The role of mobility in tax and subsidy competition*

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Abstract

In this paper, we analyse the role of mobility in tax and subsidy competition. Our primary result is that increasing 'relocation' mobility of firms leads to increasing 'net' tax revenues under conventional assumptions. While enhanced relocation mobility intensifies tax competition, it weakens subsidy competition. The resulting fall in the governments' subsidy payments overcompensates the decline in tax revenues, leading to a rise in net tax revenues. We derive this conclusion in a model in which two governments are first engaged in subsidy competition and thereafter in tax competition, and firms locate and potentially relocate in response to the two political choices.

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1 Motivation

In this paper, we analyse the role of mobility in international tax and subsidy competition for firms. More specifically, we distinguish between two different concepts of mobility: "location" and "relocation" mobility. The first concept, location mobility, refers to the additional costs that accrue to investors when they set up a new firm or plant in a foreign country rather than in their home country. The second concept, relocation mobility, refers to the costs that arise when an already established firm or plant moves to another jurisdiction. From the perspective of public finance, the two types of mobility jointly shape the countries' tax and subsidy competition and thus affect each country's 'net' tax revenues, defined as the difference between a government's tax revenues and its subsidy payments.

Our primary result is that increasing relocation mobility leads to *increasing* net tax revenues under conventional assumptions. We derive this conclusion in a four-stage model in which two symmetric jurisdictions compete for firms with subsidies and taxes, each aiming at maximising its net revenues. In the first stage, the non-cooperative governments simultaneously set subsidies for attracting investors. In the second stage, the investors decide where they will set up their firms and receive subsidies. After subsidies have been phased out, governments simultaneously choose corporate taxes in the third stage. In the fourth stage, firms decide whether to stay or to relocate, and pay taxes accordingly.

A key feature of the model is that investors face location costs in the second stage, reflecting imperfect location mobility, and relocation costs in the fourth stage, reflecting imperfect relocation mobility. The location costs, i.e., the cost disadvantage from investing abroad, imply that investors are, on average, home biased. A home bias in investment decisions is indeed an empirically well and long established result (e.g., French and Poterba, 1991; Coeurdacier and Rey, 2013). The relocation costs imply that firms are, in general, locked in once they are operating in a country because, for instance, they develop ties with the regional economy and acquire location-specific knowledge. Reversing the initial location choice is possible but costly. The resulting lock-in effect allows governments to levy higher taxes on firms than is otherwise possible, and it provides incentives to pay subsidies to attract new firms in the first place.

Surprisingly, a decline in relocation costs leads to a rise in net revenues in the two countries under conventional assumptions although it weakens the lock-in effect and intensifies tax competition. This outcome occurs because the induced fall in taxes softens the preceding subsidy competition and is more than offset by the resulting decline in subsidy payments. By contrast, a decline in location costs tends to negatively affect each country's net revenues, since it rather intensifies subsidy competition without weakening tax competition. It thus tends to increase government payments without enhancing revenues.

Distinguishing between location and relocation costs allows us to disentangle the channels through which the different types of mobility affect net tax revenues. This is particularly important, because we cannot expect the two types of mobility costs to decrease in line with one another, since the decline in location costs is at least partly driven by forces other than those which determine the decline in relocation costs.[1] We now briefly illustrate this point.

Let us first look at the initial location choice. Investors are, on average, home biased. For a variety of reasons, they prefer to set up new firms or plants in their home region. There are, for instance, international information asymmetries which mean that even large investors are simply better informed about the economic and legal conditions at home than abroad, and this leads to higher transaction costs and greater uncertainties for foreign direct investments (FDIs). This feature is captured by our location costs.

These costs, however, have been decreasing in recent years. International legal and economic harmonisation, the progress of communication and information technologies, and the liberalisation of the world capital markets are the main reasons for this decline. All these measures make the international movement of financial capital less costly and less risky, thereby facilitating foreign investments.

Next, let us consider briefly the relocation choice. Relocation is an option, but it causes substantial opportunity costs. A firm often forges strong links with local business networks and suppliers and acquires location-specific knowledge once it has become established in a region. Local links and knowledge are both worthless in the case of relocation. Also, relocation requires not only the transfer of financial capital, but also the movement of real capital goods and human capital, which is particularly costly.

Nevertheless, we argue that the relocation costs have also been declining over time. Consider the case of a smaller high-tech or services start-up initially located in, say, the Netherlands. The main assets of such smaller firms in the high-tech and services sectors are often their highly skilled employees with a very product-specific know-how, who cannot easily be replaced. In this case, the introduction of the common European labour market substantially reduced the costs of relocating such a firm, including its key employees, to adjacent Belgium. Additionally, the development of modern communication and transportation technologies and the internationalisation of the former national economies have been diminishing the role

[1] Manjón-Antolín and Arauzo-Carod (2011) show indeed that the factors affecting start-up rates, i.e., location choices in our framework, and those affecting relocation rates differ significantly.

of the established local networks.

Alternatively, consider the case of larger firms, such as large chip manufacturers in the semiconductor industry.[2] Here the pace of the technological progress has, in some sense, substantially reduced relocation costs. In this industry, the development has been so dynamic that product life cycles are nowadays extremely short. They are, in fact, now measured in months (cf. Henisz and Macher, 2004). Consequently, new production lines are set up very frequently, for example, in order to produce a new generation of microprocessors. Once production facilities have to anyway be replaced, it is only a small step to relocate, or rather replace, the entire factory. In this sense, the relocation costs have been declining as a result of the accelerating speed of technological innovations. These costs are, in general, still positive, given the partial loss of a skilled workforce and the other downsides of relocation. However, the crucial point here is the general downward trend.

The decline in relocation costs is certainly not confined to small high-tech start-ups and large semiconductor firms, but occurs in many industries for various reasons. Irrespective of the underlying reasons, it can make existing firms more footloose, with potentially dire implications from the perspective of regional politicians. A prime example of a firm that located and relocated its production facilities within a short period of time at the expense of public finance is Nokia. From 1995 onwards, the Finnish company had received approximately €90 million in subsidies for setting up and securing mobile phone production in Bochum, Germany. Despite this substantial financial support, Nokia closed down its Bochum plant and relocated production to Cluj, Romania, in 2008 (Financial Times, 2008).[3] The politicians' hope of having "locked-in" Nokia in Bochum as a long-term future taxpayer proved to be an illusion.

The German capital Berlin experienced similarly but at a much larger scale that subsidies can fail to keep firms for long. Like most OECD countries, Germany has been supporting firms which set-up new businesses or relocated old ones. During the East-West division of Europe, and until the late 1980s, firms were particularly attracted to settle in West Berlin through the very generous Berlin subsidy ("Berlinförderung"), a place-based public support scheme offered only there. Among others, several major cigarette producers, such as British-American Tobacco (BAT), Roth-

[2] The semiconductor industry is a major example of a sector that receives headline catching public financial support. For instance, the AMD Fab 36 project in Dresden, Germany, in 2003 was officially subsidised by almost €550 million (cf. Grundig et al., 2008).

[3] A similar case occurred with Motorola, another mobile phone maker. It received about €26 million for its plant in Flensburg, Germany, before shifting production to Asia and closing down in Flensburg in 2007, only nine years after opening new facilities in this location (cf. Detje et al., 2008).

mans and Philip Morris, came to Berlin after being granted annual subsidies of up to 100,000 Deutschmarks (approximately €50,000) per job created and a generous preferential sales tax treatment for goods produced in Berlin and shipped to West Germany. While this financial support might have had the desired political effect of buttressing the "front city of the Cold War", it was unsuccessful in creating a sound and long-lasting tax base (Ahrens, 2015; Koglin, 2015). Once the subsidy programme was abandoned after German reunification in 1990 and regular taxation set in, all cigarette producers but one left Berlin, and so did firms of other industries (Tagesspiegel, 1999, 2008).[4] The substantial support for firms failed to build up a long-lasting tax base. Indeed, relocations of firms are a world-wide phenomenon. For instance, analysing the US manufacturing sector, Lee (2008) shows that on average 12% of plant openings were relocations from one US state to another.

Having noticed that the lock-in effects of initial location choices are often much weaker than expected, politicians have turned more and more critical of subsidies to attract firms. Anticipating this problem, the German-based semiconductor memory producer Qimonda already mentioned in its 2006 IPO prospectus that "[a]s a general rule, we believe that government subsidies are becoming less available in each of the countries in which we have received funding in the past" (Qimonda, 2006, pp. 26–27). This reasoning is in line with our model, which shows that increasing relocation mobility leads to lower subsidies and can be a blessing in disguise in terms of net tax revenues.

Our paper is related to the 'tax holiday' literature. In this strand of literature, governments initially grant tax holidays, or upfront subsidies, to attract foreign direct investments and to compensate firms for high time-consistent taxes in the future (e.g., Bond and Samuelson, 1986; Doyle and van Wijnbergen, 1994; Janeba, 2002; Kishore and Roy, 2014; Thomas and Worrall, 1994).[5] This policy outcome is similar

[4] A similar programme of place-based subsidies to firms, the "Zonenrandförderung", led to a different result. This programme aimed at supporting municipalities within a 40-kilometer (25 mile) corridor to the west of the inner-German border ("Zonenrandgebiet"), which were disadvantaged during the country's East-West division. It caused a shift of economic activities to the subsidised municipalities which could still be measured in 2010, although the subsidies were reduced after German reunification and eventually abandoned in 1994 (von Ehrlich and Seidel, 2015). Different from the case of the "Berlinförderung", firms by and large stayed in their communities. One important reason for this outcome can be that subsidy-induced location decisions took place mainly locally, i.e., investors from slightly outside the "Zonenrandgebiet" moved to the subsidised municipalities but effectively remained in their home region. When the scheme ended, these local firms simply stayed, as they had never found it attractive to move far away in the first place due to the nature of their businesses, and as they still benefited from slowly depreciating public infrastructure.

[5] In an alternative and complementary approach to the tax holiday literature, Chisik and Davies (2004) analyse a bilateral treaty on the taxation of FDIs. They explain the gradual reduction of tax

to our subsidy and tax structure. But, unlike the papers above, we analyse the impact of changes in location mobility and relocation mobility on net tax revenues. We also examine how the mobility of firms affects the strategic interactions between the governments in the subsidy and tax stages. By contrast, the articles referred to cannot explore this issue, as they either consider the unilateral policies of a single host country or assume a large number of potential host countries, thus excluding strategic interactions from the outset.[6]

Closer to our approach is Lee's (1997) model. He analyses a two-period model in which capital is perfectly mobile in the first period and imperfectly mobile in the second period. Governments non-cooperatively levy a tax on capital and use each period's revenues to provide a public good in the very same period. Lee's (1997) model predicts only one-way capital flows, whereas our model allows for two-way capital flows. Also, Lee (1997) focuses on the question whether the public good is oversupplied or undersupplied in the second period, ignoring the first-period outcome. By contrast, we focus on the overall impact of changes in location or relocation mobility on the net tax revenues in the two periods together, and on how these changes affect the interaction between tax and subsidy competition.

More recently, Langenmayr and Simmler (2016) analyse the market entry and relocation choices of firms which differ in their relocation mobility. In their model, local governments only decide once on taxes (and not on subsidies and taxes at different stages, as in our framework), and strategic interactions between jurisdictions play no role. While Langenmayr and Simmler (2016) can thus not tackle our questions, their empirical analysis shows that, in line with their theoretical predictions, taxes indeed rise as more immobile firms are set up in a jurisdiction. This result confirms the importance of reloction costs (in addition to, and separate from, location costs) for taxation, supporting the underlying notion of our paper. In a different vein, Ferrett et al. (2016) also explicitly consider relocation decisions. In their model, two governments compete for a single firm in each of two periods. They focus on changing characteristics of the competing regions as the main driver of relocation and show that fiscal competition can make relocation not only more likely but location choices also more efficient. By contrast, we analyse the impact of mo-

rates over time. Initially, only a treaty that specifies a small tax cut is self-enforcing. This treaty, however, generates an economic environment in which treaties with further, more substantial tax reductions become self-enforcing.

[6] Haufler and Wooton (2006) analyse regional tax and subsidy coordination within an economic union when the two members of this union compete with a third country. In their model, however, each government has only one policy instrument at its disposal, which can be either a subsidy or a corporate tax. Their paper thus differs considerably from the tax holiday literature and from our contribution.

bility on public budgets and argue that declining relocation costs of firms increase net tax revenues.

Like our paper, the literature on tax competition in models of the 'new economic geography' raises some doubts about whether increasing economic integration necessarily erodes government revenues (e.g., Baldwin and Krugman, 2004; Borck and Pflüger, 2006; Kato, 2015; Kind et al., 2000). In this strand of literature, the arguments hinge on the presence of significant agglomeration economies and the emergence of a core-periphery pattern, which allow the core to tax agglomeration rents. These agglomeration effects are absent in our paper. By contrast, our conclusion that rising relocation mobility does not harm the governments' budgets follows from the interaction between tax and subsidy competition, which is not considered in the 'new economic geography' literature.[7]

Konrad and Kovenock (2009) is related to both the tax holiday and the new economic geography literature. They analyse tax competition for 'overlapping FDIs' in a dynamic model with agglomeration advantages. The vintage property of the FDI prevents a ruinous race to the bottom as long as governments only have non-discriminatory taxes at their disposal. But if governments can also offer subsidies to new FDI, international competition will again be "cut-throat in nature." Konrad and Kovenock (2009), however, are not interested in the implications of increasing mobility. By contrast, we analyse how rising location and relocation mobility reshapes tax and subsidy competition, and how it ultimately affects net tax revenues.

Our paper proceeds as follows. In section 2, the model is presented. Section 3 investigates the outcome of the subsidy and tax competition stages. We analyse the effects of increasing location and relocation mobility on net revenues in section 4. Section 5 concludes with a brief discussion of some policy implications.

2 Governments and firms

We start by presenting our two-period, four-stage, model of tax and subsidy competition for imperfectly mobile firms. In the first period (consisting of the first and second stages; see below), the governments of two jurisdictions grant subsidies to attract investors non-cooperatively. Given these subsidies, investors then decide in which country they will set up their firms. In the second period (consisting of the third and fourth stages), the two governments levy corporate taxes. Since the firms

[7] Following a different line of reasoning, Wilson (2005), among others, argues that tax competition can be welfare-enhancing. In his model, the presence of tax competition implies that selfish governments intensify their efforts in expenditure competition in order to attract mobile capital, and this second type of competition makes residents better off by reducing government waste.

are now established in a country, they are locked-in, but only imperfectly, as we will explain in more detail below. Firms can still relocate in response to the tax policies of the jurisdictions. So there is competition for mobile firms in both periods, albeit to a different degree.

Firms Consider two symmetric countries, A and B. In each of these jurisdictions, there is a continuum of home investors, normalised to 1. Here, the term 'home' refers to the fact that there are already some links between investors and a country. For instance, the investors might simply reside in this country.

Each of the investors sets up a single firm. Despite these existing links, firms can initially be located either in the investors' home country or abroad. A firm's set up costs that occur in the first period are c if it stays in its home country, and $c + m_1$ if it moves abroad. While all firms face identical cost components c, they differ with respect to their m_1. (For notational convenience, firm indices are not used.) We label the location costs m_1 and interpret them as the mobility costs or the cost disadvantage of investing abroad in the first period. This characteristic is distributed according to the distribution function $F_1(m_1)$, whose properties are described below.

In the second period, each firm realises the (gross) return π if it continues to stay in the country where it was established in the first period. Its return is $\pi - m_2$ if it relocates in the second period. Again, π is the same for all firms, while the component m_2 differs across firms. We label the *re*location costs m_2 and interpret them as the mobility costs or the cost disadvantage of relocating in the second period. Denote the 'number' or, more correctly, mass of firms which locate in jurisdiction i in period 1 by N_i. Then, the characteristic m_2 is distributed across these N_i firms according to the new distribution function $F_2(m_2)$.

