# Essays on Firms in the Global Economy

by

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*To Nicola*

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# Abstract

This thesis explores how taxes and subsidies can influence the decisions of strategic firms acting in the global economy. Chapter 1 considers tax/subsidy competition for a multinational enterprise (MNE) between the governments of two potential host countries. It is shown that the MNE's decision to locate in the proximity of firms producing a homogeneous product may be the result of government subsidies that aim to capitalise on the potential for knowledge spillovers to indigenous industry; and that fiscal competition to host the MNE may increase the welfare of both winning and losing countries when it leads to the relocation of multinationals away from countries that do not have the potential to benefit from knowledge spillovers to countries that do.

Chapter 2 analyses the impact of anti-profit-shifting policies in a model with competition for an MNE's production *plant* and its *profits* between two governments that have at their disposal two fiscal policy instruments. It is shown that any gains in tax revenues resulting from more costly profit shifting may be partly offset by higher subsidies in the bidding stage for the MNE's plant such that the positive impact of anti-tax avoidance policies on host countries' tax revenues may be smaller than anticipated.

Chapter 3 analyses the impact of anti-profit-shifting policies in a model where a developed and a developing country compete for an MNE that can shift profits to a tax haven. It is shown that the MNE's ability to shift profits makes it less likely that it locates its production plant in the less developed country; and that in cases where the less developed country does host the MNE, profit shifting has the effect of reducing its government's revenues.

Chapter 4 considers the effect of trade costs on firms' R&D investment and collaboration choices in a symmetric international duopoly setup. We show that: (i) firms' investment in R&D increases as trade costs fall; (ii) firms prefer 'collaboration' to 'no collaboration' if trade costs are sufficiently low; and (iii) that the collaboration threshold is higher if governments subsidise the R&D investment of their indigenous firms.

Keywords: multinational firms, tax competition, knowledge spillovers, trade costs, firm location, profit-shifting, tax havens, developing countries, R&D collaboration, subsidies.

# Introduction

Over the past sixty years firms have become increasingly geographically mobile and interconnected as they sought to take maximum advantage of the changing global environment. Evidence of such developments is the staggering growth in the number of multinational firms since the Second World War (Buckley and Casson, 1976; Markusen, 1995); the surge in the share of wealth deposited in tax havens during just about the same period (Zucman, 2015); and the significant growth in the number of international inter-firm research and development (R&D) collaborations since the early 1970s (Hagedoorn, 2002), to mention a few.

On their part, governments across the world, acting either as benevolent maximisers of social welfare or Leviathan tax revenue maximisers, have sought to incentivise these "global" firms to behave in ways that they deemed desirable. The policy instruments at governments' disposal to achieve their objectives were (and are) numerous and have taken several forms (Glaeser, 2001); but few are utilised as frequently and extensively as taxes and subsidies.

The objective of this thesis is to explore how these two fiscal policy instruments can influence the decisions of strategic firms acting in a global economy using an applied game theoretic approach. The games (or models) presented in this thesis necessarily abstract from other important factors that influence global firms' behavioural choices. However, as Rodrik (2015) argues, "the simplicity, formalism, and neglect of many facets of the real world is precisely what makes [small-scale economics models] valuable", and what makes them useful is that they "capture the most relevant aspect of reality in a given context".

Faithful to this philosophy, this thesis sets up a series of simple models in an attempt to answer questions such as: What factors determine the location of a multinational firm when potential host governments compete in taxes and subsidies? What determines the size of the winning subsidy? Does the fight against profit shifting affect multinationals' plant location decisions? Do such policies increase world welfare? Do they help developing countries as much as they help developed ones? Do subsidies incentivise international inter-firm collaboration?

We seek to answer these questions over four related chapters, each featuring a distinct economic model that is briefly introduced below. The main idea underlying all four models is that governments can raise domestic welfare (or tax revenues) by using taxes and/or subsidies to shift profits away from the competing governments and global firms to domestic firms, consumers and public coffers.

Chapter 1 considers lump-sum tax/subsidy competition for a multinational firm between the governments of two potential host countries that differ in their capacity to absorb knowledge spillovers from the multinational firm. Chapter 2 analyses the impact of anti-profit-shifting policies in a model with competition for a multinational's production *plant* and its *profits* between two governments that have at their disposal two fiscal policy instruments (rather than one). Chapter 3 also deals with profit shifting policy, but instead analyses the case where two countries (that differ in their level of economic development) compete for a multinational firm that can shift profits to a third country – a tax haven that plays a passive role. And finally, Chapter 4 considers how trade costs can influence investment and international inter-firm collaboration in R&D in a two-country world *with* and *without* government subsidies for R&D.

The models in Chapters 1 to 3 are rooted in the tradition of auction-type models of tax competition. As in Haufler and Wooton (1999), they all feature governments bidding for a single multinational firm that may be thought of as a lumpy/discrete investment rather than as continuously divisible capital (as in the more traditional workhorse models of tax competition of Zodrow and Mieszkowski [1986] and Wilson [1986]). In Chapters 2 and 3, our treatment of profit shifting activities again departs from these workhorse models (in which the tax base is mechanically tied to real activity); and is instead closer to the model of Keen and Konrad (2013) that allows for profits to be shifted away from real activity to low-tax countries that host little or no real investment.

In contrast, Chapter 4 builds on models with roots in industrial organisation and international trade. It takes the R&D cooperation model of d'Aspremont and Jacquemin (1988) and sets it in an international context; and it also allows for governments to subsidise indigenous firms' R&D efforts, much like Spencer and Brander (1983). However, instead of having firms from two countries compete in a third country, firms are assumed to serve their home market and that of their competitor firm such that we can analyse how trade costs affect firms' R&D investment and collaboration decisions.

There are a few other elements – each common to at least three of the four models described in these chapters – that are also worth mentioning here. The rationale for incorporating each of these elements into the models are the following three stylized facts. First, global firms (that are at the very core of these models) are prevalent in relatively concentrated industries that seem to fit the theoretical category of oligopoly (Hymer, 1976; Markusen, 1995). For this reason, with the exception of one model where the multinational firm is modelled as a monopolist, product market competition is modelled *à* la Cournot (1838).

Second, trade costs seem to have had a significant effect on the feasibility of exports and imports, and consequently on the location and collaboration choices of global firms (WTO, 2008). The incorporation of trade costs in the models presented in this thesis allows us to draw insights on the impact that their significant reduction may have had over the last half century.

Third, global firms are most likely to be observed in industries where proprietary knowledge-based assets are important, and they are generally the firms with the largest stocks of such assets (Hymer, 1976; Markusen, 1995). Three of the four models discussed below thus allow for the possibility of knowledge spillovers, either between global firms, or from global firms to less efficient indigenous firms. These are modelled to be either intentional (as in the case of inter-firm R&D collaboration) or unintentional (due to the public good nature of knowledge).

Against this background, the rest of this chapter summarises the models, and outlines the key findings and contributions of the chapters that follow.

## Chapter 1: Fiscal Competition for FDI with Knowledge Spillovers and Trade Costs

Chapter 1 studies the location choice of a multinational firm in a world with two countries where governments compete in taxes and subsidies to host the multinational firm. The distinguishing feature of the model is the countries' differing capacity to absorb (beneficial) knowledge spillovers from the multinational firm.

The chapter builds on the frequently cited work of Bjorvatn and Eckel (2006), who study tax competition between the governments of two potential host countries of different size in the presence of an immobile indigenous firm in the larger country. They show that the government of the country with the indigenous firm loses the auction for the multinational firm because it takes account of the harm that inward investment has on the indigenous firm's profits. This result, however, is at odds with empirical cases where governments frequently appear to be keen to attract inward FDI for its perceived benefits to indigenous industry. By allowing for one-way knowledge spillovers from the multinational firm to the indigenous firm, the model developed in this chapter predicts that the equilibrium location outcome might change if the governments account for the potential benefits that may accrue to the indigenous firm and their consumers from knowledge spillovers.

The model brings together two important theoretical studies in the field of tax competition for Foreign Direct Investment (FDI): Fumagalli's (2003) consideration of knowledge spillovers and Bjorvatn and Eckel's (2006) consideration of imperfectly competitive markets. We show that the decision of multinational firms to locate in the proximity of indigenous firms – which can be thought of as agglomeration – may be the result of the provision of government incentives that aim to capitalise on the potential for knowledge spillovers to indigenous industry. Somewhat different but complementary to Fumagalli (2003), we also show that fiscal competition may increase the welfare of both winning and losing countries in the auction for the multinational firm when it leads to the relocation of multinationals away from countries that do not have the potential to benefit from knowledge spillovers to countries that do. As trade costs fall and the potential for knowledge spillovers increases, both outcomes become more likely in equilibrium.

## Chapter 2: Fiscal Competition for Plant and Profits: adjusting expectations about tackling profit shifting

The research presented in Chapter 2 is motivated by the ongoing debate on aggressive tax planning by multinational firms. This has led international institutions, such as the OECD and the European Commission, to push forward a number of measures to tackle profit shifting – with some measures being implemented already, such as the automatic exchange of information on tax rulings, while others, such as the Common Consolidated Corporate Tax Base (CCCTB), are still being hotly debated. Given the importance of taxes and subsidies as determinants of the location of MNEs' production plants and their profits (see, for example, IMF [2014]), these measures are likely to affect the strategic interaction among the governments of potential host countries in the determination of the taxes/subsides that they charge/pay to MNEs in attempt to lure them, and their profits, into their country.

We study these potential effects in a model with two countries that engage in fiscal competition at two levels: first they compete for an MNE's plant via lump-sum subsidies, and after the MNE's plant location decision, they compete for its imperfectly mobile profits via proportional tax rates. The consideration of competition between Leviathan governments for *both* the multinational's plant and it profits is a key distinguishing feature of the model; with only a handful of other papers analysing outcomes with similar setups.

We show that any gains in tax revenues resulting from more costly profit shifting will be partly offset by higher subsidies in the bidding stage for the MNE's plant. Consequently, the positive impact of anti-tax avoidance policies on host countries' tax revenues may be smaller than anticipated because they also intensify the competition for real capital. The difference in the size of competing countries turns out to be key in determining whether the higher costs of profit shifting intensify competition for real capital. We also show that more costly profit shifting benefits *both* governments but harms the MNE. The latter outweighs the former, giving rise to a dead-weight loss that causes world welfare to decline.

## Chapter 3: The Threat of Tax Havens to Developing Countries

Like the previous chapter, Chapter 3 analyses the impact of anti-profit shifting polices on the location of an MNE's plant and its profits. However, there are three important differences. The first is that the setup involves tax competition between a developed and a developing country for a multinational firm that can shift profits to a third country – a tax haven. This is motivated by recent empirical evidence suggesting that tax havens may be even more problematic for less developed regions (IMF, 2014). The second is that the two governments compete using only one fiscal policy instrument (a proportional tax rate on profits). The third is that they cannot tax discriminate between the multinational (mobile) firm and their respective indigenous (immobile) firms. This ought to reflect past and ongoing efforts to abolish the preferential tax treatment given to (mobile) non-resident firms (OECD, 2017).

We show that when governments set tax rates simultaneously, the game has no equilibrium in pure strategies. Instead we look for the equilibrium outcome in a sequential tax setting, and we show that: (i) the multinational's ability to shift profits to tax havens makes it less likely that it locates its production plant in the less developed country; and (ii) in cases where the less developed country does host the MNE, profit shifting opportunities have the effect of reducing its government's revenues.

Furthermore, this chapter adds to the theoretical debate on the impacts of tax havens. One strand of literature, primarily driven by Hong and Smart (2010), argues that in a setting where governments cannot tax discriminate between firms, tax havens could be beneficial to the host country because it allows it to set a "high" tax rate on the profits of domestic (immobile) firms without driving away (mobile) MNEs. In contrast, Slemrod and Wilson (2009) argue that tax havens are detrimental to non-haven countries because they lead to wasteful expenditure of resources to limit (exercise) tax avoidance by governments (firms); and also because they "worsen" tax competition between potential host countries by causing them to reduce their tax rates. By allowing for asymmetry between the competing countries, we are able to distinguish between cases where tax havens have a positive impact on the host country's tax revenues (as argued in Hong and Smart) and those cases where they have a negative impact (as argued in Slemrod and Wilson). In our model, the impact is negative on less developed countries and, given certain conditions, positive on developed countries.

## Chapter 4: International R&D Collaboration, R&D Subsidies and Trade Costs

The research in Chapter 4 is motivated by the growing number of international inter-firm R&D collaborations (OECD, 2013); and by how little we know about the factors that drive firms to collaborate with geographically distant agents (Fitjar and Rodriguez-Pose, 2014). In particular, we are interested in the role that falling trade costs play in facilitating (or otherwise) investment and international collaborations in R&D.

There exists empirical evidence suggesting that lowering trade costs (or trade barriers) enables export growth, that, in turn, incentivises more investment in R&D (see, for example, Baldwin and Gu, 2004). And the increase in international inter-firm

R&D collaboration noted above, has taken place during a period that saw trade costs follow an overall downward trend (WTO, 2008). These suggest that firms *invest* and *collaborate* more in R&D as trade costs fall.

We study the effect of trade costs on these two factors in a simple model with two same-size countries, each hosting one firm. The two firms may collaborate by sharing their cost-reducing R&D, but are assumed to act independently in deciding how much to invest in R&D and how much to produce for their home market and the foreign market (*à* la d'Aspremont and Jacquemin, 1988). And because R&D subsidies play a key role in strategic trade policy, we analyse the investment and collaboration aspects under two scenarios: 'with' and 'without' government R&D subsidies to indigenous firms.

We draw three lessons. First, in line with Haaland and Kind (2008) and Ghosh and Lim (2013), we show that lower trade costs increase the quantity sold by the competing firms, and thereby incentivise firms to invest more in R&D. Second, we show that given a fixed collaboration cost, the two firms prefer 'collaboration' to 'no collaboration' if trade costs are sufficiently low; and that this threshold is higher if governments subsidise the R&D investment of their indigenous firms. Thus, in a model where trade costs provide a degree of market segmentation that may discourage international inter-firm R&D collaboration, governments may subsidise R&D to encourage collaboration. It turns out that the use of government subsidies for R&D will be world-welfare-improving as long as firms choose to collaborate; otherwise governments end up in a 'subsidy war' that causes world welfare to decline.

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# Chapter 1

# Fiscal Competition for FDI with Knowledge Spillovers and Trade Costs[1]

## 1.1 Introduction

An abundance of literature supports the hypothesis that knowledge spillovers are one of the more important reasons why governments want to host multinational firms (see, for example, Blomstrom and Kokko, 1998). To capitalise on such benefits, they are often willing to offer favourable tax rates – or at times even subsidies – to beat the competition of other potential host countries. In fact, a survey carried out with investment promotion agencies in over 45 countries from all regions of the world shows that nearly all countries offer some form of investment incentives (UNCTAD, 2000). Of course, it is possible that governments offer incentives for reasons other than knowledge spillovers; most importantly the creation of "good" jobs. However, it is not difficult to think of cases where the governments of regions with near

[1] **The present chapter is joint work with Ben Ferrett. Earlier versions of this work have been presented at the GEP 15th Annual Postgraduate Conference, University of Nottingham in 2016 and at the PhD Student Workshop held at Loughborough University in 2014. We thank participants for their helpful comments and useful discussions.**

full-employment offer subsidies to attract multinational enterprises (MNEs). For example, in their study of General Motors' decision to locate its Saturn plant in Tennessee, Bartik *et al.* (1987) argue that the social efficiency benefits caused by additional labour demand were zero because the county of location did not have particularly high unemployment, such that jobs went to unemployed migrants or displaced workers from other jobs. In such cases, and barring political motives, the rationale for investment incentives may well be knowledge spillovers.

Nonetheless, theoretical analysis of fiscal competition for foreign direct investment (FDI) has generally overlooked governments' incentives to capitalise on the potential for knowledge spillovers, and instead emphasized the roles of market size and structure (see, for example, Haufler and Wooton, 1999; Barros and Cabral, 2000; Bjorvatn and Eckel, 2006). For example, Bjorvatn and Eckel (2006), henceforth BE, study tax/subsidy competition between the governments of two potential host countries of different size in the presence of an immobile indigenous firm in the larger country. By assuming that the profits of the indigenous firm enter its country's welfare function, they show that the government of the country with the indigenous firm is less willing to bid for FDI due to the "market crowding effect" (i.e. the preference of imperfectly competitive firms for locations with relatively few competitors when trade is costly). This result, however, is at odds with empirical cases where governments frequently appear to be keen to attract inward FDI for its perceived *benefits* to indigenous industry.

In an attempt to capture these effects, we build on BE (2006) by incorporating into their model the potential for one-way knowledge spillovers from the MNE to the indigenous firm *if* the two firms are located in the same country. Assuming (for simplicity) that countries are symmetric in size, we show that in the absence of fiscal competition the MNE chooses to locate in the country without the indigenous firm. This outcome mirrors the symmetric-country-case in BE (2006), which is driven by the market crowding effect, but it is reinforced by the MNE's desire to limit knowledge spillovers to its rival. However, in contrast to the outcome in BE (2006), we show that the MNE's equilibrium location decision *may* change when governments compete in taxes/subsidies because, relative to BE, the potential for knowledge spillovers in our model increases the valuation of the FDI project of the country *with* the indigenous firm and decreases that of the country *without* the indigenous firm. Thus, in the presence of localised knowledge spillovers from inward FDI, the provision of investment incentives in the form of favourable taxes or subsidies may be considered to be an important determinant of agglomeration, i.e. the co-location of the MNE and the indigenous firm. We show that as trade costs fall and the potential for knowledge spillovers increases, this co-location outcome becomes more likely in equilibrium.

Baldwin and Krugman (2004) also study tax competition for mobile capital in the presence of agglomeration benefits. However, their source of agglomeration benefits, the market linkages of new economic geography, differs from ours, localised knowledge spillovers. In Baldwin and Krugman, agglomeration creates benefits for all mobile capital, which the "core" country is able to capture in tax. In essence, the Baldwin/Krugman model appears equivalent to one of two-way knowledge spillovers, such that the incoming MNE can be taxed. In contrast, the knowledge spillover is one-way (from the MNE to the indigenous firm) in our model, such that a subsidy is needed to attract the MNE. On the basis of this comparison, one may conjecture that the direction of knowledge spillovers is important for whether the MNE is subsidised or taxed in equilibrium.

Our study is also related to Fumagalli (2003) whose setup involves two countries of equal size, each of which contains an indigenous firm. The two indigenous firms have different levels of technology (reflected in different marginal costs), and thus the potential for knowledge spillovers differs between the two host countries. Similar to the model presented in this chapter, inward FDI generates a positive externality in the form of knowledge spillovers to the indigenous firm located in the same country but, unlike us, Fumagalli does not allow for a trade cost between the two host countries. Her setup yields a result that is similar to one derived from our model: in contrast to laissez-faire, fiscal competition makes it possible that the MNE will locate in the country where knowledge spillovers are maximised. However, we show that this possibility recedes as trade costs rise because, in our model, co-location becomes less attractive as national product markets become more protected.[2] Thus, our setup makes it possible to explore the tension created by the opposing effects that knowledge spillovers and trade costs have on country valuations and the consequent location decision of the MNE.

Our simultaneous consideration of knowledge spillovers and trade costs, which distinguishes our analysis from both Bjorvatn and Eckel (2006) and Fumagalli (2003), calls for a reassessment of the welfare impacts of fiscal competition. The established result that tax/subsidy competition in the form of an auction for a single firm maximises overall world welfare continues to hold. In addition, we derive two new welfare findings. Focusing first on welfare at the regional level (here defined as the welfare sum of the two countries), BE show that fiscal competition increases regional welfare only when trade costs are high. In contrast, we show that by introducing knowledge spillovers into the model, it is possible that fiscal competition improves regional welfare even at relatively low trade costs. Second, turning to the welfare of individual countries, Fumagalli shows that if *both* countries have the potential to benefit from knowledge spillovers from the MNE to indigenous industry, one country (the winner of the FDI under laissez-faire) is necessarily worse off under fiscal competition. In contrast, we show that in a model where only one country has the potential to benefit from knowledge spillovers (e.g. due to differing specialisations of indigenous industries or levels of educational attainment and "absorptive capacity"), both countries may be better off under fiscal competition.

Summing up, we contribute to the existing literature on fiscal competition for FDI by showing how trade costs and knowledge-spillover benefits interact with fiscal policy to determine multinationals' location decisions and the associated welfare outcomes. The remainder of this chapter is organised as follows: Section 1.2 describes the model under "laissez-faire" and "fiscal competition"; Section 1.3 discusses welfare issues; and Section 1.4 concludes by discussing a number of policy-relevant results.

[2]Note that, in contrast to us, Fumagalli's framework is unsuited to examining the agglomeration/non-agglomeration distinction because *both* host countries contain an indigenous firm in her model.

## 1.2 The model

Consider a model with a region consisting of two countries, A and B, which are symmetric in size.[3] Country A hosts the only indigenous and immobile firm in the region and there also exists an MNE that wishes to invest in one of the two countries to serve regional demand. The indigenous firm in country A is entirely owned within that country, whereas the MNE is entirely owned outside the host region. Each firm can export within the region at a per unit trade cost $t$ in either direction. However, the trade costs associated with serving the region through exports from outside the region are assumed to be prohibitively high so that access to regional consumers requires FDI. Setting up in one of the two countries involves a fixed investment cost, $F$, which is assumed to be the same in both countries. $F$ is sufficiently high to ensure that the MNE does not split its production between the two countries by establishing a plant in each.

The MNE produces a good identical to that of the indigenous firm but the two firms' marginal costs of production are assumed to be different. The indigenous firm is less efficient than the MNE such that its marginal cost $c \in [0, 1]$ is greater than that of the MNE which is equal to zero.[4] However, if the MNE locates in country A, the indigenous firm benefits from a localised one-way knowledge spillover by gaining partial or even total access to the MNE's technology so that its marginal cost is reduced by $\phi c$ to $(1 - \phi) c$, where $\phi \in [0, 1]$.[5] When $\phi = 1$ the knowledge spillover is the strongest possible and the indigenous firm becomes as efficient as the MNE.

After the MNE chooses in which country to invest, the firms play separate Cournot

[3] We abstract from market size issues because these have already been extensively explored in both theoretical and empirical literature (see, for example, Haufler and Wooton, 1999; Bjorvatn and Eckel, 2006). Moreover, the assumption of equal sizes gives us a clean laissez-faire benchmark: see Proposition 1.1.

[4] Setting the MNE's marginal cost equal to zero simplifies the notation significantly as it enables us to express the post-knowledge spillover marginal cost of the indigenous firm independently of the MNE's marginal costs.

[5] This has two implications that are generally supported by empirical evidence. First, knowledge spillovers are *one-way* because MNEs are significantly more productive than exporting and non-exporting firms (see, for example, Helpman *et al.*, 2004). Second, and also supported by empirical evidence, is the assumption that proximity is an important determinant for knowledge spillovers (see, for example, Jaffe *et al.*, 1993).

games in each product market. Both firms are assumed to sell in both markets, such that Cournot equilibria are always interior.[6] The inverse demand function for the good in each country is given by $P_i = 1 - Q_i$, where $Q_i$ and $P_i$ are the quantity demanded and price in country $i$. The MNE's problem is to decide in which country to locate to serve regional demand.

### 1.2.1 Laissez-faire scenario

Initially, we assume a laissez-faire scenario where there is no fiscal competition such that government intervention cannot influence the MNE's investment location. In this case, the MNE chooses its location solely on the basis of pre-tax profits, and the game involves two stages:

- in stage 1, the MNE decides where to locate; and
- in stage 2, the MNE and the indigenous firm compete *à la* Cournot to serve regional demand.

The MNE maximises its profits, and the game is solved by backward induction to isolate its subgame perfect Nash equilibrium (we focus on pure strategies throughout).

The full derivation of the equilibrium profits is presented in Appendix 1.5.1. Let $\Gamma$, which we term country B's "geographic advantage", measure the additional pre-tax profits that the MNE earns if it locates in country B rather than country A:

[6] If the MNE invests in A, the two firms' marginal costs are $(0, (1-\phi)\,c)$ on market A and $(t, (1-\phi)\,c + t)$ on market B. Alternatively, if the MNE invests in B, the two firms' marginal costs are $(t, c)$ on market A and $(0, c+t)$ on market B. We can move from the final marginal-cost pair to any of the other three by increasing the MNE's marginal cost and cutting the indigenous firm's. Therefore, if the fourth Cournot equilibrium (on market B when the MNE chooses B) is interior, then the other three will be too; and the condition for this is $c + t < 0.5$, which we assume to hold throughout.

$$
\begin{aligned}
\Gamma \;=\; & \underbrace{\left[\frac{1}{9}\left(1-2t+c\right)^{2}+\frac{1}{9}\left(1+c+t\right)^{2}\right]}_{\text{MNE's profits if it locates in B}} \\
& -\underbrace{\left[\frac{1}{9}\left(1+(1-\phi)c\right)^{2}+\frac{1}{9}\left(1-t+(1-\phi)c\right)^{2}\right]}_{\text{MNE's profits if it locates in A}} \qquad (1.1) \\
& =\frac{2}{9}\left(2t^{2}+\phi c^{2}\left(2-\phi\right)+\phi c\left(2-t\right)\right)
\end{aligned}
$$

**Proposition 1.1.** *In the absence of fiscal competition, the MNE always locates in country B, at a distance from the indigenous firm.*

*Proof.* From equation (1.1), it is clear that at $c = 0$, $\Gamma = \frac{4}{9}t^2 \geq 0$. Moreover, $\frac{d\Gamma}{dc} > 0$ for all $c \geq 0$. □

This outcome is the result of two forces, which reinforce each other. The first is the MNE's incentive to avoid proximity to the indigenous firm in order to limit competition in the product market. This tendency to avoid proximity to competitors has been recognized for a long time in location theory and is generally referred to as the "market crowding effect" (see Fujita and Thisse, 2002; Baldwin *et al.*, 2003). The second is the MNE's incentive to locate its subsidiary in the country where rent erosion due to knowledge spillovers (to its competitor) is minimized; a strategy which has been recognised both theoretically (Fumagalli, 2003; Iammarino and McCann, 2013) and empirically (Shaver and Flyer, 2000; Alcácer and Chung, 2007). As Proposition 1.1 shows, co-location will not occur in our model for purely private reasons, and thus our laissez-faire benchmark is remarkably clean: the MNE always locates in B. This provides additional justification for our assumption of equal country sizes.

