast, distribution affiliates in the high-tax country become less competitive due to the high input cost. Therefore, MNEs prefer to locate production in the high-tax country and distribution in the low-tax country.

The main results carry over to a tax-competition framework where countries non-cooperatively choose their tax rates. The difference in equilibrium tax rates between countries results from the difference in the level of efficiency in tax administration. Unlike standard NEG models, the country hosting all production plants does not enjoy agglomeration rents from it; rather, it faces tax-base erosion due to profit shifting. Another finding is that introducing profit shifting makes tax competition fiercer by reducing the high-tax country's equilibrium tax rate.

We test our prediction using bilateral FDI data on 23 OECD countries in 2008 to 2016. The empirical exercise supports the non-monotonic effect of economic integration on the share of production affiliate out of affiliates in all sectors. Furthermore, supporting evidence can be found in existing studies such as Overesch (2009) and Goldbach et al. (2019). For example, Overesch (2009) confirms that foreign affiliates in Germany invest more, as the cross-country tax difference between their source countries and high-tax Germany increases.

Although our model is admittedly stylized, we believe that it is versatile enough to accommodate further extensions. An interesting extension is to consider various ways of profit shifting, besides transfer pricing, such as licensing fees for intellectual property rights and the choice between equity and debt financing. While we solely focus on the transfer pricing of tangible goods, these alternative ways are equally important in reality. Adding another channel of profit shifting into our model would yield different implications for production location and tax revenues. Another extension is to examine the impact of different international tax systems, such as separate accounting and formula apportionment. The system which prevents profit shifting more effectively may differ depending on the degree of economic integration. We leave these avenues for future research.

Appendices

Appendix 1. Data sources

Foreign affiliates: We take bilateral outward "Number of enterprises" data from Corporate Outward activity of multinationals by country of location–ISIC Rev 4. in OECD Statistics, covering the period 2007 to 2017. Although the data is available by sector, we only use data on "TOTAL BUSINESS SECTOR" and "MANUFACTURING" because many of sector-level data are missing. The sample consists of 23 OECD counties: Australia, Austria, Belgium, Canada, Czech Republic, Germany, Finland, France, Greece, Hungary, Israel, Italy, Japan, South Korea, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom, United States. We exclude observations with missing values and/or zero affiliates from the sample, so that the sample period is reduced to the period 2008 to 2016. Note that four European countries identified as tax havens by Zucman (2014), i.e., Ireland, Luxembourg, the Netherlands, and Switzerland, are not included in the sample.

Corporate tax rates: Data on statutory corporate tax rates and effective average tax rates are from Centre for Business Taxation Tax Database 2017 (Habu, 2017).

Trade openness: We take the bilateral distance measure from Mayer and Zignago (2011) and define the trade openness as the inverse of the log of the distance measure.

Other variables: Data on real GDP are from OECD statistics. A common-language dummy and a colony dummy are from Mayer and Zignago (2011).

Appendix 2. Derivations

Optimal transfer price. We here derive the optimal transfer price given the allocation of plants. As in the text, we focus on the case where profits are shifted from high-tax country 1 to low-tax country 2, i.e., $g_1 < \tau a$ and $g_2 > \tau a$, which is equivalent to assume $\delta < (t_1 - t_2)/(1 - t_2)$. The post-tax profit of the MNE with a plant in country 1 is

$$\begin{aligned}\Pi_1 &= (1-t_1)[(p_{11}-a)q_{11} + (g_1 - \tau a)q_{12} - \delta|g_1 - \tau a|q_{12}] + (1-t_2)(p_{12} - g_1)q_{12} - 2R_1 \\ &= (1-t_1)\left[\left(\frac{p_{11}}{P_1}\right)^{1-\sigma}\frac{\mu L_1}{\sigma} + (1+\delta)(g_1 - \tau a)\left(\frac{p_{12}}{P_2}\right)^{-\sigma}\frac{\mu L_2}{P_2}\right] + (1-t_2)\left(\frac{p_{12}}{P_2}\right)^{1-\sigma}\frac{\mu L_2}{\sigma} - 2R_1,\end{aligned}$$

$$\text{where}\quad q_{1j} = \left(\frac{p_{1j}}{P_j}\right)^{-\sigma}\frac{\mu L_j}{P_j},\quad p_{11} = \frac{\sigma a}{\sigma - 1},\quad p_{12} = \frac{\sigma g_1}{\sigma - 1},\qquad j \in \{1, 2\}.$$

The optimal transfer price is obtained from taking the first derivative with respect to g_1:

$$\frac{\partial \Pi_1}{\partial g_1} = (1-t_1)(1+\delta)\left[\left(\frac{\sigma g_1}{\sigma-1}\frac{1}{P_2}\right)^{-\sigma}\frac{\mu L_2}{P_2} - \tau a(-\sigma g_1^{-\sigma-1})\left(\frac{\sigma}{\sigma-1}\frac{1}{P_2}\right)^{-\sigma}\frac{\mu L_2}{P_2}\right]$$
$$+ (1-t_2)(1-\sigma)g_1^{-\sigma}\left(\frac{\sigma}{\sigma-1}\frac{1}{P_2}\right)^{1-\sigma}\frac{\mu L_2}{\sigma} = 0,$$
$$\rightarrow g_1 = \frac{(1+\delta)\sigma\tau a}{\sigma - \Delta t_1 + \delta(\sigma-1)},$$

where it is assumed as usual in monopolistic competition that individual firms take the price index as given: $\partial P_j/\partial g_1 = 0$. The second-order condition for the post-tax profit maximization problem requires

$$\frac{\partial^2 \Pi_1}{\partial g_1^2} = g_1^{-\sigma-2}\left(\frac{\sigma}{\sigma-1}\frac{1}{P_2}\right)^{-\sigma}\frac{\sigma\tau a(1+\delta)(1-t_1)\cdot SOC_1}{(\sigma-1)[1-t_2+(1-t_1)(\sigma-1)(1+\delta)]} < 0,$$
$$\text{where} \quad SOC_1 \equiv -(1-t_1)^2(\sigma-1)^2\delta - (1-t_2)\sigma^2 + (2t_2 - 3t_1 + 1)\sigma + t_1 - t_2,$$

This inequality holds because SOC_1 is negative while noting that $\delta > 0$; $\sigma > 1$; $t_i \in [0,1]$; and $t_1 > t_2$.

Similarly, we can derive the optimal transfer price for the MNE with a plant in country 2. Supposing that profits are shifted from high-tax country 1 to low-tax country 2, i.e., $g_2 > \tau a$, the MNE's post-tax profit is

$$\Pi_2 = (1-t_2)[(p_{22}-a)q_{22} + (g_2-\tau a)q_{21} - \delta|g_2-\tau a|q_{21}] + (1-t_1)(p_{21}-g_2)q_{21} - 2R_2$$
$$= (1-t_2)\left[\left(\frac{p_{22}}{P_2}\right)^{1-\sigma}\frac{\mu L_2}{\sigma} + (1-\delta)(g_2-\tau a)\left(\frac{p_{21}}{P_1}\right)^{-\sigma}\frac{\mu L_2}{P_2}\right] + (1-t_1)\left(\frac{p_{21}}{P_1}\right)^{1-\sigma}\frac{\mu L_1}{\sigma} - 2R_2,$$
$$\text{where} \quad q_{2j} = \left(\frac{p_{2j}}{P_j}\right)^{-\sigma}\frac{\mu L_j}{P_j}, \quad p_{22} = \frac{\sigma a}{\sigma-1}, \quad p_{21} = \frac{\sigma g_2}{\sigma-1}, \qquad j \in \{1,2\}.$$

The first-order condition is

$$\frac{\partial \Pi_2}{\partial g_2} = (1-t_1)(1-\delta)\left[\left(\frac{\sigma g_2}{\sigma-1}\frac{1}{P_1}\right)^{-\sigma}\frac{\mu L_1}{P_1} - \tau a(-\sigma g_2^{-\sigma-1})\left(\frac{\sigma}{\sigma-1}\frac{1}{P_1}\right)^{-\sigma}\frac{\mu L_1}{P_1}\right]$$
$$+ (1-t_1)(1-\sigma)g_2^{-\sigma}\left(\frac{\sigma}{\sigma-1}\frac{1}{P_1}\right)^{1-\sigma}\frac{\mu L_1}{\sigma} = 0,$$
$$\rightarrow g_2 = \frac{(1-\delta)\sigma\tau a}{\sigma - \Delta t_2 - \delta(\sigma-1)}.$$

The second-order condition requires

$$\frac{\partial^2 \Pi_2}{\partial g_2^2} = -g_2^{-\sigma-2}\left(\frac{\sigma}{\sigma-1}\frac{1}{P_2}\right)^{-\sigma}\frac{\sigma\tau a(1-\delta)(1-t_1)\cdot SOC_2}{(\sigma-1)[1-t_1+(1-t_2)(\sigma-1)(1-\delta)]} < 0,$$
$$\text{where } \; SOC_2 \equiv -(1-t_2)^2(\sigma-1)^2\delta + (1-t_1)\sigma^2 + (3t_2-2t_1-1)\sigma + t_1 - t_2.$$