The distribution functions $F_1(m_1)$ and $F_2(m_2)$ are twice continuously differentiable and strictly increasing functions over the intervals $[\underline{m}_1, \overline{m}_1]$ and $[\underline{m}_2, \overline{m}_2]$, respectively. They fulfil

Assumption 1:

(i) $F_k(\underline{m}_k) = 0$ and $F_k(\overline{m}_k) = 1$, $k = 1, 2$, (ii) $\underline{m}_k < 0 < \overline{m}_k$, (iii) $F_k(0) < 0.5$,
(iv) $\underline{m}_1 < \underline{m}_2$ and $\overline{m}_1 < \overline{m}_2$, (v) $F_1(m) > F_2(m)$ for all $m \in (\underline{m}_1, \overline{m}_2)$,
(vi) $\partial(F_k/F_k')/\partial m_k \geq 0$ or, equivalently, $F_k''(m_k) \leq F_k'(m_k)^2/F_k(m_k)$,
(vii) $\partial[(1-F_k)/F_k']/\partial m_k \leq 0$ or, equivalently, $F_k''(m_k) \geq -F_k'(m_k)^2/[1-F_k(m_k)]$.

Properties (i) and (ii) restrict the relevant domains of the distribution functions, allowing for both positive and negative values of m_1 and m_2. In most cases, set up costs are lower in an investor's home region, since investors are more familiar with their domestic business environment than with the foreign one. This situation

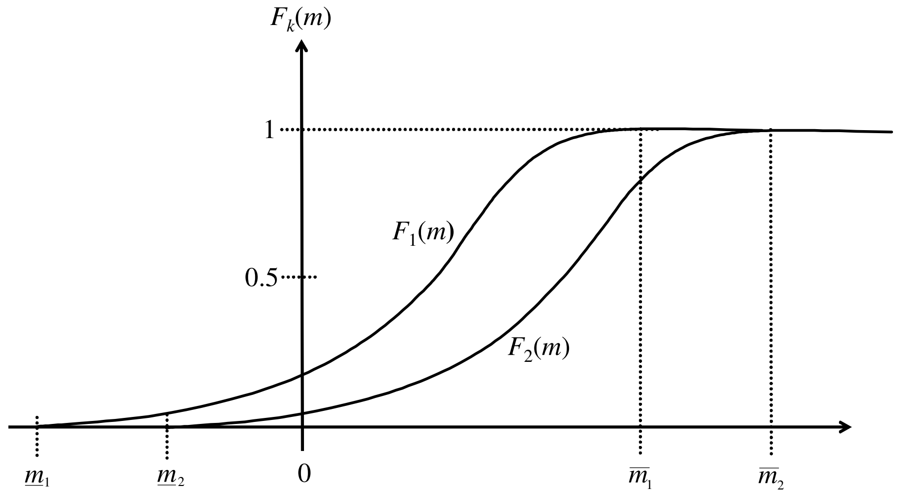

Figure 1: Distribution of location and relocation costs

corresponds with a positive m_1. But for some firms, set up costs are lower abroad. They might be able to take advantage of a particularly specialised foreign labour force. Or entrepreneurs might be able to make profitable use of their business ideas only in very specific places. For instance, a fashion label might be successful only in cities such as New York or Paris. These cases are captured by a negative m_1. Property (iii), however, implies that the set up costs of the majority of firms indeed favour their home country. Similarly, relocation costs m_2 are positive for the majority of firms. For instance, relocation after the start up phase causes the loss of immobile input factors and regional networks built up in the first period. These relocation costs, however, need not be prohibitive. Firms are thus only imperfectly locked in. Moreover, some firms might even benefit from relocating and thus increase their returns. They might, for instance, be closer to clients or suppliers.

Properties (iv) and (v) are most important for our analysis. They capture the feature that second period mobility costs m_2 exceed first period mobility costs m_1, meaning that distribution function F_2 lies to the right of F_1, as illustrated in figure 1. In other words, firms become decreasingly mobile over their life span. This 'natural' assumption reflects the imperfect lock-in effect once a firm is located in a country. It drives our results. By contrast, the properties $\underline{m}_1 < 0$ and $\underline{m}_2 < 0$ are not important for our economic mechanisms. In fact, our results would go through with $\underline{m}_1 = \underline{m}_2 = 0$.[8]

Finally, properties (vi) and (vii) impose technical restrictions on the slopes of the

[8] The 'technical' advantage of allowing negative mobility costs is that the distribution functions, and thus the governments' objective functions below, are 'smooth' for a wider range of tax and subsidy differentials. This simplifies our proofs.

density functions. Property (vi) says that the inverse hazard rate $F_k(m_k)/F'_k(m_k)$ be non-decreasing in m_k. Property (vii) is the counterpart to property (vi), saying that the ratio $[1 - F_k(m_k)]/F'_k(m_k)$ be non-increasing in m_k. These two restrictions are common in the literature (e.g., Bergemann and Strack, 2015; Konrad and Thum, 2014). They provide sufficient conditions for well-behaved objective functions by excluding too steep slopes of the distribution functions. These properties are satisfied by, among others, a uniform distribution and various specifications of the Beta distribution, which are routinely used in the case of a finite domain.

The functions F_1 and F_2 are common knowledge. Each firm learns about the realisation of its specific location costs m_1 and relocation costs m_2 before it makes its location decision in the first-period and its relocation decision in the second-period, respectively. For simplicity, we assume that a firm's first period and second period mobility costs are not correlated. This assumption enables us to put forward our arguments as simply as possible.[9]

Governments When competing for mobile firms, the non-cooperative governments have subsidies and corporate taxes at their disposal. Subsidies are used in the first period, while taxes are levied in the second period. Governments can implement preferential subsidy and tax regimes. That is, in each country subsidies would then be different for firms of home investors that receive subsidy s_i^n, and 'incoming' firms of foreign investors that receive subsidy s_i^m, where $i = A, B$.[10] Similarly, governments might set differentiated taxes. Firms that have already had their subsidised start up phase in country i then pay tax t_i^n, while those firms that relocate 'newly' to country i in the second period pay tax t_i^m.[11]

Objectives and timing Each country maximises its 'net' revenues NR_i, i.e., the difference between tax revenues R_i and subsidy payments P_i, given the decisions

[9] In fact, it is far from clear whether location and relocation costs are correlated. Take the example of a large, internationally experienced, investor. The location costs of this investor can be minor. But if he sets up a steel factory, the relocation costs will be substantial—if not prohibitive. Low location costs do not imply low relocation costs, and vice versa.

[10] As governments do not know the mobility characteristics of the investors, they cannot offer type-specific subsidies. This assumption is most appropriate for small and medium-sized firms which operate in nascent or rapidly changing high-tech markets. However, even in the case of large firms, governments often find it difficult to predict how mobile investors are before, as well as after, the initial investment, as the example of Nokia in section 1 illustrates.

[11] A firm is 'domestic' in the country where it is set up, and it is taxed accordingly in the second period. At this stage, a government discriminates between domestic and foreign firms, i.e., according to the firms' initial location, but it treats all domestically set up firms equally. Importantly, in our setting, there are no incentives for governments to discriminate between domestic firms—as defined above—according to the home base of their investors.

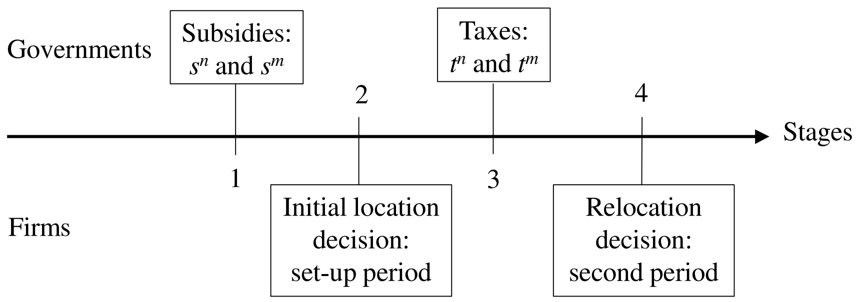

Figure 2: Timing and decisions

of its opponent. As usual, investors maximise the net profits of their firms, taking into account (gross) return π, set up costs c, firm specific mobility costs m_1 and m_2, subsidies s_i^n and s_j^m, and taxes t_i^n and t_j^m.

The precise timing of the subsidy and tax competition game between the two governments is as follows. In the first stage, the non-cooperative governments simultaneously set subsidies s_A^n, s_A^m, s_B^n and s_B^m. Given these subsidies, investors decide in the second stage whether their firms locate and receive subsidies in either country A or country B. In the third stage, the governments simultaneously set their taxes t_A^n, t_A^m, t_B^n and t_B^m, again non-cooperatively. In the fourth stage, firms decide whether they stay or relocate, and pay their taxes accordingly.

This decision structure is illustrated in figure 2. In terms of time periods, the first two stages can be interpreted as constituting period 1, the third and fourth stages as constituting period 2. As mentioned above, the specific location costs for each firm are revealed prior to the location decision at the beginning of the second stage. Similarly, the relocation costs are revealed to each firm prior to the relocation decision at the beginning of the fourth stage. The distribution of these costs is common knowledge.

3 Subsidy and tax competition

As usual, we solve our model by backward induction, starting with the tax competition stages and then going on to the subsidy competition stages.

3.1 Tax competition

The firms' decisions in the fourth stage are straightforward. A firm that was set up in region i in the first period can stay in this region and receive net return $\pi - t_i^n$ (first period costs and subsidies are sunk at this stage). Alternatively it can move to region j and gain the net return $\pi - m_2 - t_j^m$. A profit maximising firm thus stays in region i (relocates to region j) if, and only if,

$$m_2 \geq t_i^n - t_j^m \qquad (m_2 < t_i^n - t_j^m), \tag{1}$$

i.e., if, and only if, the tax differential between the countries is smaller (strictly larger) than the firm-specific relocation costs.[12] Consequently, the share of firms relocating from region i to j is $F_2(t_i^n - t_j^m)$.

Then the tax revenues of government i are

$$R_i\left(t_i^n, t_i^m\right) = t_i^n \left[1 - F_2(t_i^n - t_j^m)\right] N_i + t_i^m F_2(t_j^n - t_i^m) N_j, \tag{2}$$

where N_i and N_j result from the firms' decisions in the second stage. The first term on the right-hand side captures the tax revenues from all firms that were already located in country i in the first period (indicated by N_i) and stay there in the second period.[13] By contrast, the second term refers to the revenues from those firms that were initially located in country j (indicated by N_j) and only enter country i in the second period.

In the third stage, government i chooses taxes t_i^n and t_i^m that maximise revenues R_i, given the choices of its competitor (previous subsidy payments are sunk at this stage). The optimal taxes are characterised by the first-order conditions

$$\frac{\partial R_i}{\partial t_i^n} = 0 \quad \Leftrightarrow \quad \varepsilon_i^n := \frac{F_2'(t_i^n - t_j^m) t_i^n}{1 - F_2(t_i^n - t_j^m)} = 1, \tag{3}$$

$$\frac{\partial R_i}{\partial t_i^m} = 0 \quad \Leftrightarrow \quad \varepsilon_i^m := \frac{F_2'(t_j^n - t_i^m) t_i^m}{F_2(t_j^n - t_i^m)} = 1, \tag{4}$$

where ε_i^n and ε_i^m denote the elasticities of the tax bases with respect to the taxes t_i^n and t_i^m, respectively. These elasticity rules reflect the traditional trade-off: a higher tax rate increases the revenues from the firms ultimately located in country i, but reduces the number of those firms.

The first-order conditions (3) and (4) define the governments' reaction functions. The resultant equilibrium taxes are implicitly given by

$$t_i^n = \frac{1 - F_2(t_i^n - t_j^m)}{F_2'(t_i^n - t_j^m)} \quad \text{and} \quad t_i^m = \frac{F_2(t_j^n - t_i^m)}{F_2'(t_j^n - t_i^m)}, \tag{5}$$

[12] In principle, subsidies could be contingent on performance. In reality, incomplete contracts and other problems will make it difficult for governments to reclaim subsidies even if firms fail to comply with performance requirements and relocate their production facilities. At most, a firm will be forced to pay back a part of its subsidy in the case of plant closure and relocation. This would obviously increase the relocation costs of the firm and modify condition (1), but it would not change our conclusions qualitatively.

[13] Recall that function F_2 characterises the distribution of relocation costs of all firms whose start-up phase was in the same country, independent of the original home region of their investors.

yielding a positive tax differential[14]

$$\Delta t_{ij} := t_i^n - t_j^m = \frac{1 - 2F_2(t_i^n - t_j^m)}{F_2'(t_i^n - t_j^m)} > 0. \tag{6}$$

As equilibrium taxes are symmetric, i.e., $t_i^n = t_j^n$ and $t_i^m = t_j^m$, so are equilibrium tax differentials, i.e., $\Delta t_{ij} = \Delta t_{ii} := t_i^n - t_i^m > 0$.

These solutions contain four important conclusions. First, government i's tax on firms already established in country i in the first period exceeds the tax on firms that move to region i only in the second period, i.e., $t_i^n > t_i^m$. This tax differential arises because firms are locked in, at least imperfectly, once they have settled in a country. Since firms respond less elastically to an increase in the 'domestic' tax t_i^n than to one in the 'foreign' tax t_j^m, they end up with higher tax payments if they stick to their initial location choice, leading to positive tax differentials $\Delta t_{ij} = \Delta t_{ii}$. Nevertheless, the majority of investors set up their firms in their home region, i.e., $F_2(t_j^n - t_i^m) < 0.5$ in equilibrium. This outcome simply reflects the home bias and is in line with empirical evidence.[15]

Second, the home bias and the induced positive tax differential $\Delta t_{ii} := t_i^n - t_i^m$ translate into a positive revenue differential $\Delta\Omega_{ii} := \Omega_i^n - \Omega_i^m$, where $\Omega_i^n := t_i^n \left[1 - F_2(t_i^n - t_j^m)\right]$ and $\Omega_i^m := t_i^m F_2(t_j^n - t_i^m)$. The terms Ω_i^n and Ω_i^m stand for the tax revenues that country i can expect in the second period from a firm initially set up in country i and j, respectively. The revenue component Ω_i^n exceeds Ω_i^m, as the share $\left[1 - F_2(t_i^n - t_j^m)\right]$ is greater than $F_2(t_i^n - t_j^m)$, due to the home bias and despite the tax differential, and, additionally, the tax t_i^n is higher than t_i^m. More precisely, using conditions (5) and (6), we get

$$\Delta\Omega_{ii} := \Omega_i^n - \Omega_i^m = \Omega_i^n - \Omega_j^m = t_i^n - t_j^m = t_i^n - t_i^m =: \Delta t_{ii} > 0 \tag{7}$$

in equilibrium. That is, the revenue differential is exactly equal to the tax differential. As the revenue differential is positive, attracting investors in the first period increases tax revenues in the second period. This sets the stage for subsidy competition in the first period.

Third, taxes are independent of the number of firms N_i and thus independent of subsidies. By contrast, the optimal subsidies in the first stage are shaped by the future taxes, as will soon become evident. In this sense, there is a one-way link between tax and subsidy competition.

[14] We can exclude $t_i^n - t_j^m < 0$, since this implies $F_2(t_i^n - t_j^m) < 0.5$ and thus $\left[1 - 2F_2(t_i^n - t_j^m)\right] / F_2'(t_i^n - t_j^m) > 0$, which is obviously a contradiction. Therefore, $t_i^n - t_j^m > 0$ results (see Haupt and Peters, 2005).