### 1.2.2 Fiscal competition scenario

In the fiscal competition scenario, the governments of the two countries bid to host the MNE. The game involves three stages:

- in stage 1, the governments simultaneously and non-cooperatively announce their lump-sum tax/subsidy offers for the MNE's plant;
- in stage 2, the MNE decides where to locate and invests; and
- in stage 3, the MNE and the indigenous firm compete *à la* Cournot on both countries' product markets. A tax/subsidy transfer payment occurs between the MNE and the winning country's taxpayers.

The MNE maximises its after-tax profits and the host countries maximise their levels of social welfare; and, again, the game is solved by backward induction. However, unlike the game in the laissez-faire scenario, the outcome does not only depend on country B's geographic advantage, $\varGamma$, but also on the governments' valuations of the FDI project, which determine their willingness to bid.

In equilibrium, country A wins the auction for the MNE if its valuation of the FDI project, $V_A$, is so much higher than that of country B, $V_B$, that it more than makes up for country B's geographic advantage:

$$V_A > V_B + \varGamma \tag{1.2}$$

The bidding for the MNE's plant is a first-price auction (with complete information and private values) with an important twist. The fact that the countries offer the MNE different levels of pre-tax profits implies that, in general, the auction is not a tie (with the MNE being indifferent concerning the location of its plant) when the two countries post the same bid. Thus, for example, a country that enjoys a geographic advantage (here, country B) appreciates that it can win the FDI with a lower bid than its rival.[7]

In expression (1.2), $V_B$ is the additional consumer surplus that country B enjoys under local production via FDI compared to importing:

$$\begin{aligned} V_B &= \left[\frac{1}{18}(2-c-t)^2\right] - \left[\frac{1}{18}(2-(1-\phi)c-2t)^2\right] \\ &= \frac{1}{18}(t-\phi c)(3t-\phi c+2c-4) \end{aligned} \tag{1.3}$$

and $V_A$ is A's consumer surplus gain from local production following inward FDI *plus* the change in the profits of its indigenous firm due to inward FDI:

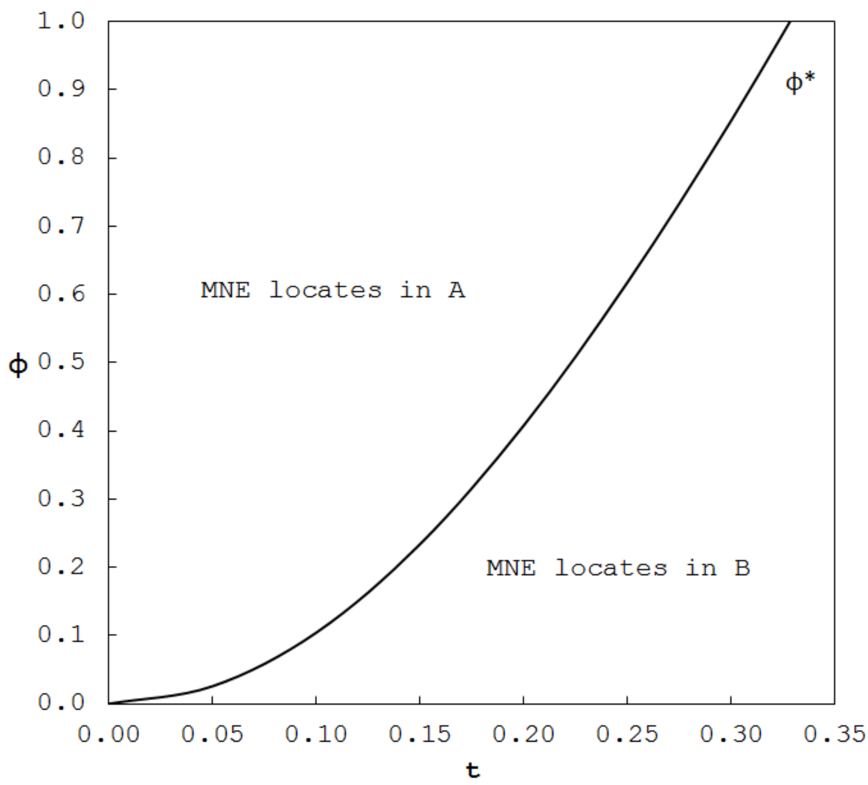
$$\begin{aligned} V_A = &\underbrace{\left[\frac{1}{18}(2-(1-\phi)c)^2\right] - \left[\frac{1}{18}(2-c-t)^2\right]}_{\text{Gain in consumer surplus from inward FDI}} \\ &+ \underbrace{\begin{array}{c} \left[\frac{1}{9}(1-2(1-\phi)c)^2 + \frac{1}{9}(1-2(1-\phi)c-t)^2\right] \\ -\left[\frac{1}{9}(1-2c+t)^2 + \frac{1}{9}(1-2c-2t)^2\right] \end{array}}_{\text{Gain in indigenous firm's profits from inward FDI}} \end{aligned} \tag{1.4}$$

In our model, both governments are benevolent social-welfare-maximisers. Inward FDI alters the market price paid by a country's consumers (both because it eliminates the trade cost from the MNE's marginal cost and because it changes the realised knowledge spillover), and both countries take account of this welfare effect; in addition, country A also takes account of how inward FDI affects its indigenous firm's profits.[8]

[7] See Ferrett and Wooton (2010) for an extensive discussion of our auction set-up, including its microfoundations and equilibrium properties.

[8] Besides consumer-welfare and spillover benefits, other possible motivations for bidding for FDI have been examined in the literature: e.g. wage premia for domestic workers in "good" MNE jobs, including the relief of involuntary unemployment (Haaparanta, 1996); and the net fiscal contribution from the mobile factors associated with inward FDI (Black and Hoyt, 1989).

Figure 1.1: MNE's Location Decision under Fiscal Competition ($c = 0.15$)




Proposition 1.2 describes the MNE's equilibrium location under fiscal competition and follows from the preceeding text:

**Proposition 1.2.** *Under fiscal competition for the MNE's plant, country A wins the FDI if and only if* $V_A > V_B + \Gamma$ *or, equivalently,* $\phi > \phi^*$*, where* $\phi^*$ *is the level of knowledge spillovers that would make the MNE indifferent between the two countries if they were both to bid their valuations. (See Appendix 1.5.2 for explicit definition of* $\phi^*$*).*

While the above proposition gives the MNE's equilibrium location, it is important to recognise that both countries do *not* actually bid their valuations in equilibrium. In equilibrium, the losing country bids its valuation; and, taking account of the pattern of geographic advantage, the winning country just trumps that losing bid.[9]

[9] Thus, for example, the winning country would be able to impose a *tax* in equilibrium if its geographic advantage were sufficiently strong.

Assuming (for simplicity) that $c = 0.15$, the proposition is illustrated in Figure 1.1.[10] It shows that country A wins the auction when trade costs, $t$, are sufficiently low and knowledge spillovers, $\phi$, are sufficiently large. Otherwise country B wins. Note that any point on the horizontal axis, where $\phi = 0$, represents an outcome identical to BE (2006), i.e. the MNE locates at a distance from the indigenous firm when the two countries are the same size. On the other hand, any point on the vertical axis, where $t = 0$, represents an outcome similar to Fumagalli (2003), i.e. the MNE locates in the country where knowledge spillovers would be greatest. This suggests that as $t$ falls and $\phi$ increases, co-location of the MNE and the indigenous firm becomes more likely in equilibrium. To understand the drivers of this result in more detail, we next consider the impact of both *trade costs* and *knowledge spillovers* on the two sides of condition (1.2).

*The trade cost effect*

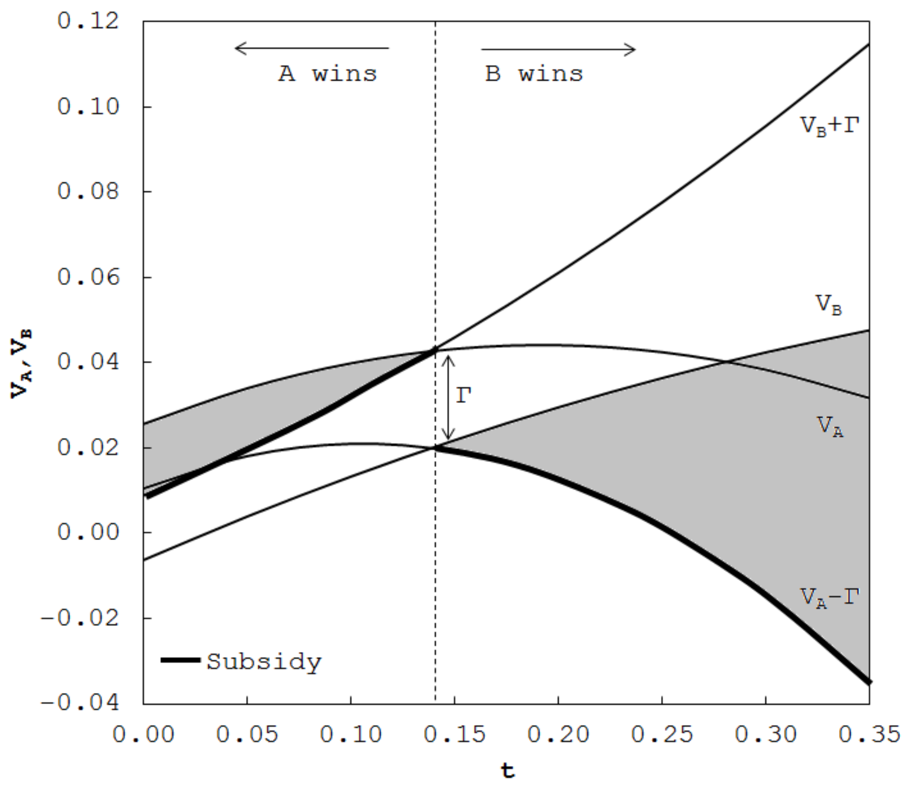
Consider the case where $\phi = 0.2$. From Figure 1.1 above, we know that at that level of knowledge spillovers, the MNE is indifferent between locating in either of the two countries in equilibrium if $t \approx 0.14$. This is also reflected in Figure 1.2, which for ease of exposition assumes $\phi$ to be constant. It shows that for $t < 0.14$, $V_A > V_B + \mathit{\Gamma}$ such that country A wins the auction for the MNE by paying a subsidy of (marginally above) $V_B + \mathit{\Gamma}$.[11] For $t > 0.14$, on the other hand, $V_B + \Gamma > V_A$ such that country B wins the auction for the MNE by paying a subsidy of (marginally above) $V_A - \mathit{\Gamma}$. Thus, country A wins the MNE for sufficiently low trade costs while country B wins the MNE for sufficiently high trade costs. The winning subsidy/tax offer in the equilibrium is depicted as a heavy bold line in Figure 1.2.[12] The winning country's surplus – representing the difference between its valuation

[10] With $c = 0.15$, our condition for interior Cournot equilibria ($c + t < 0.5$) implies that $t < 0.35$.

[11] Recall that, while the losing country bids its valuation in equilibrium, the winning country need not pay a subsidy equal to its valuation; it suffices to slightly improve on its rival's losing offer, adjusted for $\mathit{\Gamma}$. The equilibrium subsidy paid to the MNE is $V_B + \mathit{\Gamma} + \varepsilon$ if country A wins and $V_A - \mathit{\Gamma} + \varepsilon$ if country B wins, where $\varepsilon$ is an infinitesimal amount.

[12] Note that, for sufficiently large $t$, B wins the FDI and *taxes* the MNE in equilibrium. (Although $V_A > 0$ so country A offers a positive subsidy in equilibrium, B's geographic advantage, $\Gamma$, is so large that $V_A - \Gamma < 0$.)

Figure 1.2: Trade Cost Effect ($c = 0.15$, $\phi = 0.2$)




and the equilibrium subsidy it pays – is represented by the shaded areas in Figure 1.2. Note that as the auction for the FDI progressively moves away from being a tie (i.e. as $t$ moves away from the vertical dashed line), so the winning country's equilibrium surplus progressively grows. This is consistent with our finding in the welfare analysis below that the host region is more likely to be better off under fiscal competition than under laissez-faire, the further removed is the auction for the FDI from being a tie.

The result that country A becomes more likely to win the auction for the FDI as $t$ falls is driven by the way in which $t$ effects $V_A$, $V_B$ and $\Gamma$. We see from Figure 1.2 that $V_A$ varies less with $t$ than does $V_B + \Gamma$, which is sharply increasing in $t$. Thus, $V_A > V_B + \Gamma$, the condition for country A to win, becomes more likely to hold as $t$ falls. Intuitively, $V_A$ varies relatively little with $t$ because, as $t$ falls, inward FDI benefits A's consumers less (through market-price reduction) *but* it also *harms* A's indigenous firm less (through the market-crowding effect) – and these two welfare effects push $V_A$ in opposite directions, thus tending to counteract each other. In contrast, $V_B$ is clearly increasing in $t$ because country B's valuation only reflects the interests of its consumers, and the consumer-surplus gain from inward FDI varies positively with $t$. Moreover, $V_B + \Gamma$ is also increasing in $t$ because, in general, B's geographic advantage, $\Gamma$, tends to vary positively with $t$ (i.e. falls in $t$ tend to weaken the market-crowding effect of co-location in A).[13]

*The knowledge spillover effect*

For a given level of $t$, an increase in $\phi$ reduces the unit production cost of the indigenous firm *if* the MNE is located in the same country, A. This increases country A's valuation, $V_A$, and decreases that of country B, $V_B$. The latter effect is due to the benefit to consumers in country B from the knowledge spillovers to the indigenous firm in country A if the MNE locates in A. This is a benefit to B's consumers that occurs because B *fails* to win the FDI, and it arises because the indigenous firm is itself an exporter to country B. On the other hand, country A's valuation is increasing in $\phi$ because: (i) the benefit of inward FDI for its consumers is increasing in $\phi$; and (ii) the profits of its indigenous firm are also increasing in $\phi$.

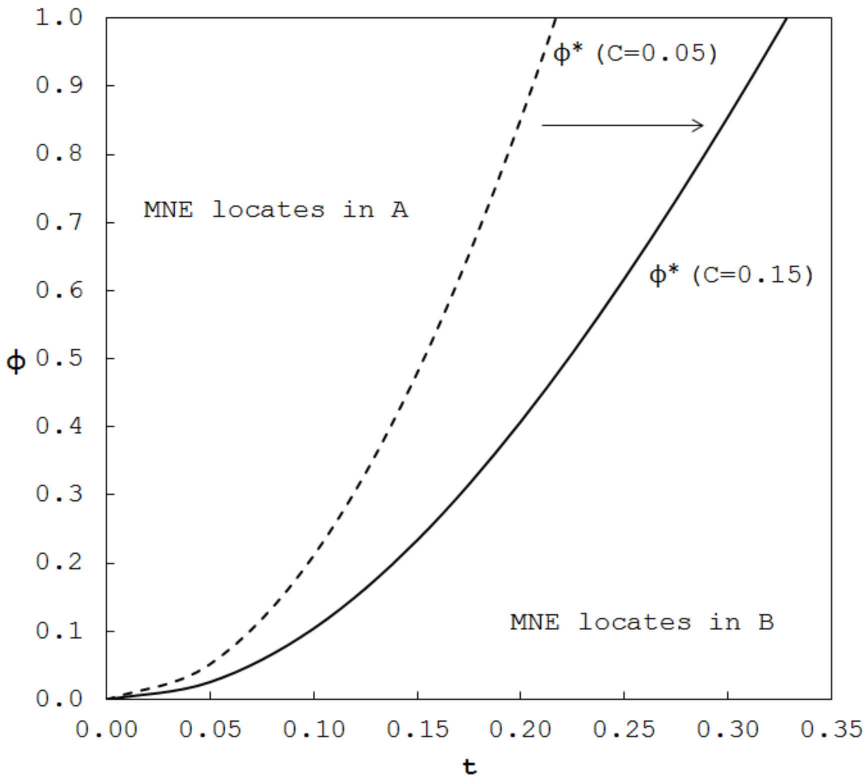
We conclude that an increase in $\phi$ increases the likelihood of a win for country A in the FDI auction (the relevant condition is (1.2): $V_A > V_B + \Gamma$). This is true even though increasing $\phi$ has a positive impact on $\Gamma$, because this positive impact is always smaller than the negative impact that an increase in $\phi$ has on $V_B$.[14] Noting that an increase in the indigenous firm's initial unit cost, $c$, also increases the *size* of the potential spillover, $\phi c$, this leads us naturally to the third proposition:

**Proposition 1.3.** *In the fiscal competition scenario, a larger "technology gap" between the MNE and the indigenous firm (i.e. a higher $c$) expands the area in the parameter space where country A wins for all* $c \leq c^* = \frac{2}{11}\left(\frac{2-t}{2-\phi}\right)$.

[13] And even on the extremely small interval (near $t = 0$) where $d\Gamma/dt < 0$, the positive effect of $t$ on $V_B$ (i.e. $dV_B/dt > 0$) dominates.

[14] Thus, $\frac{dV_A}{d\phi} > 0$, $\frac{dV_B}{d\phi} < 0$, $\frac{d\Gamma}{d\phi} > 0$, and $\frac{d(V_B+\Gamma)}{d\phi} < 0$.

Figure 1.3: Firm Heterogeneity Effects




*Proof.* For $c \leq c^*$, $\frac{d(V_A - V_B - \Gamma)}{dc} = \frac{2\phi}{9}(4 + 11c(\phi - 2) - 2t) \geq 0$, where $V_A - V_B - \mathit{\Gamma}$ is A's surplus if it wins the FDI. □

The proposition is illustrated in Figure 1.3. It shows that an increase in $c$ within $[0, c^*]$ rotates the curve along which the fiscal competition for FDI is tied clockwise around the origin such that more combinations of $t$ and $\phi$ lead the MNE to locate in country A in equilibrium. This happens because an increase in $c$ increases country A's valuation premium $(V_A - V_B)$ by more than it increases county B's geographic advantage, $\mathit{\Gamma}$, suggesting that a higher degree of firm heterogeneity makes the co-location outcome more likely under fiscal competition.[15]

In our model's equilibrium, technological spillovers are more likely to be observed flowing from subsidised inward investment (which requires country A to win the

[15] Thus, for $c < c^*$, we have $\frac{d(V_A - V_B)}{dc} > \frac{d\mathit{\Gamma}}{dc} > 0$. Note that $c > c^*$ is also compatible with our maintained assumption $c + t < 0.5$, and in this case a larger technology gap makes it more likely that the MNE locates in country B under fiscal competition (because increasing $c$ has a greater positive impact on B's geographic advantage than on A's valuation premium, i.e. $\frac{d\mathit{\Gamma}}{dc} > \frac{d(V_A - V_B)}{dc}$).

FDI), the larger is the unit cost (and hence size) gap between the MNE and the indigenous firm. This appears to be consistent with the empirical findings of Brülhart and Simpson (2016). They conclude that spillover benefits to indigenous industry are more likely to be associated with observed corporate subsidy payments in the case of very large FDI projects, as studied by Greenstone *et al.* (2010), than in the case of smaller ones.

Putting everything together, we note that in the laissez-faire scenario the MNE locates in country B for all values of $c$, $t$ and $\phi$. However, the opposing effects that knowledge spillovers and trade costs have on the countries' valuations of the FDI project may induce the MNE to co-locate alongside the indigenous firm in country A when governments compete in taxes/subsidies. Furthermore, we note that the co-location outcome is more likely the bigger the technological gap between the MNE and the indigenous firm.

## 1.3 Welfare analysis

When multinational firms' location decisions are influenced by fiscal competition, an important question is whether the use of publicly financed subsidies is efficiency enhancing. And even if fiscal competition *does* lead to a more efficient outcome, an important distributional issue remains: how are the net benefits from fiscal competition distributed, and might some players lose? We seek to answer these questions by comparing the equilibrium outcome under fiscal competition with that under laissez-faire.

*World Welfare*

Let world welfare be the sum of consumer surplus in countries A and B *plus* the profits earned by the indigenous firm and the MNE.

**Proposition 1.4.** *Under fiscal competition, the MNE chooses the efficient location for its plant, where "efficient" means world-welfare-maximizing.*

*Proof.* The condition for FDI in country A to be world-welfare-maximising is identical to that for the MNE to locate in A in fiscal-competition equilibrium, i.e. $V_A > V_B + \Gamma$. □

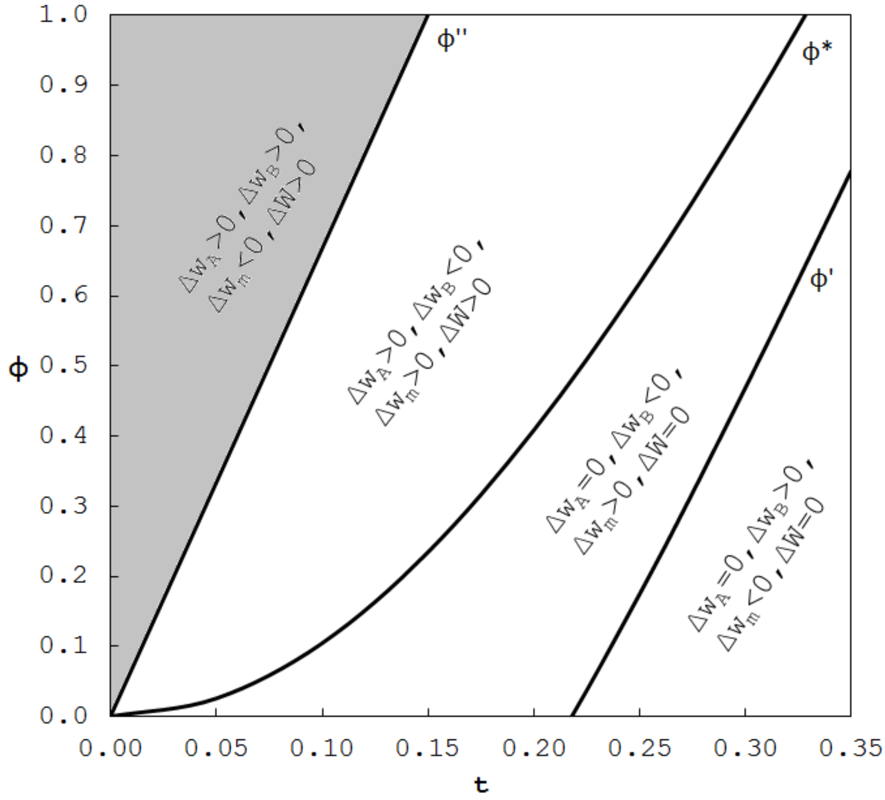
The intuition is as follows. If fiscal competition does not change the MNE's location decision (relative to the laissez-faire scenario), then consumer surplus in both countries, as well as the profits of the indigenous firm, remain unchanged. The only factor that changes is the tax (or subsidy) paid by (or to) the MNE. Because from a world welfare perspective, taxes (and subsidies) simply represent a transfer payment from one world player to another, fiscal competition thus has no impact on world welfare in the case of no change in the MNE's location decision. On the other hand, if fiscal competition *does* change the MNE's location decision, then it must be world-welfare-improving. For example, if fiscal competition prompts the MNE to change its location from B under laissez-faire to A, then this relocation will increase world welfare if $V_A > V_B + \Gamma$, where the L.H.S. is the welfare gain from inward FDI to country A and the R.H.S. is the total loss of consumer surplus and pre-tax profits to country B and the MNE; and this is also the condition, (1.2) above, for relocation from B to A to *occur* in equilibrium under fiscal competition. Thus, we conclude that fiscal competition is world-welfare-maximising, and *may* be strictly world-welfare-improving.

This result is consistent with the well-established result that an auction for a single firm leads to the efficient location (see, for example, Ferrett and Hoefele, 2015; Bjorvatn and Eckel, 2006). However, fiscal competition need not necessarily be Pareto improving: while some players must gain (at least weakly), others might lose in strict terms.

*Country A's Welfare*

**Proposition 1.5.** *Relative to the laissez-faire scenario where the MNE locates in B, fiscal competition increases country A's welfare if it wins the MNE, $\phi > \phi^*$, but otherwise leaves country A's welfare unchanged.*

Figure 1.4: Welfare Impacts of Fiscal Competition ($c = 0.15$)




This follows from the discussion above. By condition (1.2), we know that country A wins the auction for the MNE if and only if $V_A > V_B + \Gamma$. In this case, A pays a subsidy of (just above) $V_B + \Gamma$ and, relative to laissez-faire, thus enjoys a welfare gain of $V_A - (V_B + \Gamma)$.[16] If, on the other hand, country B wins the fiscal competition for the MNE, both consumer surplus in A and the profits earned by its indigenous firm remain unchanged from those under laissez-faire. Thus, when country B wins, fiscal competition does not affect country A's welfare.

*Country B's Welfare*

**Proposition 1.6.** *Relative to laissez-faire, fiscal competition increases country B's welfare if: (i) $\Gamma > V_A$ or $\phi < \phi'$ (explicitly defined in the Appendix 1.5.2), such that the MNE loctaes and gets taxed country B; and (ii) $\phi > \frac{t}{c} \equiv \phi''$ such that the*

[16] See the shaded area in the L.H.S. of Figure 1.2.

*investment of the MNE in country A in equilibrium reduces the price on country B's product market. Otherwise, country B's welfare falls.*

There are two distinct ways in which fiscal competition might benefit country B. Firstly, if fiscal competition leaves the MNE's location unchanged as B (i.e. $V_B + \mathit{\Gamma} > V_A$), then B's winning fiscal offer (in response to A's losing bid of $V_A$) is $V_A - \mathit{\Gamma}$. Thus, if B's geographic advantage is sufficiently strong (i.e. $\mathit{\Gamma} > V_A$), it is able to retain the MNE's investment and *tax* it. In this case, B's welfare rises by its level of tax revenue. Alternatively, if B retains the MNE's plant with a subsidy payment in equilibrium (i.e. $V_B > V_A - \mathit{\Gamma} > 0$), then B's welfare falls by the amount of the subsidy payment.

Secondly, even if B loses the FDI to A under fiscal competition, then it is still possible for country B to gain from fiscal competition. This gain to B occurs if the co-location of production in country A produces a spillover to A's indigenous firm that is sufficiently large to result in a *fall* in the equilibrium price on B's product market. Noting that the relocation of the MNE from B to A increases its unit cost of serving market B by $t$ but cuts that of A's indigenous firm by $\phi c$ and that the Cournot equilibrium price depends on the sum of marginal costs, it follows that the MNE's exit reduces the market price in B if $\phi c > t$ or $\phi > \phi'' \equiv \frac{t}{c}$. The condition $\phi > \phi''$ is thus equivalent to $V_B < 0$ – i.e. inward investment into B *harms* its consumers by leading to an increase in its market price.