The sufficient condition for this inequality is $\delta < 1$, in which case SOC_2 is positive. To be consistent with both the direction of profit shifting and the second-order conditions, we need to assume

$$\delta < \frac{t_1-t_2}{1-t_2} \; (<1).$$

Post-tax profit. The post-tax profit of the MNE with a plant in country 1 can be rewritten as

$$\begin{aligned}
\Pi_1 &= (1-t_1)\left[\frac{p_{11}^{1-\sigma}\mu L_1}{\sigma(N_1 p_{11}^{1-\sigma}+N_2 p_{21}^{1-\sigma})} + (1+\delta)\frac{g_1-\tau a}{p_{12}}\frac{p_{12}^{1-\sigma}\mu L_2}{N_1 p_{12}^{1-\sigma}+N_2 p_{22}^{1-\sigma}}\right] \\
&\qquad + (1-t_2)\frac{p_{12}^{1-\sigma}\mu L_2}{\sigma(N_1 p_{12}^{1-\sigma}+N_2 p_{22}^{1-\sigma})} - 2R_1 \\
&= (1-t_1)\left[\frac{\mu L_1}{\sigma(N_1+N_2(p_{21}/p_{11})^{1-\sigma})} + (1+\delta)\frac{g_1-\tau a}{p_{12}}\frac{(p_{12}/p_{22})^{1-\sigma}\mu L_2}{N_1(p_{12}/p_{22})^{1-\sigma}+N_2}\right] \\
&\qquad + (1-t_2)\frac{(p_{12}/p_{22})^{1-\sigma}\mu L_2}{\sigma(N_1(p_{12}/p_{22})^{1-\sigma}+N_2)} - 2R_1,
\end{aligned}$$

noting that the price index reduces to $P_i^{1-\sigma} = N_i p_{ii}^{1-\sigma} + N_j p_{ji}^{1-\sigma}$ because symmetric firms set the same price for each market. We use the results of optimal prices to obtain

$$\begin{aligned}
&\frac{p_{21}}{p_{11}} = \frac{\sigma g_2}{\sigma-1}\frac{\sigma-1}{\sigma a} = \tau\cdot\frac{\sigma(1-\delta)}{\sigma-\Delta t_2-\delta(\sigma-1)}, \\
&\to \left(\frac{p_{21}}{p_{11}}\right)^{1-\sigma} = \tau^{1-\sigma}\cdot\left(\frac{\sigma(1-\delta)}{\sigma-\Delta t_2-\delta(\sigma-1)}\right)^{1-\sigma} = \phi\cdot\gamma_2, \\
&\frac{p_{12}}{p_{22}} = \frac{\sigma g_1}{\sigma-1}\frac{\sigma-1}{\sigma a} = \tau\cdot\frac{\sigma(1+\delta)}{\sigma-\Delta t_1+\delta(\sigma-1)}, \\
&\to \left(\frac{p_{12}}{p_{22}}\right)^{1-\sigma} = \tau^{1-\sigma}\cdot\left(\frac{\sigma(1+\delta)}{\sigma-\Delta t_1+\delta(\sigma-1)}\right)^{1-\sigma} = \phi\cdot\gamma_1, \\
&\frac{g_1-\tau a}{p_{12}} = \frac{\sigma-1}{\sigma^2}\frac{\Delta t_1+\delta}{1+\delta}, \\
&\text{where } \; \phi \equiv \tau^{1-\sigma}, \quad \gamma_1 \equiv \left(\frac{\sigma(1+\delta)}{\sigma-\Delta t_1+\delta(\sigma-1)}\right)^{1-\sigma}, \quad \gamma_2 \equiv \left(\frac{\sigma(1-\delta)}{\sigma-\Delta t_2-\delta(\sigma-1)}\right)^{1-\sigma}.
\end{aligned}$$

We substitute these results into the above to obtain

$$\begin{aligned}\Pi_1 =&(1-t_1)\left[\frac{\mu L_1}{\sigma(N_1+\phi\gamma_2 N_2)}+\frac{(\sigma-1)(\Delta t_1+\delta)}{\sigma}\frac{\phi\gamma_1\mu L_2}{\sigma(\phi\gamma_1 N_1+N_2)}\right]\\ &+(1-t_2)\frac{\phi\gamma_1\mu L_2}{\sigma(\phi\gamma_1 N_1+N_2)}-2R_1,\end{aligned}$$

which is Eq. (5.1) in the text. The post-tax profit of the MNE with a plant in country 2 can be derived analogously.

For later reference, we provide Taylor approximations of γ_i as a function of Δt_i. Applying a Taylor approximation at $\Delta t_i = 0$ to γ_i gives

$$\begin{aligned}\gamma_1 &\simeq \gamma_1|_{\Delta t_1=0}+\left.\frac{\partial\gamma_1}{\partial\Delta t_1}\right|_{\Delta t_1=0}(\Delta t_1-0)\\ &=\left[\frac{\sigma(1+\delta)}{\sigma+\delta(\sigma-1)}\right]^{1-\sigma}\left[1-\frac{\sigma-1}{\sigma+\delta(\sigma-1)}\Delta t_1\right],\\ \gamma_2 &\simeq \gamma_2|_{\Delta t_2=0}+\left.\frac{\partial\gamma_2}{\partial\Delta t_2}\right|_{\Delta t_2=0}(\Delta t_2-0)\\ &=\left[\frac{\sigma(1-\delta)}{\sigma-\delta(\sigma-1)}\right]^{1-\sigma}\left[1-\frac{\sigma-1}{\sigma-\delta(\sigma-1)}\Delta t_2\right].\end{aligned}$$

These approximations are justified when $\Delta t_i = (t_j - t_i)/(1 - t_i)$ is sufficiently small. As far as our sample of 23 OECD countries in 2008 to 2016 is concerned, this is plausible because |average tax differential| / [1−(average tax rate)] = $0.077/(1 - 0.2747) = 0.1061$. If δ is set to zero, we can further simplify these expressions as

$$\gamma_i \simeq 1-\frac{\sigma-1}{\sigma}\Delta t_i, \quad i\in\{1,2\}. \tag{A1}$$

Appendix 3. Conditions for positive profits

We here derive sufficient conditions under which operating profits are positive. The operating profits are π_{11}, π_{12}, π_{21}, and π_{22}, but only π_{11} can be negative:

$$\begin{aligned}\pi_{11} &= \frac{\mu L_1}{\sigma(N_1+\phi\gamma_2 N_2)}+\underbrace{\frac{(\sigma-1)(\Delta t_1+\delta)}{\sigma}}_{<0}\frac{\phi\gamma_1\mu L_2}{\sigma(\phi\gamma_1 N_1+N_2)}\\ &=\frac{\mu L/2}{\sigma(n_1+\phi\gamma_2 n_2)}+\underbrace{\frac{(\sigma-1)(\Delta t_1+\delta)}{\sigma}}_{<0}\frac{\phi\gamma_1\mu L/2}{\sigma(\phi\gamma_1 n_1+n_2)},\end{aligned}$$

where $L_1 = L_2 = L/2$; $N_i = n_i L$; and $n_2 = 1 - n_1$. Note that $\Delta t_1 + \delta < 0$, or equivalently, $\delta < (t_1 - t_2)/(1 - t_1)$ because we assumed $\delta < \overline{\delta} \leq (t_1 - t_2)/(1 - t_2) < (t_1 - t_2)/(1 - t_1)$. We can check that π_{11} decreases with n_1:

$$\frac{\partial \pi_{11}}{\partial \phi} = -\frac{\mu\gamma_2 n_2}{2\sigma(n_1+\phi\gamma_2 n_2)^2} - \frac{\mu\gamma_1 n_2(\sigma-1)[t_1-t_2-\delta(1-t_1)]}{2\sigma^2(1-t_1)(\phi\gamma_1 n_1+n_2)^2} < 0,$$

where $\sigma > 1$ and $\delta < \overline{\delta} \leq (t_1-t_2)/(1-t_2) < (t_1-t_2)/(1-t_1)$. Since π_{11} takes the minimum value at $\phi = 1$, in which case n_1 must be one according to Proposition 1(ii-a), the sufficient condition for it to be positive is

$$\begin{aligned}
\pi_{11} &\geq \min_{\phi} \pi_{11} = \pi_{11}|_{(n_1,\phi)=(1,1)} \\
&\simeq \frac{\mu[\sigma(1+t_2-2t_1)+t_1-t_2+\delta(\sigma-1)(1-t_1)]}{2\sigma^2(1-t_1)} \\
&\geq \frac{\mu[\sigma(1+t_2-2t_1)+t_1-t_2]}{2\sigma^2(1-t_1)} > 0, \\
&\to 1+t_2-2t_1 > 0,
\end{aligned}$$

where we used the Taylor approximation (A1). The sufficient condition for this inequality is $(t_2 <)t_1 < 1/2$, which is close to 0.4076, i.e., the highest corporate tax-rate in 23 OECD countries in 2010 to 2016 (Japan in 2010 to 2012).

Appendix 4. Proof of Proposition 1

Proof of Propositions 1(i) and 1(ii). The zero-profit conditions for both type of multinationals requires

$$\begin{aligned}
&\Pi_1 = (1-t_1)\pi_{11} + (1-t_2)\pi_{12} - 2R_1 = 0, \\
&\to R_1 = [(1-t_1)\pi_{11} + (1-t_2)\pi_{12}]/2, \\
&\Pi_2 = (1-t_1)\pi_{21} + (1-t_2)\pi_{22} - 2R_2 = 0, \\
&\to R_2 = [(1-t_1)\pi_{21} + (1-t_2)\pi_{22}]/2.
\end{aligned}$$

The capital-return differential is

$$\begin{aligned}
\Delta R &\equiv 2(R_1 - R_2) \\
&= \frac{\mu s_1}{\sigma^2}\cdot\frac{\sigma(1-t_1)(1-\phi\gamma_2)-\phi\gamma_2(\sigma-1)[t_1-t_2-\delta(1-t_2)]}{n_1+\phi\gamma_2 n_2} \\
&\qquad - \frac{\mu s_2}{\sigma^2}\cdot\frac{\sigma(1-t_2)(1-\phi\gamma_1)-\phi\gamma_1(\sigma-1)[t_2-t_1+\delta(1-t_1)]}{\phi\gamma_1 n_1+n_2}. \qquad \text{(A2)}
\end{aligned}$$

$$\text{where}\quad \phi \equiv \tau^{1-\sigma}, \quad \Delta t_i \equiv \frac{t_j-t_i}{1-t_i}, \quad \text{for } i \neq j \in \{1,2\},$$

$$\gamma_1 \equiv \left(\frac{\sigma(1+\delta)}{\sigma-\Delta t_1+\delta(\sigma-1)}\right)^{1-\sigma}, \quad \gamma_2 \equiv \left(\frac{\sigma(1-\delta)}{\sigma-\Delta t_2-\delta(\sigma-1)}\right)^{1-\sigma}.$$

We here show that there exists a level of trade openness, denoted by $\phi^{\dagger}$, which satisfies

$\Delta R|_{n_1=1/2} = 0$ and that the long-run equilibrium becomes $n_1 < 1/2$ (or $n_1 > 1/2$) if $\phi < \phi^\dagger$ (or $\phi > \phi^\dagger$).