[15] Formally, a positive tax differential $\Delta t_{ij} := \left[1 - 2F_2(t_i^n - t_j^m)\right] / F_2'(t_i^n - t_j^m) > 0$ directly implies $F_2(t_i^n - t_j^m) < 0.5$ (see Haupt and Peters, 2005).

Fourth, the solutions (5) and (6) immediately give us the outcome of traditional tax competition without preceding subsidy competition. Consider the variation of our model in which the two governments non-cooperatively set taxes in the first stage, aiming at maximising their tax revenues, and investors decide on their location in the second stage, facing location costs as captured by the distribution function $F_1(m_1)$. Firms cannot relocate, as the game ends after the second stage. All other assumptions remain valid. Then the tax revenues of country i are $\Upsilon_i\left(\tau_i^n, \tau_i^m\right) = \tau_i^n\left[1 - F_1(\tau_i^n - \tau_j^m)\right] + \tau_i^m F_1(\tau_j^n - \tau_i^m)$, where Υ_i, τ_i^n, τ_i^m, τ_j^n and τ_j^m now denote the revenues and taxes to differentiate them from their counterparts R_i, t_i^n, t_i^m, t_j^n and t_j^m in our extended model with subsidy competition. The equilibrium taxes and tax differential are implicitly given by

$$\tau_i^n = \frac{1 - F_1(\tau_i^n - \tau_j^m)}{F_1'(\tau_i^n - \tau_j^m)}, \; \tau_i^m = \frac{F_1(\tau_j^n - \tau_i^m)}{F_1'(\tau_j^n - \tau_i^m)}, \; \tau_i^n - \tau_j^m = \frac{1 - 2F_1(\tau_i^n - \tau_j^m)}{F_1'(\tau_i^n - \tau_j^m)} > 0, \quad (8)$$

which are completely in line with solutions (5) and (6). We coin the terms *hypothetical taxes* for τ_i^n and τ_i^m and *hypothetical revenues* for $\Upsilon_i\left(\tau_i^n, \tau_i^m\right)$, as they refer to the outcome in the 'hypothetical' case with tax competition only, and will refer to them in our analysis below.

The equilibrium values (5) and (6) are analogous to the results in Haupt and Peters (2005). We derive these results in a more general setting than Haupt and Peters (2005) with respect to mobility. More importantly, they only consider tax competition and completely ignore subsidy competition while we are interested precisely in the relationship between tax and subsidy competition, and we analyse the resulting net tax revenues. Let us therefore turn next to the subsidy competition between the governments.

3.2 Subsidy competition

Since the tax t_A^n (t_A^m) is equal to t_B^n (t_B^m), and since the distributions of migration costs m_2 are the same in the two countries, a firm's expected performance in the second period is independent of its location in the first period. The location choice in the second stage, however, affects a firm's overall net profit through its location costs and received subsidy. A home investor of country i has net costs of $c - s_i^n$ ($c + m_1 - s_j^m$) in the first period if its firm is set up in country i (country j). This firm is thus located in country i (country j) in the second stage if, and only if,

$$m_1 \geq s_j^m - s_i^n \qquad (m_1 < s_j^m - s_i^n), \quad (9)$$

i.e., if, and only if, the subsidy differential between the countries is smaller (strictly larger) than the firm-specific location costs. The resultant share of i's investors who locate their firms in country j is $F_1(s_j^m - s_i^n)$. Consequently, the number of firms established in country i is

$$N_i = \underbrace{\left[1 - F_1(s_j^m - s_i^n)\right]}_{=H_i} + \underbrace{F_1(s_i^m - s_j^n)}_{=1-H_j}, \tag{10}$$

where H_i is the number of i's investors setting up their firms in country i and $(1-H_j)$ is the number of j's investors locating their firms in country i.

In the first stage, each government chooses its subsidies s_i^n and s_i^m, given the subsidies of its opponent. Government i maximises its net tax revenues

$$NR_i = \Omega_i^n \left[H_i + (1 - H_j)\right] + \Omega_i^m \left[(1 - H_i) + H_j\right] - s_i^n H_i - s_i^m (1 - H_j), \tag{11}$$

where $\Omega_i^n := t_i^n \left[1 - F_2(t_i^n - t_j^m)\right]$ and $\Omega_i^m := t_j^m F_2(t_j^n - t_i^m)$ are the expected second-period tax payments of a firm initially set up in country i and j, respectively, as already discussed in section 3.1. The first two terms on the right-hand side thus capture future tax revenues while the third and the fourth term give the subsidy payments to home and foreign investors.

The optimal subsidies are implicitly given by the first-order conditions

$$\frac{dNR_i}{ds_i^n} = -\left[1 - F_1(s_j^m - s_i^n)\right] + \left[\Omega_i^n - \Omega_i^m - s_i^n\right] F_1'(s_j^m - s_i^n) = 0, \tag{12}$$

$$\frac{dNR_i}{ds_i^m} = -F_1(s_i^m - s_j^n) + \left[\Omega_i^n - \Omega_i^m - s_i^m\right] F_1'(s_i^m - s_j^n) = 0. \tag{13}$$

A marginal rise in the subsidies s_i^n and s_i^m increases government spending by the number of recipients H_i and $1 - H_j$, respectively. This negative effect of today's subsidies on net tax revenues is captured by the first term of each of the two derivatives.

By contrast, the second term of each derivative shows the positive impact of today's subsidy on net revenues. As government i's expected future tax revenue from a firm is Ω_i^n if this firm is set up in country i, but only Ω_i^m if the firm is set up in country j, attracting an additional investor in the first period increases future tax revenues by the differential $\Delta\Omega_{ii} := \Omega_i^n - \Omega_i^m$. Taking into account the subsidy payments, the net benefit of gaining an additional home and foreign investor is $\Delta\Omega_{ii} - s_i^n$ and $\Delta\Omega_{ii} - s_i^m$, respectively. Finally, the derivatives $F_1'(s_j^m - s_i^n)$ and $F_1'(s_i^m - s_j^n)$ tell us how the number of firms established in country i changes in response to a marginal rise in subsidies s_i^n and s_i^m.

From the first-order conditions, the equilibrium subsidies and subsidy differential follow immediately:

$$s_i^n = \Delta\Omega_{ii} - \tau_i^n, \quad s_i^m = \Delta\Omega_{ii} - \tau_i^m, \tag{14}$$

$$\Delta s_{ij} := s_i^m - s_j^n = \tau_i^n - \tau_j^m =: \Delta\tau_{ij} = \frac{1 - 2F_1(\tau_i^n - \tau_j^m)}{F_1'(\tau_i^n - \tau_j^m)} > 0, \tag{15}$$

where $\Delta\Omega_{ii}$, τ_i^n and τ_i^m are given by (7) and (8). Not surprisingly, the equilibrium subsidies are symmetric, i.e., $s_i^n = s_j^n$ and $s_i^m = s_j^m$, implying symmetric differentials $\Delta s_{ij} = \Delta s_{ii} := s_i^m - s_i^n = \tau_i^n - \tau_i^m =: \Delta\tau_{ii} = \Delta\tau_{ij}$.

These equilibrium values have a straightforward interpretation. If there were no revenue differential $\Delta\Omega_{ii}$, there would be no incentives to attract investors with subsidies, and firms would have had to pay the hypothetical taxes τ_i^n and τ_i^m in the first period (that is, the same taxes that would result if there were no second period). These taxes are 'cut' by the expected revenue differential (7). In this sense, governments give up current revenues for the benefit of having future ones. But only if the future gain $\Delta\Omega_{ii}$ strictly exceeds the hypothetical tax τ_i^n or τ_i^m, will the subsidy s_i^n or s_i^m indeed be positive (see equilibrium solution (14)). This outcome, in turn, requires a sufficiently strong lock-in effect.

Each government grants a higher subsidy to foreign investors than to domestic ones. This preferential treatment reflects the initial home bias and corresponds with our previous conclusion about preferential tax treatment (see differentials (6) and (15)). Since investors respond less elastically to subsidy changes at home than to those abroad, they receive less public support for setting up their firms in their home country than for doing so in the other country. As equilibrium solution (15) shows, the resulting subsidy differential mirrors the hypothetical tax differential, which emerges for the very same reasons for which the tax differential (6) arises.

There is also an alternative interpretation of the first-order conditions (12) and (13). Using *hypothetical* taxes $\tau_i^n = \Delta\Omega_{ii} - s_i^n$ and $\tau_i^m = \Delta\Omega_{ii} - s_i^m$ and the subsidy differential (15) to reformulate these conditions, we get

$$\eta_i^n := \frac{F_1'(\tau_i^n - \tau_j^m)\tau_i^n}{1 - F_1(\tau_i^n - \tau_j^m)} = 1 \quad \text{and} \quad \eta_i^m := \frac{F_1'(\tau_j^n - \tau_i^m)\tau_i^m}{F_1(\tau_j^n - \tau_i^m)} = 1. \tag{16}$$

The similarity between the elasticity rules (3) and (4) on the one hand and (16) on the other hand is striking and proves to be convenient later on.

We have so far side-stepped the more technical topics of existence and uniqueness of the equilibrium. These issues are taken up in lemma 1.

Lemma 1 *Tax and subsidy competition.*
A subgame perfect equilibrium exists and is unique. Equilibrium taxes and subsidies satisfy conditions (5), (6), (8), (14) and (15). Moreover, $N_i = N_j = 1$ *and* $H_i = H_j$ *result for the numbers, or masses, of firms.*

Proof: *See appendix.* □

3.3 Net tax revenues

In a standard, one-period tax competition game, governments would levy the hypothetical taxes τ_i^n and τ_i^m which are implicitly determined by condition (8). In our extended model, governments aim at attracting investors in the first period for the sake of higher tax revenues in the second period. To this end, they are willing to forego hypothetical taxes τ_i^n and τ_i^m in the first period and to additionally pay subsidies s_i^n and s_i^m if the lock-in effect is sufficiently strong. With this in mind, let us define country i's opportunity costs C_i^n (C_i^m) of attracting a domestic (foreign) investor in the first period as the sum of the subsidy s_i^n (s_i^m) paid to this investor and the foregone hypothetical taxes τ_i^n (τ_i^m) of this investor, i.e., the tax this investor who set up her firm in country i would have paid if there were no second period. These opportunity costs then amount to

$$C_i^n = s_i^n + \tau_i^n = \Delta\Omega_{ii} - \tau_i^n + \tau_i^n = \Delta\Omega_{ii} = \Delta\Omega_{ii} - \tau_i^m + \tau_i^m = s_i^m + \tau_i^m = C_i^m, \quad (17)$$

where we used equilibrium condition (14). That is, the opportunity costs are the same for attracting a domestic and a foreign investor, and they equal the second-period revenue differential $\Delta\Omega_{ii}$.

Recall that the revenue differential $\Delta\Omega_{ii}$ is exactly the difference between the expected second-period tax revenues from a firm initially set up in country i (i.e., $\Omega_i^n = \Delta\Omega_{ii} + \Omega_i^m$) and those from a firm initially set up in country j (i.e., Ω_i^m). Hence, the expected second-period gain from attracting an investor in the first period is exactly offset by the associated opportunity costs. We refer to this outcome as the *What-You-Give-Is-What-You-Get* (WYGIWYG) *principle.* This principle carries over from the individual to the aggregate level and thus reappears in each country's net tax revenues:

$$NR_i = \overbrace{\underbrace{\Delta\Omega_{ii}}_{\text{rev diff}} + \underbrace{2\Omega_i^m}_{\text{basic rev}}}^{\text{revenues } R_i} - \overbrace{[\underbrace{\Delta\Omega_{ii}}_{\text{opp costs } C_i^n = C_i^m} - \underbrace{[\tau_i^n H_i + \tau_i^m (1 - H_j)]}_{\text{hypo tax revenues } \Upsilon_i}]}^{\text{subsidy payments } P_i}. \quad (18)$$

where we used the equilibrium outcome (14) and $N_i = N_j = 1$.

Rearranging revenues $R_i = \Omega_i^n + \Omega_i^m = \Delta\Omega_{ii} + 2\Omega_i^m$, we can split up country i's aggregate revenues into the two components $\Delta\Omega_{ii}$ and $2\Omega_i^m$. The first component (*rev diff*) captures the additional tax revenues that arise because firms of mass 1 are initially set up in the country i. Due to the lock-in effect, these firms contribute $\Omega_i^n = t_i^n [1 - F_2(\Delta t_{ij})]$ to country i's second-period revenues, while they would have paid only $\Omega_i^m = t_i^m F_2(\Delta t_{ji})$ in taxes in country i if they had initially been set up in country j, with only $F_2(\Delta t_{ji})$ of them relocating to country i and paying a tax of only t_i^m. As each country attracts investors of mass 1 in the first period, the aggregate revenue differential $\Delta\Omega_{ii} N_i$ equals the expected individual revenue differential $\Delta\Omega_{ii}$.

The second component captures the remaining tax revenues and is coined basic revenues (*basic rev*). By construction, they are equal to the tax revenues that would accrue to country i if no firm were located there in the first period. In this case, all firms would have been set up in country j, but the share $F_2(\Delta t_{ji})$ of these firms of mass 2 would have relocated in the second period, generating revenues of $t_i^m 2F_2(\Delta t_{ji}) = 2\Omega_i^m$.

The subsidy payments P_i can also be decomposed into two elements, the aggregate opportunity costs $C_i^n = C_i^m$ of attracting investors (*opp costs*) and the aggregate hypothetical tax revenues Υ_i (*hypo tax revenues*), which the governments forego. As investors of mass 1 set up their firms in each country, aggregate opportunity costs $\Delta\Omega_{ii}N_i$ coincide with individual ones $C_i^n = \Delta\Omega_{ii} = C_i^m$. By definition, the opportunity costs of attracting investors in the first period consist of subsidy payments and foregone tax revenues, and thus aggregate subsidy payments are the difference between aggregate opportunity costs and foregone hypothetical tax revenues.

As at the individual level, the first-period opportunity costs (*opp costs*) of and the additional second-period revenues (*rev diff)* resulting from attracting investors cancel each other out at the aggregate level. That is, the WYGIWYG principle holds at both the individual level and the aggregate level.

Intuitively, this outcome is fairly straightforward. The maximum opportunity costs a regional government is willing to accept to attract an investor is exactly equal to the difference in expected second-period tax payments between a firm set up domestically and a firm set up abroad, given by $\Delta\Omega_{ii}$. As this difference is the same for both regions (i.e., $\Delta\Omega_{AA} = \Delta\Omega_{BB}$), the maximum opportunity costs both governments are ready to tolerate are the same as well. Thus, a Bertrand-type upward competition induces them to offer a subsidy that erodes any potential net gains from attracting investors. As the opportunity costs exactly offset the revenue differential, all that remains of the second-period tax revenues, once they are consolidated for the opportunity costs of attracting investors initially, are the basic revenues. Taking the WYGIWYG principle into account, net tax revenues are

$$NR_i = 2t_i^m F_2(t_j^n - t_i^m) + \tau_i^n \left[1 - F_1(\tau_i^n - \tau_j^m)\right] + \tau_i^m F_1(\tau_j^n - \tau_i^m). \tag{19}$$

The WYGIWYG principle suggests an alternative interpretation of the basic revenues $2\Omega_i^m$. The expected revenues $\Omega_i^m = t_i^m F_2(\Delta t_{ji})$, which are generated from firms initially set up abroad, count twice: First, they increase aggregate revenues in the second period by $t_i^m F_2(\Delta t_{ji})$. Second, they reduce subsidy payments in the first period by $t_i^m F_2(\Delta t_{ji})$ because they cut the revenue differential $\Delta\Omega_{ii}$, thus reducing the incentives to attract investors. This 'double-counting' interpretation is illustrated in figure 3, where the shaded area shows the second-period tax revenues net of opportunity costs of attracting investors in the first period.