In the shaded area of Figure 1.4, $V_B < 0$ ($\phi > \phi''$) and, unsurprisingly therefore, country A wins the fiscal competition for FDI ($\phi > \phi^*$).[17] Thus, in that shaded area, *both* countries benefit from fiscal competition.[18] This contrasts with the finding of Fumagalli (2003) that fiscal competition always harms one of the competing countries (specifically, the host of the FDI under laissez-faire). The key, relevant distinction between our model and Fumagalli's is that *only one* of our competing

[17] In Figures 1.4 and 1.5, $\Delta w_A$, $\Delta w_B$, $\Delta w_m$ and $\Delta W$ represent, respectively, the changes in the welfare of country A, country B, the MNE's owners and the world as a whole.

[18] Moreover, because fiscal competition causes the MNE to change its equilibrium location, the world as a whole gains ($\Delta W > 0$). However, as we show below, the gains to the host region come partially at the expense of the MNE's owners ($\Delta w_m < 0$).

countries, A, contains an indigenous firm. Thus, when country A wins the FDI, col-location replaces non-co-location in our model; whereas in Fumagalli, the MNE is *always* co-located alongside an indigenous firm (since both host countries contain one). Moreover, if the spillover benefits of co-location in A are sufficiently strong in our model, then the country, B, that loses the FDI in the move from laissez-faire to fiscal competition ends up better off (despite the fact that trade costs now apply to all of its consumption).

*MNE's Welfare*

**Proposition 1.7.** *With fiscal competition, the MNE's after-tax profits ("welfare") increase for all* $\phi \in \left[\phi', \phi''\right]$.

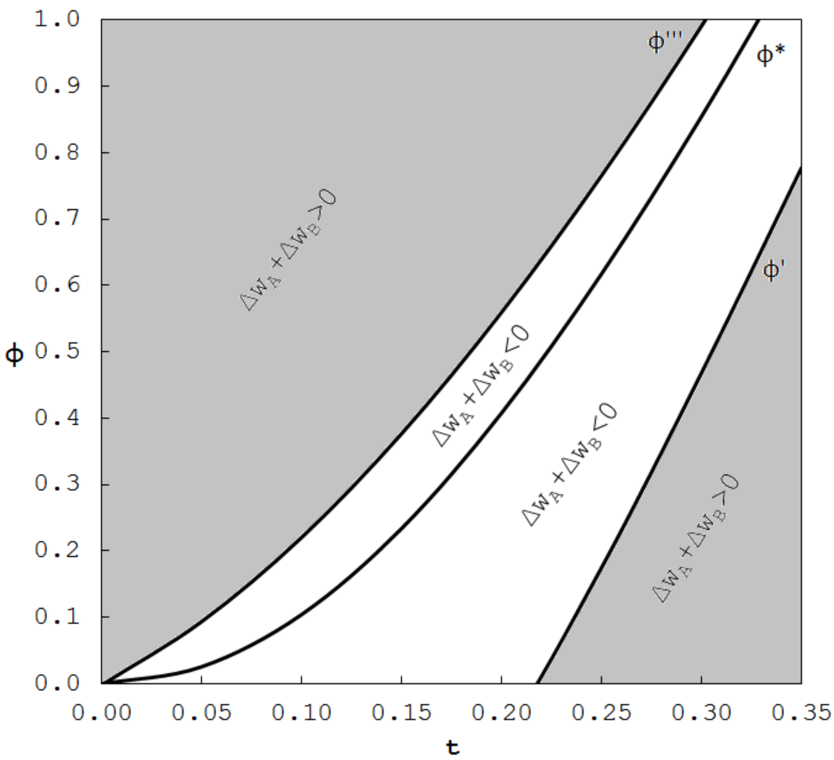
Intuitively, if the multinational locates in country B, its after-tax profits rise compared to laissez-faire if it gets subsidised ($V_A - \mathit{\Gamma} > 0$ or $\phi > \phi'$) but fall if it gets taxed ($V_A - \mathit{\Gamma} < 0$ or $\phi < \phi'$). On the other hand, if the multinational relocates to country A under fiscal competition, its after-tax profits rise only if country B's valuation (which itself determines the size of the subsidy paid by host country A, $V_B + \mathit{\Gamma}$) is positive: specifically, $V_B > 0$ or $\phi < \phi''$. However, if country B attaches a negative value to inward FDI (i.e. $V_B < 0$ or $\phi > \phi''$), then country A wins the auction for FDI with a subsidy that is lower than the relocation-induced fall in the MNE's pre-tax profits ($\mathit{\Gamma}$), leaving the MNE's owners worse off under fiscal competition. Recalling that the fiscal competition is tied at $\phi = \phi^*$, it is noteworthy from Figure 1.4 that the MNE is more likely to gain from fiscal competition, the closer is the auction to being a tie.

*Regional Welfare*

Let regional welfare be equal to the sum of the welfare of the two countries.

**Proposition 1.8.** *Relative to the laissez-faire scenario, fiscal competition decreases regional welfare for all* $\phi \in \left[\phi', \phi'''\right]$, *where* $\phi'''$ *is that level of* $\phi$ *which makes fis-*

Figure 1.5: Regional Welfare Impact of Fiscal Competition ($c = 0.15$)




*cal competition regional-welfare-neutral when country A wins the auction for FDI. Otherwise, regional welfare rises.*

The proposition is illustrated in Figure 1.5.[19] It shows that fiscal competition increases regional welfare in two (shaded) areas: first, when $\phi < \phi'$, or $V_A - \Gamma < 0$, as this enables the government of country B to retain the MNE with a tax; and second, when $\phi > \phi'''$ or $V_A > 2V_B + \Gamma$, as this implies that country A's surplus from winning the fiscal competition exceeds the loss B suffers when the MNE exits.[20] There exists an intermediate area in the $(\phi, t)$ parameter space where fiscal competition is regional-welfare-decreasing because subsidy competition between the two governments is close to being a tie, i.e. around $\phi = \phi^*$; in this case, the fiscal competition might be thought of as being "intense" or "closely fought". These results contrast with the findings of BE (2006) who show that fiscal competition increases

[19]The ranges for $\phi^*$, $\phi'$ and $\phi'''$ exist for all $c \in \left(0, \frac{1}{2} - t\right]$.

[20]A's surplus is $V_A - V_B - \Gamma$ and B's loss is $V_B$. Note that $V_A - V_B - \Gamma > V_B$ rearranges to $V_A - \Gamma > 2V_B$.

regional welfare only for high levels of $t$, which implies that the decline in trade costs observed over the past two decades makes it less likely that fiscal competition will improve regional welfare.[21]

## 1.4 Conclusion

This chapter analyses the location outcomes and welfare effects of fiscal competition for FDI in the presence of localised knowledge spillovers. We show that in the absence of government intervention, the multinational firm's optimal strategy is to locate at a distance from the indigenous firm in order to limit the market crowding effect and to minimize the knowledge spillover to its competitor. However, governments may cause a switch in the multinational's location decision by offering financial incentives – in the form of subsidies or beneficial tax rates – to the MNE. This is largely the result of the way in which the potential for knowledge spillovers pushes the two countries' valuations of the FDI project in opposite directions: with spillovers, the valuation of the country with the indigenous firm is increased, while that of the other country falls. This outcome suggests that co-location may, in part, be the result of the provision of government incentives, particularly if competing countries' other characteristics are similar. Thus, besides simplicity, an important justification for our assumption that country sizes are equal is that it creates a framework where co-location will *not* occur for purely private reasons under laissez-faire. In turn, this enables us to bring out clearly the potential role of fiscal activism in facilitating industrial co-location.

In line with existing literature, our study also shows that fiscal competition is world-welfare-maximising because it directs investment to where it is valued most. However, we add to existing literature on the welfare impacts of fiscal competition in two ways. First, in contrast to BE (2006), who show that fiscal competition increases regional welfare only when trade costs are relatively high, we show that regional

[21] WTO (2008) reports an overall downward trend in trade costs in the last half century, including traditional trade costs (such as tariff an non-tariff barriers) as well as transport and communication costs.

welfare also rises under fiscal competition at low levels of trade costs if knowledge spillovers are sufficiently strong – since, in that case, consumers in both countries benefit from spillovers to the indigenous firm. Second, in contrast to Fumagalli (2003), whose model shows that fiscal competition necessarily harms the country that would host the FDI under laissez-faire, we show that this is not the case when one potential host country cannot benefit from knowledge spillovers while the other one can (possibly due to differing industrial specialisations). Taken together, these observations suggest that for sufficiently low trade costs and high spillovers, fiscal competition may not only increase regional welfare but also improve that of all the individual competing countries.

Finally, we make two points on the practical applicability of these results. First, we note that the novel results obtained from this study are more relevant to situations where governments compete to host *highly* productive firms (which MNEs often are). This is because, for a given spillover rate (our parameter $\phi$), a larger technology gap between the MNE and the indigenous firm increases the willingness of the country containing the established firm to bid for the FDI, while it reduces the other country's willingness to bid. Second, we note that the decline in trade costs observed over the past two decades (WTO, 2008) and the likely increase in firms' absorptive capacities (associated with higher levels of educational attainment, training and worker mobility) make an co-location outcome that improves the welfare of *all* countries in the host region seem more likely.

## 1.5 Appendix

### 1.5.1 Derivation of equilibrium profits

In this appendix we provide the derivations of the firms' equilibrium profits and consumer surplus. We consider the case where the MNE locates in country A and the case where it locates in country B.

If the MNE locates in country A, the profit functions of the MNE and the indigenous firm respectively are:

$$\pi_m = P_A \cdot q_{m,A} + (P_B - t)\, q_{m,B}$$
$$\pi_a = (P_A - c)\, q_{a,A} + (P_B - c - t)\, q_{a,B} \tag{1.5}$$

where $q_{m,A}$ and $q_{m,B}$ are the quantities produced by the MNE for the markets in country A and country B, respectively; and $q_{a,A}$ and $q_{a,B}$ are the quantities produced by the indigenous firm for the markets in country A and B, respectively.

Solving for ${}^{d\pi_m}/_{dq_m} = 0$ yields the equilibrium quantity produced by the MNE if it locates in country $j$, $q_m^j$:

$$q_m^A = \frac{1}{3}\left(1 + (1-\phi)\, c\right) + \frac{1}{3}\left(1 + (1-\phi)\, c - t\right)$$
$$q_m^B = \frac{1}{3}\left(1 + c - 2t\right) + \frac{1}{3}\left(1 + c + t\right) \tag{1.6}$$

where the first term on the right-hand-side is the quantity sold in country A and the second term the quantity sold in country B. Similarly, by solving for ${}^{d\pi_a}/_{dq_a} = 0$ we obtain the equilibrium quantity produced by the indigenous firm if the MNE locates in country $j$, $q_a^j$:

$$q_a^A = \frac{1}{3}\left(1 - 2\,(1-\phi)\, c\right) + \frac{1}{3}\left(1 - (1-\phi)\, c - t\right)$$
$$q_a^B = \frac{1}{3}\left(1 - 2c + t\right) + \frac{1}{3}\left(1 - 2c - 2t\right) \tag{1.7}$$

Recalling that the inverse demand function for the good in each country is given by $P_i = 1 - Q_i$, where $Q_i$ and $P_i$ are the quantity demanded and price in country $i$, it follows that if the MNE locates in country A, the equilibrium prices in markets A and B are:

$$
\begin{aligned}
P_A^A &= \frac{1}{3}\left(1 + (1-\phi)\,c\right) \\
P_B^B &= \frac{1}{3}\left(1 + (1-\phi)\,c + 2t\right)
\end{aligned}
\tag{1.8}
$$

while the equilibrium prices in markets A and B if the MNE locates in country B are given by:

$$
\begin{aligned}
P_A^B &= \frac{1}{3}\left(1 + c + t\right) \\
P_B^B &= \frac{1}{3}\left(1 + c + t\right)
\end{aligned}
\tag{1.9}
$$

Putting everything together, the MNE's profits if it locates in country $j$, $\pi_m^j$, are:

$$
\begin{aligned}
\pi_m^A &= \frac{1}{9}\left(1 + (1-\phi)\,c\right)^2 + \frac{1}{9}\left(1 + (1-\phi)\,c - t\right)^2 \\
\pi_m^B &= \frac{1}{9}\left(1 + c - 2t\right)^2 + \frac{1}{9}\left(1 + c + t\right)^2
\end{aligned}
\tag{1.10}
$$

where the first term on the right-hand-side represents the MNE's profits in market A and the second term its profits in market B. Similarly, the indigenous firm's profits if the MNE locates in country $j$, $\pi_a^j$, are:

$$
\begin{aligned}
\pi_a^A &= \frac{1}{9}\left(1 - 2\,(1-\phi)\,c\right)^2 + \frac{1}{9}\left(1 - 2\,(1-\phi)\,c - t\right)^2 \\
\pi_a^B &= \frac{1}{9}\left(1 - 2c + t\right)^2 + \frac{1}{9}\left(1 - 2c - 2t\right)^2
\end{aligned}
\tag{1.11}
$$

where the first term on the right-hand-side represents the indigenous profits in market A and the second term its profits in market B.

### 1.5.2 Indifference conditions

Explicit definitions for $\phi^*$, $\phi^{'}$ and $\phi^{'''}$ follow.

*Explicit definition for* $\phi^*$. Let $\phi^*$ be that level of knowledge spillovers that makes the MNE indifferent in equilibrium between locating in country A or B when there is fiscal competition for FDI; i.e. $V_A = V_B + \Gamma$. This is given by:

$$\phi^* = \tfrac{1}{22c^2}\left(22c^2 - 8c + 4ct + \sqrt{308c^2t^2 + (8c - 22c^2 - 4ct)^2}\right).$$

*Explicit definition for* $\phi^{'}$. Let $\phi^{'}$ be that level of knowledge spillovers that makes fiscal competition welfare-neutral (because fiscally neutral) from country B's perspective when the MNE locates in country B; i.e. $V_A - \Gamma = 0$. This is given by:

$$\phi^{'} = \tfrac{1}{21c^2}\left(21c^2 - 6c + 2ct + \sqrt{c^2\left(9\left(2 - 7c\right)^2 + 18t \cdot (7c - 6) + 361t^2\right)}\right).$$

*Explicit definition for* $\phi^{'''}$. Let $\phi^{'''}$ be that level of knowledge spillovers that makes fiscal competition regional-welfare-neutral when the MNE locates in country A. This requires $V_A > 2V_B + \Gamma$ and is given by:

$$\phi^{'''} = \tfrac{1}{23c^2}\left(23c^2 - 10c + 6ct + \sqrt{c^2\left((10 - 23c)^2 + 2t \cdot (115c - 4) + 289t^2\right)}\right).$$

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# Chapter 2

# Fiscal Competition for Plant and Profits: adjusting expectations about gains from tackling profit shifting[1]

## 2.1 Introduction

Over the past few years, a number of national and international institutions have become increasingly concerned about highly profitable multinational enterprises (MNEs) that pay very little corporate income tax in their host countries. By one estimate, in 2012 US MNEs shifted between $500-700 billion – a quarter of their annual profits – out of the US, Germany, the UK and elsewhere to a handful of countries including the Netherlands, Ireland, Switzerland and Luxembourg to reduce their tax bill (Clausing, 2016; Cobham and Jansky, 2017). As a result, the OECD and the

[1]**The present chapter is joint work with Ben Ferrett. Earlier versions of this work have been presented at the Centre for Business Taxation Doctoral Conference 2018, University of Oxford, the Workshop on Tax Competition between National Governments for Footloose Multinationals: Perspectives from Economics held at Loughborough University in 2017, and the European Trade Study Group (ETSG) 2017 Conference held at l'Universita Degli Studi di Firenze. We thank the discussants of the paper Ben Lockwood and David Collie as well as participants for their helpful comments and useful discussions.**

European Commission have been pushing forward a number of measures to fight profit shifting and tax avoidance.[2]

In a world where taxes/subsidies seem to be an important determinant of MNEs' 'plant' and 'profit' location decisions (see Grubert and Mutti, 1991; Hines and Rice, 1994; Mintz and Smart, 2004; Huizinga and Laeven, 2008), these measures are likely to affect the strategic interaction among the governments of potential host countries in the determination of the taxes/subsides that they charge/pay to MNEs in attempt to lure them, and their profits, into their country. This raises a number of questions: How do the two types of competition (for plant and profits) interact? Do profit shifting opportunities exert further downward pressure on statutory tax rates? Does the fight against profit shifting affect MNEs' plant location decisions? Do such policies impact on countries' and world welfare?

We attempt to answer these questions in a model with two countries that engage in fiscal competition at two levels. First, countries compete via lump sum subsidies for an MNE's plant (in the tradition of Haufler and Wooton, 1999); and after the MNE's plant location decision, countries compete via proportional tax rates for its imperfectly mobile profits. Assuming complete information and sunk investment costs, in the bidding stage for the plant, the competing governments anticipate the extent to which they would be able to extract additional profits from hosting the MNE, such that they are willing to make up for it with upfront subsidies. Thus, a key insight from this model is that any gains in tax revenues resulting from more costly profit shifting may be *partly offset* by higher subsidies in the bidding stage. In practice, it means that the positive impact of anti-tax avoidance policies on host countries' tax revenues will be smaller than anticipated because they also lead to more intense competition for real capital.

The setup incorporates three important features. First, the opportunity to shift profits between competing countries eliminates the possibility that the host country's

[2]These include both short-term measures, such as the automatic exchange of information on tax rulings, or country-by-country reporting of tax-related information concerning multinationals; but also longer-term measures such as the potential introduction of the Common Consolidated Corporate Tax Base (CCCTB) in the European Union.

government extracts all of the MNE's profits in taxes (what in the literature is referred to as the hold-up or the commitment problem; see, for example, Janeba [2000]). Second, the 'costly' shifting of profits ensures that profits are not perfectly mobile, such that competing governments can set positive tax rates on the MNE's profits. Third, we allow for differences in country size, and this turns out to be key in determining whether higher costs for profit shifting intensify the competition for real capital.

On the basis of this setup, our model returns a number of basic results that are in line with those obtained from variants of standard models of international tax competition. First, similar to Haufler and Wooton (1999), who consider competition between two countries for a foreign owned monopolist, the larger country hosts the MNE's plant if trade costs are positive. We show that this is also true if the location decision is made with the foresight that the two countries would subsequently compete for the MNE's mobile profits. Second, we show that in equilibrium the larger country sets the higher tax rate on profits. This too seems like a plausible result and is in line with the conclusions drawn by Keen and Konrad (2013) who reinterpret the model of Kanbur and Keen (1993) as one of profit shifting.[3] Third, in line with Gordon and MacKie-Mason (1995) and Haufler and Schjelderup (2000), we show that profit shifting exerts downward pressure on competing countries' tax rates.

This chapter adds to this literature with the following results. We show that more costly profit shifting harms the MNE and benefits the governments of both the host and the competing countries; the latter reflecting the strategic complementarity of their tax rates. We also show that when countries are "close competitors" for both the MNE's plant and its profits, limiting profit shifting benefits the host and the competing countries *equally*. This happens because more costly profit shifting increases the two governments' valuation of the Foreign Direct Investment (FDI)

[3] In Keen and Konrad (2013), investment is considered as a continuously divisible quantity, such that the smaller government sets the lower tax rate because by cutting tax rates it loses little local tax revenues but gains a lot by attracting foreign plants. In contrast, we model investment as being "lumpy" (or discrete) such that the smaller country sets the lower tax rate because it doesn't host the MNE.

project, such that the losing country's government pushes the winning bidder further in the auction for the MNE's plant. Finally, we also show that any policy-induced increase in the cost of profit shifting gives rise to a dead-weight loss that causes world welfare to decline. This happens because policies that reduce profit shifting give rise to administration and compliance costs that benefit "no one" and that otherwise would not have been incurred.

This study differs from others that consider competition for *both* plant and profits in important ways. First, in contrast to Amerighi and Peralta (2010), who analyse an MNE's incentive to set up a plant in each country rather than one, our setup is sufficiently tractable to permit derivation of equilibrium policy variables; theirs isn't. Second, in contrast to Ma and Raimondos-Møller (2015), we set up a model where firms are able to shift profits between two competing countries that belong to the same region (rather than shifting profits from outside the region). This ought to reflect empirical evidence that profit shifting is mostly foreign-to-foreign rather than parent-to-foreign (Huizinga and Laeven, 2008). Third, in contrast to Stöwhase (2013), we assume that governments set their tax rates simultaneously rather than sequentially because the latter approach introduces potentially undesirable asymmetry between the two countries by giving one of them an advantage over the other. In real world situations, where countries seem to be competing head-to-head, tax-rate-setting-simultaneity may be a desirable property. Finally, our model refines all three papers by considering competition with two fiscal policy instruments rather than one. This allows us to analyse competition for plant and profits *separately* while enabling us to understand how the two types of competition interact.

In spite of these differences, we obtain a number of comparable results. First, Ma and Raimondos-Møller (2015) show that the 'geographic advantage' of the larger country may be overturned if the small country is more lenient on profit shifting. This is not possible in our model as the large and the small country are subject to "equally lenient" tax regimes imposed by a supranational authority. Consequently, in our model, the MNE always locates its plant in the larger country. Second, like us, Stöwhase (2015) shows that more costly profit shifting harms the MNE and benefits the government of the larger country; but unlike us, he shows that the smaller country's government is worse off with more costly profit shifting if it becomes "too costly". This happens because in Stöwhase's model the chosen tax rate affects both the location of the plant and the profits. Thus, more costly profit shifting may lead the government of the smaller to country to reduce its tax rate in an attempt to attract the MNE's plant. In contrast, in our model, more costly profit shifting always has the effect of increasing the small country's tax rate because governments compete for profits *after* the MNE decides on the location of its plant. Finally, we get a result that is similar to Amerighi and Peralta (2010), who argue that granting more profit shifting opportunities to the MNE may be total welfare improving.

The rest of the chapter is organised as follows. In Section 2.2 we present and analyse the model; in Section 2.3 we discuss the impact of more costly profit shifting on world welfare and on the welfare of individual players; and in Section 2.4 we conclude by discussing the practical significance of the results.

## 2.2 The model

The basic setup is similar to that in Haufler and Wooton (1999). An MNE wants to invest in a region that consists of two countries, A and B, with country B being $n > 1$ times the size of country A. To set up the plant the MNE incurs a fixed cost, $F$, that is the same in both countries and is sufficiently large to ensure that the MNE does not set up a plant in both countries. It is assumed that the MNE would be able to operate as a profit-maximising monopolist and that it would have the possibility of exporting to country B if it locates in A and vice versa. The countries' inverse demand functions are $P_A = 1 - Q_A$ and $P_B = 1 - {}^{Q_B}/_{n}$, where $P_i$ and $Q_i$ represent the price and quantity sold in country $i$. For simplicity, we assume that the marginal cost of production is zero, but that there is a per unit trade cost, $\tau$, for intra-regional exports.

As in Haufler and Wooton (1999), the governments of potential host countries A and B can pay a lump-sum subsidy, $S \geq 0$, to the MNE to incentivise it to locate within their respective frontiers. However, we deviate from their setup by also allowing the two revenue-maximising governments to compete for the MNE's mobile profits via proportional tax rates, $t_i$, following the MNE's plant location decision. This ought to represent cases where countries impose taxes on the profits of foreign investors while also having in place subsidies that are designed to attract them.

In principle, we assume source-based taxation such that the MNE only pays tax in the country where it locates its plant. However, it is possible for the MNE to shift a share of its profits, $\delta \in [0, 1]$, within the region; from the country where it locates its plant to the competing country. We assume that this is possible without the MNE having to set up a second production plant in the country to where it shifts its profits.[4] In practice, MNEs do this in several ways. For example, they often set up shell companies that exist to hold only intellectual property rights such that they can transfer profits by charging other subsidiaries within the group for their use. Or they set up 'coordination centres' to provide other parts of the group with "services" at above-market rates. The end result is that there is little connection between where economic activity takes place and where profits are booked (The Economist, 2013).[5]

Although the shifting of profits does not require the setting up of a second plant, it entails a variable cost, $\frac{1}{2}\gamma\delta^2$, where $\gamma$ is a parameter that reflects the ease with which firms can shift profits between the two countries.[6] The size of $\gamma$ is determined

[4]Alternatively, we may think of the fixed cost of establishing a presence in the second country as being very small. For MNE's decisions on opening a second *production* plant see Amerighi and Peralta (2010).

[5]Supporting this argument is data reported in Clausing (2016) that shows that 50% of all foreign income earned by affiliates of US MNEs is reported in countries with an effective tax rate of less than 5%, but that only account for 5% of all foreign employment in such firms.

[6]Literature models the cost of profit shifting in several ways: proportional to the absolute value of profit shifted (see, for example, Keen and Konrad [2013]); or as a proportion of the share of profit shifted (see, for example, Stöwhase [2013]). In our model, the cost of profit shifting depends on the share of profits shifted, $\frac{1}{2}\gamma\delta^2$, reflecting the idea that the risk of "getting caught avoiding tax" depends on the extent to which the profits declared in the host country deviate from the "true value" (e.g. if a firm shifts profit through transfer pricing, its cost is increasing in the difference between the unit transfer price and the "true" price). However, the results obtained from this model hold even if the cost of profit shifting is modelled proportional to the absolute value of profit shifted, $\frac{1}{2}\gamma\left(\pi_i + \pi_j\right)\delta^2$. See Appendix 2.5 for the equilibrium tax rates charged, and revenues earned, by the two governments for the case where the cost of profit shifting is modelled proportional to the absolute value of profit shifted.

exogenously (at a supranational level) and reflects a number of factors such as government leniency, the extent to which governments share information, differences in the countries' tax codes, etc.[7] It is therefore a key parameter because it determines the extent to which taxable profits are mobile (or what Slemrod and Kopczuk [2002] refer to as 'the elasticity of the tax base'). By analysing the impacts of changes in $\gamma$, we are able to assess the likely impact of policies aiming to curb tax avoidance through profit shifting.

The game evolves in four stages:

- in stage 1, the two governments offer lump-sum subsidies to the MNE;
- in stage 2, the MNE decides where to locate its plant;
- in stage 3, governments set proportional tax rates on the MNE's profits;
- in stage 4, the MNE decides on the quantity to produce for each market and the extent of profit-shifting.

The setup and order of play can be motivated as follows: MNEs typically choose to set up in a country over another only after the government of the host country would have committed to a subsidy. However, once the fixed costs for setting up are incurred, the MNE is still liable to pay tax on profits in the host country – if not immediately, after some period of time. Typically, the tax rate charged on the MNEs' profits can vary over time because – unlike the subsidy – it is not directly tied to the location of the plant.