Assuming symmetric country size: $s_1 = 1/2$, we evaluate the capital-return differential at $n_1 = 1/2$:

$$\Delta R|_{n_1=1/2} = \frac{\mu \cdot F(\phi)}{\sigma^2(1+\phi\gamma_1)(1+\phi\gamma_2)},$$

where

$$\begin{aligned} F(\phi) \equiv\ & \gamma_1\gamma_2[(2-\sigma)(t_1-t_2)+\delta(\sigma-1)(2-t_1-t_2)]\phi^2 \\ & + [2\sigma\{\gamma_1(1-t_1)-\gamma_2(1-t_2)\}+(\gamma_1+\gamma_2)(t_1-t_2)+\delta(\sigma-1)\{\gamma_1(1-t_1)+\gamma_2(1-t_2)\}]\phi \\ & -\sigma(t_1-t_2), \end{aligned}$$

The sign of the capital-return differential is determined by the quadratic function of ϕ: $F(\phi)$. At the level of ϕ that satisfies $F(\phi) = 0$, the equilibrium distribution of plants becomes one-half.

We readily observe that (i)$F(\phi)$ is a quadratic function of ϕ and (ii)$F(\phi = 0) = -\sigma(t_1 - t_2) < 0$. When $\delta = 0$, we can also confirm (iii)$F(\phi = 1) < 0$:

$$F(\phi = 1) \simeq \frac{2(\sigma-1)(t_1-t_2)^3}{\sigma^2(1-t_1)(1-t_2)} > 0,$$

where the Taylor approximation (A1) is used. From these three observations, we can conclude that there exists $\phi^\dagger \in (0, 1)$ that satisfies $F(\phi) = 0$ (or equivalently $\Delta R|_{n_1=1/2} = 0$), as can be seen in Fig. A1. Regardless of the sign of the coefficient of ϕ^2, $F(\phi)$ has a unique solution in $\phi \in (0, 1)$. In addition, if $\phi < \phi^\dagger$, $F(\phi) < 0$ and thus $\Delta R|_{n_1=1/2} < 0$ holds, implying that MNEs with production in country 1 have an incentive to relocate. Thus, the long-run equilibrium must be $n_1 < 1/2$. Similarly, if $\phi > \phi^\dagger$, $F(\phi) > 0$ and thus $\Delta R|_{n_1=1/2} > 0$ holds. The positive return differential at $n_1 = 1/2$ requires that the long-run equilibrium be $n_1 > 1/2$. These findings establish Propositions 1(i) and 1(ii).

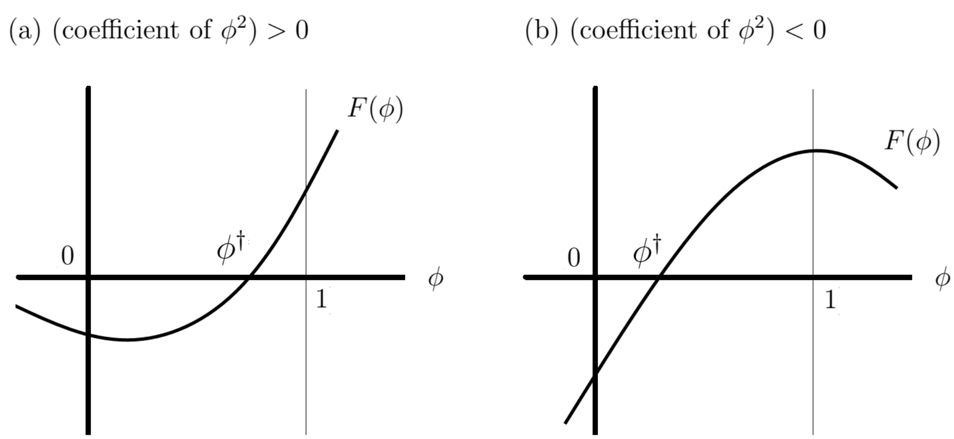

Fig. A1. Function $F(\phi)$

Proof of Proposition 1(ii-a). We first confirm that all MNEs prefer to locate their production plant in the high-tax country 1 when trade costs are zero. In other words, capital-return differential ΔR is positive irrespective of plant share n_1 at $\tau = 1$ (or $\phi = 1$). Then, we show that there exists a level of trade openness above which the full agglomeration is achieved; that is, the agglomeration threshold, or also known as the sustain point, denoted by ϕ^S. Finally, we show that ϕ^S decreases with t_1, but increases with t_2

Full agglomeration at zero trade costs. We set δ to zero and evaluate the capital-return differential (A2) at $\phi = 1$ to obtain

$$\Delta R|_{\phi=1} = \underbrace{\frac{\mu(t_2 - t_1)(\sigma - 1)}{2\sigma^2}}_{<0} \left(\frac{\omega_1}{\gamma_1 n_1 + n_2} + \frac{\omega_2}{n_1 + \gamma_2 n_2} \right),$$

$$\text{where } \ \omega_i \equiv \gamma_i + \frac{\sigma(1 - \gamma_i)}{(\sigma - 1)\Delta t_j}, \qquad \text{for } i \neq j \in \{1, 2\},$$

noting that $\Delta t_1 < 0 < \Delta t_2$ and $\gamma_1 > 1 > \gamma_2$. The capital-return differential is positive (or negative) if the big bracket term is negative (or positive). We check that the big bracket term is indeed negative. The condition for this is

$$\begin{aligned}
&\frac{\omega_1}{\gamma_1 n_1 + n_2} + \frac{\omega_2}{n_1 + \gamma_2 n_2} < 0, \\
&\to \omega_1(n_1 + \gamma_2 n_2) + \omega_2(\gamma_1 n_1 + n_2) < 0, \\
&\to n_1 \underbrace{[\omega_1(1 - \gamma_2) + \omega_2(\gamma_1 - 1)]}_{>0} + \omega_1\gamma_2 + \omega_2 < 0,
\end{aligned}$$

noting that $n_2 = 1 - n_1$ and $\gamma_1 > 1 > \gamma_2$. The inequality holds for any $n_1 \in [0, 1]$ if the following holds:

$$\begin{aligned}
&n_1[\omega_1(1 - \gamma_2) + \omega_2(\gamma_1 - 1)] + \omega_1\gamma_2 + \omega_2 \\
&< 1 \cdot [\omega_1(1 - \gamma_2) + \omega_2(\gamma_1 - 1)] + \omega_1\gamma_2 + \omega_2 \\
&= \omega_1 + \omega_2\gamma_1 < 0.
\end{aligned}$$

Using the Taylor approximation (A1), we can confirm that the inequality holds:

$$\omega_1 + \omega_2\gamma_1 \simeq -\frac{(t_1 - t_2)^2}{2\sigma^2(1 - t_1)(1 - t_2)} < 0.$$

Hence, it holds that $\Delta R|_{\phi=1} > 0$ for any $n_1 \in [0, 1]$. All MNEs are willing to establish production plants in the high-tax country 1; that is, $n_1|_{\phi=1} = 1$ is achieved in the long-run equilibrium.

Agglomeration threshold (or sustain point). Evaluating the capital-return differential

(A2) at $n_1 = 1$ gives

$$\Delta R|_{n_1=1} = \frac{\mu \cdot I(\phi)}{2\sigma^2\phi\gamma_1},$$
$$\text{where } \; I(\phi) \equiv -\gamma_1\gamma_2(1-t_2)(\sigma-\Delta t_2)\phi^2 + \gamma_1(1-t_1)(2\sigma-\Delta t_1)\phi - \sigma(1-t_2).$$

Since the denominator is positive, the sign of the profit differential is determined by $I(\phi)$. Solving $I(\phi) = 0$ for $\phi \in [0, 1]$ gives the agglomeration threshold ϕ^S (if any).

We observe that $I(\phi)$ is a quadratic function of ϕ with a negative coefficient of ϕ^2. Further inspections reveal that

$$I(\phi = 0) = -\sigma(1-t_2) < 0,$$
$$I(\phi = 1) = \sigma[2\gamma_1(1-t_1) - (1+\gamma_1\gamma_2)(1-t_2)] + \gamma_1(1+\gamma_2)(t_1-t_2) > 0,$$

noting that $2\gamma_1(1-t_1)-(1+\gamma_1\gamma_2)(1-t_2) > 2\gamma_1(1-t_1)-(1+\gamma_1)(1-t_2) = (\gamma_1-1)(1-t_1) > 0$ holds because $\gamma_1 > 1 > \gamma_2$.

These observations imply that (i) the agglomeration threshold $\phi^S \in (0, 1)$ always exists and is given by the smaller root of $I(\phi) = 0$ and that (ii) $I(\phi)$ or the capital-return differential is negative for $\phi \in [0, \phi^S)$ but positive for $\phi \in (\phi^S, 1]$.

Agglomeration threshold and taxes. As Fig. 2 clearly shows, higher $\phi^\#$, which will be given in Eq. (A3) in Appendix 5, makes ϕ^S higher. A close inspection of $\phi^\#$ reveals that

$$\frac{d\phi^\#}{dt_1} = \frac{\sigma(\sigma-1)(1-t_2)(2-t_1-t_2)(t_2-t_1)}{[(\sigma-1)(t_1-t_2)^2 + \sigma(1-t_1)(1-t_2)]^2} < 0,$$
$$\frac{d\phi^\#}{dt_2} = \frac{\sigma(\sigma-1)(1-t_2)(2-t_1-t_2)(t_1-t_2)}{[(\sigma-1)(t_1-t_2)^2 + \sigma(1-t_1)(1-t_2)]^2} > 0,$$

implying that ϕ^S also decreases (or increases) with t_1 (or t_2). As the tax difference is larger, multinational production is more likely to be agglomerated in the high-tax country 1.