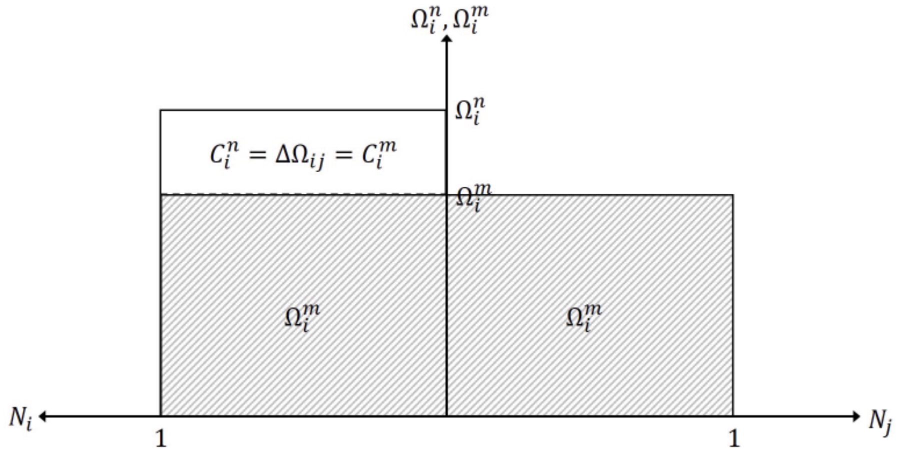

Figure 3: Decomposition of second-period tax revenues

4 Net tax revenues and mobility

We now turn to our key issue, the relationship between mobility and net tax revenues. With net tax revenues reduced to expression (19), investigating this relationship is straightforward. We distinguish between an increase in location mobility and in relocation mobility. This distinction proves to be crucial.

4.1 Net tax revenues and relocation mobility

We first look at the implications of an increase in relocation mobility for net tax revenues. As already argued above, even firms that are well established in a country are for various reasons becoming more and more mobile. In our model, the increase in mobility comes as a reduction in the firms' relocation costs. More specifically, we capture the rise in mobility as a change in the value of the distribution function $F_2(\Delta t_{ij}; z_2)$ in equilibrium $(t_A^n, t_A^m, t_B^n, t_B^m)$ which is formally caused by a marginal increase in a parameter z_2. In particular, we start by considering

Scenario 1: $\partial F_2(\Delta t_{ij}; z_2)/\partial z_2 > 0$ and $\partial F_2'(\Delta t_{ij}; z_2)/\partial z_2 = 0$

at the 'old' equilibrium level Δt_{ij}. We stick, for convenience, to our notation $F' = \partial F/\partial \Delta t$, $F'' = \partial^2 F/\partial \Delta t^2$, etc. All derivatives with respect to the parameter z_2 are explicitly expressed as $\partial F/\partial z_2$, etc.

Scenario 1 means that we consider an upward shift of the distribution curve that leaves its slope, i.e., the density F_2', at the 'old' equilibrium level Δt_{ij} unaltered, as illustrated in figure 4. The corresponding rise in mobility weakens the lock-in effect. As a result, a greater number of established firms relocate for given taxes. Moreover, since firms respond more elastically to international tax differentials, governments

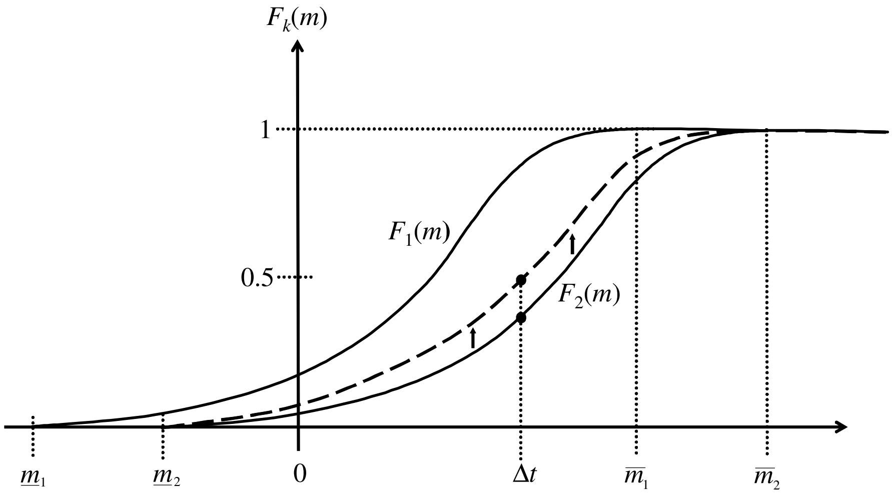

Figure 4: Declining mobility costs and distribution functions

adjust their taxes. Although tax competition is intensified and the old differential Δt_{ij} cannot be maintained, net tax revenues actually rise under assumption 1. More precisely, proposition 1 provides three sufficient and necessary conditions for this outcome to occur. These conditions are related to the tax elasticity, to the nature of the strategic interaction between the governments, and to the properties of the distribution function. In proposition 1, we refer to the reaction function $g_j^n(t_i^m) = t_j^n$, which gives country j's optimal choice of tax t_j^n for each level of tax t_i^m.

Proposition 1 *Net tax revenues and relocation mobility.*
In scenario 1, the net tax revenues NR_i increase with the firms' mobility parameter z_2 if, and only if, (a) the elasticity of the elasticity ε_j^n with respect to t_j^n is greater than unity in equilibrium or, equivalently, (b) country j's optimal tax t_j^n increases with country i's tax t_i^m or, equivalently, (c) assumption 1, part (vii), is satisfied. That is,

$$\frac{dNR_i}{dz_2} \geq 0 \Leftrightarrow \frac{\partial \varepsilon_j^n}{\partial t_j^n}\frac{t_j^n}{\varepsilon_j^n} \geq 1 \Leftrightarrow \frac{dg_j^n(t_i^m)}{dt_i^m} \geq 0 \Leftrightarrow F_2''(\Delta t_{ji}) \geq -\frac{[F_2'(\Delta t_{ji})]^2}{1 - F_2(\Delta t_{ji})}. \quad (20)$$

Proof: See appendix. □

Let us first discuss the intuition for the elasticity rule (condition (a)). An increase in relocation mobility affects the revenue differential, that is, the additional revenues a government can generate by attracting investors in the first period. However, recall that the revenue differential is always identical in magnitude to the opportunity costs of attracting investors, as the WYGIWYG principle stresses. Thus, any decline in the revenue differential leaves net revenues unaffected, since it is matched by an equal fall in subsidy payments. Attracting firms in the first period is simply less beneficial if these firms are more mobile and pay fewer taxes in the second period. Consequently, subsidy competition is reduced. Taking the WYGIWYG principle into account, all that ultimately matters is the impact of relocation mobility on basic revenues (see figure 3), as reflected in the derivative

$$\frac{dNR_i}{dz_2} = 2t_i^m \frac{\partial F_2\left(\Delta t_{ji}; z_2\right)}{\partial z_2} + 2t_i^m F_2'\left(\Delta t_{ji}; z_2\right) \frac{dt_j^n}{dz_2}, \tag{21}$$

where we made use of the envelope theorem, i.e., of $\partial NR_i/\partial t_i^m = 2\partial\left[t_i^m F_2(\Delta t_{ji})\right]/\partial t_i^m = 2\left(\partial R_i/\partial t_i^m\right) = 0$.

The first term on the right-hand side captures the direct effect of increasing mobility in the second period. For given taxes t_j^n and t_i^m, the number of firms relocating from country j to country i rises, since the lock-in effect is weakened. This positive effect raises country i's 'basic' tax base by $2[\partial F_2\left(\Delta t_{ji}; z_2\right)/\partial z_2]$ and, for given taxes, net revenues by $2t_i^m[\partial F_2\left(\Delta t_{ji}; z_2\right)/\partial z_2]$. The second term shows the indirect effect of increasing relocation mobility through the tax changes in equilibrium. If the tax t_j^n increases with mobility parameter z_2, country i's tax base will grow, reinforcing the positive direct effect on net revenues. Only if the tax t_j^n decreased with mobility parameter z_2, country i's tax base would erode, thus counteracting the positive direct effect. But even in this case, the overall impact on net revenues will be positive as long as the drop in the tax t_j^n is not too drastic, since the positive direct effect will then dominate the indirect effect. Indeed, the elasticity condition in proposition 1 is sufficient and necessary for tax t_j^n either to rise or to fall non-drastically, implying the net revenues go up as relocation mobility increases.

The intuition for this outcome is as follows. The rise in mobility, which is captured by $\partial F_2(\Delta t_{ji}; z_2)/\partial z_2 > 0$, increases the elasticity ε_j^n for given taxes, and thus distorts the initial equilibrium, as the first-order condition (3) reveals. To restore the equilibrium, the tax t_j^n has to adjust more, the less elastically the elasticity ε_j^n responds to changes in t_j^n. That is, if the elasticity of ε_j^n is sufficiently large (i.e., above one), then the tax t_j^n will only non-drastically decline or even rise, and the net revenues will thus increase.

The effects of an increase in relocation mobility can be explained from a different angle, referring to the strategic interactions between the two countries (condition (b) of proposition 1). Figure 5 illustrates the second-period tax competition for firms initially set up in country j. The solid reaction curves $g_j^n(t_i^m; z_2')$ and $g_i^m(t_j^n; z_2')$ capture the case of low relocation mobility, the broken reaction curves $g_j^n(t_i^m; z_2'')$ and $g_i^m(t_j^n; z_2'')$ the case of high relocation mobility, i.e., $z_2'' > z_2'$. Both iso-revenue curves $I(z_2')$ and $I(z_2'')$ depict tax bundles (t_j^n, t_i^m) that would lead to the same

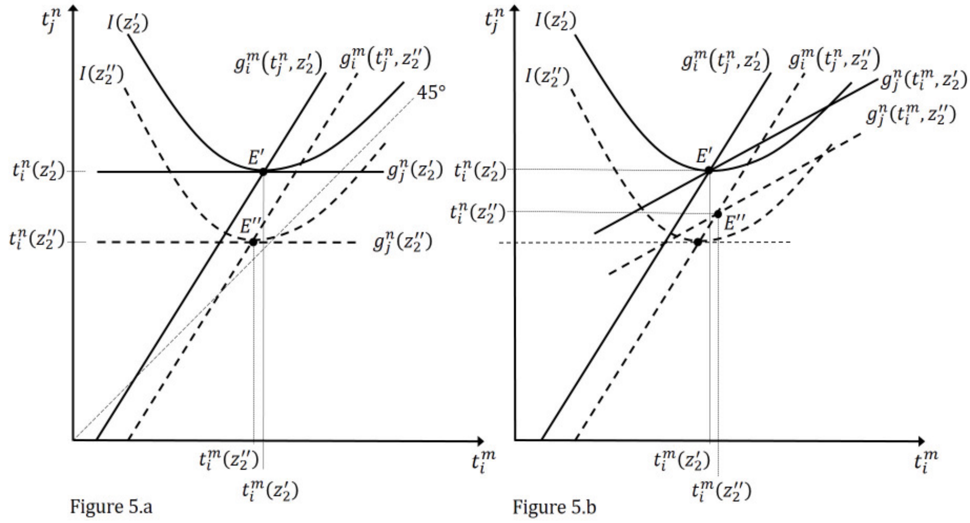

Figure 5: Reaction curves and iso-revenue curves

revenues $t_i^m F_2(\Delta t_{ji}; z_2')$, and thus to the same basic revenues $2t_i^m F_2(\Delta t_{ji}; z_2')$, as in the subgame-perfect equilibrium E'. Only, the solid curve $I(z_2')$ does so for low relocation mobility while the broken curve $I(z_2'')$ shows the respective bundles for high relocation mobility. In other words, the two curves represent the same revenue level, but for different mobility levels.

Now, consider an increase in the mobility parameter from z_2' to z_2''. Firstly, for given taxes, more firms move from country j to i, and revenues increase in country i, as relocation mobility rises. This direct effect is reflected in a downward shift of the iso-revenue curve, with $I(z_2'')$ being strictly below $I(z_2')$ and thus equilibrium point E'. Clearly, the revenues are now higher for the tax levels in the initial equilibrium E'. Secondly, equilibrium taxes change in response to higher relocation mobility. The best-response curve $g_j^n(t_i^m)$ shifts downwards while its counterpart $g_i^m(t_j^n)$ shifts to the right. That is, country j (i) now prefers a lower (higher) tax t_j^n (t_i^m) for each tax t_i^m (t_j^n), since the firms initially set up in country j now respond more (less) sensitively to tax increases in country j (i). The indirect effect of an increase in relocation mobility on revenues transmitted through changes in the equilibrium taxes is ambiguous, and so is the total effect.

Figure 5.a depicts the borderline case in which the reaction curve $g_j^n(t_i^m)$ is horizontal around the initial equilibrium E'. This situation would occur if the elasticity of the elasticity ε_j^n with respect to t_j^n equalled one (see proof of proposition 1 for details). In this case, both taxes, t_j^n and t_i^m, would be lower in the new equilibrium E'' than in the old one E', and the negative indirect effect of a fall in tax t_j^n on net tax revenues in country i would exactly offset the direct positive effect of an increase

in relocation mobility.

With this borderline case in mind, we can easily grasp the implication of an upward sloping reaction curve $g_j^n(t_i^m)$. Figure 5.b illustrates that, if tax t_j^n is increasing with tax t_i^m, the resulting tax t_j^n in the new equilibrium E'' is higher than in the borderline case in figure 5.a, leading to higher tax revenues $t_i^m F_2(\Delta t_{ji}; z_2'')$, and thus basic revenues $2t_i^m F_2(\Delta t_{ji}; z_2'')$, than in both the old equilibrium E' and the borderline case. Intuitively, the shift of the reaction curve $g_i^m(t_j^n)$ to the right will drive tax t_j^n up if the reaction curve $g_j^n(t_i^m)$ is upward sloping. This effect counteracts, or even reverses, the downward pressure on tax t_j^n, which results from more mobile firms in the second period. It is exactly this effect that is missing in the borderline case with a horizontal reaction curve $g_j^n(t_i^m)$. This additional effect at least curbs the indirect effect of a rise in relocation mobility on net tax revenues, which is potentially negative as explained above and captured by the second term on the right-hand side of derivative (21). Then, the overall impact of an increase in relocation mobility is positive, and since the two countries are symmetric, both of them will experience the same positive overall impact.

The 'strategic-interaction rule' (i.e. condition (b) of proposition 1) affirms that the rise in net tax revenues is not an odd abnormality in this framework, but a very likely outcome. Taxes are strategic complements in traditional tax competition models under standard assumptions. In this sense, our 'unconventional' conclusion that an increase in mobility can raise net tax revenues holds under 'conventional' circumstances.[16]

As condition (c) of proposition 1 shows, the elasticity and strategic-interaction rules can also be expressed in terms of a property of the distribution function, which is commonly assumed (see assumption 1 and its discussion in section 2). The last inequality of conditions (20) requires that the slope of the density function of the relocation costs is not too negative. This condition is obviously fulfilled for a uniform distribution, which we use in our example in section 4.3. More generally, all distributions which are unimodal and symmetric certainly satisfy this condition.[17]

There is an interesting similarity between our results and those in the papers on preferential tax regimes (e.g., Bucovetsky and Haufler, 2007, 2008; Haupt and Peters, 2005; Janeba and Smart, 2003; Keen, 2001; Mongrain and Wilson, 2015).

[16] We have to interpret the strategic interactions between the two countries carefully. In our framework, the fact that country j's optimal tax t_j^n increases with country i's tax t_i^m does not imply that country i's optimal tax t_i^m increases with country j's tax t_j^n. While the countries are symmetric, the taxes t_j^n and t_i^m are not.