We solve the game by backward induction:

**Stage 4: MNE decides on output and the extent of profit-shifting**

The profit function for the monopolist MNE is:

$$\varPi = (1 - t_i)(1 - \delta)(\pi_i + \pi_j) + (1 - t_j) \cdot \delta \cdot (\pi_i + \pi_j) - \frac{1}{2}\gamma\delta^2 + S - F \qquad (2.1)$$

[7] A clear example where anti-tax avoidance policies are imposed by a supranational authority and apply to a number of competing countries is the EU's Anti-Tax Avoidance Directive.

where $\pi_i$ are the pre-tax profits earned in *host* country $i$ and $\pi_j$ are the pre-tax profits earned from sales in the competing country $j$. Rearranging we get:

$$\Pi = \underbrace{(1 - t_i)(\pi_i + \pi_j)}_{\text{Net profit without PS}} + \underbrace{(t_i - t_j) \cdot \delta \cdot (\pi_i + \pi_j)}_{\text{Tax avoidance from PS}} - \frac{1}{2}\gamma\delta^2 + S - F \tag{2.2}$$

Let $\pi_i = P_i \cdot Q_i$ and $\pi_j = (P_j - \tau) Q_j$. Then using $^{d\Pi}/_{d\delta} = 0$ we can express the optimal share of profits shifted to country $j$ if the MNE locates in $i$ as:

$$\delta^* = \begin{cases} 0 & \text{if } t_i \leq t_j \\ (t_i - t_j)(\pi_i + \pi_j)/\gamma & \text{if } t_j + \gamma/(\pi_i + \pi_j) > t_i > t_j \\ 1 & \text{if } t_i \geq t_j + \gamma/(\pi_i + \pi_j) \end{cases} \tag{2.3}$$

We restrict attention to the intermediate case, where $\delta^* = (t_i - t_j)(\pi_i + \pi_j)/\gamma$. Note that, in this case, the extent of profit shifting is increasing in the tax differential between the two countries, $t_i - t_j$; the ease with which profits can be shifted, $^1/_\gamma$; and in the market size of the region as a whole, $\pi_i + \pi_j$.

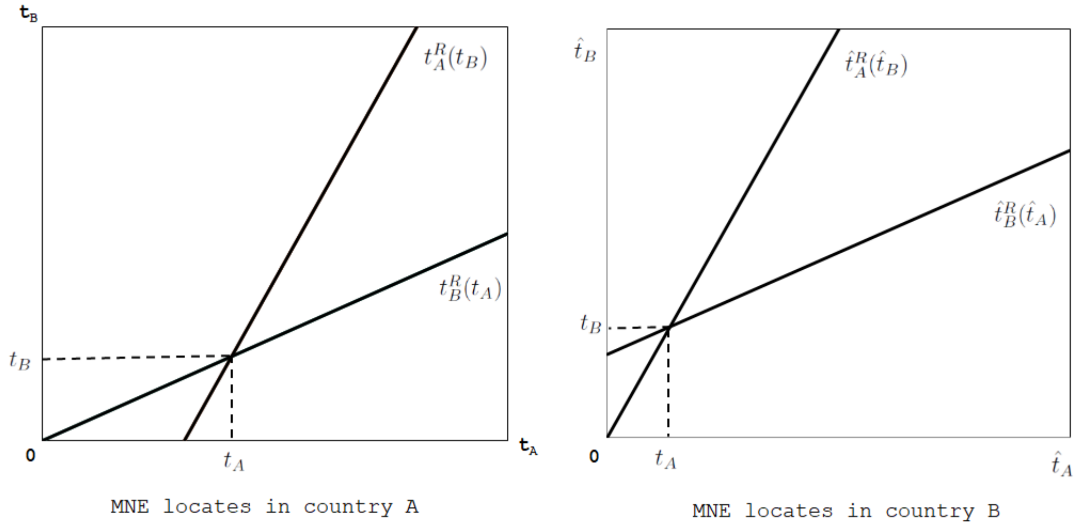
#### Stage 3: Governments choose profit tax rates

In stage 3, the revenue-maximising governments choose the tax rates they want to apply on the MNE's profits reported in their country taking the MNE's plant location decision as given. Governments' tax revenue functions are:

$$R_i = \begin{cases} t_i (1 - \delta^*)(\pi_i + \pi_j) & \text{if } t_i > t_j \\ t_i (\pi_i + \pi_j) & \text{if } t_i \leq t_j \end{cases}$$

$$R_j = \begin{cases} t_j \cdot \delta^* (\pi_i + \pi_j) & \text{if } t_j < t_i \\ 0 & \text{if } t_j \geq t_i \end{cases} \tag{2.4}$$

Figure 2.1: Governments' Tax Reaction Functions




where $R_i$ are the tax revenues earned by *host* country $i$ and $R_j$ are the tax revenues earned by competing country $j$.

Starting with the case where governments take as given the MNE's plant location in country A, we get each government's tax reaction function, $t_i^R(t_j)$, by taking ${dR_A}/{dt_A} = 0$ and ${dR_B}/{dt_B} = 0$. The host governments tax reaction function is given by $t_A^R = \frac{1}{2}\left({\gamma}/{(\pi_i+\pi_j)}\right) + \frac{1}{2}t_B$ and that for competing government B is given by $t_B^R = \frac{1}{2}t_A$. These are presented in Figure 2.1 which shows that the profit tax rates set by the two governments are strategic complements.[8] Solving for each government's optimal tax rate (determined by the intersection of the tax reaction functions), we get:

$$t_A = \frac{8\gamma}{3\left(1+n\cdot(1-\tau)^2\right)}, \quad t_B = \frac{4\gamma}{3\left(1+n\cdot(1-\tau)^2\right)} \tag{2.5}$$

noting that $t_A = 2t_B$. Using equations (2.3)-(2.5), it is easy to see that the tax revenues for countries A and B when the MNE locates its plant in A are $R_A = {4\gamma}/{9}$ and $R_B = {\gamma}/{9}$; noting that $R_A = 4R_B$. Note too that although countries' optimal tax rates are increasing in trade costs and decreasing in relative country size, their

[8]See Zodrow (2010) and Keen and Konrad (2013) for a theoretical discussion on strategic complementarity in competing governments' tax rates; and Devereux, Lockwood and Redoano (2008) for empirical evidence supporting it.

tax revenues aren't. This means that the two governments set their tax rates in such a way that for any $n$ and $\tau$ they earn constant revenues, $R_i(\gamma)$.[9]

If instead governments take as given the MNE's plant location in country B (denoted by $\hat{}$), the two countries' optimal tax rates are:

$$\hat{t}_A = \frac{4\gamma}{3\left(n + (1-\tau)^2\right)}, \quad \hat{t}_B = \frac{8\gamma}{3\left(n + (1-\tau)^2\right)} \tag{2.6}$$

such that we get a result that is symmetric to the case where the MNE locates its plant in A: $\hat{t}_B = 2\hat{t}_A$ and countries' tax revenues are $\hat{R}_B = {}^{4\gamma}/_{9}$ and $\hat{R}_A = {}^{\gamma}/_{9}$. Thus, using equations (2.5) and (2.6), we make the following proposition:

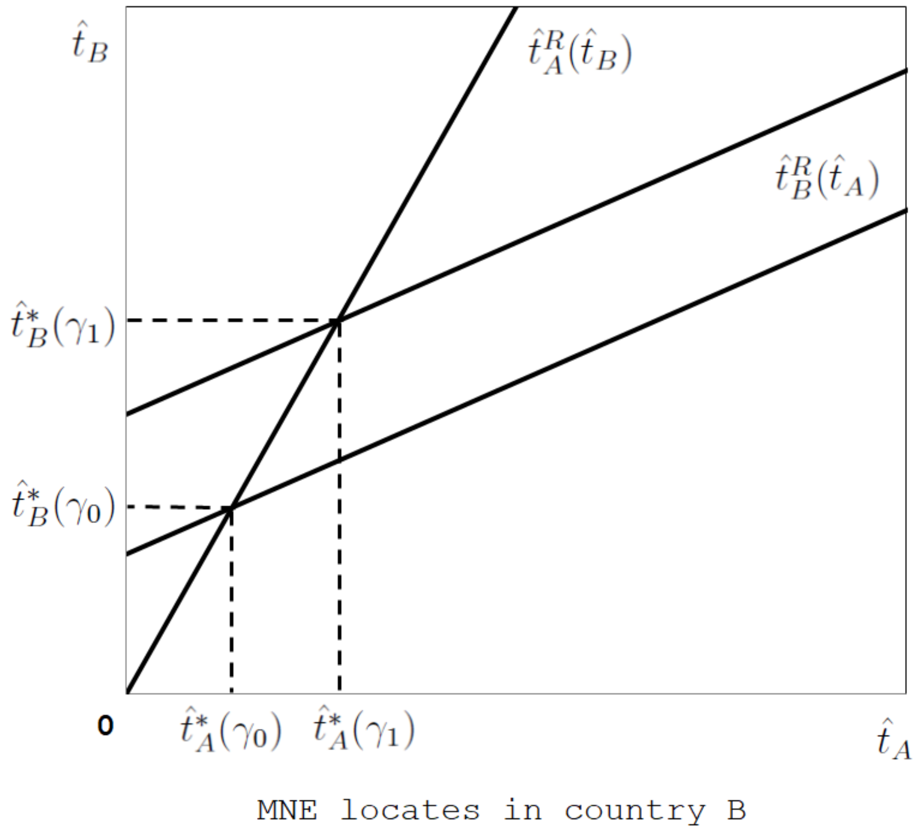
**Proposition 2.1.** *The country that hosts the MNE's plant charges the higher tax rate on profits.*

*Proof.* For any $\gamma > 0$, $t_A - t_B = {}^{4\gamma}/_{3\left(1+n\cdot(1-\tau)^2\right)} > 0$ and $\hat{t}_B - \hat{t}_A = {}^{4\gamma}/_{3\left(n+(1-\tau)^2\right)} > 0$. □

To understand this intuitive result, note that if profit shifting were costless ($\gamma = 0$), the MNE would report all of its profits in the country that sets the lower tax rate. This would lead to a race to the bottom in tax rates such that in equilibrium $t_A = t_B = 0$. With a convex cost for profit-shifting $\left(\frac{1}{2}\gamma\delta^2 > 0\right)$, however, the MNE finds it increasingly costly to transfer more of its profits to the lower tax country. This ensures that a portion of the MNE's profits are reported in the host country, thereby enabling its government to set a positive tax rate. This is chosen in such a way that it maximises the host country's tax revenues in a classic rate-versus-base trade-off: charging a higher tax rate means losing some of the MNE's profits to the lower tax competitor, but also means extracting more revenue from the profits that are reported in its jurisdiction. This leads us to the next proposition:

[9] This is consistent with the idea that governments lower tax rates as the tax base widens, leaving the effective tax rate unchanged. See, for example, Haufler and Schjelderup (2000).

Figure 2.2: Governments' Tax Reaction Functions (increase in $\gamma$)




**Proposition 2.2.** *The profit tax rates set by the host and the competing countries' governments are increasing in $\gamma$.*

*Proof.* If the MNE locates in A, noting that $t_A = 2t_B$, it suffices to show that ${}^{dt_A}/_{d\gamma} = {}^8/_{3(1+n(1-\tau)^2)} > 0$; and if the MNE locates in B, noting that $\hat{t}_B = 2\hat{t}_A$, it suffices to show that ${}^{d\hat{t}_B}/_{d\gamma} = {}^8/_{3(n+(1-\tau)^2)} > 0$. $\square$

To understand why *both* countries' tax rates are increasing in $\gamma$, note that more costly profit-shifting makes the MNE's profits "less mobile", and thereby enables the host country's government to set a higher tax rate. The strategic complementarity between the two countries' tax rates means that the tax rate of the competing country increases as well. This is shown in Figure 2.2 which shows that the host country's tax reaction function shifts outwards as the cost of profit shifting increases from $\gamma_0$ to $\gamma_1$, while leaving that of the competing country unchanged.[10] Note that the new point of intersection of the two tax reaction functions leads to equilibrium tax rates that are higher than the original ones.[11] Note too that a higher $\gamma$ widens the tax differential between the two countries. For example, if we consider the case where the MNE locates its plant in country B we get ${d\hat{t}_B}/{d\gamma} > {d\hat{t}_A}/{d\gamma} > 0$.

**<u>Stage 2:</u> MNE's plant location decision**

In stage 2, the MNE decides where to locate its plant for given subsidy offers, $S$ and $\hat{S}$; the former representing country A's subsidy offer while the latter represents that of country B. The winner of the auction for the MNE's plant is the country that offers the MNE the higher level of profits net of taxes and subsidies. Therefore, the larger country B wins the auction for the plant if and only if $\hat{\Pi} > \Pi$. Using equations (2.2)-(2.3) and (2.5)-(2.6), this condition can be written as:

$$\hat{\Pi} - \Pi = \frac{1}{4}\left[(n-1)(2-\tau)\tau\right] + \hat{S}(\gamma) - S(\gamma) > 0 \tag{2.7}$$

Note that if both countries offer a zero subsidy ($\hat{S} = S = 0$), then for any $\tau > 0$ the MNE locates its plant in the larger country, reflecting the net-of-tax 'geographic advantage' of country B, $\Gamma = \frac{1}{4}\left[(n-1)(2-\tau)\tau\right] > 0$.[12] Note too, that in the absence of trade costs ($\tau = 0$) or, if countries were of similar size ($n = 1$), the MNE locates its plant in the country offering the larger subsidy. Finally, note that higher trade costs and differences in country size favour the larger country in the auction for the MNE's plant.

[10] To see why $\gamma$ impacts only the tax reaction function of the host country, note that the tax reaction functions are $t_i^R = \frac{\gamma}{2(\pi_i+\pi_j)} + \frac{t_j}{2}$ for host government $i$ and $t_j^R = \frac{t_i}{2}$ for competing government $j$.

[11] We constrain $\gamma \in \left(0, {3}/{8}\left(1+n(1-\tau)^2\right)\right]$ to ensure that the tax rates set by the two governments do not exceed 100%.

[12] This represents the MNE's net-of-tax profit differential (i.e. exclusive of subsidies) arising from locating its plant in the larger country B rather than A.

**Stage 1: Subsidy competition for the MNE's plant**

In stage 1, governments bid via lump-sum subsidies, $S$ and $\hat{S}$, to host the MNE's plant. The bidding process is akin to a first price auction with complete information and private values.[13] If countries were of similar size, such that B has no geographic advantage ($\varGamma = 0$), then each government's dominant strategy is to keep bidding some small amount $\varepsilon$ more than the previous highest bid by its competitor until it reaches its valuation (i.e. the maximum subsidy that it is willing to pay to attract the MNE's plant), and then stop. This leads to a 'race to the top' in subsidies with the auction resulting in the maximum bids being a tie.

With differences in country size, however, the larger country B can win the auction for the MNE's plant with a lower bid than its rival's because of its geographic advantage, $\varGamma > 0$. This is reflected in the governments' subsidy best response functions:

$$\underline{S}\left(\hat{S}\right) = \begin{cases} \hat{S}(\gamma) + \varGamma + \varepsilon & \text{if } V_A > \hat{S} + \varGamma \\ V_A(\gamma) & \text{if } V_A \leq \hat{S} + \varGamma \end{cases} \qquad \text{for government A}$$

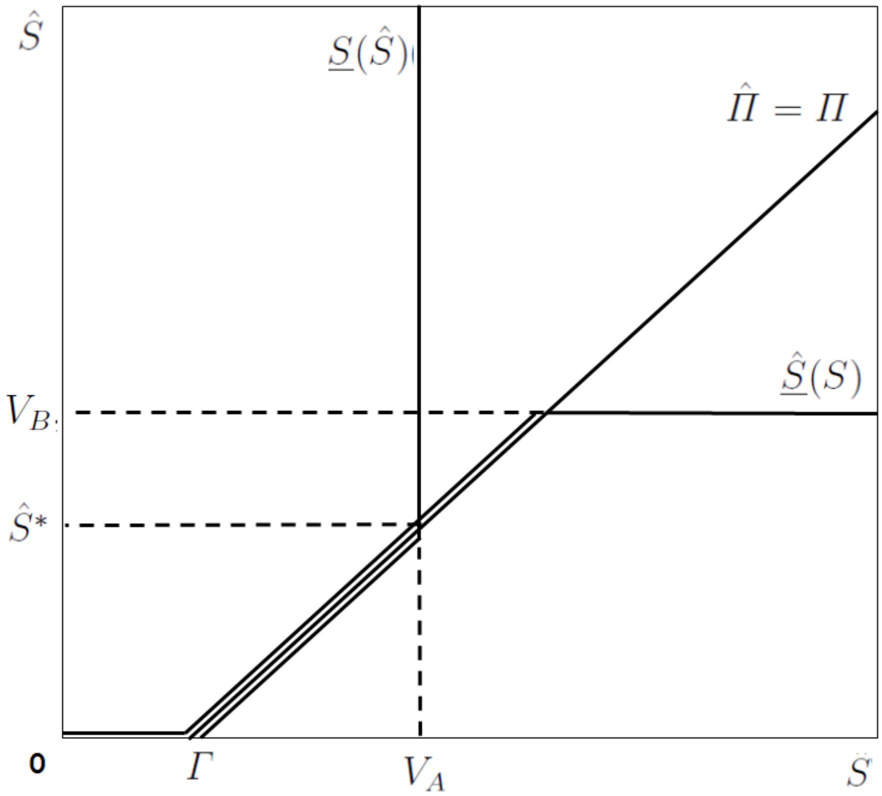
$$\underline{\hat{S}}\left(S\right) = \begin{cases} 0 & \text{if } S < \varGamma \\ S(\gamma) - \varGamma + \varepsilon & \text{if } V_B > S - \varGamma \geq 0 \\ V_B(\gamma) & \text{if } V_B \leq S - \varGamma \end{cases} \qquad \text{for government B} \tag{2.8}$$

where $\underline{S}$ and $\underline{\hat{S}}$ are the minimum subsidies that governments have to offer to win the auction for the MNE's plant, and $V_i$ is government $i$'s valuation of the FDI project. These are put together in Figure 2.3 which shows that each government is willing to push its competitor all the way up to its valuation, at which point it would be indifferent between winning and losing the auction.

Since governments are assumed to be revenue maximisers, each government's valu-

[13] See Ferrett and Wooton (2010) for a discussion on our auction set-up, including its micro-foundations and equilibrium properties.

Figure 2.3: Subsidy Best Response Functions




ation of the FDI project, $V_i$, is the difference between the tax revenues earned when they host the MNE's plant and the tax revenue earned when the plant is hosted by their competitor. Thus, country B's valuation is $V_B = \hat{R}_B - R_B = \gamma/3$, and country A's valuation is $V_A = R_A - \hat{R}_A = \gamma/3$.[14] Noting that in equilibrium the two government's valuations are equal, $V_A = V_B$, and using condition (2.7), we can make the following proposition:

**Proposition 2.3.** *For any $\tau > 0$, in equilibrium the larger country wins the auction for the plant of the MNE.*

*Proof.* For any $\tau \in (0, 1)$, $\hat{\Pi} - \Pi = \frac{1}{4}\left[(n-1)(2-\tau)\tau\right] > 0$ for all $n > 1$.[15] □

[14] Governments' valuations are equal because they are revenue maximisers. If we allow for welfare maximising governments (that also value consumer welfare), the larger country's valuation of the FDI project would be higher than that of the smaller country; but the MNE's plant location decision would remain unchanged.

[15] We constrain $\tau \in (0, 1)$ to ensure: (i) that market size matters for the MNE's location choice; and (ii) that it serves that markets in both countries.

Since the two governments value the FDI project equally, the outcome of the auction is determined by country B's net-of-tax geographic advantage, $\varGamma = \frac{1}{4}\left[(n-1)(2-\tau)\tau\right]$. Noting that $\varGamma > 0$ for any $\tau > 0$ and $n > 1$, we conclude that in a segmented regional market, the larger country wins the auction for the MNE's plant. This means that the MNE's plant location decision is similar to that in a world without taxes and subsidies.

To understand what determines the size of the winning subsidy, $\hat{S}^{*}$, note from Figure 2.3 that for any $S < \varGamma$ country B wins the auction for the MNE's plant even with a zero subsidy. This will be the equilibrium outcome when country B's net-of-tax geographic advantage exceeds A's valuation of the FDI project, or equivalently:[16]

$$n > 1 + \frac{4\gamma}{3(2-\tau)\tau} = n^{*} \tag{2.9}$$

If, on the other hand, $V_A \geq \varGamma$ (or equivalently $n \leq n^{*}$), in equilibrium, the losing country, A, bids its valuation, $V_A$, while the winning country, B, just trumps A's bid in the eyes of the MNE to win the auction for its plant. In this case, we may think of the two countries as being "close competitors" because the larger country's geographic advantage is sufficiently small to allow the two countries to "credibly" compete for the MNE's plant. Thus, the subsidy paid by the winning country B is:

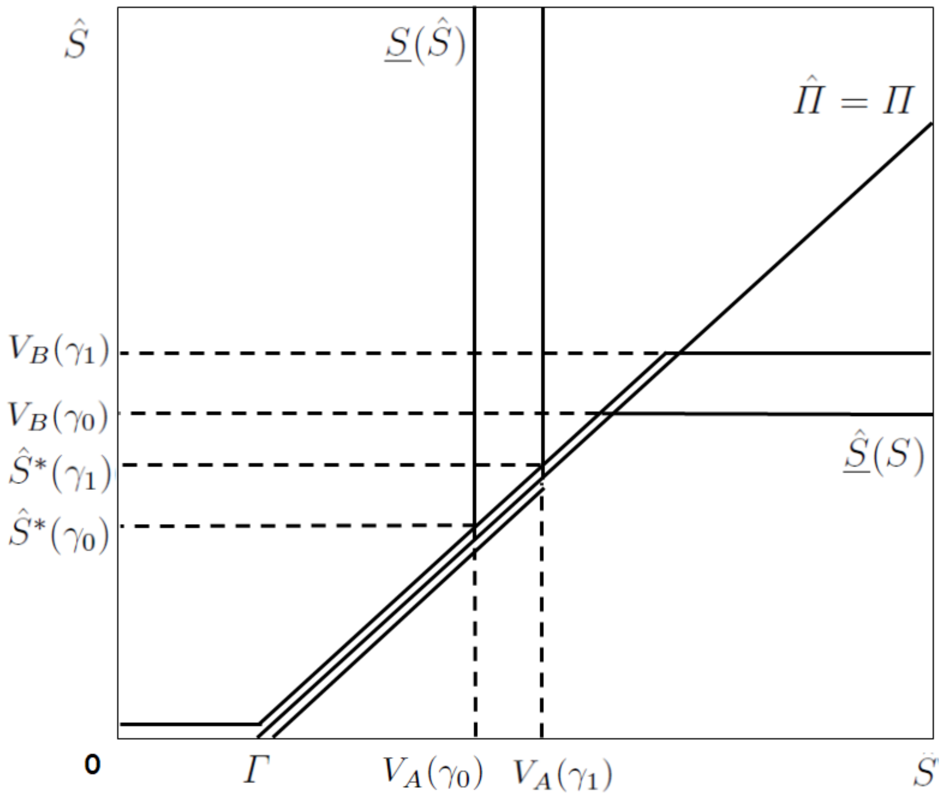
$$\hat{S}^{*} = \begin{cases} V_A(\gamma) - \varGamma + \varepsilon & \text{for } n \leq n^{*} \\ 0 & \text{for } n > n^{*} \end{cases} \tag{2.10}$$

On the basis of equation (2.10) we make the following proposition:

**Proposition 2.4.** *For $n \leq n^{*}$, a higher $\gamma$ increases the host country's winning bid (or equivalently its equilibrium subsidy offer), $\hat{S}^{*}$, but it leaves it unchanged for $n > n^{*}$.*

[16]Note that $n^{*}$ is increasing in $\gamma$ because less costly profit-shifting (low $\gamma$) makes it easier for the larger country to host the MNE; and decreasing in $\tau$ because higher trade costs increases the MNE's incentive to locate in the larger country.

Figure 2.4: Subsidy Best Response Functions (increase in $\gamma$)




*Proof.* For any $n \leq n^*$, $\hat{S}^* = \frac{\gamma}{3} - \frac{1}{4}\left[(n-1)(2-\tau)\tau\right] + \varepsilon$ and ${}^{d\hat{S}^*}\!/_{d\gamma} = {}^{1}\!/_{3} > 0$. □

From equation (2.10) it is straightforward to see that $\gamma$ has no affect on $\hat{S}^*$ for $n > n^*$, but that it has a positive effect when the two countries are close competitors ($n \leq n^*$). Focusing on the latter case, recall that more costly profit-shifting makes the MNE's profits less mobile, such that more of the MNE's profits can be taxed away by the *host* government (see Proposition 1.2). Thus, as $\gamma$ increases, the two governments' valuation of the FDI project increases, ${}^{dV_A}\!/_{d\gamma} = {}^{dV_B}\!/_{d\gamma} = {}^{1}\!/_{3} > 0$, such that the losing country's government pushes the winning bidder further in the auction for the MNE's plant. This is shown Figure 2.4 which shows how the equilibrium subsidy, $\hat{S}^*$, changes as the cost of profit shifting increases from $\gamma_0$ to $\gamma_1$.

The extent to which profit shifting effects the subsidy paid to the MNE may be better understood by bench-marking to the extreme case of no profit shifting. Consider first a scenario with a region consisting of only one potential host country. In that case, the host government sets $t_i = 1 - \varepsilon$ such that production is just profitable, and in the bidding stage, it pays a subsidy equal to the fixed cost of setting up a plant, $S = F$, to ensure entry by the MNE. With profit shifting opportunities, however, the host government is unable to extract all of the MNE's profits in taxes, such that entry by the MNE is ensured with $S < F$.

A similar analogy applies in a scenario with two potential host country. When profit shifting is not possible, the host government taxes away all of the MNE's profits, such that in the bidding stage it would have to cover all of the MNE's fixed cost with a subsidy, $S \geq F$.[17] But the opportunity that arises from profit shifting for the MNE to earn positive post-tax profits, reduces the size of the subsidy that is required to ensure entry by the MNE. In contrast to the case with no profit shifting, this need not cover the fixed cost of setting up the plant.

## 2.3 Welfare analysis

In this section we analyse the impact of $\gamma$ on the "welfare" of individual players and on world welfare (here defined as the sum of net-of-subsidy tax revenues earned by governments A and B, the profits of the MNE and consumer surplus in the two countries). We focus on the case where the MNE's plant is locates in the larger country B (as per Proposition 2.3).