Appendix 5. Proof of Proposition 2

We here show that as trade costs decline, the equilibrium share of production plants in country 1 first decreases, then increases. By solving the capital-return differential for n_1, we obtain

$$n_1 = \frac{\Upsilon - \phi\gamma_2\Upsilon'}{(1-\phi\gamma_1)\Upsilon + (1-\phi\gamma_2)\Upsilon'},$$
$$\text{where } \; \Upsilon \equiv (\sigma-\phi\gamma_2)(1-t_1) - \phi\gamma_2(1-\delta)(\sigma-1)(1-t_2),$$
$$\Upsilon' \equiv (\sigma-\phi\gamma_1)(1-t_2) - \phi\gamma_1(1+\delta)(\sigma-1)(1-t_1).$$

We differentiate this with respect to ϕ:

$$\frac{dn_1}{d\phi} = \frac{G(\phi)}{H(\phi)^2},$$

where

$$\begin{aligned}
G(\phi) &\equiv G_2\phi^2 + G_1\phi + G_0, \quad G_i\text{s are bundles of parameters of } \gamma_i,\ t_i,\ \sigma \text{ and } \delta, \\
H(\phi) &\equiv \gamma_1\gamma_2[\sigma(2-t_1-t_2) - \delta(\sigma-1)(t_1-t_2)]\phi^2 \\
&\quad -[2\sigma\{\gamma_1(1-t_1)+\gamma_2(1-t_2)\} + (\gamma_1-\gamma_2)(t_1-t_2) + \delta(\sigma-1)\{\gamma_1(1-t_1)-\gamma_2(1-t_2)\}]\phi \\
&\quad +\sigma(2-t_1-t_2)^2 > 0.
\end{aligned}$$

Because $H(\phi)^2 > 0$, the sign of the derivative, $dn_1/d\phi$, is determined by $G(\phi)$. We assume $\delta = 0$ in what follows.

We note that (i) the numerator is a quadratic function of ϕ and that (ii) $H(\phi) > 0$ for any $\phi \in [0, 1]$. Furthermore, we can verify that (iii) the slope is negative at $\phi = 0$:

$$G(\phi = 0) = G_0 \simeq -\sigma(t_1 - t_2)(2 - t_1 - t_2) < 0,$$

where we used the Taylor approximation (A1). We then solve for $\phi^{\#}$ that satisfies $dn_1/d\phi = 0$, or equivalently $G(\phi) = 0$, while assuming $\delta = 0$:

$$\phi^{\#} \simeq \frac{\sigma^2}{(\sigma - \Delta t_1)(\sigma - \Delta t_2)}, \tag{A3}$$

where the Taylor approximation (A1) is used. It can easily be confirmed that $\phi^{\#} \in (0, 1)$.

We know from Proposition 1(ii-a) that if $\delta = 0$, country 1 achieves full agglomeration with sufficiently low trade costs such that $\phi \in [\phi^S, 1]$, in which case the slope becomes zero: $dn_1/d\phi = 0$. Combining this with observations (i) to (iii), we can summarize the sign of $dn_1/d\phi$ as follows: In sum,

$$\frac{dn_1}{d\phi}\begin{cases} < 0 & \text{if} \quad \phi \in [0, \phi^{\#}) \\ = 0 & \text{if} \quad \phi = \phi^{\#} \\ > 0 & \text{if} \quad \phi \in (\phi^{\#}, \phi^S) \\ = 0 & \text{if} \quad \phi \in [\phi^S, 1] \end{cases},$$

where ϕ^S is the agglomeration threshold, which was discussed in detail in Appendix 4.

Appendix 6. Pure exporters

We here introduce pure exporters into the main model, who serve foreign market through direct exporting. Pure exporters use two units of capital as fixed inputs, one for producing goods for home market and the other for producing goods for foreign market. We assume that arm's length trade is subject to a higher level of trade costs than intra-firm trade. Letting τ^E

and τ^M be arm's length trade costs and intra-firm trade costs, this implies $\tau^E > \tau^M$. In terms of trade openness, we have $\phi^E/\phi^M = \eta \in [0, 1]$, where $\phi^E \equiv (\tau^E)^{1-\sigma}$ and $\phi^M \equiv (\tau^M)^{1-\sigma}$. Whether a firm becomes a MNE or a pure exporter is endogenously determined. The timing of actions is modified as follows. First, each firm chooses the location of a production plant in one country. Second, they decide whether to establish a export plant in the same country or to set up a distribution affiliate in the other country. The one using a distribution affiliate is called a MNE and the one not using it is called a pure exporter. Third, MNEs set transfer prices. Fourth, distribution affiliates and production plants of both MNEs and pure exporters set selling prices. Finally, production and consumption take place.

In what follows, there are three things we want to show. First, (i) given the location of production, all firms producing (or headquartered) in the high-tax country 1 become MNEs, while those producing in the low-tax country 2 become pure exporters. Second, (ii) at the prohibitive level of intra-firm trade costs ($\tau^M = \infty$ or $\phi^M = 0$), a fall in τ^M decreases the plant share in country 1. Third, (iii) at zero intra-firm trade costs ($\tau^M = 1$ or $\phi^M = 1$), all firms become MNEs and are agglomerated in country 1 if the difference between intra-firm and arm's length trade costs is sufficiently large such that $\eta < \eta^*$.

We solve the problem from the fourth stage. The superscript M (or E) stands for MNEs (or pure exporters). For a MNE with production in country 1, the pre-tax operating profits of a production plant and a distribution affiliate are

$$
\begin{aligned}
&\pi_{11}^M = (p_{11}^M - a)q_{11}^M + (g_1 - \tau^M a)q_{12}^M - \delta|g_1 - \tau^M a|q_{12}^M,\\
&\pi_{12}^M = (p_{12}^M - g_1)q_{12}^M,\\
&\text{where } \ q_{11}^M = \left(\frac{p_{11}^M}{P_1}\right)^{-\sigma}\frac{\mu L_1}{P_1}, \ \ q_{12}^M = \left(\frac{p_{12}^M}{P_2}\right)^{-\sigma},\\
&\qquad\qquad P_j = \left[\sum_{i=1}^{2}\left\{N_i^M (p_{ij}^M)^{1-\sigma} + N_i^E (p_{ij}^E)^{1-\sigma}\right\}\right]^{\frac{1}{1-\sigma}}, \quad j \in \{1, 2\},
\end{aligned}
$$

and where N_i^M is the mass of MNEs with production in country i and N_i^E the mass of pure exporters in country i. We note that pure exporters in country i locate their two production plants in the same country i. The optimal prices are

$$
p_{11}^M = \frac{\sigma a}{\sigma - 1}, \qquad p_{12}^M = \frac{\sigma g_1}{\sigma - 1}.
$$

For a pure exporter in country 1, the pre-tax operating profits consist of

$$
\begin{aligned}
&\pi_{11}^E = (p_{11}^E - a)q_{11}^E,\\
&\pi_{12}^E = (p_{12}^E - \tau^E a)q_{12}^E,\\
&\text{where } \ q_{11}^E = \left(\frac{p_{11}^E}{P_1}\right)^{-\sigma}\frac{\mu L_1}{P_1}, \ \ q_{12}^E = \left(\frac{p_{12}^E}{P_2}\right)^{-\sigma}\frac{\mu L_2}{P_2}.
\end{aligned}
$$

The optimal prices are

$$p_{11}^E = \frac{\sigma a}{\sigma - 1}(= p_{11}^M), \qquad p_{12}^E = \frac{\sigma \tau^E a}{\sigma - 1}.$$

We can similarly derive optimal prices of MNEs with production in country 2 and pure exporters in country 2.

In the third stage, MNEs with production in country 1 set transfer prices to maximize the following post-tax profits:

$$\Pi_1^M = (1-t_1)[(p_{11}^M - a)q_{11}^M + (g_1 - \tau^M a)q_{12}^M - \delta|g_1 - \tau^M a|] + (1-t_2)[(p_{12}^M - a)q_{12}^M] - 2R_1.$$

The optimal transfer price is the same as in the text:

$$g_1^M = \frac{(1+\delta)\sigma\tau^M a}{\sigma - \Delta t_1 + \delta(\sigma - 1)}.$$

Similarly, MNEs with production in country 2 sets the transfer price as

$$g_2^M = \frac{(1-\delta)\sigma\tau^M a}{\sigma - \Delta t_2 - \delta(\sigma - 1)}.$$

We substitute these optimal prices into the post-tax profit of MNEs to obtain

$$\begin{aligned}
\Pi_1^M &= (1-t_1)\pi_{11}^M + (1-t_2)\pi_{12}^M - 2R_1 \\
&= (1-t_1)\cdot\left[\frac{\mu L_1}{\sigma(N_1 + \phi^M\gamma_2 N_2^M + \phi^E N_2^E)} + \frac{(\sigma-1)(\Delta t_1 + \delta)}{\sigma}\cdot\frac{\phi^M\gamma_1\mu L_2}{\sigma(\phi^M\gamma_1 N_1^M + \phi^E N_1^E + N_2)}\right] \\
&\quad + (1-t_2)\cdot\frac{\phi^M\gamma_1\mu L_2}{\sigma(\phi^M\gamma_1 N_1^M + \phi^E N_1^E + N_2)} - 2R_1, \\
\Pi_2^M &= (1-t_1)\pi_{21}^M + (1-t_2)\pi_{22}^M - 2R_2 \\
&= (1-t_1)\cdot\frac{\phi^M\gamma_2\mu L_1}{\sigma(N_1 + \phi^M\gamma_2 N_2^M + \phi^E N_2^E)} \\
&\quad + (1-t_2)\left[\frac{\mu L_2}{\sigma(\phi^M\gamma_1 N_1^M + \phi^E N_1^E + N_2)} + \frac{(\sigma-1)(\Delta t_2 - \delta)}{\sigma}\cdot\frac{\phi^M\gamma_2\mu L_1}{\sigma(N_1 + \phi^M\gamma_2 N_2^M + \phi^E N_2^E)}\right] \\
&\quad - 2R_2,
\end{aligned}$$

where $\phi^M \equiv (\tau^M)^{1-\sigma}$; $\phi^E \equiv (\tau^E)^{1-\sigma}$; and $N_i = N_i^M + N_i^E$ is the total mass of production plants in country $i \in \{1, 2\}$. Note that pure exporters in country i locate their two plants there. The above expressions reduce to Eqs. (5-1) and (5-2) if $N_i^E = 0$. We set δ to zero in what follows.