[17] Recall that $F(\Delta t_{ji}) < 0.5$ in equilibrium, which follows from (6). Define $\widetilde{m}$ such that $F(\widetilde{m}) = 0.5$. Then unimodality and symmetry imply $F''(m) \gtreqless 0 \Leftrightarrow m \lesseqgtr \widetilde{m}$ and thus $F''(\Delta t_{ji}) > 0$ in equilibrium.

These contributions consider tax competition when countries differentiate their taxes levied on domestic and foreign firms operating in their jurisdictions, but ignore subsidy competition. They analyse whether limiting the differentials between the taxes paid by domestic and foreign firms can raise the countries' tax revenues compared to the outcome without any cap. According to Haupt and Peters (2005), the paper closest to our contribution, a moderate restriction on preferential tax regimes always increases revenues. In our paper, there is no exogenous political cap on tax differentials. However, as the increase in relocation mobility weakens the lock-in effect, the initial gap Δt_{ii} cannot be maintained any more. The tax differential certainly declines in equilibrium, and net revenues rise under the conditions outlined above. In this sense, an increase in relocation mobility indirectly reduces the tax differential, and it can make governments financially better off, as can an externally imposed limit on tax differentials. Despite this similarity, however, there are three major differences between the two analyses.

First, any improvement in revenues depends on the interaction between tax and subsidy competition in our paper. In Haupt and Peters (2005), limiting preferential tax regimes increases government revenues because it raises revenues from domestic firms. This positive effect does not occur at all in the current model, since any additional taxes paid by domestic firms (i.e., by those which were initially set up in the country considered) in the second period are completely offset by higher subsidies in the first period, as the WYGIWYG principle applies. Second, the positive direct effect of an increase in relocation mobility, which is highly important in our analysis, is absent in Haupt and Peters (2005) because they do not investigate the impact of a change in mobility. Third, Haupt and Peters (2005) apply an ad hoc mobility function, which they call erosion function. A key property of this function is equivalent to assuming in our context that the slope of the density curve of the relocation costs is nonnegative, i.e., $F'' \geq 0$. This property is more restrictive than our condition (see assumption 1, part (vii)) and excludes from the outset potentially critical cases in which limiting preferential tax regimes might yield lower tax revenues. Importantly, analysing tax and subsidy competition jointly should weaken the argument in favour of restricting preferential tax regimes, as any improvement in tax revenues from domestic firms is offset by higher subsidy payments.

More fundamentally, the basic mechanisms at work in our model do not hinge on the fact that we allow for preferential tax regimes. They would be the same even if foreign and domestic firms were subject to the same taxes. To see this, recall that key to our analysis is the revenue differential that arises between domestic and foreign firms, and that sets the stage for subsidy competition. This revenue differential would still exist under a non-preferential tax regime, since firms initially set up in a country are more likely to end up as tax payers in the very same country than firms initially located in the other country. In the case of non-preferential regimes, in which a uniform tax t_i is levied on both domestic and foreign firms, the equilibrium revenue differential is $\Delta\Omega_{ii} = t_i [1 - 2F_2(0)] > 0$, where the inequality sign follows from $F_2(0) < 0.5$ and is due to the relocation costs. In this sense, the assumption that firms are imperfectly mobile in the second period is important, but not the fact that countries can levy differentiated taxes.

Before we turn our attention to the implications of changes in location mobility, we extend our previous result and take into account the fact that changes in relocation mobility might also affect the slope of the distribution function. The additional effects that arise if $\partial F_2'(\Delta t_{ij}; z_2)/\partial z_2 \neq 0$ holds at the 'old' equilibrium level Δt_{ij} are stated in Proposition 2.

Proposition 2 *Net tax revenues and relocation mobility (continued).*
The revenue increasing effect of a marginal rise in relocation mobility is reinforced (counteracted) if $\partial F_2'(\Delta t_{ij}; z_2)/\partial z_2 < 0$ ($\partial F_2'(\Delta t_{ij}; z_2)/\partial z_2 > 0$) holds.

Proof: See appendix. □

The economic explanation for this conclusion is straightforward. If the density F_2' decreases (increases) with the mobility parameter z_2, the firms' response to tax increases becomes less (more) elastic, as the first-order conditions (3) and (4) show. This causes a rise (decline) in tax t_j^n. Such a tax change, however, increases (erodes) the basic revenues of country i. This additional channel would be captured by a change in the second term of derivative (21).

4.2 Net tax revenues and location mobility

Next, we investigate the implications of an increase in location mobility. That is, we analyse the case in which investors are more mobile and less home biased when they decide where their firms are set up in the first period.

Analogously to scenario 1, we now consider

Scenario 2: $\partial F_1(\Delta\tau_{ij}; z_1)/\partial z_1 > 0$ and $\partial F_1'(\Delta\tau_{ij}; z_1)/\partial z_1 = 0$.

We formally express scenario 2 in terms of hypothetical taxes instead of subsidies. The two interpretations are equivalent, since a rise in hypothetical taxes τ_i^n and τ_i^m corresponds with a decline in subsidies s_i^n and s_i^m of the same magnitude (see equilibrium subsidies (14)). Referring to taxes, however, proves to be more convenient and allows us to compare the different impacts caused by an increase in location mobility and in relocation mobility more explicitly.

An increase in location mobility does not affect future *real* taxes, but only current *hypothetical* tax revenues or, equivalently, *real* subsidy payments:

$$\frac{dNR_i}{dz_1} = -\left(\tau_i^n - \tau_i^m\right) \frac{\partial F_1 \left(\Delta\tau; z_1\right)}{\partial z_1} + \tau_i^m F_1' \left(\Delta\tau_{ji}; z_1\right) \frac{d\tau_j^n}{dz_1} + \tau_i^n F_1' \left(\Delta\tau_{ij}; z_1\right) \frac{d\tau_j^m}{dz_1}, \quad (22)$$

where we take again advantage of the envelope theorem, i.e., of the fact that $\partial NR_i/\partial\tau_i^n = \partial NR_i/\partial s_i^n = 0$ and $\partial NR_i/\partial\tau_i^m = \partial NR_i/\partial s_i^m = 0$ are satisfied in equilibrium.

The first term on the right-hand side again reflects the direct impact of mobility on the tax bases. In contrast to its counterpart in derivative (21), this effect is now negative. For given hypothetical taxes, and thus subsidies, an increase in location mobility reduces the number of firms that domestic investors set up in country i by $\partial F_1 \left(\Delta\tau_{ij}; z_1\right)/\partial z_1$, but it raises the number of firms that foreign investors set up by the same amount $\partial F_1 \left(\Delta\tau_{ji}; z_1\right)/\partial z_1$ (as $\Delta\tau_{ij} = \Delta\tau_{ji}$ in equilibrium). The impact of these changes on net revenues is negative, since the former firms pay a higher hypothetical tax than the later ones (as $\tau_i^n > \tau_i^m$). To put it differently, increasing mobility implies that highly subsidised foreign investors who take advantage of the subsidy differential replace less subsidised home investors who now set up their firms abroad, thereby increasing each country's overall subsidy payments.

The second and third term capture the indirect effects of an increase in location mobility via its impact on equilibrium taxes τ_j^n and τ_j^m. The indirect effect erodes (raises) country i's tax bases, if country j's hypothetical taxes τ_j^n and τ_j^m decrease (increase), and thus real subsidies s_j^n and s_j^m rise (decline).[18] This negative (positive) effect depresses (raises) net revenues NR_i. However, as long as the indirect effect is not too positive, the direct effect dominates, and net revenues of country i fall.

As this discussion shows, there are two major differences between the effects of an increase in location and relocation mobility. First, the direct impact is now negative, driven by the fact that, for given hypothetical taxes, hypothetical revenues from home investors fall by $\tau_i^n \partial F_1 \left(\Delta\tau_{ij}; z_1\right)/\partial z_1$, as discussed above. This negative effect in scenario 2 has no counterpart in scenario 1 (see derivative (21)). In scenario 1, which considers an increase in relocation mobility, any decline in the additional tax revenues paid by domestic firms in the second period—i.e., any decline in the revenue differential in (18)—is exactly offset by a decrease in subsidy payments, as stated by the WYGIWYG principle. The remaining direct effect of an increase in relocation mobility is positive.

[18] We know that the hypothetical tax, or subsidy, differential (15) decreases with the location mobility parameter z_1. The previous discrimination against home investors is simply no longer viable once they become less attached to their home country. However, both taxes τ_i^n and τ_i^m might rise or fall, or τ_i^n might fall and τ_i^m might rise in response to a larger location mobility parameter z_1.

Second, the induced changes in both hypothetical taxes of country j, τ_j^n and τ_j^m, matter for the net tax revenues of country i in the current scenario. In scenario 1, by contrast, tax t_j^n is the only tax of country j that ultimately affects the revenues of country i, since there is need to account only for basic revenues $2t_i^m F_2(t_j^n - t_i^m)$, which are simply twice the revenues generated from firms initially set up abroad, again due to the WYGIWYG principle. To put it differently, only the market for foreign firms counts for country i's net tax revenues in scenario 1 while the markets for home and foreign investors do so in scenario 2.

As a starting point, proposition 3 examines these two markets separately. Here, $h_j^n(\tau_i^m) = \tau_j^n$ and $h_j^m(\tau_i^n) = \tau_j^m$ stand for country j's hypothetical reaction functions in the first stage. The rearranged first-order conditions (16) implicitly define these functions.

Proposition 3 *Net tax revenues and location mobility.*
1. In scenario 2, the hypothetical tax revenues from firms set up in country i by foreign investors, $\tau_i^m F_1(\Delta\tau_{ji}; z_1) =: \Psi_i^m$, increase with mobility parameter z_1 if, and only if, (a) the elasticity of the elasticity η_j^n with respect to τ_j^n is greater than unity in equilibrium or, equivalently, (b) country j's optimal hypothetical tax τ_j^n increases with country i's tax τ_i^m or, equivalently, (c) assumption 1, part (vii), is satisfied. That is,

$$\frac{d\Psi_i^m}{dz_1} \geq 0 \Leftrightarrow \frac{\partial \eta_j^n}{\partial \tau_j^n}\frac{\tau_j^n}{\eta_j^n} \geq 1 \Leftrightarrow \frac{dh_j^n(\tau_i^m)}{d\tau_i^m} \geq 0 \Leftrightarrow F_1''(\Delta\tau_{ji}) \geq -\frac{[F_1'(\Delta\tau_{ji})]^2}{1 - F_1(\Delta\tau_{ji})}. \quad (23)$$

2. The hypothetical tax revenues from firms set up in country i by domestic investors, $\tau_i^n [1 - F_1(\Delta\tau_{ij}; z_1)] =: \Psi_i^n$, decrease with mobility parameter z_1 if, and only if, (a) the elasticity of the elasticity η_j^m with respect to τ_j^m is greater than unity in equilibrium or, equivalently, (b) country j's optimal hypothetical tax τ_j^m increases with country i's tax τ_i^n or, equivalently, (c) assumption 1, part (vi), is satisfied. That is,

$$\frac{d\Psi_i^n}{dz_1} \leq 0 \Leftrightarrow \frac{\partial \eta_j^m}{\partial \tau_j^m}\frac{\tau_j^m}{\eta_j^m} \geq 1 \Leftrightarrow \frac{dh_j^m(\tau_i^n)}{d\tau_i^n} \geq 0 \Leftrightarrow F_1''(\Delta\tau_{ij}) \leq \frac{[F_1'(\Delta\tau_{ij})]^2}{F_1(\Delta\tau_{ij})}. \quad (24)$$

Proof: See appendix. □

Proposition 3, part 1, is fully in line with proposition 1. The conditions that ensure that the revenue component $\tau_i^m F_1(\Delta\tau_{ji}; z_1)$ increases are qualitatively the same as those that guarantee that the basic revenues $2t_i^m F_2(\Delta t_{ji}; z_2)$ do so. Again, under those conditions, the positive direct effect, which is now $\tau_i^m \partial F_1(\Delta\tau_{ji}; z_1)/\partial z_1$, dominates the potentially negative indirect effect, which is now $\tau_i^m F_1'(\Delta\tau_{ji}; z_1)(d\tau_j^n/dz_1)$.

The reasoning for part 1 is entirely analogous to the one for proposition 1 and thus needs not be repeated.

In part 2, the conditions (a), (b) and (c) guarantee that the direct effect of an increase in location mobility dominates the indirect effect through changes in the equilibrium taxes, as the corresponding conditions in part 1 do. Only, the direct effect $-\tau_i^n F_1' (\Delta\tau_{ij}; z_1) / dz_1$ is now negative. As location mobility increases, more domestic investors set up firms abroad for given tax levels, and the corresponding domestic tax revenues fall.

This direct effect might be opposed by the indirect effect $\tau_i^n F_1' (\Delta\tau_{ij}; z_1) \, d\tau_j^m / dz_1$, which is potentially positive for reasons very much in line with our previous arguments. Take, for instance, the interpretation of condition (a). An increase in location mobility decreases the elasticity η_j^m for given hypothetical taxes. This can exert upward pressure on the hypothetical tax τ_j^m, equivalent to downward pressure on the subsidy s_j^m, as the initial equilibrium is distorted (see first-order condition (16)). To restore the equilibrium, the hypothetical tax τ_j^m increases more, the less elastically the elasticity η_j^m responds to changes in τ_j^m. The more the tax τ_j^m increases, and thus the subsidy s_j^m declines, the more the tax base of country i grows, and thus the net revenues rise. However, the negative direct effect still prevails over the potentially positive indirect effect as long as this potential increase in the hypothetical tax τ_j^m is not too pronounced, that is, as long as the elasticity condition (a) is fulfilled. Then, the tax revenues from firms set up by domestic investors decline with the location cost parameter z_1. Again, this outcome results because the direct effect dominates, which again occurs under the same circumstances under which the key taxes are strategic complements.

To avoid getting lost in details, let us summarise the key message of proposition 3: an increase in location mobility raises each country's hypothetical tax revenues from firms set up by foreign investors while it reduces tax payments from firms of domestic investors. Intuitively, a higher location mobility makes it easier to attract and tax foreign investors, but more difficult to retain and charge domestic ones. This outcome holds under assumption 1 or, equivalently, under the 'textbook' situation in which taxes are strategic complements. Proposition 4 covers the remaining issue of how an increase in location mobility affects overall net tax revenues.

Proposition 4 *Net tax revenues and location mobility (continued).*
In scenario 2, the net tax revenues NR_i decrease with the investors' mobility parameter z_1 if, and only if, (a) the weighted elasticities of the elasticities η_j^n and η_j^m with respect to t_j^n and t_j^m, respectively, exceed unity or, equivalently (b) the slope of

the density function is not too large. More precisely,

$$\frac{dNR_i}{dz_1} \leq 0 \Leftrightarrow \frac{\tau_i^n}{\tau_i^n - \tau_i^m}\frac{\partial \eta_j^m}{\partial \tau_j^m}\frac{\tau_j^m}{\eta_j^m} - \frac{\tau_i^m}{\tau_i^n - \tau_i^m}\frac{\partial \eta_j^n}{\partial \tau_j^n}\frac{\tau_j^n}{\eta_j^n} \geq 1 \tag{25}$$

$$\Leftrightarrow F_1''(\Delta\tau_{ji}) \leq \frac{[F_1'(\Delta\tau_{ji})]^2 [1 - 2F_1(\Delta\tau_{ji})]}{2F_1(\Delta\tau_{ji})[1 - F_1(\Delta\tau_{ji})]}. \tag{26}$$

Proof: See appendix. □

With the preceding discussion in mind, the intuition for proposition 4 is straightforward. The overall direct effect of an increase in location mobility, captured by the first term of derivative (22), is negative, as already explored above. This direct effect dominates the combined indirect effects, reflected in the second and third term of derivative (22), as long as the increase in tax τ_j^m is not too large, which requires a sufficiently large elasticity $\left(\partial\eta_j^m/\partial\tau_j^m\right)\left(\tau_j^m/\eta_j^m\right)$, and the decline in tax τ_j^n is fairly large, which requires a sufficiently small elasticity $\left(\partial\eta_j^n/\partial\tau_j^n\right)\left(\tau_j^n/\eta_j^n\right)$. Hence, net tax revenues decrease with the mobility parameter z_1 if, and only if, the former elasticity is not too small compared to the latter one, as condition (a) of proposition 4 expresses. Alternatively, a sufficient and necessary condition for a decline in net tax revenues is that the slope of the density function is not too large, as condition (b) states.