**Proposition 2.5.** *A higher $\gamma$ benefits the host and the competing countries' governments equally if $n \leq n^*$; and benefits the host country's government more than that of the competing country if $n > n^*$.*

*Proof.* For $n \leq n^*$, $d\hat{R}_A/d\gamma = d\left(\hat{R}_B - \hat{S}^*\right)/d\gamma = 1/9 > 0$; and for $n > n^*$, $d\hat{R}_A/d\gamma = 1/9 < d\left(\hat{R}_B - \hat{S}^*\right)/d\gamma = 4/9$. □

[17] It is assumed that without any form of fiscal policy (i.e. absent taxes and subsidies), the MNE would be profitable in both countries, $\pi_i + \pi_j > F$.

Focusing first on the revenues earned by country A's government, and recalling from stage 3 that $\hat{R}_A = \gamma/9$, it is easy to see that more costly profit shifting increases $\hat{R}_A$. This happens because an increase in $\gamma$ induces A's government to charge a higher tax rate (see Proposition 2.2) that is applied on an unchanged tax base, $\hat{\delta}^* (\hat{\pi}_A + \hat{\pi}_B)$. To understand why the two components of the tax base are unaffected by $\gamma$, note that: (i) in this model we have a 'pure profits tax' that leaves equilibrium pre-tax profits from markets A and B unchanged for any given $n$ and $\tau$;[18] and (ii) in equilibrium $\hat{\delta}^* = 1/3$ is unaffected by $\gamma$ because the direct negative impact that $\gamma$ has on $\hat{\delta}$ is neutralised by the indirect effect that $\gamma$ has on $\hat{\delta}^*$ through $\hat{t}_B$ and $\hat{t}_A$.

Turning to country B's government, note that for $n \leq n^*$, the revenues earned from taxing the MNE's profits, $\hat{R}_B$, are reduced by the size of the subsidy paid to the MNE, $\hat{S}^*$:

$$\hat{R}_B - \hat{S}^* = \frac{\gamma}{9} + \frac{1}{4} \left[ (n-1)(2-\tau)\tau \right] \tag{2.11}$$

It is straightforward to see that equation (2.11) is increasing in $\gamma$, and that the extent of its effect is similar to that on the revenues of the government in country A. This happens because the positive effect that $\gamma$ has on the tax revenues earned by B's government is reduced by the positive impact that $\gamma$ has on the subsidy paid to the MNE (see Proposition 2.4). The end result is that the host and the competing countries' governments both benefit equally from policies that make profit shifting more costly when the two countries are close competitors.

However, if country B's net-of-tax geographic advantage exceeds A's valuation of the FDI project, $n > n^*$, the larger country hosts the MNE with a zero subsidy (see equation (2.10)). Consequently, government B's revenues are $\hat{R}_B = 4\gamma/9$, such that an increase in $\gamma$ benefits the host government more than the government of the competing country, $d(\hat{R}_B - \hat{S}^*)/d\gamma = 4/9 > d\hat{R}_A/d\gamma = 1/9$.

Turning to the impact of $\gamma$ on the MNE's profits:

[18] Diamond and Mirrlees (1971) show that a pure profits tax does not distort the decision making of a producer. This means that, in our model, $\gamma$ has no impact on $\pi_A^* + \pi_B^* = ((1-\tau)^2 + n)/4$ through taxes imposed by the two governments, $t(\gamma)$.

**Proposition 2.6.** *The MNE's profits, $\hat{\Pi}$, are decreasing in the cost of profit shifting, $\gamma$.*

*Proof.* For $n \leq n^*$, $\hat{\Pi} = {}^1\!/\!_4\left[1 + n(1-\tau)^2\right] - {}^5\!/\!_{18}\gamma - F$, and ${}^{d\hat{\Pi}}\!/\!_{d\gamma} = -{}^5\!/\!_{18} < 0$; and for $n > n^*$, $\hat{\Pi} = {}^1\!/\!_4\left[n + (1-\tau)^2\right] - {}^{11}\!/\!_{18}\gamma - F$ and ${}^{d\hat{\Pi}}\!/\!_{d\gamma} = -{}^{11}\!/\!_{18} < 0$. □

The intuition is fairly straightforward. If $n \leq n^*$, $\gamma$ affects $\hat{\Pi}$ in two ways: negatively because it increases the MNE's cost of tax avoidance;[19] and positively because it increases the size of the subsidy paid by the host government to the MNE (see Proposition 2.4). And the former effect outweighs the latter. If $n > n^*$, however, $\gamma$ has no effect on the subsidy. Thus, if country B's net-of-tax geographic advantage exceeds A's valuation , the impact of more costly profit shifting on $\hat{\Pi}$ is simply negative, leaving the MNE worse off than it would in a case where governments are close competitors.

Putting everything together, we can make the following proposition:

**Proposition 2.7.** *World welfare, $W$, is decreasing in the cost of profit-shifting, $\gamma$.*

*Proof.* ${}^{d\hat{W}}\!/\!_{d\gamma} = {}^{d\hat{R}_A}\!/\!_{d\gamma} + {}^{d\left(\hat{R}_B - \hat{S}^*\right)}\!/\!_{d\gamma} + {}^{d\hat{\Pi}}\!/\!_{d\gamma} = -{}^1\!/\!_{18} < 0$. □

To understand what drives this result, note that changes in the cost of profit shifting have no impact on consumer surplus because the location of the MNE's plant is the same for all values of $\gamma$ (see proposition 2.3). The impact on world welfare works through $\gamma$'s impact on the revenues of governments A and B, and the profits of the MNE. Thus, any additional tax revenue resulting from higher tax rates induced by an increase in $\gamma$ has no effect on world welfare because it simply represents a transfer payment to government from the MNE. A similar interpretation applies in the case of a subsidy: it increases the MNE's profits but reduces government's revenues. However, any policy-induced increase in the cost of profit shifting gives rise to a dead-weight loss that causes world welfare to decline. This happens because more

[19] Note that since the portion of profits that are shifted, $\hat{\delta}^*$, is not affected by changes in $\gamma$, more costly profit-shifting increases the MNE's cost of tax avoidance.

costly profit shifting involves what may be thought of as compliance costs, $\frac{1}{2}\gamma\delta^2$, that are higher than otherwise would have been.[20] These additional costs are gains that would have accrued to the MNE had the cost of profit shifting remained unchanged.

## 2.4 Conclusion

This chapter analyses the impact of policies aiming to curb tax avoidance through profit shifting in a model with two countries that compete, first, for an MNE's plant via subsidies, and then for its profits via proportional tax rates. We show that in equilibrium the larger country hosts the MNE's plant and charges the higher tax rate. We also show that the tax revenues of both governments are increasing in the cost of profit shifting to the detriment of the MNE.

The key insight of the chapter follows the following chain of thought. More costly profit shifting makes the profit tax base less mobile, enabling the host country government to earn higher tax revenues. This relative immobility of profits increases governments' valuation of the FDI project such that they are willing to bid more in the auction for the plant. Consequently, any gains in the host government's tax revenues that result from more costly profit shifting will be *partly* offset by higher subsidies.

In practical terms, this means that host governments' ability to raise tax revenues following an increase in the cost of profit shifting will be hindered by more generous subsidies to attract MNEs' plants. Thus, "static" estimates of tax revenues lost due to profit shifting – for some countries running into billions of euros/dollars as shown in Table 2.1 – are likely to overestimate what host country governments would be able to "recoup" by limiting profit shifting. These estimates simply do not account for the behavioural responses brought about by more costly profit shifting, i.e. they don't account for endogenous subsidies.

[20]Recalling that in equilibrium, $\hat{\delta}^* = 1/3$, the cost of profit shifting may be written as $\gamma/18$, such that $d/d\gamma = 1/18$. Note that this is equivalent to $d\hat{W}^*/d\gamma = -1/18$ in the proof for proposition 2.7.

Table 2.1: Estimated Revenue Loss due to Profit Shifting (2012)

| | | | |
|---|---|---|---|
| Australia | \$7.4 billion | Japan | \$39.8 billion |
| Denmark | \$1.3 billion | Norway | \$2.3 billion |
| France | \$15.3 billion | Poland | \$1.3 billion |
| Germany | \$17.2 billion | Portugal | \$1.1 billion |
| Greece | \$0.7 billion | Spain | \$6.6 billion |
| Italy | \$9.0 billion | United States | \$93.8 billion |

*Source: Clausing (2016), National Tax Journal.*

Note that, in our model, the behavioural aspect is not reflected in the MNE's plant location decision. In equilibrium, this remains unchanged for any value of $\gamma$.[21] Rather, the change in behaviour is reflected in more aggressive bidding by potential host governments that is induced by the MNE's threat to choose an alternative location for its plant. This should not be surprising as ample literature notes that MNEs' plant location decisions become more sensitive to cross-country differences in taxes/subsidies as profit shifting becomes more costly (see, for example, Mintz and Smart, 2004; Zodrow, 2010).

Note too, that in our model, the winning subsidy paid by the larger country is increasing in the cost of profit shifting only if the potential host countries are "close competitors" for the plant. Thus, the above argument wouldn't apply to cases involving a large country and a small island economy that is likely to be an attractive location for the MNE's profits but not for its plant. Rather we're thinking of cases where the smaller country 'closely' competes to host the MNE's plant while also being an attractive location for its profits. A good example would be the Netherlands: it has a long track record in attracting large MNEs, and also has an attractive, effective tax rate lower than 5%. For such reasons, the Netherlands and other countries, like Ireland and Belgium, that are successful in attracting MNEs' plants, are sometimes included in lists of tax havens.[22]

[21] In part, this reflects that real economic activity is less elastic to changes in taxes/subsidies than profits (see Saez et al., 2012).

[22] See, for example, Clausing (2016). Alternatively, as in Slemrod (2010), we may think of these countries as non-havens, but that sometimes have tax system features that facilitate MNEs' tax avoidance.

If, on the other hand, countries are not close competitors, then the larger country may win the auction for the plant with a zero subsidy. Consequently, in such cases, a higher cost of profit shifting increases the tax revenues of the host government without affecting the size of its winning subsidy. In theory, a similar outcome may also be expected in cases where economic unions, such as the EU, restrain countries' ability to subsidise MNEs. In such cases, policies that aim to curb tax avoidance through profit shifting may bring about additional tax revenues for host country governments without intensifying the bidding war for the MNE's plant.

Although such occurrences are not uncommon, as MNEs do shift profits to small island economies (like Bermuda and the Cayman Islands); and the EU's State Aid regulations do prohibit subsidisation, it is also true that: (i) countries with a successful track record of attracting MNEs' plants are among the largest recipients of shifted profits (see Clausing, 2016; Cobham and Jansky, 2017); and (ii) countries forming part of an economic union that restricts their ability to subsidise may well find alternative ways to bid for MNEs (e.g. by providing industrial space or by building roads leading to factories).

Another result obtained from this model is that the tax revenues earned by the government of the small, low-tax country are increasing in the cost of profit shifting (as long as the cost does not become prohibitive). For sufficiently low levels of $\gamma$, a similar result is obtained by Stöwhase (2013). Since small countries generally oppose policies that limit profit shifting, this may appear to be counter-intuitive. However, it is not implausible to think of a scenario where more costly profit shifting enables the governments of large countries to increase their tax rates, and, in turn, that this enables the governments of small countries to increase theirs while remaining an attractive location for MNEs' profits. This suggests that multilateral action to curb tax avoidance through profit shifting, such as that captured by an increase in $\gamma$ in our model, benefits competing governments and harms the MNE; and contrasts with literature supporting cases where governments are unwilling to close loopholes for tax planning because of fears of losing employment by MNEs.

A final insight obtained from this model is that combating tax avoidance through profit shifting is not a zero sum game. We show that more costly profit shifting reduces world welfare because it does not only lead to transfer payments from the MNE to the competing governments, but it also gives rise to a dead-weight loss that results from additional effort by the MNE to transfer a given share of its profits (e.g. by hiring additional financial experts). Thus, if supranational authorities also care about MNEs' profits, this logic provides another reason why limiting profit shifting may yield smaller returns than anticipated. Note too, that in our model, we assume that implementing policies to reduce profit shifting does not entail additional administrative costs to governments. Such considerations – as in Amerighi (2008) and Slemrod and Wilson (2009) – would further dampen world welfare and that of individual countries.

## 2.5 Appendix

In this section we show the expressions for the equilibrium outcome if the cost of profit shifting relates to the *absolute* level of profits shifted rather than the *share* of profits shifted (as in the model presented in this chapter). Let the cost of profit shifting be $\frac{1}{2}\gamma\left(\pi_i+\pi_j\right)\delta^2$ . Then the profit function for the monopolist MNE is:

$$\varPi = \left(1-t_i\right)\left(1-\delta\right)\left(\pi_i+\pi_j\right)+\left(1-t_j\right)\cdot\delta\cdot\left(\pi_i+\pi_j\right)-\frac{1}{2}\gamma\left(\pi_i+\pi_j\right)\delta^2+S-F \quad (2.12)$$

Taking ${d\varPi}/{d\delta}=0$, we can express the optimal share of profits shifted to country $j$ if the MNE locates in $i$ as:

$$\delta^* = \begin{cases} 0 & \text{if } t_i \leq t_j \\ \left(t_i-t_j\right)/\gamma & \text{if } t_j+\gamma > t_i > t_j \\ 1 & \text{if } t_i \geq t_j+\gamma \end{cases} \quad (2.13)$$

As in the main model, we restrict attention to the intermediate case, where $\delta^* = \left(t_i-t_j\right)/\gamma$. Note that, in this case, the extent of profit shifting is increasing in the tax differential between the two countries, $t_i - t_j$; and the ease with which profits can be shifted, $1/\gamma$.

Noting that the governments' tax revenue functions are:

$$R_i = \begin{cases} t_i\left(1-\delta^*\right)\left(\pi_i+\pi_j\right) & \text{if } t_i > t_j \\ t_i\left(\pi_i+\pi_j\right) & \text{if } t_i \leq t_j \end{cases}$$
$$R_j = \begin{cases} t_j \cdot \delta^*\left(\pi_i+\pi_j\right) & \text{if } t_j < t_i \\ 0 & \text{if } t_j \geq t_i \end{cases} \tag{2.14}$$

we can derive the governments' equilibrium tax revenues. Starting with the case where governments take as given the MNE's plant location in country A, and solving for $dR_A/dt_A = 0$ and $dR_B/dt_B = 0$, we get each government's optimal tax rate:

$$t_A = \frac{2\gamma}{3}, \quad t_B = \frac{\gamma}{3} \tag{2.15}$$

noting that $t_A = 2t_B$ (as in the main model). It follows that the tax revenues for countries A and B when the MNE locates its plant in A are $R_A = \frac{\gamma}{9}\left(1+n\left(1-\tau\right)^2\right)$ and $R_B = \frac{\gamma}{36}\left(1+n\left(1-\tau\right)^2\right)$; noting that $R_A = 4R_B$ (as in the main model). If instead governments take as given the MNE's plant location in country B (denoted by $\hat{}$), the two countries' optimal tax rates are:

$$\hat{t}_A = \frac{\gamma}{3}, \quad \hat{t}_B = \frac{2\gamma}{3} \tag{2.16}$$

such that we get a result that is symmetric to the case where the MNE locates its plant in A: $\hat{t}_B = 2\hat{t}_A$ and countries' tax revenues are $\hat{R}_B = \frac{\gamma}{9}\left(n+(1-\tau)^2\right)$ and $\hat{R}_A = \frac{\gamma}{36}\left(n+(1-\tau)^2\right)$.

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# Chapter 3

# The Threat of Tax Havens to Developing Countries[1]

## 3.1 Introduction

Over recent years, there seems to have emerged a consensus among policymakers that profit shifting to tax havens by large multinational enterprises (MNEs) is problematic because it erodes tax revenues in multinationals' home countries. The extent of the problem is reflected in data published in the IMF's Coordinated Direct Investment Survey (CDIS) showing that in 2010, Bermuda, Barbados and the British Virgin Islands received more Foreign Direct Investment (FDI) combined than Germany or Japan, and that during the same year they made more investment in the world economy than Germany.

Advanced economies' concerns about such activity have long been reflected in their policy actions, such as the BEPS initiative by the OECD.[2] However, recent empirical evidence suggests that tax havens may be even more problematic for less developed

[1] **An earlier version of the chapter was presented at the Tax and Environment Competition Workshop held at Loughborough University in 2016. I thank participants for their helpful comments and useful discussions.**

[2] The Base Erosion and Profit Shifting (BEPS) initiative led to the production of an action plan intended to facilitate multilateral cooperation among governments with regards to the taxation of MNEs to better align rights to be taxed within each country (OECD, 2013).

countries. Literature proposes two main reasons supporting this argument. The first is that developing countries typically have greater reliance on revenues from corporate taxation. In fact, UNCTAD (2015) reports that corporate tax revenues as a percentage of total tax revenues averaged 21% in developing countries but only 11% in developed countries. The second is that multinationals' profit shifting responses to tax incentives appear to be stronger in less developed countries. For example, using a global data-set with information on 210,000 corporations in 42 countries, Johannesen et al. (2017) show that cross-border profit shifting is more prevalent in less developed countries. Similar findings are reported in Fuest et al. (2011), IMF (2014), and Jansky and Prats (2015).

In this chapter, we go one step further, and argue that the detrimental effect of tax havens on less developed countries goes beyond the tax revenue losses referred to in this literature because profit shifting also makes it less likely that MNEs locate real activity in less developed countries in the first place. This happens because profit shifting opportunities limit developing countries' ability to make up for their inherent disadvantages by offering tax rates that are more favourable than those offered by more developed countries.[3]

We study these effects of profit shifting to tax havens in a model of tax competition for an MNE's production plant between a developed and a developing country, where the respective governments cannot tax discriminate between the (mobile) MNE and indigenous (immobile) firms. Consequently, by lowering their statutory tax rates, revenue-maximisng governments make their countries a more attractive location for the MNE, but that comes at the cost of losing tax revenues from indigenous firms.

In our model, the difference in the countries' level of economic development is captured by the technology gap between their respective indigenous firms and the MNE (as measured by differences in their marginal cost of production). And because indigenous firms in developing countries have a bigger technology gap relative to the MNE, they benefit more from cost-reducing knowledge spillovers if the MNE co-

[3]See Azemar and Delios (2008) for empirical evidence that statutory tax rates may enable developing countries to compensate for lack of economic development.

locates. Thus, the revenue-maximising government of the developing country has a strong incentive to host the MNE. But "winning" it requires making up for inherent disadvantages, as absent tax incentives, the MNE's preferred location is the developed country.

We show that if competing governments set tax rates simultaneously, the game has no sub-game perfect equilibrium in pure strategies; so instead, we look for the equilibrium outcome for the case where the competing governments set their tax rates sequentially.[4] We find that profit shifting opportunities to a tax haven make it less likely that the MNE locates its plant in the less developed country; a conclusion that holds regardless of which of the two governments sets its tax rate first. This is the result of: (i) the MNE's reduced willingness to locate in the developing country as tax rate differences between the competing countries become less important; and (ii) governments' reduced incentive to bid "aggressively" to host the MNE because hosting an MNE with profit shifting opportunities yields less tax revenues than one that does not.

Even in cases where the developing country hosts the MNE's plant, the ability of the MNE to shift more of its profits to the tax haven reduces the developing country's tax revenues (due to reductions in both the tax base and the tax rate); a conclusion that does not necessarily hold when the developed country hosts the MNE. Depending on the timing of the moves in the tax setting stage of the game, the government of the developed country may be better off with increased profit shifting. This happens if the reduced importance of tax rate differences between the two countries (in the eyes of the MNE) enables the developed country's government to set a higher tax rate and still remain an attractive location for the MNE's plant.

Our study is related to a growing literature on the welfare and tax revenue impacts of tax havens. In contrast to the consensus among host countries' governments that tax havens are detrimental to their revenues, the theoretical literature on the subject is divided. One strand of literature, primarily driven by Hong and Smart (2010),

[4] In Appendix 3.5 we also consider a special case where governments set their tax rates simultaneously and we look for the mixed strategy equilibrium.

argues that in a setting where governments cannot tax discriminate between firms, tax havens could be beneficial to the host country because it allows it to set a “high” tax rate on the profits of domestic (immobile) firms without driving away (mobile) MNEs. Similar arguments are made in Peralta et al. (2006) and Becker and Fuest (2005) who argue that the host government may wish to alter other aspects of the tax code (such as weakening the enforcement of the arm’s length principle) to lower effective taxation on mobile firms. In contrast, Slemrod and Wilson (2009) argue that tax havens are detrimental to non-haven countries because they lead to wasteful expenditure of resources to limit (exercise) tax avoidance by governments (firms); and also because they “worsen” tax competition between potential host countries by causing them to reduce their tax rates.

We contribute to this literature in two ways. First, by setting up a model of discrete investment choice, we are able to focus on the ‘plant location’ impact of profit shifting; an aspect that is largely overlooked in related literature. Second, by allowing for asymmetry between the competing countries, we are able to distinguish between cases where tax havens have a positive impact on the host country’s tax revenues (as argued in Hong and Smart [2010]) and those cases where they have a negative impact (as argued in Slemrod and Wilson [2009]). In our model, the impact is negative on less developed countries and, given certain conditions, positive on developed countries.

These findings are also related to Gresik et al. (2015) who study the differential welfare effect of tax havens on developed and developing countries. In their model, the MNE can shift profits to a tax haven via interest rate charges on intra-company debt (transfer pricing), while governments set the corporate tax rate and thin capitalisation rules. Using numerical simulations, they show that MNEs are able to shift most of their profits out of developing countries to tax havens such that they negate the benefits of FDI. This happens because their low institutional quality in tax administration makes them less able to prevent transfer pricing. In contrast, developed countries can better curb transfer pricing while attracting FDI with a combination of moderate thin capitalisation limits and moderate tax rates.

The key difference between their model and ours is that we allow for 'location choice', while they consider a single host country and instead allow for cases 'with' and 'without' FDI. Thus, while in our model the negative impact of tax havens on developing countries stems from their inherent technology disadvantage, in Gresik et al. it arises because of developing countries' relative inability to limit profit shifting. In our model, the potential share of profits shifted out of developed and developing countries is assumed to be the same as imposed by a supranational authority.

The rest of the chapter is organised as follows. In Section 3.2 we present a model of tax competition without tax havens, while in Section 3.3 we introduce tax havens into the model described in Section 3.2 to shed light on the location and tax revenue impacts of coordinated (exogenous) action to limit, or outright eliminate, profit shifting to tax havens. Finally, Section 3.4 discusses the main results.

## 3.2 Model without tax haven(s)

The model consists of a region with two asymmetric countries, A and B, that together make up a completely integrated market. This is assumed to be characterised by an inverse demand function $P = 1 - \sum q_i$, where $P$ is the price of a homogeneous product sold by firms operating within the region, and $q_i$ is the quantity sold by firm $i \in \{1, 2, m\}$. Firms 1 and 2 are country A's and country B's indigenous firms, respectively, and are immobile; while firm $m$ is a multinational that wants to locate its production plant in country A or B to serve the regional market. Exports from outside the region are assumed to be prohibitively costly such that serving the regional market requires that the MNE locates in either A or B.

Following Fumagalli (2003), we assume that the asymmetry between the two countries stems from the differing levels of efficiency of their indigenous firms. This is reflected in the firms' marginal costs: $c_2 = \frac{1}{3} > c_1 > c_m = 0$.[5] The difference in

[5] We assume that the MNE is more efficient than the two indigenous firms, reflecting a greater "know how" that is typical of firms undertaking FDI (Markusen, 1995). We set $c_m = 0$ because this simplifies the notation significantly as it enables us to express the post-knowledge spillover marginal cost of the indigenous firms independently of the MNE's marginal cost.

the indigenous firms' marginal costs gives rise to a "technology gap" between the two countries; which in our interpretation of the model is assumed to capture differences in the countries' level of economic development. Since $c_2 > c_1$, we think of country A as the developed country and country B as the developing country.[6] Like Fumagalli, we also assume that following the setting up of the MNE's plant, there are one-way knowledge spillovers from the MNE to the indigenous firm located in the same country that reduces the indigenous firm's marginal cost by $\phi c_i$, where $\phi \in [0, 1]$. If $\phi = 1$, then the indigenous firm benefiting from the knowledge spillover becomes as efficient as the MNE.

Governments A and B are assumed to maximise tax revenues, and levy a proportional tax rate, $t_i$, on the profits of any firm that serves the regional market from their country. Thus, hosting the MNE's plant is beneficial to governments for two reasons: (i) it enables the host government to earn tax revenues from the MNE's profits; and (ii) it enables the host country's government to raise *additional* tax revenues from the indigenous firm as a result of the increase in its profits due to the knowledge spillover from the MNE. Like Hong and Smart (2010) and Peralta et al. (2006), we also assume that governments cannot tax discriminate between the indigenous (immobile) firms and the (mobile) MNE. This ought to reflect past and ongoing efforts to abolish the preferential tax treatment given to (mobile) non-resident firms.[7] However, wherever we think it is helpful, we do point out what would happen in cases where governments are able to tax discriminate between the two groups.

The game evolves in 3 stages:

- in stage 1, governments set tax rates on profits;
- in stage 2, the MNE decides where to locate its plant; and

[6] The variable $c_1$ captures the technology gap between the two firms. As $c_1 \to c_m = 0$, the technology gap between the two countries widens.

[7] In its 2017 Progress Report on Preferential Regimes, the OECD (2017) reported that countries already acted on 95 out of 100 regimes that required changes to conform with a new set of standards that aim to eliminate harmful tax practices.

– in stage 3, all firms decide how much to produce.