Similarly we use the optimal prices to write the post-tax profits of pure exporters as

$$\begin{aligned}
\Pi_1^E &= (1-t_1)(\pi_{11}^E + \pi_{12}^E) - 2R_1 \\
&= (1-t_1)\left[\frac{\mu L_1}{\sigma(N_1 + \phi^M\gamma_2 N_2^M + \phi^E N_2^E)} + \frac{\phi^E \mu L_2}{\sigma(\phi^M\gamma_1 N_1^M + \phi^E N_1^E + N_2)}\right] - 2R_1, \\
\Pi_2^E &= (1-t_2)(\pi_{21}^E + \pi_{22}^E) - 2R_2 \\
&= (1-t_2)\left[\frac{\phi^E \mu L_1}{\sigma(N_1 + \phi^M\gamma_2 N_2^M + \phi^E N_2^E)} + \frac{\mu L_2}{\sigma(\phi^M\gamma_1 N_1^M + \phi^E N_1^E + N_2)}\right] - 2R_2.
\end{aligned}$$

In the second stage, given the location of production, firms choose their way of serving the foreign market, either through distribution affiliates or through exporting. A firm with plant in country i choose to use distribution affiliates if $\Pi_i^M > \Pi_i^E$. Noting that $L_1 = L_2 = L/2$ and $\phi^E = \eta\phi^M$, we have

$$\Pi_1^M - \Pi_1^E = \frac{\phi^M \mu L[\sigma(\eta\gamma_1 - 1)(1-t_1) + \eta\gamma_1(t_1 - t_2)]}{2\sigma^2(\phi^M\gamma_1 N_1^M + \eta\phi^M N_1^E + N_2)},$$

which is positive because the numerator is positive:

$$\sigma(\eta\gamma_1 - 1)(1-t_1) + \eta\gamma_1(t_1-t_2) \simeq \frac{(1-t_1)(1+t_2-2t_1)\sigma^2 + (t_1-t_2)^2(\sigma-1)}{2\sigma(1-t_1)} > 0,$$

where $\sigma > 1$; $1/2 > t_1 > t_2$; $\delta \in [0, \bar{\delta})$; $\gamma_1 > 1$; and we used the Taylor approximation (A1) from the first to the second line. This inequality implies that a firm with plant in country 1 always prefers serving the foreign market through its distribution affiliate. On the other hand, a firm with plant in country 2 always prefers direct exporting:

$$\Pi_2^M - \Pi_2^E = -\frac{\phi^M \mu L[\sigma(1-\eta\gamma_2)(1-t_2) + \eta\gamma_2(t_1-t_2)]}{2\sigma^2(N_1 + \phi^M\gamma_2 N_2^M + \eta\phi^M N_2^E)} < 0,$$

noting that $0 < \eta < 1$; $0 < \gamma_2 < 1$. In sum, (i) all firms with plant in country 1 choose to use distribution affiliate and thus there are no pure exporters' plants in country 1, i.e., $N_1^E = 0$; those with plant in country 2 choose direct exporting and thus there are no MNEs' plants in country 2 and no distribution affiliates in country 1, i.e., $N_2^M = 0$.

In the first stage, free entry and exit of firms drives the post-tax profits to zero:

$$
\begin{aligned}
&\Pi_1^M = (1-t_1)\pi_{11}^M + (1-t_2)\pi_{12}^M - 2R_1 = 0,\\
&\to 2R_1 = (1-t_1)\pi_{11}^M + (1-t_2)\pi_{12}^M,\\
&\qquad\quad = (1-t_1)\left[\frac{\mu L}{2\sigma(N_1^M + \eta\phi^M N_2^E)} + \frac{(\sigma-1)\Delta t_1}{\sigma}\cdot\frac{\phi^M\gamma_1\mu L}{2\sigma(\eta\phi^M\gamma_1 N_1^M + N_2^E)}\right]\\
&\qquad\qquad + (1-t_2)\cdot\frac{\phi^M\gamma_1\mu L}{\sigma(\phi^M\gamma_1 N_1^M + N_2^E)},\\
&\Pi_2^E = (1-t_2)(\pi_{11}^E + \pi_{12}^E) - 2R_2 = 0,\\
&\to 2R_2 = (1-t_2)(\pi_{11}^E + \pi_{12}^E)\\
&\qquad\quad = (1-t_2)\left[\frac{\eta\phi^M\mu L}{2\sigma(N_1^M + \eta\phi^M N_2^E)} + \frac{\mu L}{2\sigma(\phi^M\gamma_1 N_1^M + N_2^E)}\right].
\end{aligned}
$$

The world capital-market clearing requires that the total mass of plants/affiliates of both MNEs and pure exporters must be equal to the mass of world capital endowment: $2(N_1^M + N_2^E) = K = 2L$ or $N_1^M + N_2^E = L$. Letting $n_1 \in [0,1]$ be the world share of (the headquarters of) MNEs with production in country 1, there are $N_1^M = n_1 L$ MNEs in country 1 and $N_2^E = (1-n_1)L$ pure exporters in country 2.[39] Capital owners invest in MNEs/pure exporters who guarantee higher return: $R_i > R_j$. Solving $\Delta R \equiv 2(R_1 - R_2) = 0$ gives, if any, the interior long-run equilibrium $n_1 \in (0,1)$, which we do not show here for brevity.

We first check that (ii) a fall in intra-firm trade costs τ^M (or an increase in intra-firm trade openness ϕ^M) from the prohibitive level $\tau^M = \infty$ (or zero openness $\phi^M = 0$) decreases the share of MNEs in country 1:

$$
\left.\frac{dn_1}{d\phi^M}\right|_{\phi^M=0} \simeq -\frac{(t_1-t_2)[2\eta(1-t_2)\sigma^2 + \{1-t_2-2\eta(t_1-t_2)\}\sigma + \eta(t_1-t_2)]}{\sigma^2(2-t_1-t_2)^2} < 0,
$$

where $0 < \eta < 1$; $\sigma > 1$; and we used the Taylor approximation (A1). We then derive the conditions under which (iii) all capital owners invest in MNEs with production in country 1 at zero intra-firm trade costs ($\phi^M = 1$). Inspections of the capital-return differential at $(n_1, \phi^M) = (1,1)$ reveal

$$
\begin{aligned}
&\Delta R|_{(n_1,\phi^M)=(1,1)} = \frac{\mu\cdot\Lambda(\eta)}{2\eta\gamma_1\sigma^2},\\
&\Lambda(\eta) \equiv -\sigma\gamma_1(1-t_2)\eta^2 + \gamma_1[\sigma(1+t_2-2t_1) + t_1 - t_2]\eta + \sigma(\gamma_1-1)(1-t_2),\\
&\Lambda(\eta=0) = \sigma(\gamma_1-1)(1-t_2) > 0,\\
&\Lambda(\eta=1) \simeq -\frac{(t_1-t_2)[(1-t_2)\sigma^2 - (t_1-t_2)(2\sigma-1)]}{\sigma(1-t_1)} < 0,
\end{aligned}
$$

where $\gamma_1 > 1$; $\sigma > 1$; and we used the Taylor approximation (A1). The sign of the capital-return differential $\Delta R|_{(n_1,\phi^M)=(1,1)}$ is determined by that of $\Lambda(\eta)$. From the facts that (iii-a)

[39] In terms of plants/affiliates, country 1 has N_1^M production plants of MNEs, while country 2 has N_1^M distribution affiliates of MNEs and $2N_2^E$ production plants of pure exporters.

$\Lambda(\eta)$ is a quadratic function of η with a negative coefficient of η^2; (iii-b) $\Lambda(\eta = 0) < 0$; and (iii-c) $\Lambda(\eta = 1) > 0$, we can conclude that $\Lambda(\eta) = 0$ has a unique solution of $\eta \in (0, 1)$, which we denote as η^*, and that $\Delta R|_{(n_1,\phi^M)=(1,1)}$ is positive if $\eta \in [0, \eta^*)$.

Appendix 7. Asymmetric country size

We here allow countries to have unequal size, i.e., $s_1 \neq 1/2$, and derive conditions under which all production plants are agglomerated in the high-tax country 1 at zero trade costs ($\tau = 1$ or $\phi = 1$). We set δ to zero and evaluate the capital-return differential (A2) at $\phi = 1$ to obtain

$$\Delta R|_{\phi=1} = \underbrace{\frac{\mu(t_2 - t_1)(\sigma - 1)}{\sigma^2}}_{<0} \left(\frac{s_2\omega_1}{\gamma_1 n_1 + n_2} + \frac{s_1\omega_2}{n_1 + \gamma_2 n_2} \right),$$

$$\text{where } \; \omega_i \equiv \gamma_i + \frac{\sigma(1 - \gamma_i)}{(\sigma - 1)\Delta t_j}, \qquad \text{for } i \neq j \in \{1, 2\},$$

noting that $\Delta t_1 < 0 < \Delta t_2$ and $\gamma_1 > 1 > \gamma_2$. The capital-return differential is positive (or negative) if the big bracket term in the first line is negative (or positive). The condition for the big bracket term to be negative is

$$\begin{aligned}
&\frac{s_2\omega_1}{\gamma_1 n_1 + n_2} + \frac{s_1\omega_2}{n_1 + \gamma_2 n_2} < 0,\\
&\to s_2\omega_1(n_1 + \gamma_2 n_2) + s_1\omega_2(\gamma_1 n_1 + n_2) < 0,\\
&\to n_1 \underbrace{[s_2\omega_1(1 - \gamma_2) + s_1\omega_2(\gamma_1 - 1)]}_{>0} + s_2\omega_1\gamma_2 + s_1\omega_2 < 0,
\end{aligned}$$

noting that $n_2 = 1 - n_1$ and $\gamma_1 > 1 > \gamma_2$. The inequality holds for any $n_1 \in [0, 1]$ if the following holds

$$\begin{aligned}
&n_1[s_2\omega_1(1 - \gamma_2) + s_1\omega_2(\gamma_1 - 1)] + s_2\omega_1\gamma_2 + s_1\omega_2\\
&< 1 \cdot [s_2\omega_1(1 - \gamma_2) + s_1\omega_2(\gamma_1 - 1)] + s_2\omega_1\gamma_2 + s_1\omega_2\\
&= s_2\omega_1 + s_1\omega_2\gamma_1\\
&\simeq \frac{(t_1 - t_2)[\sigma(2s_1 - 1)(1 - t_2) - s_1(t_1 - t_2)]}{\sigma^2(1 - t_1)(1 - t_2)} < 0,
\end{aligned}$$

where we used the Taylor approximation (A1) from the second last to the last line. This inequality holds if the following holds:

$$\begin{aligned}
&\sigma(2s_1 - 1)(1 - t_2) - s_1(t_1 - t_2) < 0,\\
&\to s_1 < \frac{\sigma}{2\sigma - \Delta t_2} \equiv \overline{s}_1 \in \left(\frac{1}{2}, 1 \right).
\end{aligned}$$

As long as the high-tax country is not too large such that $s_1 < \overline{s}_1$, the capital-return differential at $\phi = 1$ is positive for any $n_1 \in [0, 1]$. In this case, production plants are agglomerated in the high-tax country 1 in the long-run equilibrium: $n_1|_{\phi=1} = 1$.