Propositions 1 and 4 jointly imply that if the slope of the density function is not too steep, i.e. if $-\left(F_1'\right)^2/\left(1-F_1\right) \leq F'' \leq \left(F_1'\right)^2\left(1-2F_1\right)/\left[2F_1\left(1-F_1\right)\right]$ holds, then the net tax revenues (i) increase with relocation mobility and (ii) decrease with location mobility. The latter outcome is driven by a decline in hypothetical tax revenues generated from firms set up by domestic investors. By contrast, any decline in 'real' tax payments by domestic firms in the second period is irrelevant because it is exactly offset by lower subsidies, according to the WYGIWYG principle. As a result, an increase in relocation mobility positively affects net tax revenues. A uniform distribution, for instance, satisfies the conditions of both proposition 1 and proposition 4.

Proceeding analogously to section 4.1, we now extend our analysis to the case $\partial F_1'(\Delta\tau_{ij}; z_1)/\partial z_1 \neq 0$.

Proposition 5 *Net tax revenues and location mobility (continued).*
The revenue decreasing effect of a marginal change in location mobility is strengthened (weakened) if $\partial F_1'(\Delta\tau_{ij}; z_1)/\partial z_1 > 0$ ($\partial F_1'(\Delta\tau_{ij}; z_1)/\partial z_1 < 0$) holds.

Proof: See appendix. □

Proposition 5 is completely in line with proposition 2. The conclusion of proposition 5 reflects again the fact that the tax base becomes less (more) elastic if

$\partial F_1'(\Delta\tau_{ij}; z_1)/\partial z_1 < 0$ ($\partial F_2'(\Delta\tau_{ij}; z_2)/\partial z_2 > 0$) holds. This change pushes the hypothetical taxes τ_j^n and τ_j^m up (down), and the corresponding subsidies s_j^n and s_j^m fall (rise). Consequently, country i's tax base and net revenues increase (decrease). Formally, these additional effects would be captured by changes in the second and third term of derivative (22).

4.3 An example and repeated relocation choice

To illustrate our conclusions, we consider the case of uniformly distributed mobility costs, i.e., $F_k(m_k) = \frac{m_k - \underline{m}_k}{\overline{m}_k - \underline{m}_k}$ and $F_k'(m_k) = \frac{1}{\overline{m}_k - \underline{m}_k}$, where $k = 1, 2$. Then, properties (vi) and (vii) of assumption 1 are fulfilled, and we continue to assume that all other properties of assumption 1 are satisfied. (Notice that, with a uniform distribution, property (iii) $F_k(0) < 0.5$ implies $\overline{m}_k > |\underline{m}_k|$.) In this example, the two distribution curves in figures 1 and 4 are straight lines. As in the general case, the relocation costs exceed location costs, investors are home biased, and firms are locked in.

Following our previous line of reasoning, the first-order conditions of the governments lead to the reaction functions

$$t_j^n = g_j^n(t_i^m) = \frac{\overline{m}_2}{2} + \frac{1}{2}t_i^m \quad \text{and} \quad t_i^m = g_i^m(t_j^n) = -\frac{\underline{m}_2}{2} + \frac{1}{2}t_j^n, \tag{27}$$

$$s_j^n = \frac{\Delta t_{ii} - \overline{m}_1}{2} + \frac{1}{2}s_i^m \quad \text{and} \quad s_i^m = \frac{\Delta t_{ii} + \underline{m}_1}{2} + \frac{1}{2}s_j^n, \tag{28}$$

where (28) is equivalent to the hypothetical reaction functions

$$\tau_j^n = h_j^n(t_i^m) = \frac{\overline{m}_1}{2} + \frac{1}{2}\tau_i^m \quad \text{and} \quad \tau_i^m = h_i^m(\tau_j^n) = -\frac{\underline{m}_1}{2} + \frac{1}{2}\tau_j^n. \tag{29}$$

Thus, taxes and subsidies (or, alternatively, hypothetical taxes) are strategic complements.

Then, the equilibrium taxes and subsidies are

$$t_i^n = \frac{2\overline{m}_2 - \underline{m}_2}{3} > \frac{\overline{m}_2 - 2\underline{m}_2}{3} = t_i^m, \tag{30}$$

$$s_i^n = \underbrace{\frac{\overline{m}_2 + \underline{m}_2}{3}}_{=\Delta\Omega_{ii}} - \underbrace{\frac{2\overline{m}_1 - \underline{m}_1}{3}}_{=\tau_i^n} < \underbrace{\frac{\overline{m}_2 + \underline{m}_2}{3}}_{=\Delta\Omega_{ii}} - \underbrace{\frac{\overline{m}_1 - 2\underline{m}_1}{3}}_{=\tau_i^m} = s_i^m. \tag{31}$$

The home bias of investors and the lock-in effect that established firms experience lead to preferential tax and subsidy regimes in favour of foreign investors and firms, i.e., $t_i^n > t_i^m$ and $s_i^m > s_i^n$.[19] Using equilibrium taxes and subsidies and the equilib-

[19] Equilibrium values (30) and (31) yield $t_i^n - t_i^m = (\overline{m}_2 + \underline{m}_2)/3 > 0$ and $s_i^m - s_i^n = (\overline{m}_1 + \underline{m}_1)/3 > 0$, since $F_k(0) < 0.5$ implies $\overline{m}_1 > |\underline{m}_1|$ and $\overline{m}_2 > |\underline{m}_2|$ under a uniform distribution of (re-)location costs. Both subsidies, s_i^n and s_i^m, are positive if the condition $\overline{m}_2 > 2\overline{m}_1 - \underline{m}_1 - \underline{m}_2$ is satisfied. By contrast, if this condition is not fulfilled, at least domestic firms already face a tax in the first period. Even in this case, however, this tax will be lower than the tax on domestic firms in the second period.

rium outcome $N_i = N_j = 1$, the resulting net tax revenues can be determined:

$$NR_i = \underbrace{\frac{2(\overline{m}_2 - 2\underline{m}_2)^2}{9(\overline{m}_2 - \underline{m}_2)}}_{=2t_i^m F_2(\Delta t_{ji})} + \underbrace{\frac{(2\overline{m}_1 - \underline{m}_1)^2}{9(\overline{m}_1 - \underline{m}_1)}}_{=\tau_i^n(1-F_1(\Delta\tau_{ij}))} + \underbrace{\frac{(\overline{m}_1 - 2\underline{m}_1)^2}{9(\overline{m}_1 - \underline{m}_1)}}_{=\tau_i^m F_1(\Delta\tau_{ji})}. \tag{32}$$

Let us define $\underline{m}_k = \underline{\omega}_k - z_k$ and $\overline{m}_k = \overline{\omega}_k - z_k$. In line with scenario 1, we can then formally capture an increase in relocation mobility, i.e., a decline in relocation costs, by an increase in the parameter z_2, shifting the distribution $F_2(m_2)$ to the left without changing its slope. Differentiating (32) then yields

$$\frac{dNR_i}{dz_2} = \frac{4(\overline{m}_2 - 2\underline{m}_2)}{9(\overline{m}_2 - \underline{m}_2)} > 0. \tag{33}$$

Hence, a decrease in relocation costs, resulting in a higher relocation mobility, unambiguously increases net revenues.

Similarly, we now consider the impact of an increase in the location mobility, i.e., a decline in location costs, captured by a marginal shift of the distribution $F_1(m_1)$ to the left. Formally, we analyse a marginal change in z_1. Differentiating the net-revenue function (32) yields

$$\frac{dNR_i}{dz_1} = -\frac{2(\overline{m}_1 + \underline{m}_1)}{9(\overline{m}_1 - \underline{m}_1)} < 0. \tag{34}$$

Hence, we sum up the outcome in this example in corollary 1.

Corollary 1 *Net tax revenues and mobility: uniform distribution.*
Assume that location and relocation costs are uniformly distributed as specified above. Then, the taxes t_j^n and t_i^m as well as the hypothetical taxes τ_j^n and τ_i^m (or, equivalently, subsidies s_j^n and s_i^m) are strategic complements. Also, the net tax revenues NR_i increase with the mobility parameter z_2 and decrease with the mobility parameter z_1. □

Up to this point, firms can relocate only once after the initial set-up period. Obviously, this assumption is a crude simplification, since firms can repeatedly reconsider their location choice in their usual life spans.[20] The question arises whether our results about the implications of increasing relocation and location mobility are still valid when we allow for repeated relocations over time.

To get an idea of how robust our results are, let us extend our example with a uniform distribution. We introduce an additional, intermediate period lying between

[20]For instance, consider the example of Nokia, which moved its production from Bochum, Germany, to Cluj, Romania, in 2008, as discussed in section 1. The Finnish firm closed the Cluj factory, which was replaced by Asian plants, only three years later (Financial Times, 2011).

the two periods considered so far; that is, we now have an initial set-up period (period 1), an intermediate period (period 2), and the final period (period 3). Firms can relocate in both the second and third period. Assumption 1 now describes not only the declining mobility between the first and the second period, but also between the second and the third period. For the latter relationship, just replace the subscripts 1 and 2 with 2 and 3 in assumption 1. Firms experience the lowest mobility costs (i.e., the highest mobility) in the initial set-up period, higher mobility costs in the intermediate period, and even higher mobility costs in the final period. In this sense, the lock-in effect becomes gradually stronger over time.

As before, firms cash in subsidy payments s_i^n or s_i^m in the initial set-up period and face a tax t_i^n or t_i^m in the final period. In the intermediate period, firms receive a subsidy, or pay a tax, v_i^n or v_i^m, where $v_i^n, v_i^m > 0$ ($v_i^n, v_i^m < 0$) indicates subsidies (taxes). In keeping with the previous convention, a firm will be considered a domestic firm in country i in the second (third) period if it stayed in, or relocated to, country i in the first (second) period.

Following precisely the previous line of reasoning, the extended system arrives at the following equilibrium tax and subsidy payments:

$$t_i^n = \frac{2\overline{m}_3 - \underline{m}_3}{3} > \frac{\overline{m}_3 - 2\underline{m}_3}{3} = t_i^m, \quad (35)$$

$$v_i^n = \frac{\overline{m}_3 + \underline{m}_3}{3} - \frac{2\overline{m}_2 - \underline{m}_2}{3} < \frac{\overline{m}_3 + \underline{m}_3}{3} - \frac{\overline{m}_2 - 2\underline{m}_2}{3} = v_i^m, \quad (36)$$

$$s_i^n = \frac{\overline{m}_2 + \underline{m}_2}{3} - \frac{2\overline{m}_1 - \underline{m}_1}{3} < \frac{\overline{m}_2 + \underline{m}_2}{3} - \frac{\overline{m}_1 - 2\underline{m}_1}{3} = s_i^m, \quad (37)$$

The resemblance between the equilibrium values (35) to (37) on the one hand and (30) to (31) on the other hand is remarkable. The relationships between the taxes in the final period and the parameters of the uniform distribution of the mobility costs in the very same period are exactly identical in the two-period and three-period scenario (see eqs. (30) and (35)). Similarly, the formulas for the subsidies, or taxes, in the first and intermediate period of the current scenario are completely in line with the corresponding expressions for the first-period subsides in the two-period model (see eqs. (31), (36), and (37)). Again, the home bias of investors and firms give rise to preferential tax and subsidy regimes in all periods.

Using equilibrium taxes and subsidies (35) to (37), we can calculate the net tax revenues:

$$NR_i = \underbrace{\frac{2(\overline{m}_3 - 2\underline{m}_3)^2}{9(\overline{m}_3 - \underline{m}_3)}}_{\text{basic revenues period 3}} + \underbrace{\frac{2\left(\overline{m}_2 - 2\underline{m}_2\right)^2}{9(\overline{m}_2 - \underline{m}_2)}}_{\text{basic revenues period 2}} + \underbrace{\frac{(2\overline{m}_1 - \underline{m}_1)^2}{9(\overline{m}_1 - \underline{m}_1)} + \frac{(\overline{m}_1 - 2\underline{m}_1)^2}{9(\overline{m}_1 - \underline{m}_1)}}_{\text{hypothetical tax payments period 1}}. \quad (38)$$

The similarity between net tax revenues (38) and (32) is obvious. The net tax revenues (38) can be decomposed into three components: (i) the hypothetical tax payments in the initial set-up period, (ii) the basic revenues in the final period, and (iii) as the new component in the case of three periods, the basic revenues in the intermediate period. Thus, introducing an intermediate period does not alter the WYGIWYG principle. The opportunity costs of attracting investors in the initial set-up period exactly offset the generated revenue differentials in the succeeding periods. Each country is left with the hypothetical tax payments in the initial period and the basic revenues in the following periods.

Using the previous definition $\underline{m}_k = \underline{\omega}_k - z_k$ and $\overline{m}_k = \overline{\omega}_k - z_k$, now with $k = 1, 2, 3$, we can again formally capture an increase in mobility in period k, i.e., a decline in (re-)location costs, by an increase in the parameter z_k. This is completely in line with scenarios 1 and 2 above. Differentiating net tax revenues (38) gives

$$\frac{dNR_i}{dz_3} = \frac{4(\overline{m}_3 - 2\underline{m}_3)}{9(\overline{m}_3 - \underline{m}_3)} > 0, \tag{39}$$

$$\frac{dNR_i}{dz_2} = \frac{4(\overline{m}_2 - 2\underline{m}_2)}{9(\overline{m}_2 - \underline{m}_2)} > 0, \tag{40}$$

$$\frac{dNR_i}{dz_1} = -\frac{2(\overline{m}_1 + \underline{m}_1)}{9(\overline{m}_1 - \underline{m}_1)} < 0. \tag{41}$$

These derivatives confirm and extend our previous results, as a comparison with the derivatives (33) and (34) shows. An increase in the location mobility in the initial set-up period reduces net revenues, since it intensifies subsidy competition. By contrast, a higher relocation mobility in the second or the third period raises net revenues, as it boosts basic revenues. Introducing an intermediate period leaves our fundamental conclusions unaffected. On the contrary, an increase in the relocation mobility in both the second and the third period now positively affects net revenues.

We summarise the results above in the final proposition:

Proposition 6 *Net tax revenues and mobility in the three-period case.*
Consider the three-period case with uniformly distributed mobility costs as specified above. Then, the net tax revenues NR_i increase with mobility parameters z_3 (final period) and z_2 (intermediate period), but decrease with z_1 (initial set-up period). □

Finally, note that the marginal effect of a change in the relocation mobility in the second and third period is proportional to the share of country j's firms that relocate to country i in the respective period, i.e., to $F_k = (\overline{m}_k - 2\underline{m}_k) / [3(\overline{m}_k - \underline{m}_k)]$. Also, this share is greater in the second period than in the third period, which reflects the fact that firms are more mobile in the second period. As a result, the marginal impact of an increase in the relocation mobility in the second period is even stronger than that in the third period.[21]

[21] Comparing eqs. (39) and (40) reveals that $dNR_i/dz_2 > dNR_i/dz_3 \Leftrightarrow -\overline{m}_3\underline{m}_2 > -\overline{m}_2\underline{m}_3$,

5 Concluding remarks

Governments compete for mobile firms with both subsidies and taxes. We have analysed the resulting interplay between tax competition and subsidy competition, leading to the WYGIWYG principle. That is, the additional revenues generated by attracting firms through subsidies are exactly offset by the opportunity costs of these subsidies. This result has helped us to shed some light on the impact of an increase in mobility on net tax revenues, thereby distinguishing between location mobility and relocation mobility. Our key conclusion is that a rise in relocation mobility increases net tax revenues under conventional assumptions. A higher relocation mobility reinforces tax competition, but weakens subsidy competition. Overall, the fall in subsidy payments overcompensates for the decline in tax revenues, yielding higher net tax revenues. Considering the example of a uniform distribution of mobility costs, we have shown that our key conclusion remains valid when we allow for repeated relocation choices. An increase in the relocation mobility in the intermediate period boosts net revenues even more than a similar increase in the final period.