We assume that all this is common knowledge and we solve the game by backward induction. In stage 3, firms choose their profit-maximising quantities in standard Cournot fashion. So, if in stage 2, the MNE locates in country $j$, then firm $i$'s pre-tax profits, $\pi_i^j$, are:

$$\begin{aligned} \pi_m^A &= \tfrac{1}{16}\left(1+(1-\phi)\,c_1+c_2\right)^2 & \pi_m^B &= \tfrac{1}{16}\left(1+c_1+(1-\phi)\,c_2\right)^2 \\ \pi_1^A &= \tfrac{1}{16}\left(1-3\,(1-\phi)\,c_1+c_2\right)^2 & \pi_1^B &= \tfrac{1}{16}\left(1-3c_1+(1-\phi)\,c_2\right)^2 \\ \pi_2^A &= \tfrac{1}{16}\left(1-3c_2+(1-\phi)\,c_1\right)^2 & \pi_2^B &= \tfrac{1}{16}\left(1-3\,(1-\phi)\,c_2+c_1\right)^2 \end{aligned} \tag{3.1}$$

Note that for any $\phi > 0$, $\pi_1^A > \pi_1^B$ and $\pi_2^B > \pi_2^A$, i.e. the indigenous firms' pre-tax profits are higher if the MNE co-locates. However, for any $\phi > 0$, the MNE's pre-tax profits are higher if it locates in country A rather than B:

$$\pi_m^A - \pi_m^B = \frac{1}{16}\,(c_2-c_1)\,\phi\,[2+(2-\phi)\,(c_1+c_2)] > 0 \tag{3.2}$$

We refer to this as country A's 'technology advantage'; and it is due to the MNE's incentive to locate its plant in the country where knowledge spillovers to competitor firm(s) would be minimised.[8] Noting that $d\left(\pi_m^A-\pi_m^B\right)/d\phi = 1/8\,(c_2-c_1)\,\phi\,[1+(1-\phi)\,(c_1+c_2)] > 0$, it follows that in the absence of taxes, the MNE would locate in developed country A for all $\phi > 0$.

On observing the tax rates set by the two governments in stage 1, in stage 2, the MNE locates its plant in country $i$ iff $(1-t_i)\,\pi_m^i \geq (1-t_j)\,\pi_m^j$, i.e. the MNE locates in country $i$ if its net-of-tax profits in country $i$ exceed those that it would make in country $j$.[9] By rearranging, we obtain a tax rate, $\hat{t}_i$, that would leave the MNE indifferent between locating in country $i$ or country $j$:

[8] This has been recognised both theoretically (Fumagalli, 2003) and empirically (Shaver and Flyer, 2000; Alcacer and Chung, 2007).

[9] For simplicity, we assume that when indifferent, the MNE locates in developed country A due to, say, a marginal technology advantage when compared to country B.

$$\hat{t}_i = \frac{\pi_m^i - \pi_m^j}{\pi_m^i} + t_j \left(\frac{\pi_m^j}{\pi_m^i}\right) \tag{3.3}$$

such that the MNE locates in country A if $t_A < \hat{t}_A$, or equivalently if $t_B > \hat{t}_B$, and vice versa. The first term on the right-hand side of equation (3.3) represents the tax rate levied by government $i$ that leaves the MNE indifferent between locating its plant in $i$ or $j$ when country $j$ imposes a zero tax rate, $t_j = 0$. From equation (3.2), it is easy to see that this term will be positive for country A and negative for country B. In contrast, the term ${\pi_m^j}/{\pi_m^i}$ on the right-hand side of equation (3.3) shows by how much government $i$ can increase its tax rate in response to an increase in government $j$'s tax rate to leave the MNE indifferent between locating in countries $i$ and $j$. This would be one-to-one if firms 1 and 2 were equally efficient (or, perhaps more intuitively, if countries A and B were at the same level of economic development). But since $\pi_m^A > \pi_m^B$, an increase in $t_B$ would require a less than proportionate increase in $t_A$ to leave the MNE indifferent between A and B; but a more than proportionate increase would be required if we take country B's perspective rather than A's. Note that as $t_j \to 1$, $\hat{t}_i \to 1$ such that $\hat{t}_i = t_j$ if $t_j = 1$.[10]

The respective tax rates are chosen by the two governments in stage 1, and in turn, determine the equilibrium location of the MNE. By lowering the tax rate, each government makes its country more attractive to the MNE; but because governments cannot tax discriminate between the MNE and the indigenous firms, they are only willing to reduce tax rates up to the point where they would be indifferent between 'hosting and taxing the MNE' and 'taxing the indigenous (immobile) firm at 100%'. Therefore, government A deviates from the 100% tax rate only if $t_A\left(\pi_1^A + \pi_m^A\right) \geq \pi_1^B$ and government B deviates only if $t_B\left(\pi_2^B + \pi_m^B\right) > \pi_2^A$. Thus the minimum tax rate that each government is willing to set is given by:

$$\underline{t}_A = \frac{\pi_1^B}{\pi_1^A + \pi_m^A} \qquad \text{for government A}$$

[10]To see this, we can rewrite equation (3.3) as $\hat{t}_i = 1 - (1 - t_j)\left({\pi_m^j}/{\pi_m^i}\right)$; noting that as $t_j \to 1$, $(1 - t_j) \to 0$ such that $\hat{t}_i = t_j$ when $t_j = 1$.

(3.4)

$$\underline{t}_B = \frac{\pi_2^A}{\pi_2^B + \pi_m^B} \qquad \text{for government B}$$

where $0 < \underline{t}_A, \underline{t}_B < 1$. Country A will never set $t_A < \underline{t}_A$ because all such (low) $t_A$ are strictly dominated by $t_A = 1$; since even if some $t_A < \underline{t}_A$ attracts the MNE, government A is still better off setting $t_A = 1$. The same reasoning applies for country B.

At the same time, the MNE would only set up a plant in host country $i$ if government $i$'s tax rate is sufficiently low to allow the MNE to make a profit, i.e. $t_i < 1$. Thus, the range within which governments' non-discriminating tax rates can vary in their bid to host the MNE has $t_i = 1$ as its maximum and $t = \underline{t}_i$ as its minimum, $t \in (\underline{t}_i, 1]$.

### 3.2.1 Simultaneous tax setting

Using equations (3.3) and (3.4), we get the following result:

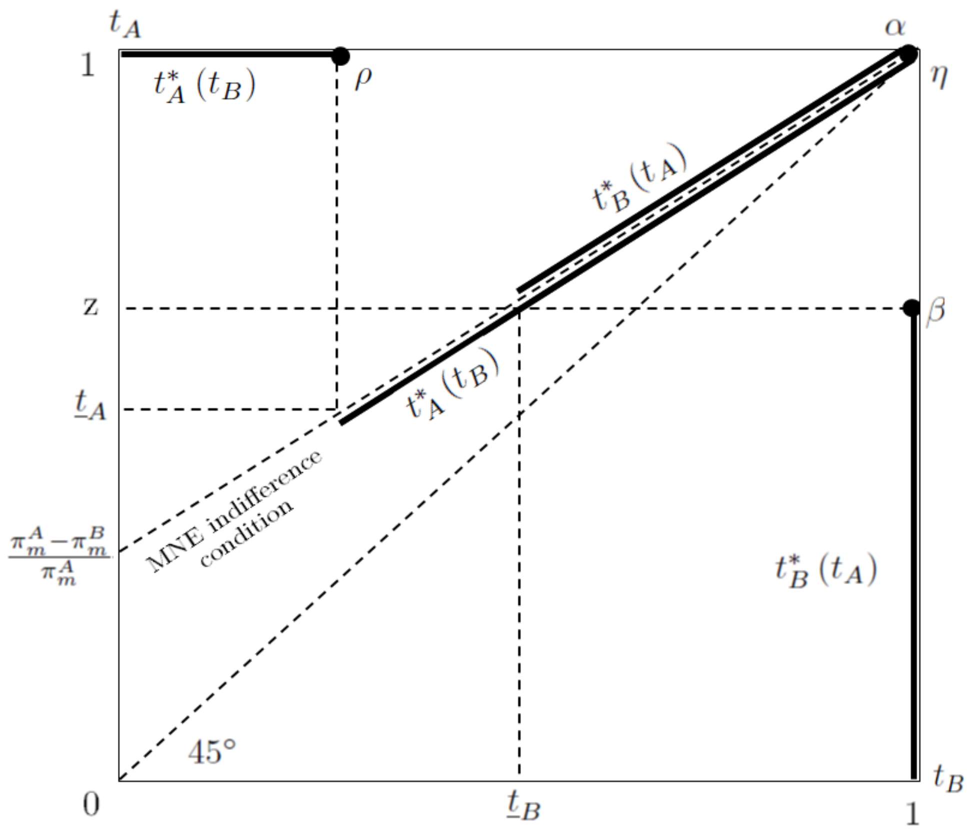
**Proposition 3.1.** *If governments set their tax rates simultaneously, the game has no sub-game perfect equilibrium in pure strategies.*

To show why no Nash equilibrium in pure strategies exists, we present the two governments' tax reaction functions in Figure 3.1; where $t_i^*(t_j)$ is government $i$'s best response for any given tax rate set by government $j$.[11] Note that government $i$ has an incentive to undercut government $j$'s tax rate as long as $\hat{t}_i(t_j) > \underline{t}_i$.[12] The same reasoning applies to government $j$, such that the two governments engage in Bertrand-like competition in effective tax rates. But since countries are asymmetric, such that $\underline{t}_i \neq \underline{t}_j$, then one of the two governments is better off pulling out of the tax

[11]Note that government B's tax reaction function always exhibits discontinuity because $\underline{t}_B \in (0, 1)$; but government A's tax reaction function may (or may not) be discontinuous, depending on whether $\underline{t}_A \gtrless \frac{\pi_m^A - \pi_m^B}{\pi_m^A}$. In Figure 3.1, we show the case where $\underline{t}_A > \frac{\pi_m^A - \pi_m^B}{\pi_m^A}$ such that government A's tax reaction function is discontinuous.

[12]Given the technology advantage of country A, whenever governments undercut each other in a bid to host the MNE, they do so in *effective* tax rates, i.e. government $i$ undercuts $\hat{t}_i(t_j)$ rather $t_j$.

Figure 3.1: Tax Reaction Functions




war for the MNE and setting its tax rate on its indigenous firm's profits at 100%. And if one government sets its tax rate at 100%, then the other government would want to increase its tax rate too. The problem is that each government desires to set a high tax rate when the competing government sets a low tax rate, while also desiring to set a low tax rate when the other government sets a high tax rate. Consequently, the two governments' tax reaction functions do not intersect; and we conclude that there is no sub-game perfect equilibrium in pure strategies.[13]

Note that an equilibrium in pure strategies would exist if governments were able to tax discriminate between the (mobile) MNE and the (immobile) indigenous firms. In that case, the two governments would set the highest possible tax rate on the profits of their indigenous firms and engage in Bertrand-like competition in tax rates for the MNE. Because $\pi_m^A > \pi_m^B$, equilibrium would have $t_B = 0$ and government A

[13] For similar outcomes see Baldwin and Krugman (2004), Wilson (2005), and Marceau et al. (2010).

would win the MNE with $t_A = \frac{\pi_m^A - \pi_m^B}{\pi_m^A}$.

### 3.2.2 Sequential tax setting

To overcome this problem, instead of assuming that the two governments set their tax rates simultaneously, we model a game with sequential tax setting;[14] and since there is no obvious reason why one government should be the leader and the other the follower, we consider both possibilities. Note that although traditional analysis of tax competition assumes that governments set tax rates simultaneously, the assumption of Stackelberg competition in tax rates is not uncommon in more recent literature. See, for example, Baldwin and Krugman (2004), Borck and Pfluger (2006), Marceau et al. (2010), Elsayyad and Konrad (2012), and Janeba and Osterloh (2013).

Consider first the case where the government of developed country A moves first (stage 1a), and the government of developing country B sets its tax rate after observing government A's tax rate (stage 1b). Then we get the following result:

**Lemma 3.2.** *If government A set its tax rate first, the MNE locates its plant in developed country A iff $\hat{t}_A(\underline{t}_B) \geq \underline{t}_A$, but otherwise it locates the plant in developing country B.*

This follows from Figure 3.1. In stage 1a, government A chooses its most preferred point on government B's tax reaction function, $t_B^*(t_A)$. This will be either point $\beta$, in which case it sets $t_A = \hat{t}_A(\underline{t}_B)$, wins the MNE, and earns revenues $\hat{t}_A(\underline{t}_B) \cdot \left(\pi_1^A + \pi_m^A\right)$; or point $\alpha$, in which case government A sets $t_A = 1$, loses the auction for the MNE, and earns revenues $\pi_1^B$ from its indigenous firm. Therefore, in equilibrium, country A wins the auction for the MNE iff $\hat{t}_A(\underline{t}_B) \cdot \left(\pi_1^A + \pi_m^A\right) > \pi_1^B$; that can be re-written as $\hat{t}_A(\underline{t}_B) > \frac{\pi_1^B}{\left(\pi_1^A + \pi_m^A\right)} = \underline{t}_A$.

[14] In Appendix 3.5 we consider the special case where governments set their tax rates simultaneously and we look for the mixed strategy equilibrium.

Suppose that we now reverse the order in which the two governments set their tax rates, such that the government of developing country B moves first (stage 1a), and on observing government B's tax rate, government A sets its own tax rate (stage 1b). Then we get the following result:

**Lemma 3.3.** *If government B sets its tax rate first, the MNE locates its plant in developing country B iff* $\hat{t}_B(\underline{t}_A) > \underline{t}_B$, *but otherwise it locates its plant in developed country A.*

In this case, government B chooses its most preferred point on government A's tax reaction function, $t_A^*(t_B)$. This is either point $\eta$, in which case it sets $t_B = 1$, loses the MNE and earns revenues $\pi_2^A$; or point $\rho$, in which case it sets $t_B = \hat{t}_B(\underline{t}_A)$, hosts the MNE and earns revenues $\hat{t}_B(\underline{t}_A) \cdot \left(\pi_2^B + \pi_m^B\right)$. Thus, in equilibrium, country B only hosts the MNE iff $\hat{t}_B(\underline{t}_A) \cdot \left(\pi_2^B + \pi_m^B\right) > \pi_2^A$, i.e. $\hat{t}_B(\underline{t}_A) > \frac{\pi_2^A}{\left(\pi_2^B + \pi_m^B\right)} = \underline{t}_B$. This is analogous to the case where government A leads.

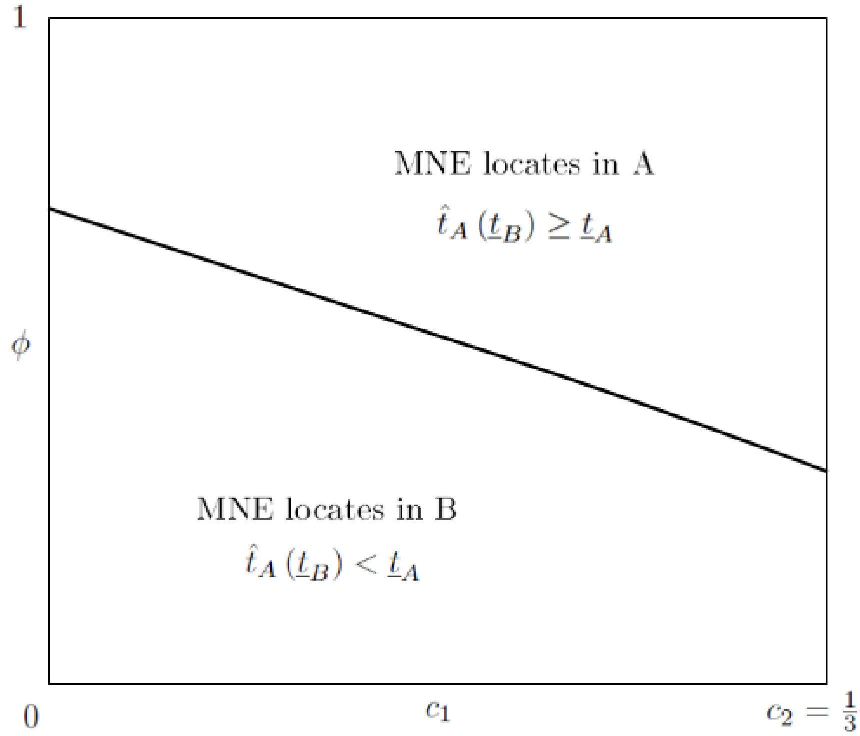
Note that Figure 3.1 is drawn for the case where $\underline{t}_A > \frac{\pi_m^A - \pi_m^B}{\pi_m^A}$ such that government A's tax reaction function is discontinuous. It is possible that $\underline{t}_A \leq \frac{\pi_m^A - \pi_m^B}{\pi_m^A}$ such that $t_A^*(t_B)$ is continuous. In this case, government B never wins the MNE because it will be marginally undercut by government A for all $t_B \in [0, 1]$. Thus, in equilibrium, government B sets $t_B = 1$ and earns $\pi_2^A$ from its indigenous firm, and government A wins the MNE.

On the basis of Lemmas 3.2 and 3.3, and recalling from equation (3.3) that whenever $\hat{t}_A(\underline{t}_B) > \underline{t}_A$ it must be the case that $\hat{t}_B(\underline{t}_A) < \underline{t}_B$, we can make the following proposition:

**Proposition 3.4.** *In a sequential tax setting, irrespective of which government sets its tax rate first, the MNE locates its plant in developed country A if* $\hat{t}_A\left(\underline{t}_B\right) \geq \underline{t}_A$, *or equivalently if* $\hat{t}_B(\underline{t}_A) < \underline{t}_B$, *but otherwise locates its plant in developing country B.*

We illustrate the equilibrium location decision of the MNE in Figure 3.2. It shows that for a given technology gap between the two countries (as measured by $c_1$), the

Figure 3.2: MNE's Location Decision without Tax Havens




MNE locates in developed country A when the potential for knowledge spillovers, $\phi$, is sufficiently high. There are two effects driving this result. As $\phi$ increases, the incentive of the MNE to locate in country A increases (see equation [3.2]), such that government A can win the auction for the MNE with a higher tax rate. At the same time, as $\phi$ increases, governments are willing to bid more aggressively to host the MNE because it would have the effect of increasing their indigenous firms' profits, and hence their tax revenues.

The MNE's location is determined by how these two effects impact the equilibrium location condition, $\hat{t}_A(\underline{t}_B) \geq \underline{t}_A$. The incentive to bid more aggressively reduces both $\underline{t}_A$ and $\underline{t}_B$. Thus, the impact on the right-hand side of the equilibrium location condition is negative. But the negative impact on the left-hand side (that works through $\underline{t}_B$) has to be offset against the positive impact that stems from the MNE's increased willingness to locate in developed country A (that works through the term

$\frac{\pi_m^A - \pi_m^B}{\pi_m^A}$).[15] Except in cases where the technology gap between the two countries is extremely small, the latter dominates such that an increase in $\phi$ increases $\hat{t}_A\left(\underline{t}_B\right)$ and decreases $\underline{t}_A$.[16] Thus, in equilibrium, the MNE locates in developed country A for sufficiently high values of $\phi$. And because $\phi$ enters the firms' profit functions as a multiplicative of $c_i$, this effect is stronger for higher values of $c_1$.

While the equilibrium location of the plant (as determined by parameters $\phi$ and $c_1$) is independent of the order of play, the tax revenues earned by the two governments are not. This leads us to the next proposition.

**Proposition 3.5.** *The revenues earned by the government that loses the auction for the MNE's plant are independent of the order in which the two governments set their tax rates; but the host government benefits if it sets the tax rate after observing the tax rate chosen by its competitor.*

To see this, we summarise the tax revenues for government A, $R_A$, and government B, $R_B$, for the two alternative orderings in the tax setting stage of the game. If government A leads these are:

$$R_A = \begin{cases} \hat{t}_A(\underline{t}_B) \cdot \left(\pi_1^A + \pi_m^A\right) & \text{if } \hat{t}_A(\underline{t}_B) \geq \underline{t}_A \\ \pi_1^B & \text{if } \hat{t}_A(\underline{t}_B) < \underline{t}_A \end{cases}$$

$$R_B = \begin{cases} \pi_2^A & \text{if } \hat{t}_A(\underline{t}_B) \geq \underline{t}_A \\ \hat{t}_B(t_A = 1) \cdot \left(\pi_2^B + \pi_m^B\right) & \text{if } \hat{t}_A(\underline{t}_B) < \underline{t}_A \end{cases} \tag{3.5}$$

These follow from the discussion of Lemmas 3.2 and 3.3. If government A leads and $\hat{t}_A(\underline{t}_B) \geq \underline{t}_A$, in stage 1a it anticipates that government B is willing to bid all the way to $\underline{t}_B$, and thus sets $t_A = \hat{t}_A(\underline{t}_B)$ such that it wins the MNE and earns revenues

[15]The term $\frac{\pi_m^A - \pi_m^B}{\pi_m^A}$ is the first term on the right-hand side of equation (3.3): $\hat{t}_A\left(\underline{t}_B\right) = \frac{\pi_m^A - \pi_m^B}{\pi_m^A} + t_B\left(\frac{\pi_m^B}{\pi_m^A}\right)$.

[16]The positive effect dominates only for very low values of $\phi$ such that it has no impact on the equilibrium location of the MNE (i.e. the MNE would have located in country B anyway).

$\hat{t}_A(\underline{t}_B) \cdot \left(\pi_1^A + \pi_m^A\right)$. If instead $\hat{t}_A(\underline{t}_B) < \underline{t}_A$, government A sets $t_A = 1$ such that it loses the MNE and earns revenues $\pi_1^B$ from the indigenous firm.

Similarly, if government A leads and $\hat{t}_A(\underline{t}_B) \geq \underline{t}_A$, government B sets $t_B = 1$ and earns revenues $\pi_2^A$ from its indigenous firm. But if $\hat{t}_A(\underline{t}_B) < \underline{t}_A$, then in stage 1b government B can undercut A's tax rate and win the MNE by setting $t_B = \hat{t}_B(t_A = 1)$ rather than $t_B = \hat{t}_B(\underline{t}_A)$. Noting from equation (3.3) that $\hat{t}_B(t_A = 1) = 1$, it follows that government B sets $t_B = 1$ (less some marginal amount), hosts the MNE and earns revenues $\pi_2^B + \pi_m^B$.

On the other hand, if government B leads in the tax-setting stage of the game, the two governments' revenues are:

$$R_A = \begin{cases} \hat{t}_A\left(t_B = 1\right) \cdot \left(\pi_1^A + \pi_m^A\right) & \text{if } \hat{t}_A(\underline{t}_B) \geq \underline{t}_A \\ \pi_1^B & \text{if } \hat{t}_A(\underline{t}_B) < \underline{t}_A \end{cases}$$

$$R_B = \begin{cases} \pi_2^A & \text{if } \hat{t}_A(\underline{t}_B) \geq \underline{t}_A \\ \hat{t}_B(\underline{t}_A) \cdot \left(\pi_2^B + \pi_m^B\right) & \text{if } \hat{t}_A(\underline{t}_B) < \underline{t}_A \end{cases} \qquad (3.6)$$

These are analogous to the case where government A leads. The interpretation is similar and will not be repeated here.

We make two observations about these outcomes. First, governments' revenues are by definition higher if they host the MNE: government A only deviates from $t_A = 1$ if $t_A \cdot \left(\pi_1^A + \pi_m^A\right) \geq \pi_1^B$, and government B only deviates from $t_B = 1$ if $t_B \cdot \left(\pi_2^B + \pi_m^B\right) \geq \pi_2^A$. Second, if a government hosts the MNE, its revenues are higher if it "follows" in the tax-setting stage of the game. If $\hat{t}_A(\underline{t}_B) \geq \underline{t}_A$, such that in equilibrium the MNE locates in country A, government A's revenues are $\hat{t}_A(\underline{t}_B) \cdot \left(\pi_1^A + \pi_m^A\right)$ if it 'leads' and $\pi_1^A + \pi_m^A$ if it 'follows'. Thus, for all $\hat{t}_A(\underline{t}_B) < 1$, government A's revenues are higher if it sets its tax rate after observing government B's tax rate. A similar reasoning applies for government B.

## 3.3 Model with tax haven(s)

In this section, we build on the baseline model described in Section 3.2 to analyse how the equilibrium outcome changes when the MNE can shift a share of its profits, $\delta$, to a tax haven that charges a zero tax rate.[17] Benefiting from the tax haven's advantageous tax regime requires that the MNE sets up an affiliate in the tax haven that involves a fixed cost, $f$ (as in Krautheim and Schmidt-Eisenlohr, 2011). We assume that the maximum share of profits that the MNE is able to shift to the tax haven, $\delta^*$, is determined exogenously, depending on regulations imposed by a supranational authority.[18] We also assume that this is sufficiently large to ensure that the MNE shifts a share of its profits to the tax haven irrespective of its location decision.[19]

The order of moves of the game is the same as in the case without tax havens; but in stage 3 the MNE also decides on the share of profits to shift to the tax haven. The MNE's total net-of-tax profits are:

$$\Pi_m^i = (1 - T_i)(1 - \delta)\,\pi_m^i + \delta \cdot \pi_m^i - f \tag{3.7}$$

where $\pi_m^i$ are the MNE's pre-tax profits and $T_i$ is the tax rate set by host government $i \in \{A, B\}$ in the presence of the tax haven. The MNE's pre-tax profits, $\pi_m^i$ , remain unchanged from the case without tax havens, such that the conclusions drawn from equations (3.1) and (3.2) also apply if the MNE shifts a share of its profits to the tax haven. And since the cost of profit shifting is fixed, in equilibrium, the MNE shifts as much of its profits as possible to the tax haven, i.e. $\delta^* \pi_m^i$.

In stage 2, the MNE locates its plant in country A iff $\Pi_m^A > \Pi_m^B$. Thus, we can solve

[17] The tax haven country is assumed to play a passive role (i.e. its government makes no strategic choices), and that its tax rate is equal to zero. See Dharmapala and Hines (2009) for a discussion on (zero) tax rates charged by havens countries.

[18] For a discussion on an effectively similar assumption see Langenmayr (2015).

[19] This requires that $\delta^* > f/T_i \cdot \pi_m^i$, where $T_i$ is the tax rate set by host government $i \in \{A, B\}$ in the presence of the tax haven. This restriction rules out cases where profit shifting by the MNE is profitable if it locates in one country but not if it locates in the other.

for a tax rate, $\hat{T}_i$, that equates $\Pi_m^A$ and $\Pi_m^B$ such that it leaves the MNE indifferent between locating its plant in A or B:

$$\hat{T}_i = \frac{1}{1-\delta^*}\left(\frac{\pi_m^i - \pi_m^j}{\pi_m^i}\right) + T_j\left(\frac{\pi_m^j}{\pi_m^i}\right) \tag{3.8}$$

Recalling that $\frac{\pi_m^A - \pi_m^B}{\pi_m^A} > 0$, it is straightforward to see from the first term on the right-hand side of equation (3.8) that for any $\delta^* > 0$ the tax rate charged by government A that would leave the MNE indifferent between locating in A or B is higher than that in the case without the tax haven. As $\delta^* \to 1$, $\hat{T}_A$ increases because less of the MNE's profits are taxed at source and more are (un)taxed in the tax haven. For the exact same reason, the opposite is true for government B. Since $\frac{\pi_m^B - \pi_m^A}{\pi_m^B} < 0$, as $\delta^* \to 1$, $\hat{T}_B$ falls, *ceteris paribus*. Therefore, an increase in $\delta^*$ requires a bigger "tax-cut" by the government of developing country B to make up for the technology disadvantage it has in comparison to country A.