Appendix 8. Centralized decision making

In the text, we considered the case of decentralized decision making, in which the foreign affiliate chooses a price to maximize its own profit. We here examine the case of centralized decision making, where the MNE chooses all prices to maximize its total profit, using the same framework as in the text. As we shall see, the two different organization forms give qualitatively similar results.

A MNE with a plant in country 1 solves the following problem:

$$\begin{aligned}
&\max_{p_{11}, g_1, p_{12}} \Pi_1 = \max_{p_{11}, g_1, p_{12}} (1 - t_1)\pi_{11} + (1 - t_2)\pi_{12} - 2R_1, \\
&\text{where } \ \pi_{11} = (p_{11} - a)q_{11} + (g_1 - \tau a)q_{12} - C(g_1, q_{12}), \\
&\qquad\quad \pi_{12} = (p_{12} - g_1)q_{12}.
\end{aligned}$$

In contrast to decentralized decision making, p_{12} is chosen to maximize Π_1 rather than π_{12}. $C(\cdot)$ is the concealment cost specified as $C(g_i, q_{ij}) = \delta(g_i - \tau a)^2 q_{ij}$ with $\delta \geq 0$ (see Nielsen et al., 2003; Kind et al., 2005; Haufler et al., 2018 for similar specifications).

The first order conditions give the following optimal prices:

$$\begin{aligned}
&p_{11} = \frac{\sigma a}{\sigma - 1}, \quad g_1 = \tau a + \frac{\Delta t_1}{2\delta}, \quad p_{12} = \frac{\sigma a}{\sigma - 1}\left(\tau + \frac{\Delta t_1 \Delta t_2}{4a\delta}\right), \\
&\text{where } \ \Delta t_i \equiv \frac{t_j - t_i}{1 - t_i}, \quad i \neq j \in \{1, 2\}.
\end{aligned}$$

Mirror expressions hold for MNEs with production in country 2:

$$p_{22} = \frac{\sigma a}{\sigma - 1}, \quad g_2 = \tau a + \frac{\Delta t_2}{2\delta}, \quad p_{21} = \frac{\sigma a}{\sigma - 1}\left(\tau + \frac{\Delta t_1 \Delta t_2}{4a\delta}\right).$$

As in the decentralized case, g_i decreases with t_i, while it increases with t_j. Since $p_{12} = p_{21}$ and $g_1 < g_2$ hold, we see $p_{12} - g_1 > p_{21} - g_2$, implying a higher profitability of the affiliate in country 1 than that of the affiliate in country 2. As trade costs decline and the shifted profits are larger, more MNEs are likely to locate their affiliate in country 2 to exploit the higher price-cost margin. As a result, plants are agglomerated in country 1 for low trade costs. The mechanism here that transfer pricing does not just shift profits but affects profitability is very close to the one in the decentralized-decision case in the text.

Using the optimal prices, we can rewrite the post-tax profit as

$$\Pi_1 = \frac{(1-t_1)\mu L/2}{\sigma(N_1+\gamma N_2)} + (1-t_2)\left[\tau + \frac{(2\sigma-1)\Delta t_1 \Delta t_2 - 2(\sigma-1)(\Delta t_1+\Delta t_2)}{4a\delta}\right]\frac{\gamma^{\frac{\sigma}{\sigma-1}}\mu L/2}{\sigma(\gamma N_1+N_2)} - 2R_1,$$
$$\Pi_2 = \frac{(1-t_2)\mu L/2}{\sigma(\gamma N_1+N_2)} + (1-t_1)\left[\tau + \frac{(2\sigma-1)\Delta t_1 \Delta t_2 - 2(\sigma-1)(\Delta t_1+\Delta t_2)}{4a\delta}\right]\frac{\gamma^{\frac{\sigma}{\sigma-1}}\mu L/2}{\sigma(N_1+\gamma N_2)} - 2R_2,$$
$$\text{where} \quad \gamma \equiv \left(\tau + \frac{\Delta t_1 \Delta t_2}{4a\delta}\right)^{1-\sigma}.$$

Free entry and exit of firms drive these post-tax profits to zero ($\Pi_i = 0$), determining the capital-return, R_i.

As in the decentralized-decision case, the long-run equilibrium distribution of plants is interior if $R_1 - R_2 = 0$ has a solution for $n_1 \in (0,1)$. If $R_1 - R_2 > 0$ (or $R_1 - R_2 < 0$) for any $n_1 \in [0,1]$, then the economy reaches the corner equilibrium of $n_1 = 1$ (or $n_1 = 0$). We obtain

$$n_1 = \begin{cases} \dfrac{1}{2} + \dfrac{(\gamma+1)(t_1-t_2)}{2(\gamma-1)(2-t_1-t_2)} & \text{if } \tau \in (\tau^{S1}, \infty) \quad \text{(i)} \\ 0 & \text{if } \tau \in (\tau^{S2}, \tau^{S1}] \quad \text{(ii)} \\ [0,1] & \text{if } \tau = \tau^{S2} \quad \text{(iii)} \\ 1 & \text{if } \tau \in [1, \tau^{S2}) \quad \text{(iv)} \end{cases},$$
$$\text{where} \quad \gamma \equiv \left(\tau + \frac{\Delta t_1 \Delta t_2}{4a\delta}\right)^{1-\sigma}, \qquad \Delta t_i \equiv \frac{t_j - t_i}{1-t_i}, \quad i \neq j \in \{1,2\},$$
$$\tau^{S1} \equiv \left(\frac{1-t_1}{1-t_2}\right)^{\frac{1}{1-\sigma}} - \frac{\Delta t_1 \Delta t_2}{4a\delta}, \qquad \tau^{S2} \equiv 1 - \frac{\Delta t_1 \Delta t_2}{4a\delta},$$

which is illustrated in Fig. A2 (see Appendix 12 for parameter values). The horizontal dashed line represents the share at which the equilibrium share converges as trade costs go to infinity:

$$\widehat{n}_1 \equiv \lim_{\tau\to\infty} n_1 = \frac{1}{2} + \frac{t_2 - t_1}{2(2-t_1-t_2)}.$$

If trade costs are high such that $\tau \in (\tau^{S1}, \infty)$, then the low-tax country hosts more production plants than the high-tax country does. If trade costs are low such that $\tau \in [1, \tau^{S1})$, on the other hand, the high-tax country attracts all production plants. The result is qualitatively the same as that under decentralized decision making.

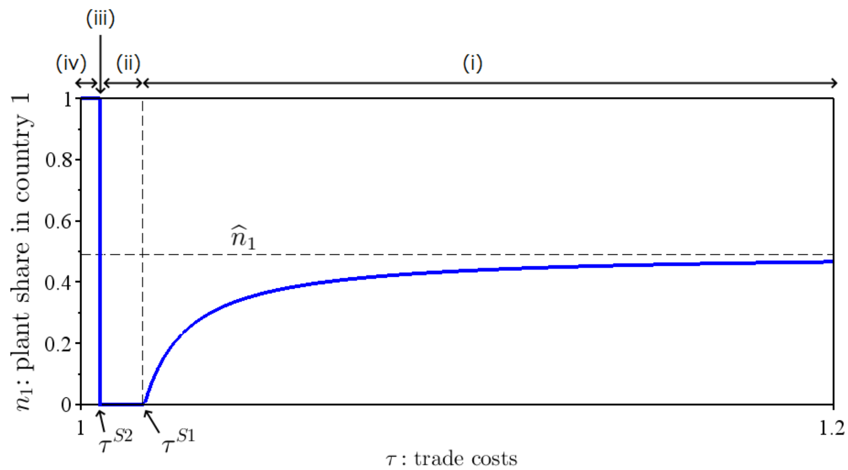

Fig. A2. Plant share under centralized decision making

Appendix 9. Proof of Lemma 2

In the no-transfer-pricing case, the capital-return differential at $n_1 = 0$ is

$$\Delta\widehat{R}|_{n_1=0} = \frac{\mu \cdot \widehat{\Theta}(\phi)}{2\sigma\phi},$$
$$\text{where } \widehat{\Theta}(\phi) \equiv (1-\phi)[1 - t_1 - \phi(1 - t_2)].$$

$\widehat{\Theta}(\phi) = 0$ has two solutions, $\phi = 1$ and $\phi = \widehat{\phi}^S$:

$$\widehat{\phi}^S \equiv \frac{1 - \widehat{t}_1}{1 - \widehat{t}_2} \in (0, 1),$$

noting $\widehat{t}_1 > \widehat{t}_2$. Clearly, $\widehat{\Theta}(\phi)$ or $\Delta\widehat{R}|_{n_1=0}$ are negative if $\phi \in (\widehat{\phi}^S, 1)$. That is, if $\phi \in (\widehat{\phi}^S, 1)$, then all production plants are located in low-tax country 2: $n_2 = 1 - n_1 = 1$, or $n_1 = 0$.