These conclusions are in contrast to the common belief that increasing mobility erodes national revenues—a belief that is backed by 'pure' tax competition models. Notably, our contrasting conclusions are derived in a 'conventional' tax competition framework, but in one that is supplemented by subsidy competition stages. In this setting, we also argue that an increase in location mobility tends to reduce net tax revenues, somewhat in line with the 'conventional' tax competition literature and common beliefs (see for a review, e.g., Genschel and Schwarz, 2011, and Keen and Konrad, 2013).

Our findings have important policy implications. They directly imply that fiercer tax competition (here, due to an increase in relocation mobility) might be advantageous to governments because of its feedback effect on subsidy competition. In the public debate, however, the focus is on weakening tax competition, or preventing harmful tax competition, through various measures (cf. OECD, 1998). In our model, weakening tax competition actually implies intensifying subsidy competition, with potentially adverse effects on net tax revenues. So an exclusive concentration on tax harmonisation might be misleading and thus detrimental to future revenues. In this sense, our paper cautions politicians against narrow minded tax harmonisation on grounds different from those previously discussed in the literature.[22] Our paper

where the latter inequality follows from $\overline{m}_3 > \overline{m}_2 > 0 > \underline{m}_3 > \underline{m}_2$ (see assumption 1, parts (ii) and (iv)).

[22] In general, when countries compete in taxes and another policy instrument, cooperation on one instrument may or may not enhance efficiency. In the context of tax and infrastructure competition,

also indicates that more attention should be paid to subsidy competition and its interaction with tax competition. Reducing subsidy competition might indeed be a more successful avenue for larger tax revenues than restrictions on tax competition.

Exploring the implication of various forms of harmonisation and cooperation in our framework in detail can be a promising extension of our analysis. Such an extension would also include the discussion of limitations on preferential tax and subsidy regimes—as far as such limitations are enforceable, given that subsidies are frequently granted in the form of somewhat hidden and indirect transfers, and even preferential tax treatments are often hidden.[23] As a further extension, the impact of correlated location and relocation costs could be checked. Firms might then sort themselves according to their mobility characteristics, and multiple equilibria might arise. Nevertheless, the underlying mechanisms explored in our simplified version should remain the same, and our conclusions should therefore still be valid, perhaps with some modifications.

Going one step further, we could endogenise relocation mobility. As briefly indicated in section 1, relocation costs are at least partly driven down by political decisions, such as the European labour market integration. Also, firms can reduce relocation costs, for instance, by renting production facilities rather than buying. Many small start-ups use the facilities of application-oriented research institutes, such as the Fraunhofer Institute in Germany.

Another challenging extension would be to combine our approach of repeated decisions of governments and firms on policies and location with models which analyse other motives for attracting firms. For instance, Haufler and Mittermaier (2011) argue that governments face an incentive to attract a foreign firm as a means to curb the wage setting power of unions. In their model, however, governments decide on a tax or subsidy only once at the very beginning. They show that a country with strong unions is particularly prone to grant high subsidies. It would be interesting to see whether this conclusion still holds in the case of repeated decisions on taxes/subsidies, location and wages. Similarly, it would be interesting to see to what extent our conclusions would still hold in an economic framework such as the

for instance, Becker and Fuest (2010) analyse the impact of a coordinated increase in infrastructure investment upon the non-cooperative equilibrium when the additional infrastructure reduces trade costs and thus deepens economic integration. They show that such a measure can mitigate the negative effects tax competition. Han et al. (2017) also consider tax and infrastructure competition. In their model, infrastructure investment in a jurisdiction improves the productivity of firms in this jurisdiction. Depending on the timing of decisions, different forms of tax coordination may increase or decrease social welfare.

[23] See the papers on preferential tax regimes referred to in section 4.1 and also Krieger and Lange (2010) for a discussion of the implications of preferential and non-preferential regimes in the context of student and graduate mobility.

one in Haufler and Mittermaier (2011).

Appendix

Proof of lemma 1 We start by analysing the tax competition equilibrium (third and fourth stage). As argued above, this equilibrium is independent of the governments' subsidies (first stage) and the investors' initial location choice (second stage). In step 1, we exclude any 'boundary' equilibria. Uniqueness and existence of the tax competition equilibrium are proved in step 2. In step 3, we show that our lines of reasoning can easily be repeated to prove existence and uniqueness of the subsidy competition equilibrium, and thus of the subgame perfect equilibrium.

Step 1 (No 'boundary' equilibrium) The first-order conditions

$$\frac{\partial R_i}{\partial t_i^n} = \left\{\left[1 - F_2(t_i^n - t_j^m)\right] - t_i^n F_2'(t_i^n - t_j^m)\right\} N_i = 0, \tag{42}$$

$$\frac{\partial R_j}{\partial t_j^m} = \left[F_2(t_i^n - t_j^m) - t_j^m F_2'(t_i^n - t_j^m)\right] N_i = 0, \tag{43}$$

implicitly define the governments' continuous reaction functions g_i^n and g_j^m in the case of an interior solution, since, first, the second-order conditions

$$\frac{\partial^2 R_i}{\partial (t_i^n)^2} = -\left[2F_2'(\Delta t_{ij}) + \frac{\left[1 - F_2(\Delta t_{ij})\right] F_2''(\Delta t_{ij})}{F_2'(\Delta t_{ij})}\right] N_i < 0, \tag{44}$$

$$\frac{\partial^2 R_j}{\partial (t_j^m)^2} = \left[-2F_2'(\Delta t_{ij}) + \frac{F_2(\Delta t_{ij}) F_2''(\Delta t_{ij})}{F_2'(\Delta t_{ij})}\right] N_i < 0, \tag{45}$$

are fulfilled for all taxes that constitute a solution to (42) and (43) according to assumption 1 (vi) and (vii), and since, second, F is a twice continuously differentiable function.

Obviously, negative taxes can never be revenue maximising so that we can focus on non-negative solutions, i.e., $t_A^n, t_B^n, t_A^m, t_B^m \geq 0$. Moreover, $\partial R_i/\partial t_i^n|_{t_i^n=0} = \left[1 - F_2(-t_j^m)\right] N_i > 0$ and $\partial R_i/\partial t_i^n|_{t_i^n=t_j^m+\overline{m}_2} = -t_i^n F_2'(\overline{m}_2) < 0$, implying that $0 < t_i^n = g_i^n(t_j^m) < t_j^m + \overline{m}_2$. Similarly, $\partial R_j/\partial t_j^m\big|_{t_j^m=0} = F_2(t_i^n)N_i > 0$ and $\partial R_j/\partial t_j^m\big|_{t_j^m=t_i^n-\underline{m}_2} = -t_j^m F_2'(\underline{m}_2) < 0$, implying that $0 < t_j^m = g_j^m(t_i^n) < t_i^n - \underline{m}_2$. Thus, taxes are positive and boundary solutions with $F_2(\Delta t_{ij}) = F_2(\overline{m}_2) = 1$ or $F_2(\Delta t_{ij}) = F_2(\underline{m}_2) = 0$ can be excluded. Then, the reaction function g_i^n (g_j^m) gives a unique optimal tax t_i^n (t_j^m) for each tax t_j^m (t_i^n), and any equilibrium is characterised by conditions (5) and (6). (We implicitly assume that the firms' gross returns π are sufficiently large so that they do not constrain government taxation.)

Step 2 (Existence and uniqueness) We first show that a solution to condition (6), or equivalently to condition $\Delta t_{ij} - \left[1 - 2F_2(\Delta t_{ij})\right]/F_2'(\Delta t_{ij}) = 0$, exists and is unique.

To this end, we differentiate the term $[1 - 2F_2(\Delta t_{ij})] / F_2'(\Delta t_{ij}) =: \Phi(\Delta t_{ij})$ with respect to Δt_{ij}, leading to

$$\frac{\partial \Phi(\Delta t_{ij})}{\partial \Delta t_{ij}} < 0 \Leftrightarrow F_2''(\Delta t_{ij}) > -2\frac{[F_2'(\Delta t_{ij})]^2}{1 - 2F_2(\Delta t_{ij})} \tag{46}$$

for $F_2(\Delta t_{ij}) \in [0, 0.5] \Leftrightarrow \Delta t_{ij} \in [\underline{m}_2, m^{crit}]$, where m^{crit} is defined as $m^{crit} : F_2(m^{crit}) = 0.5$ and $m^{crit} > 0$ holds (see assumption 1 (iii)). Furthermore, inequality $F_2''(\Delta t_{ij}) > -2[F_2'(\Delta t_{ij})]^2 / [1 - F_2(\Delta t_{ij})]$ is satisfied (see assumption 1 (vii)), and inequality $-2[F_2'(\Delta t_{ij})]^2 / [1 - F_2(\Delta t_{ij})] \geq -2[F_2'(\Delta t_{ij})]^2 / [1 - 2F_2(\Delta t_{ij})]$ is also fulfilled for $\Delta t_{ij} \in [\underline{m}_2, m^{crit}]$. Thus, $F_2''(\Delta t_{ij}) > -2[F_2'(\Delta t_{ij})]^2 / [1 - 2F_2(\Delta t_{ij})]$ indeed results for $\Delta t_{ij} \in [\underline{m}_2, m^{crit}]$, and $\Phi(\Delta t_{ij})$ continuously declines with Δt_{ij} in the interval $[\underline{m}_2, m^{crit}]$. Also, we know that $\Phi(0) = [1 - 2F_2(0)] / F_2'(0) > 0$ (which follows from assumption 1 (iii)), $\Phi(m^{crit}) = 0$, and, for $\Delta t_{ij} \in (m^{crit}, \overline{m}_2]$, $\Phi(\Delta t_{ij}) < 0$ hold. As a result, the term $\Delta t_{ij} - \Phi(\Delta t_{ij}) = 0$ continuously increases with Δt_{ij} in the interval $[\underline{m}_2, m^{crit}]$, with $[\Delta t_{ij} - \Phi(\Delta t_{ij})]|_{\Delta t_{ij}=0} < 0$ and $[\Delta t_{ij} - \Phi(\Delta t_{ij})]|_{\Delta t_{ij} \geq m^{crit}} > 0$. Given these properties, the intermediate value theorem implies that a solution Δt_{ij} to the condition $\Delta t_{ij} - \Phi(\Delta t_{ij}) = 0$ (or, equivalently, to the condition (6)) exists and is unique, with $\Delta t_{ij} \in [0, m^{crit}]$. Then, equilibrium taxes $t_A^n = t_B^n$ and $t_A^m = t_B^m$ exist and are uniquely determined by (5).

Step 3 (Subsidy Competition and Subgame-Perfect Equilibrium) The first-order conditions (12) and (13) are equivalent to

$$\frac{\partial NR_i}{\partial \tau_i^n} = \left[1 - F_1(\tau_i^n - \tau_j^m)\right] - \tau_i^n F_1'(\tau_i^n - \tau_j^m) = 0, \tag{47}$$

$$\frac{\partial NR_j}{\partial \tau_j^m} = F_1(\tau_i^n - \tau_j^m) - \tau_j^m F_1'(\tau_i^n - \tau_j^m) = 0, \tag{48}$$

where (7), (14) and (15) are used. The similarity between (47) and (48) on the one hand and (42) and (43) on the other hand is obvious. Not surprisingly, the proof of existence and uniqueness of the subsidy competition equilibrium follows the lines of reasoning explored in step 1 and 2, which need not be repeated here. The hypothetical taxes τ_i^n and τ_i^m are independent of the second-period equilibrium. The only impact of the second-period equilibrium on the first-period equilibrium is that the taxes t_i^n and t_i^m raise the resulting subsidies s_i^n and s_i^m by the revenue differential $\Delta\Omega_{ii}$. The symmetric nature of the framework and the resulting equilibrium imply $N_i = N_j = 1$ and $H_i = H_j$.

Consequently, we can conclude that (i) a subgame-perfect equilibrium exists and is unique, (ii) equilibrium taxes and subsidies are characterised by (5), (6), (8), (14) and (15), and (iii) $N_i = N_j = 1$ and $H_i = H_j$ result.

Proof of propositions 1 and 2

Preliminary results Inserting the optimal taxes (5) and (8) into the net tax revenues (19) and rearranging to resulting terms lead to

$$NR_i = 2\frac{F_2^2(\Delta t_{ji}; z_2)}{F_2'(\Delta t_{ji}; z_2)} + \frac{[1 - F_1(\Delta \tau_{ij}; z_1)]^2}{F_1'(\Delta \tau_{ij}; z_1)} + \frac{F_1^2(\Delta \tau_{ji}; z_1)}{F_1'(\Delta \tau_{ji}; z_1)}. \tag{49}$$

Differentiating net tax revenues (49) with respect to mobility parameter z_2 yields

$$\frac{dNR_i}{dz_2} = \frac{\partial NR_i}{\partial z_2} + \frac{\partial NR_i}{\partial \Delta t_{ji}} \frac{d\Delta t_{ji}}{dz_2}. \tag{50}$$

The components of this derivative are given by

$$\frac{\partial NR_i}{\partial z_2} = 2\frac{2F_2'(\Delta t_{ji}; z_2) F_2(\Delta t_{ji}; z_2) \frac{\partial F_2(\Delta t_{ji}; z_2)}{\partial z_2} - [F_2(\Delta t_{ji}; z_2)]^2 \frac{\partial F_2'(\Delta t_{ji})}{\partial z_2}}{[F_2'(\Delta t_{ji}; z_2)]^2}, \tag{51}$$

$$\frac{\partial NR_i}{\partial \Delta t_{ji}} = 2\frac{2[F_2'(\Delta t_{ji}; z_2)]^2 F_2(\Delta t_{ji}; z_2) - [F_2(\Delta t_{ji}; z_2)]^2 F_2''(\Delta t_{ji}; z_2)}{[F_2'(\Delta t_{ji}; z_2)]^2}, \tag{52}$$

$$\frac{d\Delta t_{ji}}{dz_2} = -\frac{2F_2'(\Delta t_{ji}; z_2) \frac{\partial F_2(\Delta t_{ji}; z_2)}{\partial z_2} + [1 - 2F_2(\Delta t_{ji}; z_2)] \frac{\partial F_2'(\Delta t_{ji}; z_2)}{\partial z_2}}{[F_2'(\Delta t_{ji}; z_2)]^2 [3 + \rho_2]}, \tag{53}$$

where

$$\rho_2 = \frac{\Delta t_{ji} F_2''(\Delta t_{ji}; z_2)}{F_2'(\Delta t_{ji}; z_2)} = \frac{[1 - 2F_2(\Delta t_{ji}; z_2)] F_2''(\Delta t_{ji}; z_2)}{[F_2'(\Delta t_{ji}; z_2)]^2} \tag{54}$$

is the elasticity of the density function $F_2'(\Delta t_{ji}; z_2)$ with respect to changes in the tax differential Δt_{ji}, evaluated at the equilibrium. Note that derivative (53) follows from tax differential (6) and the associated comparative statics: $d\Delta t_{ji}/dz_2 = -(\partial \kappa_2/\partial z_2)/(\partial \kappa_2/\partial \Delta t_{ji})$, where $\kappa_2(\Delta t; z_2) := \Delta t_{ji} - [1 - 2F_2(\Delta t_{ji}; z_2)] / F_2'(\Delta t_{ji}; z_2)$ and $\partial \kappa_2/\partial \Delta t_{ji} = 3 + \rho_2$.