The tax rates that determine the MNE's equilibrium location decision are set by the two governments in stage 1. Note, however, that profit shifting also affects the minimum tax rates that the two governments are willing to charge in their bid to attract the MNE. These are:[20]

$$\begin{aligned} \underline{T}_A &= \frac{\pi_1^B}{\pi_1^A + (1-\delta^*)\,\pi_m^A} \qquad \text{for government A} \\ \underline{T}_B &= \frac{\pi_2^A}{\pi_2^B + (1-\delta^*)\,\pi_m^B} \qquad \text{for government B} \end{aligned} \tag{3.9}$$

Note that $d\underline{T}_i/d\delta^* > 0$, reflecting governments' reduced willingness to lower their tax rates because hosting an MNE that shifts profits yields less revenues than one that does not. However, the maximum tax rate that can be charged by government

[20] Government A only deviates from $T_A = 1$ if $T_A\left(\pi_1^A + (1-\delta^*)\,\pi_m^A\right) > \pi_1^B$. It follows that the minimum tax rate that it is willing to set in its bid to host the MNE is $\underline{T}_A = \pi_1^B / \pi_1^A + (1-\delta^*)\pi_m^A$. $\underline{T}_B$ is derived in a similar manner.

$i$ remains unchanged from the case without tax havens, i.e. $T_i = 1$.[21] Putting everything together, the tax range within which the two governments compete to host the MNE is $T_i \in [\underline{T}_i, 1]$.

As in the case without tax havens, and for the exact same reasons, the simultaneous tax setting game has no equilibrium in pure strategies. Solving for the case where the governments set their tax rates sequentially, we note that in equilibrium the MNE locates its plant in developing country B iff $\Pi_m^B > \Pi_m^A$, or equivalently, $\hat{T}_B(\underline{T}_A) > \underline{T}_B$.[22] Otherwise it locates in developed country A. On the basis of this equilibrium location condition, we can make the following proposition:

**Proposition 3.6.** *Profit shifting decreases the area in the $(\phi, c_1)$ parameter space where in equilibrium the developing country B hosts the MNE's plant.*

*Proof.* The MNE locates in country B iff $\hat{T}_B(\underline{T}_A) > \underline{T}_B$. Since $d\underline{T}_B/d\delta^* > 0$ and $d\hat{T}_B(\underline{T}_A)/d\delta^* < 0$ for all relevant $\phi$, it follows that an increase in $\delta^*$ decreases the area in the parameter space where developing country B hosts the MNE. □

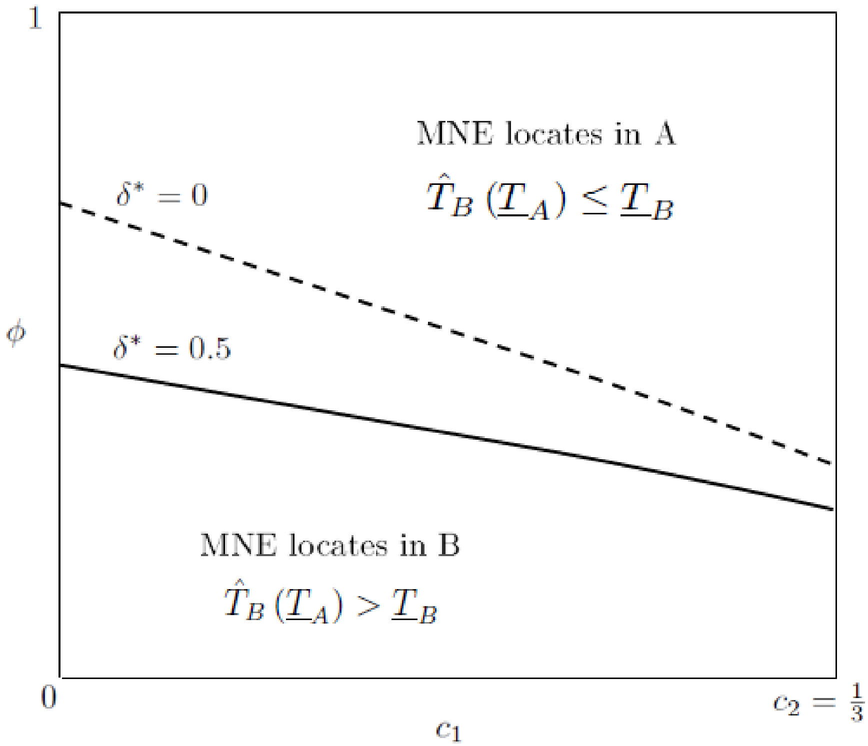
This effect of profit shifting on the MNE's equilibrium location decision is captured in Figure 3.3. It shows how profit shifting reduces the area in the $(\phi, c_1)$ parameter space where developing country B hosts the MNE. Two factors drive this result. First, by making the tax rate differential between the two countries less important, profit shifting requires a bigger 'tax-cut' by the government of developing country B to make up for its inherent technology disadvantage in its bid to host the MNE. Second, the minimum tax rate that government $i$ is willing to charge in its bid to host the MNE is increasing in $\delta^*$, $d\underline{T}_i/d\delta^* > 0$. This happens because an MNE that has profit shifting opportunities yields less tax revenues than one that does not.

The location of the MNE's plant is determined by how these two factors affect the equilibrium location condition, $\hat{T}_B(\underline{T}_A) > \underline{T}_B$; where $\hat{T}_B(\underline{T}_A) = \frac{1}{1-\delta^*}\left[\frac{\pi_m^B - \pi_m^A}{\pi_m^B}\right] +$

[21] To see why the top tax rate within the range is $T_i = 1$, note that for the MNE to make a profit it must be the case that $(1 - T_i)(1 - \delta^*)\pi_m^i + \delta^* \pi_m^i - f > 0$. Thus, the maximum tax rate is $\min\left[\frac{1}{1-\delta^*}\left(\frac{\pi_m^i - f}{\pi_m^i}\right), 1\right]$. For $\frac{1}{1-\delta^*}\left(\frac{\pi_m^i - f}{\pi_m^i}\right)$ to be less than 1, it must be the case that $\delta^* < \frac{f}{\pi_m^i}$, which cannot be since we assume that $\delta^* > \frac{f}{T\pi_{im}^i}$.

[22] Note that this equilibrium location condition is equivalent to $\hat{T}_A(\underline{T}_B) < \underline{T}_A$.

Figure 3.3: MNE's Location Decision with Tax Havens




$\underline{T}_A \left[\frac{\pi_m^A}{\pi_m^B}\right]$. From the discussion above, it follows that the impact on $\underline{T}_B$ is positive, but the impact on $\hat{T}_B(\underline{T}_A)$ may be positive or negative. The positive effect works indirectly through $\underline{T}_A$, while the negative effect works through the term $\frac{\pi_m^B - \pi_m^A}{\pi_m^B}$. It turns out that the positive effect dominates only for very low values of $\phi$ such that it has no impact on the equilibrium location of the MNE (i.e. the MNE would have located in country B anyway). On the other hand, at higher values of $\phi$, an increase in $\delta^*$ makes it less likely that the MNE locates in developing country B because the negative effect dominates such that it decreases $\hat{T}_B(\underline{T}_A)$ and increases $\underline{T}_B$. We illustrate this case with a numerical simulation presented in Table 3.1. For given values of $\phi$ and $c_1$, it shows how an increase in $\delta^*$ affects $\hat{T}_B(\underline{T}_A)$ and $\underline{T}_B$. Note that as $\delta^*$ increases, $\hat{T}_B(\underline{T}_A)$ decreases and $\underline{T}_B$ increases, such that for $\delta^* \leq \frac{1}{5}$, $\hat{T}_B(\underline{T}_A) > \underline{T}_B$ and the MNE locates in country B, while for $\delta^* > \frac{1}{5}$, $\hat{T}_B(\underline{T}_A) \leq \underline{T}_B$ and the MNE locates in country A.[23]

Any change in the "permissible" extent of profit shifting, $\delta^*$, also impacts govern-

[23]The figures in Table 3.1 are rounded, and should be interpreted with caution.

Table 3.1: Equilibrium effects of profit shifting ($c_1 = 1/5; \phi = 1/2$)

| $\delta^*$ | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Eq. location | B | B | B | A | A | A | A | A | A | A |
| $\hat{T}_B\,(\underline{T}_A)$ | 0.013 | 0.010 | 0.005 | -0.002 | -0.013 | -0.031 | -0.063 | -0.123 | -0.261 | -0.722 |
| $\underline{T}_B$ | 0.004 | 0.005 | 0.005 | 0.006 | 0.006 | 0.007 | 0.008 | 0.010 | 0.012 | 0.015 |

ments' revenues. To see this, we summarise the tax revenues earned by the two governments for the two alternative orderings in the tax-setting stage of the game. If the government of country A sets its tax rate first, the two governments' revenues are:

$$R_A = \begin{cases} \hat{T}_A(\underline{T}_B) \cdot \left(\pi_1^A + (1-\delta^*)\,\pi_m^A\right) & \text{if } \hat{T}_B(\underline{T}_A) \leq \underline{T}_B \\ \pi_1^B & \text{if } \hat{T}_B(\underline{T}_A) > \underline{T}_B \end{cases}$$

$$R_B = \begin{cases} \pi_2^A & \text{if } \hat{T}_B(\underline{T}_A) \leq \underline{T}_B \\ \hat{T}_B(T_A = 1) \cdot \left(\pi_2^B + (1-\delta^*)\,\pi_m^B\right) & \text{if } \hat{T}_B(\underline{T}_A) > \underline{T}_B \end{cases} \tag{3.10}$$

Note that similar to the case without a tax haven, if $\hat{T}_B(\underline{T}_A) \leq \underline{T}_B$, government A sets $\hat{T}_A(\underline{T}_B)$ and wins the MNE, while government B sets $T_B = 1$ and earns revenues $\pi_2^A$ from its indigenous firm. On the other hand, if $\hat{T}_B(\underline{T}_A) > \underline{T}_B$, government A sets $T_A = 1$, loses the MNE, and earns revenues $\pi_1^B$ from its indigenous firm; while government B sets $\hat{T}_B(T_A = 1)$ and hosts the MNE.[24]

[24] Unlike the case without tax havens, where $\hat{t}_B(t_A = 1) = 1$, in the case with the tax haven $\hat{T}_B(T_A = 1) < 1$ for all $\delta^* > 0$.

If, instead, government B sets its tax rate first, the two governments' revenues are:

$$R_A = \begin{cases} \pi_1^A + (1-\delta^*)\,\pi_m^A & \text{if } \hat{T}_B(\underline{T}_A) \leq \underline{T}_B \\ \pi_1^B & \text{if } \hat{T}_B(\underline{T}_A) > \underline{T}_B \end{cases}$$

$$R_B = \begin{cases} \pi_2^A & \text{if } \hat{T}_B(\underline{T}_A) \leq \underline{T}_B \\ \hat{T}_B(\underline{T}_A) \cdot \left(\pi_2^B + (1-\delta^*)\,\pi_m^B\right) & \text{if } \hat{T}_B(\underline{T}_A) > \underline{T}_B \end{cases} \tag{3.11}$$

Note that if $\hat{T}_B(\underline{T}_A) \leq \underline{T}_B$ government B sets $T_B = 1$, loses the MNE, and earns revenues $\pi_2^A$ from its indigenous firm; while government A sets $T_A\,(T_B = 1) = 1$ and hosts the MNE. On the other hand, if $\hat{T}_B(\underline{T}_A) > \underline{T}_B$, government B sets $\hat{T}_B(\underline{T}_A)$ and wins the MNE, while government A sets $T_A = 1$ and earns revenues $\pi_1^B$. On the basis of these observations, we can make the following propositions:

**Proposition 3.7.** *Irrespective of which government sets its tax rate first, an increase in $\delta^*$ that changes the location of the MNE's plant increases the winning government's tax revenues and reduces those of the losing government.*

*Proof.* (i) Case where government A leads: if $\hat{T}_B\,(\underline{T}_A) \leq \underline{T}_B$, government A sets $T_A = \hat{T}_A(\underline{T}_B)$, hosts the MNE and earns revenues $\hat{T}_A(\underline{T}_B) \cdot \left(\pi_1^A + (1-\delta^*)\,\pi_m^A\right)$. Government A deviates from $T_A = 1$ iff $\hat{T}_A(\underline{T}_B) \cdot \left(\pi_1^A + (1-\delta^*)\,\pi_m^A\right) > \pi_1^B$. (ii) Case where government B leads: if $\hat{T}_B\,(\underline{T}_A) > \underline{T}_B$, government B sets $T_B = \hat{T}_B(\underline{T}_A)$, hosts the MNE and earns revenues $\hat{T}_B(\underline{T}_A) \cdot \left(\pi_2^B + (1-\delta^*)\,\pi_m^B\right)$. Government B deviates from $T_B = 1$ iff $\hat{T}_B(\underline{T}_A) \cdot \left(\pi_2^B + (1-\delta^*)\,\pi_m^B\right) > \pi_2^A$. □

Consider the case where government A sets its tax rate first. If $\hat{T}_B(\underline{T}_A) \leq \underline{T}_B$, country A wins the MNE by setting $\hat{T}_A(\underline{T}_B)$. Since government A only deviates from $T_A = 1$ if $\hat{T}_A(\underline{T}_B) \cdot \left(\pi_1^A + (1-\delta^*)\,\pi_m^A\right) > \pi_1^B$ (see equation [3.9]), it follows that winning the MNE increases government A's revenues, and losing it decreases them. Turning to government B's perspective, we note that it only deviates from $T_B = 1$

if $\hat{T}_B(\underline{T}_A) \cdot \left(\pi_2^B + (1-\delta^*)\,\pi_m^B\right) > \pi_2^A$. It follows that ann increase in $\delta^*$ that leads to country B losing the MNE reduces its government's revenues and vice versa.

A similar argument applies if government B sets its tax rate first (see equation [3.11]). A change in $\delta^*$ that leads to relocation of the MNE's plant increases the winning government's tax revenues and reduces those of the losing government. The only difference to the case where government A moves first is that government A's equilibrium tax rate is $T_A = 1$ irrespective of whether it wins or loses the MNE's plant.[25] It follows that hosting the MNE increases government A's revenues because it applies the same tax rate to a larger tax base, and vice versa.

**Proposition 3.8.** *Equilibrium effects of an increase in $\delta^*$ that does not lead to a change in location of the MNE's plant. (i) $R_B$ decreases if government B hosts but does not change if doesn't host. (ii) $R_A$ increases (decreases) if government A leads (follows) and hosts the MNE but remains unchanged if it does not host.*

To understand Proposition 3.8, note from equations (3.10) and (3.11) that an increase in $\delta^*$ lowers the share of profits reported in the host country. We refer to this as the 'base effect' of profit shifting and it has a negative impact on the host government's tax revenues ($R_i$). Depending on how $\delta^*$ affects the tax rate applied to the lower tax base, the tax revenues of the host government may increase or decrease.

Starting with the case where country B hosts the MNE, note that government B sets $T_B = \hat{T}_B(\underline{T}_A)$ if it leads and $T_B = \hat{T}_B(T_A = 1)$ if it follows. Using equations (3.8) and (3.9), it is easy to see that $d\hat{T}_B(\underline{T}_A)/d\delta^* < 0$ and $d\hat{T}_B(T_A{=}1)/d\delta^* < 0$.[26] Since a lower tax rate is applied to a lower tax base, it follows that a change in $\delta^*$ that does not lead to a change in location reduces the revenues of host government B.

Turning to the case where country A hosts the MNE, note that government A sets $T_A = \hat{T}_A(\underline{T}_B)$ if it leads and $T_A = 1$ if it follows. Since an increase in $\delta^*$ reduces the

[25] If $\hat{T}_B(\underline{T}_A) \leq \underline{T}_B$, country A wins the MNE by setting $\hat{T}_A(T_B = 1) = 1$.

[26] This happens because of the declining importance – from the perspective of the MNE – of the tax rate difference between the two potential host countries as $\delta^*$ increases. Note that in cases where $\phi$ is very low such that $\hat{T}_B\left(\underline{T}_A\right)$ is increasing in $\delta^*$, the positive effect of the increase in the government B's equilibrium tax rate is more than offset by the negative impact resulting from the reduction in the tax base. Consequently, the impact of an increase in $\delta^*$ on its revenues is also negative.

host country's tax base, it follows that ${dR_A}/{d\delta^*} < 0$ in the case where government A follows because an unchanged tax rate, $T_A = 1$, is applied to a smaller tax base. In contrast, using equations (3.8) and (3.9), we note that in the case where government A leads ${d\hat{T}_A(\underline{T}_B)}/{d\delta^*} > 0$, i.e. by reducing the MNE's sensitivity to the tax rate difference between the two countries, government A can increase its tax rate and remain an attractive location for the plant. Since the higher tax rate also applies to the indigenous firm's profits (which unlike the MNE's are immobile), we get ${dR_A}/{d\delta^*} > 0$.

Finally, note from equations (3.10) and (3.11) that the effect of $\delta^*$ on the losing government's revenues is independent of $\delta^*$. Hence, a change in $\delta^*$ that does not lead to relocation has no effect on the losing government's revenues. This is part (iii) of Proposition 3.8.

## 3.4 Conclusion

This chapter studies the effect of tax havens on less developed countries in a sequential tax-setting model. We draw two major conclusions. The first is that the opportunity to shift profits to tax havens works against developing countries that are in competition with developed countries to host MNEs' plants. This happens because profit shifting reduces the importance of tax rate differences between developed and developing countries in the eyes of MNEs. Consequently, it makes it harder for developing countries to make up for their inherent (technological) disadvantages by offering favourable tax rates to MNEs.

Second, in cases where less developed countries do host MNEs' plants, profit shifting opportunities have the effect of reducing their governments' revenues; not only because of the tax-base-reducing effect of profit shifting, but more interestingly because it also requires that developing countries' governments reduce their tax rates to remain attractive locations for MNEs' plants. These two conclusions hold irrespective of the order of moves in the tax setting stage of the game; and suggest that less developed countries would be the bigger beneficiaries of coordinated multilateral action to limit profit shifting to tax havens.

It follows that profit shifting opportunities favour more developed countries in their bid host MNEs' plants. However, the impact of profit shifting on the tax revenues of developed countries may be either positive or negative, depending on the order of moves of the game. If the developed country's government 'follows' in the tax-setting stage of the game, the tax rate set by the developed country's government is unaffected by profit shifting; but its tax revenues fall because the unchanged tax rate is applied to a smaller tax base. On the other hand, if the government of the developed country 'leads' in the tax setting stage of the game, profit shifting increases its revenues because the negative impact of the shrinking tax base is more than made up for by a higher tax rate.

The latter result is similar to that reported in Hong and Smart (2010) who argue that tax havens could be beneficial to host countries because it allows them to set "high" tax rates on the profits of domestic (immobile) firms without driving away (mobile) MNEs. However, the conclusions drawn from our model suggest that the reasoning of Hong and Smart does not apply when it is developing countries that host the MNE. Rather, we show that tax havens put downward pressure on the developing country's tax rate. This is closer to the arguments put forward by Slemrod and Wilson (2009) who argue the tax havens "worsen" tax competition. Thus, by allowing for asymmetry between countries, we are able to distinguish between cases where tax havens have a positive impact and cases where they have a negative impact.

In deriving these results, we assume that governments cannot tax discriminate between indigenous (immobile) firms and the (mobile) MNE. In practice, this may be justified by ongoing efforts by the OECD to eliminate harmful, discriminatory tax practices. But it also allows us to capture the "benefit" that developed countries might derive from profit shifting because it allows them to set a high tax rate on the profits of indigenous firms while still remaining an attractive location for the MNE (as argued in Hong and Smart [2010]). Because governments cannot tax discriminate, the game has no equilibrium in pure strategies.[27]

We thus assume that governments set their tax rates sequentially, and this may require some justification for the selected order of moves. A case may be made on the basis of institutional constraints on governments' ability to adjust tax rates quickly in response to changes in other governments' tax rates. There is, in fact, some empirical evidence suggesting sequential tax choices following the 1986 US tax reform between the US and European countries, with the USA acting as a Stackelberg leader and European countries acting as followers vis-a-vis the USA and simultaneously vis-a-vis each other (see Altshuler and Goodspeed, 2015). In addition, we find that the main conclusions drawn from our model hold irrespective of the selected order of moves in the tax setting stage of the game.

Finally, we note that the asymmetric impact that profit shifting may have on developed and developing countries has received little attention in the theoretical literature. There are thus several ways of extending this research. For example, one may explore how the outcomes derived from our model(s) might change if governments were benevolent, with particular to attention to differences that may exist in the marginal cost of public funds in developed and developing countries. Another possibility is to consider how tax havens would affect tax revenues and plant location choices if there were multiple developed and (multiple) developing countries competing to host the MNE. We leave these to future research.

## 3.5 Appendix

Recall from Proposition 3.1, that if governments set their tax rates simultaneously, then this game has no equilibrium in pure strategies. So instead, in this appendix, we look for the mixed strategy equilibrium (as in Wilson [2005], Konrad [2008], Davies and Eckel [2010], Marceau et al. [2010], and Elsayyad and Konrad [2012]).

[27] Note from Section 3.2.1 that an equilibrium in pure strategies exists if governments can tax discriminate between the MNE and the indigenous firms.

We do this for the case without tax havens, and we show why asymmetry between the two countries is problematic for the derivation of a mixed strategy equilibrium.

We assume that each government's strategy consists of a cumulative distribution function over tax rates that it may levy, and that in equilibrium, it is indifferent between pure strategies that receive a positive weight in the distribution. Therefore, government A's mixing (cumulative) density function must make government B indifferent between all $t_B \in [\underline{t}_B, 1]$, and vice versa. Consequently, governments would no longer face an incentive to undercut each other in *effective* tax rates because there would be no single effective tax rate set by the other government. Rather there is an equilibrium probability distribution of rates such that if a government lowers its tax rate, it merely increases the probability that its effective tax rate will lie below $\hat{t}_i(t_j)$, thereby increasing the probability that it will host the MNE's plant.

In this case, Government A's and B's expected revenues are:

$$E\left[R_A\right] = Pr\left\{\text{A wins MNE}\right\} \cdot t_A\left(\pi_1^A + \pi_m^A\right) + \left(1 - Pr\left\{\text{A wins MNE}\right\}\right) \cdot t_A\left(\pi_1^B\right)$$

$$= t_A\left[\pi_1^B + Pr\left\{\text{A wins MNE}\right\} \cdot \left(\pi_1^A - \pi_1^B + \pi_m^A\right)\right] \tag{3.12}$$

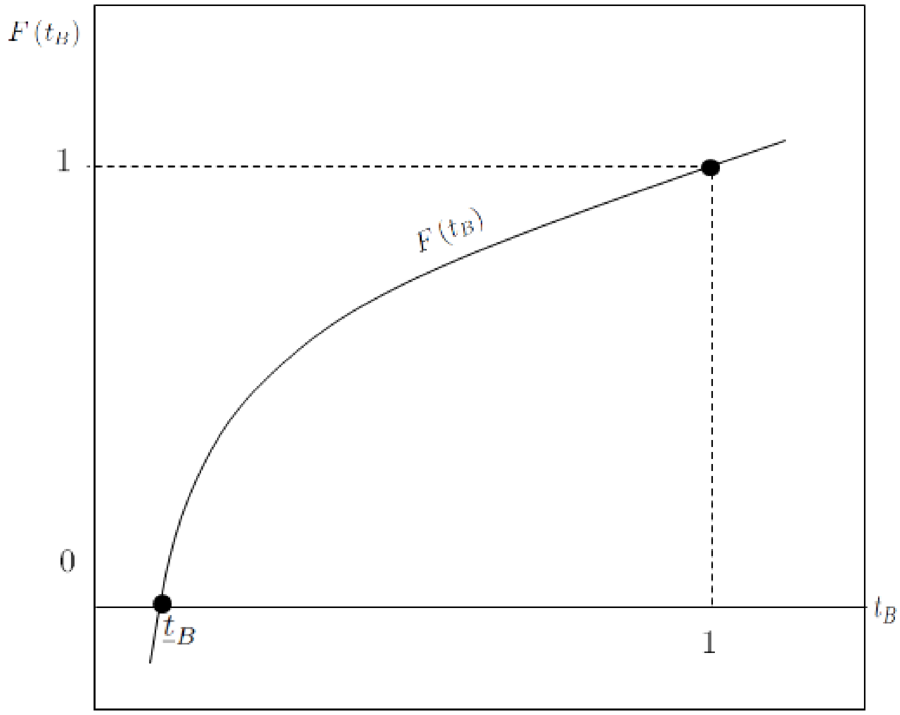
$$E\left[R_B\right] = Pr\left\{\text{B wins MNE}\right\} \cdot t_B\left(\pi_2^B + \pi_m^B\right) + \left(1 - Pr\left\{\text{B wins MNE}\right\}\right) \cdot t_B\left(\pi_2^A\right)$$

$$= t_B\left[\pi_2^A + Pr\left\{\text{B wins MNE}\right\} \cdot \left(\pi_2^B - \pi_2^A + \pi_m^B\right)\right] \tag{3.13}$$

Since government $i$'s expected revenue must be constant over all $t_i \in [\underline{t}_i, 1]$, an increase in $t_i$ must be offset by a decline in the probability that country $i$ wins the MNE. From Figure 3.1, it is easy to see that a problem arises when point $(\underline{t}_B, \underline{t}_A)$ lies off the MNE's indifference condition. In such case, we have government B choosing on $t_B \in [\underline{t}_B, 1]$, such that for all $t_A \in [\underline{t}_A, z]$, the probability that government A wins the MNE does not fall as $t_A$ increases.

A possible solution is to consider the case of symmetric countries. Then the MNE's

Figure 3.4: Cumulative density function, $F(t_B)$




indifference condition lies on the 45-degree line and $\underline{t}_B = \underline{t}_A$. Thus, it follows that point $(\underline{t}_B, \underline{t}_A)$ would lie on the MNE's indifference condition. For illustrative purposes we solve for the mixed strategies Nash equilibrium with symmetric countries.