Appendix 10. Proof of Proposition 3

We first check the second-order condition (SOC) for the maximization problem. For government 2, we have

$$\frac{\partial^2 G_2}{\partial t_2^2} = -\frac{2\alpha_2}{(1 - t_2)^3} < 0.$$

Evaluating the SOC of government 1 at $t_2 = t_2^* = \widehat{t}_2$ gives

$$\left.\frac{\partial^2 G_1}{\partial t_1^2}\right|_{t_2 = t_2^*} = -\frac{\sqrt{2\alpha_2\sigma}[\sqrt{2\alpha_2\sigma^3} + (\sigma - 1)\sqrt{\mu L}]}{\sigma(1 - t_1)^3} < 0.$$

We then confirm that t_i^* lies in $(0, 1/2)$ and the government payoffs are positive. From the analysis of no-transfer-pricing case, we know that $t_2^* = \widehat{t_2} \in (0, 1/2)$ and $G_2(t_2 = t_2^*) > 0$ hold because $\alpha_1 < \alpha_2$ and $\alpha_i \in (\mu L/(3\sigma), \mu L/(2\sigma))$. We only have to confirm $t_1^* \in (0, 1/2)$. The condition for $t_1^* > 0$ is

$$t_1^* = 1 - \sqrt{\frac{2\alpha_1\sigma^2 + (\sigma-1)\sqrt{2\alpha_2\sigma\mu L}}{\mu L(2\sigma-1)}} > 0,$$
$$\rightarrow \alpha_1 < \frac{\mu L(2\sigma-1) - (\sigma-1)\sqrt{2\alpha_2\sigma\mu L}}{2\sigma^2} \equiv \alpha^\dagger.$$

As we assumed $\alpha_1 < \alpha_2$, it suffices to check $\alpha_2 \leq \alpha^\dagger$:

$$\alpha_2 \leq \alpha^\dagger \equiv \frac{\mu L(2\sigma-1) - (\sigma-1)\sqrt{2\alpha_2\sigma\mu L}}{2\sigma^2},$$
$$\rightarrow 2\alpha_2\sigma^2 + (\sigma-1)\sqrt{2\alpha_2\sigma\mu L} \leq \mu L(2\sigma-1).$$

This inequality always holds because $\alpha_2 < \mu L/(2\sigma)$:

$$2\alpha_2\sigma^2 + (\sigma-1)\sqrt{2\alpha_2\sigma\mu L} \leq 2\sigma^2 \cdot \frac{\mu L}{2\sigma} + (\sigma-1)\sqrt{2\sigma\mu L \cdot \frac{\mu L}{2\sigma}} = \mu L(2\sigma-1).$$

The condition for $t_1^* < 1/2$ is

$$t_1^* = 1 - \sqrt{\frac{2\alpha_1\sigma^2 + (\sigma-1)\sqrt{2\alpha_2\sigma\mu L}}{\mu L(2\sigma-1)}} < \frac{1}{2},$$
$$\rightarrow \alpha_1 > \frac{\mu L(2\sigma-1)/4 - (\sigma-1)\sqrt{2\alpha_2\sigma\mu L}}{2\sigma^2} \equiv \alpha^\ddagger.$$

As we assumed $\mu L/(3\sigma) < \alpha_1$, it suffices to check $\alpha^\ddagger < \mu L/(3\sigma)$:

$$\frac{\mu L(2\sigma-1)/4 - (\sigma-1)\sqrt{2\alpha_2\sigma\mu L}}{2\sigma^2} < \frac{\mu L}{3\sigma},$$
$$\rightarrow \mu L(2\sigma-3) + 12(\sigma-1)\sqrt{2\alpha_2\sigma\mu L} > 0,$$

which holds as we assumed $\sigma > 3/2$.

We can see that the government 1's payoff in equilibrium is positive:

$$\begin{aligned} G_1(t_1 = t_1^*, t_2 = t_2^*) &= \frac{\mu L t_1^*}{2\sigma}\left[1 + \frac{(\sigma-1)\Delta t_1^*}{\sigma}\right] - \frac{\alpha_1 t_1^*}{1-t_1^*} \\ &> G_1(t_1 = t_2^*, t_2 = t_2^*) = \frac{\mu L t_2^*}{2\sigma} - \frac{\alpha_1 t_2^*}{1-t_2^*} \\ &> G_2(t_2 = t_2^*) = \frac{\mu L t_2^*}{2\sigma} - \frac{\alpha_2 t_2^*}{1-t_2^*} = \left(\frac{\mu L}{2\sigma} - \alpha_2\right)^2 \\ &> 0, \end{aligned}$$

where we used $t_2^* = \widehat{t}_2 = 1 - \sqrt{2\alpha_2\sigma/(\mu L)}$ and $\alpha_1 < \alpha_2$.

(i) Country 1's tax rate vs. country 2's. We check the condition under which in the transfer-pricing case the equilibrium tax in country 1 is higher than that in country 2 ($t_1^* > t_2^*$):

$$
\begin{aligned}
& t_1^* = 1 - \sqrt{\frac{2\alpha_1\sigma^2 + (\sigma-1)\sqrt{2\alpha_2\sigma\mu L}}{\mu L(2\sigma-1)}} > 1 - \sqrt{\frac{2\alpha_2\sigma}{\mu L}} = t_2^*, \\
& \to \sqrt{\frac{2\alpha_2\sigma}{\mu L}} > \sqrt{\frac{2\alpha_1\sigma^2 + (\sigma-1)\sqrt{2\alpha_2\sigma\mu L}}{\mu L(2\sigma-1)}}, \\
& \to 2\alpha_2\sigma(2\sigma-1) > 2\alpha_1\sigma^2 + (\sigma-1)\sqrt{2\alpha_2\sigma\mu L}, \\
& \to \alpha_1 < \frac{2\alpha_2\sigma(2\sigma-1) - (\sigma-1)\sqrt{2\alpha_2\sigma\mu L}}{2\sigma^2} \equiv \alpha^*.
\end{aligned}
$$

We can further check that $\alpha^* \in (\mu L/(3\sigma), \alpha_2)$ hold in a similar manner. When ϕ is smaller than ϕ^S, all production plants are located in the high-tax country ($n_1^* = 1$) as long as $\alpha_1 < \alpha^*$ and thus $t_1^* > t_2^* (= \widehat{t}_2)$ hold. The equilibrium is unique because both government do not benefit from changes in the tax rate from the equilibrium one.

Conversely, if $\alpha \geq \alpha^*$ and thus $t_1^* \leq t_2^*$ hold, the lower tax rate of country 1 is inconsistent with the presumption that all production plants are in country 1. In this case, government 1 sets a tax rate equal to government 2's, and the plants are equally distributed between the two countries: $n_1^* = 1/2$. As both governments try to avoid tax-base erosion from full agglomeration of plants, the equal equilibrium tax rate of $t_1^* = t_2^* (= \widehat{t}_2)$is unique one.

(ii) Tax rates with and without transfer pricing. Assume $\delta = 0$ and $\alpha_1 < \alpha^*$. Supposing $t_1 > t_2$, the objective function of government 1 under the case with and without transfer pricing is summarized as

$$
\begin{aligned}
& G_1 = \frac{\mu L t_1}{2\sigma} + \mathbb{1} \underbrace{\frac{\mu L t_1}{2\sigma} \frac{(\sigma-1)\Delta t_1}{\sigma}}_{<0} - \frac{\alpha_1 t_1}{1-t_1}, \\
& \text{where} \quad \mathbb{1} = \begin{cases} 1 & \text{transfer-pricing case} \\ 0 & \text{no-transfer-pricing case} \end{cases},
\end{aligned}
$$

where the second negative term represents tax-base erosion. A higher t_1 increases the tax-base erosion:

$$
\frac{\partial}{\partial t_1} \left[\frac{\mu L t_1}{2\sigma} \frac{(\sigma-1)\Delta t_1}{\sigma} \right] = -\frac{\mu L(2\sigma-1)}{2\sigma^2} \cdot \frac{t_1(2-t_1) - t_2}{(1-t_1)^2} < 0.
$$

Using this, we can compare the marginal effect of tax on the objective with and without transfer pricing:

$$\begin{aligned}
\left.\frac{\partial G_1(\mathbb{1}=1)}{\partial t_1}\right|_{t_i=\widehat{t}_i} &= \frac{\partial}{\partial t_1}\left[\frac{\mu L t_1}{2\sigma} - \frac{\alpha_1 t_1}{1-t_1}\right]\Bigg|_{t_i=\widehat{t}_i} + \frac{\partial}{\partial t_1}\left[\frac{\mu L t_1}{2\sigma}\frac{(\sigma-1)\Delta t_1}{\sigma}\right]\Bigg|_{t_i=\widehat{t}_i} \\
&= \left.\frac{\partial G_1(\mathbb{1}=0)}{\partial t_1}\right|_{t_i=\widehat{t}_i} + \frac{\partial}{\partial t_1}\left[\frac{\mu L t_1}{2\sigma}\frac{(\sigma-1)\Delta t_1}{\sigma}\right]\Bigg|_{t_i=\widehat{t}_i} \\
&= 0 - \frac{\mu L(2\sigma-1)}{2\sigma^2}\cdot\frac{\widehat{t}_1(2-\widehat{t}_1)-\widehat{t}_2}{(1-\widehat{t}_1)^2} \\
&< 0 = \left.\frac{\partial G_1(\mathbb{1}=0)}{\partial t_1}\right|_{t_i=\widehat{t}_i},
\end{aligned}$$

where taxes are evaluated at the equilibrium under no transfer pricing: $(t_1, t_2) = (\widehat{t}_1, \widehat{t}_2)$. Government 1 has an incentive to reduce its tax rate from $\widehat{t}_1$. Since the concave objective function has a unique maximizer, government 1 sets a lower tax rate in the transfer-pricing case than in the no-transfer-pricing case: $t_1^* < \widehat{t}_1$. Under our assumption of $\alpha_1 < \alpha^*$, $t_1^* > t_2^*$ actually holds.