We can prove propositions 1 and 2 in a more convenient and shorter manner by making use of the derivatives (50)-(53) instead of the more intuitive derivative (21) and the tedious comparative statics that leads to dt^n/dz_2.

Proposition 1 We now consider scenario 1 with $\partial F_2(\Delta t_{ji}; z_2)/\partial z_2 > 0$ and $\partial F_2'(\Delta t_{ji}; z_2)/\partial z_2 = 0$ at the equilibrium value of Δt_{ji}, which simplifies the derivatives (51) and (53). To prove proposition 1, we insert derivatives (51), (52) and (53) into derivative (50) and rearrange the resulting terms (using eq. (54)):

$$\begin{aligned} \frac{dNR_i}{dz_2} &= 4\frac{F_2 \frac{\partial F_2}{\partial z_2}}{F_2'(3 + \rho_2)} \left(1 + \frac{(1 - F_2) F_2''}{(F_2')^2}\right) \\ &= 4\frac{F_2 \frac{\partial F_2}{\partial z_2}}{F_2'(3 + \rho_2)} \left(\frac{\partial \varepsilon_j^n}{\partial t_j^n} \frac{t_j^n}{\varepsilon_j^n} - 1\right) \geq 0 \Leftrightarrow \frac{\partial \varepsilon_j^n}{\partial t_j^n} \frac{t_j^n}{\varepsilon_j^n} \geq 1, \end{aligned} \tag{55}$$

where the elasticity of the elasticity ε_j^n with respect to t_j^n,

$$\frac{\partial \varepsilon_j^n}{\partial t_j^n} \frac{t_j^n}{\varepsilon_j^n} = \frac{[1 - F_2(\Delta t_{ji})] F_2''(\Delta t_{ji})}{[F_2'(\Delta t_{ji})]^2} + 2, \tag{56}$$

is evaluated at the equilibrium (see the first-order and equilibrium conditions (3) and (5)). The functions' argument Δt_{ji} and parameter z_2 are suppressed in eq. (55) for notational convenience. The sign of derivative (55) depends on the terms in the brackets, since all other terms are positive. In particular, $F_2'' > -(F_2')^2 / (1 - F_2)$ (see assumption 1 (vii)) implies that the inequality $3+\rho_2 > 3-[(1 - 2F_2) / (1 - F_2)] > 2$ is fulfilled, where eq. (54) is used.

Furthermore, comparative statics yields

$$\begin{aligned} \frac{dg(t_i^m)}{dt_i^m} \geq 0 &\Leftrightarrow \frac{\partial^2 R_j}{\partial t_j^n \partial t_i^m} = \left[F_2'(\Delta t_{ji}) + \frac{1 - F_2(\Delta t_{ji})}{F_2'(\Delta t_{ji})} F_2''(\Delta t_{ji}) \right] N_i \geq 0 \\ &\Leftrightarrow \frac{\partial \varepsilon_j^n}{\partial t_j^n} \frac{t_j^n}{\varepsilon_j^n} = \frac{1 - F_2(\Delta t_{ji})}{[F_2'(\Delta t_{ji})]^2} F_2''(\Delta t_{ji}) + 2 \geq 1, \end{aligned} \tag{57}$$

where the first-order condition (42) and eqs. (5) and (56) are used. The last inequality holds if, and only if, assumption 1 (vii) is satisfied. Thus, inequality (55) proves condition (a) of proposition 1, and inequalities (55) and (57) jointly imply conditions (b) and (c).

Proposition 2 To calculate the additional impact of a change in the mobility parameter z_2 on net revenues NR_i that arises if $\partial F_2'(\Delta t_{ji}; z_2)/\partial z_2 > 0$, we evaluate the derivatives (51) and (53) for $\partial F_2(\Delta t_{ji}; z_2)/\partial z_2 = 0$ and $\partial F_2'(\Delta t_{ji}; z_2)/\partial z_2 > 0$ at the equilibrium value of Δt_{ji}. Inserting again the derivatives (51)-(53) into derivative (50) yields, after some rearrangements,

$$\frac{dNR_i}{dz_2} = -2 \frac{\frac{\partial F_2'}{\partial z_2}}{(F_2')^2} \left[F_2^2 + \left(\frac{2(F_2')^2 F_2 - F_2^2 F_2''}{(F_2')^2} \right) \left(\frac{1 - 2F_2}{3 + \rho_2} \right) \right] \gtrless 0, \tag{58}$$

where we again suppress the functions' argument Δt_{ji} and parameter z_2. Assumption 1 (vi), i.e., $F_2'' \leq (F_2')^2 / F_2$, implies that $2(F_2')^2 F_2 - (F_2)^2 F_2'' > 0$ holds. Also, assumption 1 (vii), i.e., $F_2'' > -(F_2')^2 / (1 - F_2)$, implies that the inequality $3 + \rho_2 > 3 - [(1 - 2F_2) / (1 - F_2)] > 2$ is satisfied, with eq. (54) being used. Finally, $F_2 < 0.5$ and thus $1 - 2F_2 > 0$ hold in equilibrium (see tax differential (6) and the explanation in footnote 14). Thus, all terms in the square brackets are positive, resulting in

$$\frac{dNR_i}{dz_2} \gtreqless 0 \Leftrightarrow \frac{\partial F_2'(\Delta t_{ji}; z_2)}{\partial z_2} \lesseqgtr 0, \tag{59}$$

which proves proposition 2.

Proof of Propositions 3, 4 and 5

Preliminary results This proof follows along the lines of the previous reasoning and uses the fact that the equilibrium is symmetric, i.e., $\tau_i^n = \tau_j^n$, $\tau_i^m = \tau_j^m$ and $\Delta\tau_{ij} = \Delta\tau_{ji} =: \Delta\tau$. Now, equilibrium net tax revenues (49) are affected by a change in the mobility parameter z_1:

$$\frac{dNR_i}{dz_1} = \frac{\partial NR_i}{\partial z_1} + \frac{\partial NR_i}{\partial \Delta\tau}\frac{d\Delta\tau}{dz_1}. \tag{60}$$

The three terms in (60) are given by

$$\begin{aligned}
\frac{\partial NR_i}{\partial z_1} &= -2\frac{F_1'(\Delta\tau;z_1)\left[1-2F_1(\Delta\tau;z_1)\right]\frac{\partial F_1(\Delta\tau;z_1)}{\partial z_1}}{\left[F_1'(\Delta\tau;z_1)\right]^2} \\
&\quad -\frac{\left[1-2F_1(\Delta\tau;z_1)+2F_1^2(\Delta\tau;z_1)\right]\frac{\partial F_1'(\Delta\tau;z_1)}{\partial z_1}}{\left[F_1'(\Delta\tau;z_1)\right]^2}, \qquad (61)\\
\frac{\partial NR_i}{\partial \Delta\tau} &= -2\frac{\left[F_1'(\Delta\tau;z_1)\right]^2\left[1-2F_1(\Delta\tau;z_1)\right]}{\left[F_1'(\Delta\tau;z_1)\right]^2} \\
&\quad -\frac{\left[1-2F_1(\Delta\tau;z_1)+2F_1^2(\Delta\tau;z_1)\right]F_1''(\Delta\tau;z_1)}{\left[F_1'(\Delta\tau;z_1)\right]^2}, \qquad (62)\\
\frac{d\Delta\tau}{dz_1} &= -\frac{2F_1'(\Delta\tau;z_1)\frac{\partial F_1(\Delta\tau;z_1)}{\partial z_1}+\left[1-2F_1(\Delta\tau;z_1)\right]\frac{\partial F_1'(\Delta\tau;z_1)}{\partial z_1}}{\left[F_1'(\Delta\tau;z_1)\right]^2\left[3+\rho_1\right]}, \qquad (63)
\end{aligned}$$

where

$$\rho_1 = \frac{\Delta\tau F_1''(\Delta\tau;z_1)}{F_1'(\Delta\tau;z_1)} = \frac{\left[1-2F_1(\Delta\tau;z_1)\right]F_1''(\Delta\tau;z_1)}{\left[F_1'(\Delta\tau;z_1)\right]^2}. \tag{64}$$

is the elasticity of the density function $F_1'(\Delta\tau;z_1)$ with respect to changes in the differential $\Delta\tau$. Analogously to (53), derivative (63) follows from the differential in (8) and the respective comparative statics: $d\Delta\tau/dz_1 = -(\partial\kappa_1/\partial z_1)/(\partial\kappa_1/\partial\Delta\tau)$, where $\kappa_1(\Delta\tau;z_1) := \Delta\tau - \left[1-2F_1(\Delta\tau;z_1)\right]/F_1'(\Delta\tau;z_1)$ and $\partial\kappa_1/\partial\Delta\tau = 3+\rho_1$.

Propositions 3 and 4 We consider scenario 2 with $dF_1(\Delta\tau;z_1)/dz_1 > 0$ and $dF_1'(\Delta\tau;z_1)/dz_1 = 0$ at the equilibrium differential $\Delta\tau$. Proving proposition 4 first, we insert the derivatives (61), (62) and (63) into derivative (60) and rearrange the resulting terms:

$$\begin{aligned}
\frac{dNR_i}{dz_1} &= \frac{-2\frac{\partial F_1}{\partial z_1}}{F_1'\left(3+\rho_1\right)}\left[\left(1-\frac{F_1F_1''}{\left(F_1'\right)^2}\right)\left(1-F_1\right)-\left(1+\frac{\left(1-F_1\right)F_1''}{\left(F_1'\right)^2}\right)F_1\right] \\
&= \underbrace{\frac{-2\left(1-2F_1\right)\frac{\partial F_1}{\partial z_1}}{F_1'\left(3+\rho_1\right)}}_{<0}\left[\frac{\tau_j^n}{\tau_j^n-\tau_j^m}\frac{\partial\eta_j^m}{\partial\tau_j^m}\frac{\tau_j^m}{\eta_j^m}-\frac{\tau_j^m}{\tau_j^n-\tau_j^m}\frac{\partial\eta_j^n}{\partial\tau_j^n}\frac{\tau_j^n}{\eta_j^n}-1\right], \qquad (65)
\end{aligned}$$

where we make use of eq. (64) and of the elasticities of the elasticities η_j^n and η_j^m with respect to τ_j^n and τ_j^m,

$$\frac{\partial \eta_j^m}{\partial \tau_j^m}\frac{\tau_j^m}{\eta_j^m} = 2 - \frac{F_1 F_1''}{(F_1')^2} \quad \text{and} \quad \frac{\partial \eta_j^n}{\partial \tau_j^n}\frac{\tau_j^n}{\eta_j^n} = \frac{(1-F_1)F_1''}{(F_1')^2} + 2, \tag{66}$$

again evaluated at the equilibrium (see eqs. (8) and (16)). For notational convenience, we again omit the functions' argument $\Delta\tau$ and parameter z_1.

As already mentioned above, assumption 1 (vii), i.e., $F_1'' > -(F_1')^2/(1-F_1)$, implies the inequality $3+\rho_1 > 3-[(1-2F_1)/(1-F_1)] > 2$, with eq. (64) being used. Since F_1', $\partial F_1/\partial z_1$ and, in equilibrium, $1-2F_1$ are also positive, the quotient outside the square brackets is definitely negative. The overall sign of (65) then depends on the sign of the terms in the square brackets. Then, the terms in the square brackets of line 1 and 2 imply conditions (b) and (a), respectively, of proposition 4 (see (25) and (26)).

Let us turn to proposition 3. The proof of the first part completely follows along the lines of the proof of proposition 1 and need not be repeated. To prove the second part of proposition 3, we first establish the relationship between the hypothetical tax payments from domestic firms and the elasticity of the elasticity η_j^m with respect to τ_j^m:

$$\begin{aligned}\frac{d\left[\tau_i^n(1-F_1)\right]}{dz_1} &= \frac{-2(1-F_1)\frac{\partial F_1}{\partial z_1}}{F_1'(3+\rho_1)}\left(1-\frac{F_1''F_1}{(F_1')^2}\right) \\ &= \underbrace{\frac{-2(1-F_1)\frac{\partial F_1}{\partial z_1}}{F_1'(3+\rho_1)}}_{<0}\left(\frac{\partial \eta_j^m}{\partial \tau_j^m}\frac{\tau_j^m}{\eta_j^m} - 1\right) \leq 0 \Leftrightarrow \frac{\partial \eta_j^m}{\partial \tau_j^m}\frac{\tau_j^m}{\eta_j^m} \geq 1, \end{aligned} \tag{67}$$

where eq. (67) coincides with the first part of eq. (65), which is weighted by the term $\tau_j^n/\left(\tau_j^n - \tau_j^m\right)$.

Comparative statics yields

$$\begin{aligned}\frac{dh_j^m(\tau_i^n)}{d\tau_i^n} &\geq 0 \Leftrightarrow \frac{\partial^2 NR_j}{\partial \tau_j^m \partial \tau_i^n} = \left[F_1'(\Delta\tau) - \frac{F_1(\Delta\tau)}{F_1'(\Delta\tau)}F_1''(\Delta\tau)\right]N_i \geq 0 \\ &\Leftrightarrow \frac{\partial \eta_j^m}{\partial \tau_j^m}\frac{\tau_j^m}{\eta_j^m} = 2 - \frac{F_1(\Delta\tau)}{[F_1'(\Delta\tau)]^2}F_1''(\Delta\tau) \geq 1, \end{aligned} \tag{68}$$

where the first-order condition (48) and eq. (66) are used. The last inequality holds if, and only if, assumption 1 (vi) is satisfied. Thus, inequality (67) implies condition (a) of the second part of proposition 3, and inequalities (67) and (68) jointly prove conditions (b) and (c).

Proposition 5 We follow the lines of reasoning applied in the proof of proposition 2. That is, to determine the additional impact of a change in the parameter z_1 on the net tax revenues NR_i that arises if $\partial F_1'(\Delta\tau; z_1)/\partial z_1 > 0$, we evaluate the derivatives (61) and (63) for $\partial F_1(\Delta\tau; z_1)/\partial z_1 = 0$ and $\partial F_1'(\Delta\tau; z_1)/\partial z_1 > 0$ at the equilibrium value of $\Delta\tau$. Then, inserting (61)-(63) into derivative (60) yields, after some rearrangements,

$$\frac{dNR_i}{dz_1} = -\frac{\frac{\partial F_1'}{\partial z_1}}{(F_1')^2}\left[(1-F_1)^2 + F_1^2 - \frac{2(1-2F_1)(F_1')^2 + (1-2F_1)F_1''}{3(F_1')^2 + (1-2F_1)F_1''}(1-2F_1)\right], \tag{69}$$

where we again omit the functions' argument $\Delta\tau$ and parameter z_1. Note that $3(F_1')^2 + (1-2F_1)F_1'' = (F_1')^2(3+\rho_1) > 0$, since $3+\rho_1 > 2$, which is shown in the proof of proposition 4. Then, the quotient in the square brackets is positive and smaller than one. This conclusion, jointly with the fact that $(1-F_1)^2 + F_1^2 = 1 - 2F_1 + 2F_1^2 > 1 - 2F_1 > 0$ (where the last inequality follows from $F_1 < 0.5$ in equilibrium; see again the proof of proposition 4), implies that the expression in the square bracket is positive. Consequently, $dNR_i/dz_1 \gtreqless 0 \Leftrightarrow \partial F_1'/\partial z_1 \lesseqgtr 0$ results, which proves proposition 5.

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