Appendix 11. Tax competition under the Cobb-Douglas preferences

We here check the robustness of our result that introducing transfer pricing makes the tax difference narrower using the Cobb-Douglas utility function. The main model assumed the quasi-linear utility function such that $u_1 = \mu \ln Q_1 + q_1^O$, implying that expenditures for manufacturing varieties are fixed. To see this first, let E_1 be the total expenditure for manufacturing varieties in country 1. Using Eq. (1), we calculate the goods-market clearing condition as

$$\begin{aligned}
E_1 &= \sum_{i=1}^{2}\int_{\omega\in\Omega_i} p_{i1}(\omega)q_{i1}(\omega)d\omega \\
&= \sum_{i=1}^{2}\int_{\omega\in\Omega_i}\left(\frac{p_{i1}(\omega)}{P_1}\right)^{1-\sigma}\mu L_1 d\omega \\
&= \mu L_1 P_1^{\sigma-1}\sum_{i=1}^{2}\int_{\omega\in\Omega_i} p_{i1}(\omega)^{1-\sigma}d\omega \\
&= \mu L_1 P_1^{\sigma-1}\cdot P_1^{1-\sigma} \\
&= \mu L_1,
\end{aligned}$$

which is exogenously given.

We instead adopt the Cobb-Douglas utility function such that $u_1 = Q_1^{\theta}(q_1^O)^{1-\theta}$ with $\theta \in (0,1)$ being the weight attached to the manufacturing goods. We also assume that tax revenues in each country are repatriated to its residents. The aggregate demand for variety

ω defined in Eq.(1) is modified as

$$q_{i1}(\omega) = \left(\frac{p_{i1}(\omega)}{P_1}\right)^{-\sigma} \frac{\theta(L_1 + TR_1)}{P_1},$$

where $L_1(= w_1 L_1)$ is labor income and TR_1 is tax revenues. The total expenditure is no longer constant:

$$\begin{aligned} E_1 &= \sum_{i=1}^{2} \int_{\omega \in \Omega_i} \left(\frac{p_{i1}(\omega)}{P_1}\right)^{1-\sigma} \theta(L_1 + TR_1) d\omega \\ &= \theta(L_1 + TR_1). \end{aligned}$$

We note that optimal prices are the same as those derived in the text. Using the results of optimal prices, we rearrange tax revenues as

$$\begin{aligned} TR_1 &= t_1 \cdot TB_1, \\ TB_1 &= N_1 \pi_{11} + N_2 \pi_{21} \\ &= N_1[(p_{11} - a)q_{11} + \mathbb{1}(g_1 - \tau a)q_{12}] + N_2(p_{21} - g_2)q_{21} \\ &= N_1[(p_{11} - a)q_{11} + N_2(p_{21} - g_2)q_{21}] + \mathbb{1}N_1(g_1 - \tau a)q_{12} \\ &= (N_1 p_{11} q_{11} + N_2 p_{21} q_{21})/\sigma + \mathbb{1}N_1(g_1 - \tau a)q_{12} \\ &= E_1/\sigma + \mathbb{1}N_1(g_1 - \tau a)q_{12} \\ &= \frac{\theta(L_1 + t_1 TB_1)}{\sigma} + \mathbb{1}N_1 \frac{(\sigma - 1)\Delta t_1}{\sigma} \frac{\phi\gamma_1\theta(L_2 + t_2 TB_2)}{\sigma(\phi\gamma_1 N_1 + N_2)} \end{aligned} \tag{A4-1}$$

$$\text{where } \mathbb{1} = \begin{cases} 1 & \text{transfer-pricing case} \\ 0 & \text{no-transfer-pricing case} \end{cases}.$$

Similarly, tax revenues in country 2 are given by

$$\begin{aligned} TR_2 &= t_2 \cdot TB_2, \\ TB_2 &= N_2 \pi_{22} + N_1 \pi_{12} \\ &= \frac{\theta(L_2 + t_2 TB_2)}{\sigma} + \mathbb{1}N_2 \frac{(\sigma - 1)\Delta t_2}{\sigma} \frac{\phi\gamma_2\theta(L_1 + t_1 TB_1)}{\sigma(N_1 + \phi\gamma_2 N_2)}. \end{aligned} \tag{A4-2}$$

The tax bases of the two countries are obtained by solving the system of equations: (A4-1) and (A4-2). In the following, we derive Nash-equilibrium tax rates in the case with and without transfer pricing.

No-transfer-pricing case. In the case without transfer pricing, government $i \in \{1, 2\}$'s payoff becomes

$$\begin{aligned} G_i(\mathbb{1} = 0) &= t_i TB_i - \frac{\alpha_i t_i}{1 - t_i} \\ &= \frac{\theta L_i t_i}{\sigma - \theta t_i} - \frac{\alpha_i t_i}{1 - t_i}, \end{aligned}$$

where $\alpha_1 < \alpha_2$. Solving the first-order conditions give the equilibrium tax rates:

$$\widehat{t}_i = 1 - \frac{(\sigma - \theta)\sqrt{2\alpha_i\theta}}{\sqrt{\sigma L} - \sqrt{2\alpha_i\theta}},$$

noting that the tax base does not depend on the plant distribution n_i. We assume that $\sigma > 2\alpha_2\theta/L$ and $\alpha_1 > L/2$ to ensure positive tax rates: $\widehat{t}_i > 0$, in which case the second-order conditions also hold. Clearly, $\widehat{t}_i$ decreases with α_i. Government 1 with a more efficient tax administration sets a higher tax rate than government 2 with a less efficient one.

Transfer-pricing case. In the case with transfer pricing and full production agglomeration in country 1, government 1's payoff becomes

$$\begin{aligned}
G_1(\mathbb{1} = 1) &= \frac{\theta t_1}{\sigma - \theta t_1}(L_1 + X) - \frac{\alpha_1 t_1}{1 - t_1}, \\
\text{where } \; X &\equiv \frac{(\sigma - 1)\Delta t_1}{\sigma} \cdot (L_2 + t_2 TB_2) \\
&= \frac{(\sigma - 1)\Delta t_1}{\sigma} \cdot \left(L_2 + \frac{\theta L_2 t_2}{\sigma - \theta t_2}\right) < 0.
\end{aligned}$$

X is a negative term accruing from the profits that the MNEs with production in country 1 transfer to their affiliates in country 2. It increases with t_1:

$$\frac{\partial X}{\partial t_1} = -\frac{\theta L(\sigma - 1)[\sigma(1 - t_1) + \theta\{t_2(2t_1 - 1) - t_1^2\}]}{2(1 - t_1)^2(\sigma - \theta t_1)^2(\sigma - \theta t_2)} < 0,$$

noting that $\sigma > 1$; $\theta \in (0, 1)$; and $t_i \in [0, 1]$.

Government 2's payoff is the same as that in the no-transfer-pricing case and thus its equilibrium tax rate, denoted by t_2^*, is unchanged: $t_2^* = \widehat{t}_2$. Using this, we can compare the marginal effect of tax on government 1's payoff with and without transfer pricing:

$$\begin{aligned}
\left.\frac{\partial G_1(\mathbb{1} = 1)}{\partial t_1}\right|_{t_i = \widehat{t}_i} &= \left.\frac{\partial}{\partial t_1}\left[\frac{\theta L_i t_i}{\sigma - \theta t_i} - \frac{\alpha_i t_i}{1 - t_i}\right]\right|_{t_i = \widehat{t}_i} + \left.\frac{\partial}{\partial t_1}\left[\frac{\theta t_1}{\sigma - \theta t_1}X\right]\right|_{t_i = \widehat{t}_i} \\
&= \left.\frac{\partial G_1(\mathbb{1} = 0)}{\partial t_1}\right|_{t_i = \widehat{t}_i} + \left.\frac{\partial}{\partial t_1}\left[\frac{\theta t_1}{\sigma - \theta t_1}X\right]\right|_{t_i = \widehat{t}_i} \\
&= 0 + \left.\left[\frac{\sigma\theta}{(\sigma - \theta t_1)^2}X + \frac{\theta t_1}{\sigma - \theta t_1}\frac{\partial X}{\partial t_1}\right]\right|_{t_i = \widehat{t}_i} \\
&< 0 = \left.\frac{\partial G_1(\mathbb{1} = 0)}{\partial t_1}\right|_{t_i = \widehat{t}_i}.
\end{aligned}$$

where taxes are evaluated at the equilibrium under no transfer pricing: $t_i = \widehat{t}_i$. Government 1 has an incentive to reduce its tax rate from $\widehat{t}_1$. Since the concave objective function has a unique maximizer, government 1 sets a lower tax rate in the transfer-pricing case than in the no-transfer-pricing case: $t_1^* < \widehat{t}_1$. To be consistent with full production agglomeration in country 1, we choose the range of parameters such that $t_1^* > t_2^*$ holds.

Appendix 12. Parameter values

The figures in the text were produced using the following parameter values:
Figs. 2 and 3: $\sigma = 5$, $t_1 = 0.3$, $t_2 = 0.2$, $\delta = 0$, $L = 20$, $s_1 = 0.5$, $\mu = 1$, $a = 1$.
Fig. 4: Parameter values are the same as those in Figs. 2 and 3 except for $\delta \in \{0, 0.07, 0.143\}$.
Fig. 5: Parameter values are the same as those in Figs. 2 and 3 except for $\eta \in \{0.88, 0.88135, 0.882\}$.
Fig. 6: $\sigma = 5$, $\alpha_1 = 0.3$, $\alpha_2 = 0.25$, $\delta = 0$, $L = 20$, $s_1 = 0.5$, $\mu = 1$, $a = 1$.
Fig. 7: $\sigma = 5$, $\alpha_1 = 0.3$, $\alpha_2 = 0.25$, $\delta = 0$, $L = 20$, $s_1 = 0.5$, $\mu = 1$, $a = 1$.
Fig. A1 does not depend on specific parameter values.
Fig. A2: $\sigma = 5$, $t_1 = 0.3$, $t_2 = 0.267$, $\delta = 0.1$, $L = 20$, $s_1 = 0.5$, $\mu = 1$, $a = 1$.

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