With $t_B = 1$, $Pr\{\text{B wins MNE}\} = 0$. In this case, government B gets revenue $\pi_2^A$. Therefore, government B must earn $\pi_2^A$ for all $t_B$ that it mixes over. Let $F(t_B) = Pr\{t_A < t_B\} = Pr\{\text{A wins MNE}\}$. Note that because countries are symmetric, this is equal to government A's cumulative density function. Therefore, $F(t_B)$ must satisfy:

$$t_B \left[\pi_2^A + (1 - F(t_B)) \left(\pi_2^B - \pi_2^A + \pi_m^B\right)\right] = \pi_2^A \tag{3.14}$$

for all $t_B \in [\underline{t}, 1]$, where $\underline{t} = \underline{t}_A = \underline{t}_B$.

At $t_B = \underline{t}$, $F(\underline{t}) = 0$, i.e. $Pr\{\text{A wins MNE}\} = 0$. Then from equation (3.14) we get $\underline{t}\left(\pi_2^B + \pi_m^B\right) = \pi_2^A$; which is consistent with the definition of $\underline{t}_B = \pi_2^A / \left(\pi_2^B + \pi_m^B\right)$. Therefore, government B's expected tax revenue is equal at its supports $t_B = \underline{t}, 1$.

Using (3.14) to solve for $F(t_B)$:

$$F\left(t_B\right) = 1 - \frac{\pi_2^A\left(1 - t_B\right)}{t_B\left(\pi_2^B - \pi_2^A + \pi_m^B\right)} \\ = \frac{\pi_2^B + \pi_m^B}{\pi_2^B - \pi_2^A + \pi_m^B} - \frac{\pi_2^A}{t_B\left(\pi_2^B - \pi_2^A + \pi_m^B\right)} \tag{3.15}$$

This is presented in Figure 3.4. Note that at $t_B = 1$, $F(1) = 1$, and $F\left(t_B\right) = 0$ at $t_B = \frac{\pi_2^A}{\pi_2^B + \pi_m^B} = \underline{t}_B$.

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# Chapter 4

# International R&D Collaboration, R&D Subsidies and Trade Costs[1]

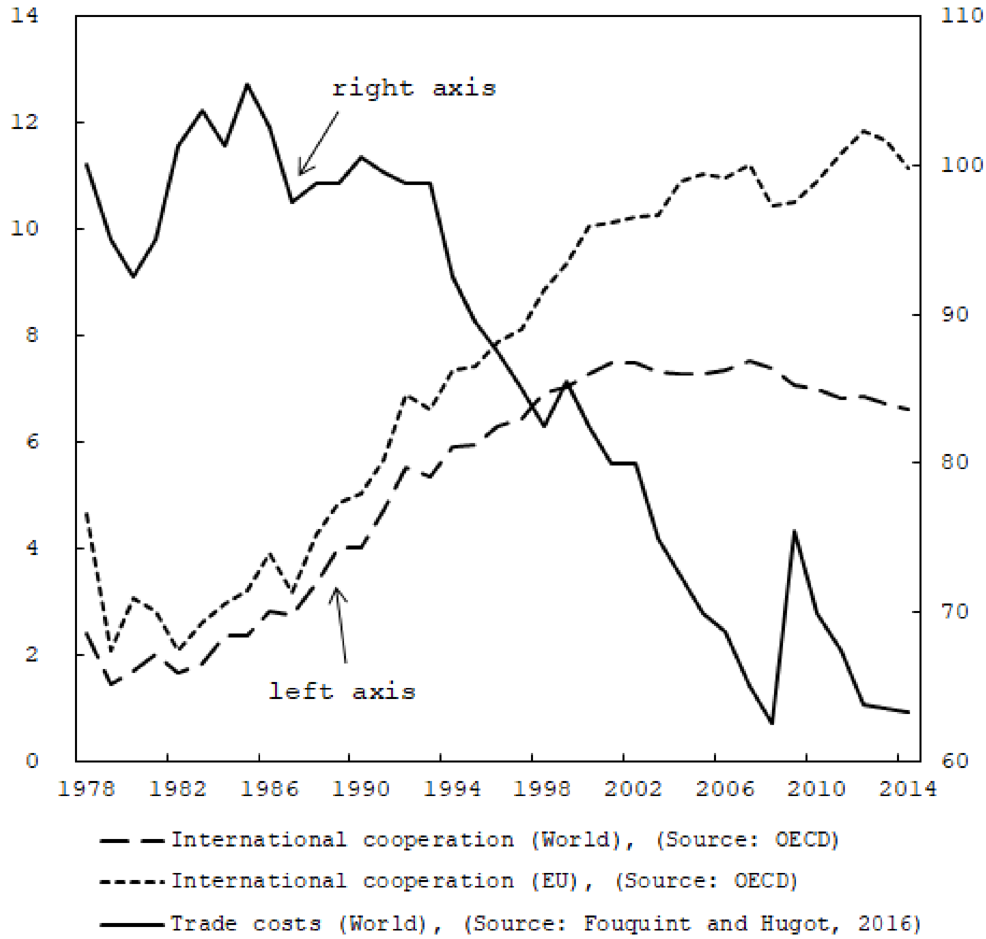
## 4.1 Introduction

The number of research and development (R&D) collaborations between firms from different countries has increased significantly over the past few decades. Data from the MERIT-CATI database, covering the period between 1960 and 1998, shows that 40% of collaborations were inter-regional (Hagedoorn, 2002); and OECD data covering the more recent period between 1978 and 2014 shows that the share of world patents with a foreign co-inventor tripled over the last three decades (see Figure 4.1). Yet the factors that drive firms to collaborate with far-away agents are still poorly understood (Fitjar and Rodriguez-Pose, 2014).

It is thus not surprising that there is a growing theoretical literature on international R&D collaboration (see, for example, Song and Vannetelbosch, 2007; Qui and Tao, 1998; Zu, Dong and Zhang, 2011; Edwards and Poyago-Theotoky, 2013; Falvey and

[1] **The present chapter is joint work with Terence H. Edwards and Ben Ferrett. Very early versions of this work have been presented at the 7th NIE Doctoral Colloquium organised by the Network of Industrial Economists at Loughborough University in 2017; and the 6th NIE Doctoral Colloquium organised by the same Network at the University of Nottingham in 2016. We thank the discussant of the paper Matthew Olczak as well as participants for their helpful comments and useful discussions.**

Figure 4.1: Share of Patents with a Foreign Co-inventor (%) and World Trade Costs (1978=100)




Teerasuwannajak, 2016); but the role of *trade costs* has been largely overlooked. Empirical evidence suggests that lowering trade costs (or trade barriers) enables export growth, that in turn incentivises more investment in R&D (see, for example, Baldwin and Gu, 2004). In addition, the increase in international inter-firm R&D collaboration that can be observed in Figure 4.1, has taken place during a period that saw trade costs follow an overall downward trend.[2] These observations suggest that firms *invest* and *collaborate* more in R&D as trade costs fall.

In this chapter, we investigate precisely this aspect in a simple model with two same-size countries and two firms, one in each country. The two firms produce a homogeneous good which they sell in their home market and in the foreign market;

[2]See also WTO (2008) for a detailed account of declining 'world trade costs' during the same period.

the latter involving a trade cost per unit of exported output. Note that this setup differs from that in the majority of literature on international R&D collaboration that typically builds on Spencer and Brander's (1983) model, in which firms from different countries compete in a third country's market. Instead, our model is based on Brander and Krugman (1983), where each firm competes in its home market and in the foreign market by choosing the quantity to sell in the two markets separately. In this setup, trade costs have the effect of reducing competition in the firms' home market and decreasing their market share in the foreign market. This allows us to analyse how the impact of trade costs on firms' relative market power affects their R&D investment and collaboration decisions.

The way in which we model firms' R&D investment and collaboration decisions is standard in the literature.[3] The two firms may collaborate by sharing their cost-reducing R&D, but are assumed to act independently in deciding how much to invest in R&D and how much to produce (à la d'Aspremont and Jacquemin, 1988). And because R&D subsidies play a key role in strategic trade policy, we analyse the investment and collaboration aspects under two scenarios: 'with' and 'without' government R&D subsidies to indigenous firms.[4]

On the basis of this setup, we reach three major conclusions. First, we show that lower trade costs have the effect of increasing the quantity sold, and thereby incentivise firms to invest more in R&D. This holds true irrespective of firms' R&D collaboration choices for both the case with R&D subsidies and the one without. Second, we show that the two firms collaborate if trade costs are sufficiently low; and that this threshold is higher if governments subsidise the R&D effort of their indigenous firms. This suggests that government intervention through R&D subsidies simply amplifies the 'without subsidies' outcome. However, the underlying drivers of these results differ substantially.

[3]We deviate from standard R&D models by assuming that there are no unintended knowledge spillovers as this has already been dealt with extensively in other literature (Katz, 1986; d'Aspremont and Jacquemin, 1988; Kamien et al., 1992; Motta, 1992; Leahy and Neary, 1997).

[4]International agreements that restrict export subsidies have led governments to rely on R&D subsidies as a strategic trade policy tool. See, for example, Spencer and Brander (1983) and Leahy and Neary (1999).

In the case without subsidies, the extent to which the marginal cost of production is reduced due to firms' investments in R&D is the same irrespective of the firms' collaboration choice. The benefit of collaboration simply takes the form of a cost saving that results from the elimination of duplication of investment in R&D. And because lower trade costs incentivise firms to invest more in R&D, the cost saving is larger at lower trade costs. Hence, this model suggests that lower trade costs incentivise international inter-firm collaboration in R&D.

In contrast, in the case with R&D subsidies, the reduction in firms' marginal cost of production due to investment in R&D is larger if firms collaborate; and since reductions in the marginal cost increase firms' profits, it follows that R&D subsidies widen the gap between the profits earned if firms collaborate and those earned if they do not. Therefore, by incentivising firms to invest more in R&D, subsidies make international inter-firm R&D collaboration more likely.

It is worth noting that in the case with R&D subsidies, the positive impact of lower trade costs on firms' profits does not only work (directly) through firms' higher investment in R&D (as in the case without subsidies), but also (indirectly) through higher R&D subsidies. The latter happens because lower trade costs have the effect of increasing firms' total output such that it strengths the incentive of welfare-maximising governments' to subsidise R&D. And for a given reduction in trade costs, the increase in the R&D subsidy is bigger if firms collaborate.

Third, we show that international R&D collaboration is world-welfare-improving in the cases with and without government R&D subsidies. In the case without subsidies, R&D competition is (partly) motivated by the business stealing effect that leads to over-investment in R&D. By eliminating the duplication of effort, R&D collaboration saves costs and causes world welfare to increase. However, in the case with R&D subsidies, the welfare improvement that results from collaboration is not only the result of the elimination of duplication of effort; it also reflects improved consumer surplus. Motivated by social incentives, subsidies can therefore improve world-welfare as long as firms choose to collaborate; otherwise governments end up in a subsidy war that causes world welfare to decline.

Our welfare results relate to those in Qui and Tao (1998) who study the R&D investment and collaboration decisions by two firms competing in a third country; with a focus on how these are affected by governments' R&D subsidies in a world 'with' and 'without' policy coordination. Similar to our model, they note that when firms fully share their investment in R&D, each firms' R&D investment reduces by the same amount its own and its competitor's marginal cost, such that by committing to a higher R&D investment a firm cannot gain a cost advantage over its competitor. Nonetheless, like us, they show that governments may still have unilateral incentives to subsidise their firms' investment R&D.

This study is also closely related to Haaland and Kind (2008) and Ghosh and Lim (2013). Haaland and Kind explore the relationship between trade costs and R&D investments in a international duopoly setup; and the effects of competition versus cooperation in R&D subsidies on product varieties in the market. Like us, they show that lower trade costs increase the firms' investment in R&D and that it is optimal for governments to provide higher subsidies at lower levels of trade costs. Unlike us, however, they do not explore how trade costs affect firms R&D collaboration decisions; and instead focus on cooperation at the policy level.

The relationship between trade costs and investment in R&D is also studied in Ghosh and Lim (2013); who focus on the impact of spillovers on R&D investment levels and the mode of R&D (cooperation vs non-cooperation). Like us, they show that a reduction in trade costs increases R&D irrespective of the mode of R&D; and that firms prefer cooperation in R&D only if trade costs are low. However, they do not consider how this decision is affected if governments subsidise investment R&D; and, as noted above, the underlying determinants of the equilibrium R&D collaboration choice in a world with government subsidies differ substantially from those in a world without subsidies.

The rest of the chapter is organised as follows. In Section 4.2 we describe the basic model; in Section 4.2.1 we consider the case without R&D subsidies, while in Section 4.2.2 we consider the case where governments simultaneously and independently determine the R&D subsidy level that maximises their country's welfare. Finally

Section 4.4 concludes.

## 4.2 The basic model

Consider a model with two symmetric countries, with one firm in each country. The two firms are assumed to produce homogeneous goods which they sell in their home market and in the foreign market, incurring an additional per unit trade cost, $t$, on exports. The consumers in both countries are assumed to have a quadratic utility function such that the inverse demand function is $P_i = 1 - Q_i$, where $P_i$ is the price consumers face in country $i$ and $Q_i = q_{ii} + q_{ji}$ is the total quantity sold by firms $i$ and $j$ in country $i$.

Firm $i$ faces marginal cost of production, $c_i$, that can be reduced via investment in R&D, $x_i$. There is also the possibility that firms collaborate in R&D (but not in output), such that firm $i$'s marginal cost is $c_i = C - (x_i + \beta x_j)$, where $C \in [x_i + \beta x_j, 1]$ is a positive parameter that is common to both firms, and $\beta$ is a parameter that takes a value of 1 if firm $i$ collaborates with firm $j$ (what Kamien at al. [1992] call RJV competition) and zero otherwise (what Kamien at al. call R&D competition).[5] This implies that firms are equally efficient in the absence of any investment in R&D, and that if firms collaborate they fully enjoy each others cost-reducing investments in R&D.

The cost of R&D is quadratic, reflecting diminishing marginal returns to R&D investments, $\frac{\gamma}{2}x_i^2$, where $\gamma$ is a positive parameter that has a scaling effect reflecting the firms' R&D capabilities. In case of collaboration, the two firms also incur a coordination cost, $F \geq 0$, that is modelled as a fixed cost (as in Goyal and Joshi [2003]) and shared equally between the two firms.[6] This reflects costs that arise due

[5] Kamien et al. (1992) consider four different modes of R&D under which firms can cooperate: (i) R&D competition is when firms choose the level of R&D independently to maximize individual profits; (ii) R&D cartelization is when firms coordinate their R&D effort by maximizing joint profits; (iii) RJV competition is when firms maximize individual profits by choosing R&D independently but share their R&D knowledge; and (iv) RJV cartelization is when firms share their knowledge and also coordinate their efforts to maximize joint profits.

[6] See Katz (1986) for a discussion on varying degrees of R&D cost-sharing.

to challenges in communication over large distances, differences in corporate culture, time-zone differences, etc.

### 4.2.1 Model without R&D subsidies

In the case without government subsidies for R&D, the game involves three stages:

- in stage 1, firms decide whether (or not) to collaborate in R&D;
- in stage 2, firms independently decide how much to invest in R&D; and
- in stage 3, firms compete à la Cournot in the two markets.

We solve the game by backward induction and we look for the sub-game perfect equilibrium. In stage 3, the two profit-maximising firms decide how much output to produce for each market. Firm $i$'s profit function is:

$$\Pi_i = (P_i - c_i)\, q_{ii} + (P_j - c_i - t)\, q_{ij} - \frac{\gamma}{2} x_i^2 - \frac{\beta}{2} F \tag{4.1}$$

where the first term on the right-hand-side of equation (4.1) represents firm $i$'s profits from its home market, the second its profits from the foreign market, the third the cost of R&D, and, finally, the fourth the coordination cost of collaboration. Solving for ${}^{d\Pi_i}/_{dq_{ii}} = 0$ and ${}^{d\Pi_i}/_{dq_{ij}} = 0$ gives firm $i$'s equilibrium quantities for its home and foreign markets:

$$\begin{aligned} q_{ii}^* &= \frac{1}{3}(1 - 2c_i + c_j + t) \\ q_{ij}^* &= \frac{1}{3}(1 - 2c_i + c_j - 2t) \end{aligned} \tag{4.2}$$

Note that the equilibrium quantities produced by firm $i$ depend on its marginal cost, $c_i$, that in turn depends on its R&D effort, $x_i$, and in case of collaboration, also on that of its competitor, $x_j$.[7] Note too, that $t$ increases firm $i$'s output in its home market but reduces its output in the foreign market.[8] Overall, the latter effect dominates such that a higher $t$ reduces the total quantity produced by firm $i$.

Using equation (4.2) to substitute for $q_{ii}$ and $q_{ij}$ in equation (4.1) gives:

$$\Pi_i = \frac{1}{9}\left(1 - 2c_i + c_j + t\right)^2 + \frac{1}{9}\left(1 - 2c_i + c_j - 2t\right)^2 - \frac{\gamma}{2}x_i^2 - \frac{\beta}{2}F \tag{4.3}$$

Anticipating the equilibrium quantities that determine the firm's profits given by equation (4.3), in stage 2, firms decide how much to invest in R&D. Recall that if firms do not collaborate, i.e. $\beta = 0$, then firm $i$'s marginal cost is $c_i^n = C - x_i$; but if they do, i.e. $\beta = 1$, then its marginal cost is $c_i^c = C - (x_i + x_j)$. Substituting for $c_i$ in equation (4.3), there exist unique solutions satisfying ${}^{d\Pi_i}/_{dx_i} = 0$, from which we obtain firm $i$'s R&D reaction functions:

$$\begin{aligned} x_i^n\left(x_j^n\right) &= \frac{8\left(1 - C - {}^{t}/_{2} - x_j^n\right)}{9\gamma - 16} \\ x_i^c\left(x_j^c\right) &= \frac{4\left(1 - C - {}^{t}/_{2} + x_j^c\right)}{9\gamma - 4} \end{aligned} \tag{4.4}$$

where $x_i^k$ is firm $i$'s R&D effort in collaboration case $k \in \{n, c\}$, and $n$ and $c$ represent the cases *without* and *with* collaboration between the two firms, respectively. To simplify the notation, in what follows we do not use the superscript $k$ unless there is the need to distinguish between the cases relating to the firms' alternative collaboration choices.

Note from equation (4.4) that the firms' R&D efforts are strategic substitutes if, in stage 1, firms choose not to collaborate, but strategic complements if they do. Using these reaction functions we can solve for the firms' equilibrium R&D efforts:

[7] The dependence of $c_i$ on $x_i$ and $x_j$ follows from the definition of the marginal cost: $c_i = C - (x_i + \beta x_j)$.

[8] We assume that $t < \frac{1}{2} - \left(c_i + \frac{1}{2}c_j\right)$ to ensure that both firms sell in the two markets.

$$x_i^{n*} = \frac{8\left(1 - C - {}^{t}\!/_{2}\right)}{9\gamma - 8}$$

$$x_i^{c*} = \frac{4\left(1 - C - {}^{t}\!/_{2}\right)}{9\gamma - 8} \tag{4.5}$$

We make a number of observations. First, firms' R&D efforts are increasing in their R&D capability (as measured by $1/\gamma$).[9] Second, when firms collaborate, they halve their investment in R&D, $x_i^{c*} = \frac{1}{2}x_i^{n*}$, but get to benefit from the same marginal-cost-reduction level as in the no collaboration case, i.e. $c_i^{c*} = c_i^{n*}$ because $x_i^c + x_j^c = x_i^n$. Third, $t$ reduces firm $i$'s R&D effort, which in turn increases its marginal cost, $c_i$, and causes its equilibrium quantities and profits to fall. This leads us to the first proposition.

**Proposition 4.1.** *Firm $i$'s equilibrium R&D effort, $x_i^*$, is decreasing in trade costs, $t$, irrespective of its R&D collaboration decision.*

*Proof.* For any $\gamma > \frac{16}{9}$, $dx_i^{n*}/dt = -4/(9\gamma-8) < 0$ and $dx_i^{c*}/dt = -2/(9\gamma-8) < 0$. □

To understand this result, note that a reduction in trade costs increases competition in firm $i$'s home market that, in turn, reduces its home-market output and discourages it from investing in R&D. At the same time, a reduction in trade costs reduces firm $i$'s effective marginal cost to export to the foreign market. This enables firm $i$ to export more and thereby incentivises firm $i$ to invest more in R&D. The latter effect dominates such that a reduction in trade costs increases $x_i^*$.

Finally, in stage 1, firms decide whether or not to collaborate in R&D. Their decisions are based on a comparison between the profits that they would earn 'with' and 'without' collaboration. Therefore, firm $i$ collaborates in R&D with firm $j$ iff $\Pi_i^c > \Pi_i^n$. Using the equilibrium R&D efforts obtained in stage 2 and substituting for $c_i$ in

[9] In the case without government subsidies for R&D, we require that $\gamma > \frac{16}{9}$ to ensure that the second order condition for R&D choice is satisfied.

equation (4.3) to obtain the firms' equilibrium profits, the collaboration condition can be re-written as $12\gamma\left(\frac{2-2C-t}{9\gamma-8}\right)^2 > F$. This brings us to the next proposition:

**Proposition 4.2.** *Equilibrium collaborative R&D agreement in the case without subsidies. Let $t^*$ be such that $\Pi_i^{c*} = \Pi_i^{n*}$ if $t = t^*$; while $\Pi_i^{c*} > (<)\, \Pi_i^{n*}$ if $t < (>)\, t^*$. Then firms collaborate if $t < t^*$, but otherwise do not.*

*Proof.* By definition, $\pi_i^{c*} - \pi_i^{n*} = 0$ if $t = t^*$. Since $\frac{d\left(\Pi_i^{c*}-\Pi_i^{n*}\right)}{dt} = \frac{-24\gamma(1-C-t/2)}{(9\gamma-8)^2} < 0$ for all $\gamma > \frac{16}{9}$, it follows that $\Pi_i^{c*} - \Pi_i^{n*} > (<)\, 0$ if $t < (>)\, t^*$. □

Therefore, firms prefer 'collaboration' to 'no collaboration' for any level of trade costs lower than $t^*$, which we term as the 'collaboration threshold'. To understand this result, recall from equation (4.5) that collaboration halves firm $i$'s R&D effort and expenditure. However, the firm still benefits from the same marginal-cost-reduction level as in the case without collaboration because firms are assumed to fully share the benefit of their investments in R&D.[10] Thus, the benefit of R&D collaboration simply takes the form of cost savings. And because lower trade costs incentivise firms to invest more in R&D (see equation [4.5]), this cost saving is bigger at lower trade costs. Consequently, as $t$ decreases $\Pi_i^c$ increases relative to $\Pi_i^n$.

Defining the welfare of country $i$ as $W_i = V_i + \Pi_i$, where $V_i = \frac{1}{2}\left(1 - P_i^*\right) Q_i^*$ is country $i$'s consumer surplus, we can make the following proposition:

**Proposition 4.3.** *Welfare impact of R&D collaboration in the case without subsidies. Let world welfare be the sum of the welfare of the two countries, $\sum_i W_i$. Then if R&D collaboration arises in equilibrium, it improves world welfare relative to the 'no collaboration' case, i.e. $\sum_i W_i^c > \sum_i W_i^n$ for all $t < t^*$.*

*Proof.* Recall from equation (4.5) that $x_i^{c*} = \frac{1}{2}x_i^{n*}$ such that $c_i^c = c_i^n$. It follows that collaboration leaves the equilibrium price and quantity unchanged. This implies that in a world without R&D subsidies consumer surplus is unaffected by collaboration,

[10] Firm $i$'s marginal cost is $c_i^c = C - x_i^c - x_j^c$ if it collaborates and $c_i^n = C - x_i^n$ if it does not collaborate. Since $x_i^c = \frac{1}{2}x_i^n$ and the two firms invest equally in R&D, it follows that $c_i^c = c_i^n$.

such that collaboration only affects $W_i$ through $\Pi_i$. And the positive impact of collaboration on $\Pi_i$ is implied by the formation of the partnership; otherwise firms would have chosen not to collaborate. □

### 4.2.2 Model with R&D subsidies

We now consider the case where governments subsidise the R&D effort of their indigenous firms. We assume that each government's objective is to maximise the welfare of its country and that the subsidy levels are determined simultaneously and non-cooperatively by the two governments before the two firms make their collaboration decision.

Thus, the game involves four stages:

- in stage 1, governments independently set the R&D subsidy levels for their indigenous firms;
- in stage 2, firms decide whether (or not) to collaborate in R&D;
- in stage 3, firms independently decide how much to invest in R&D; and
- in stage 4, firms compete à la Cournot in the two markets.

We solve the game by backward induction, and we look for the sub-game perfect equilibrium. Starting from stage 4, we note that firm $i$'s profit function now includes a subsidy per unit of R&D, $s_i$:

$$\hat{\Pi}_i = \left(\hat{P}_i - \hat{c}_i\right)\hat{q}_{ii} + \left(\hat{P}_j - \hat{c}_i - t\right)\hat{q}_{ij} - \frac{\gamma}{2}\hat{x}_i^2 + s_i\hat{x}_i - \frac{\beta}{2}F \tag{4.6}$$

where the superscript ^ denotes the case with R&D subsidies. Note that $s_i$ does not enter the profit function as a multiplicative of $\hat{q}_{ii}$ or $\hat{q}_{ij}$, such that the equilibrium quantities produced by firm $i$ for each market remain unchanged from equation (4.2).

In stage 3, the firms choose their R&D effort taking their output decision as given. Solving for ${d\hat{\Pi}_i}/{d\hat{x}_i} = 0$, we get firm $i$'s equilibrium level of R&D effort in the 'no collaboration' and 'collaboration' cases:[11]

$$\hat{x}_i^{n*} = \frac{8\left(1 - C - {t}/{2}\right)}{9\gamma - 8} + \frac{3\left(\left(9\gamma - 16\right)s_i - 8s_j\right)}{\left(3\gamma - 8\right)\left(9\gamma - 8\right)}$$
$$\hat{x}_i^{c*} = \frac{4\left(1 - C - {t}/{2}\right)}{9\gamma - 8} + \frac{\left(9\gamma - 4\right)s_i + 4s_j}{\gamma\left(9\gamma - 8\right)} \tag{4.7}$$

Term 1 on the right-hand-side of equation (4.7) is identical to firm $i$'s R&D effort in the case without R&D subsidies (see equation [4.5]). However, the firms' R&D efforts are also affected by the subsidies paid by the two governments. It is easy to see from the second term on the right-hand-side of equation (4.7) that if firms do not collaborate, the R&D effort of firm $i$ is increasing in the subsidy offered by its government, ${d\hat{x}_i^n}/{ds_i} > 0$, but decreasing in the subsidy offered by the government of its competitor, ${d\hat{x}_i^n}/{ds_j} < 0$. In contrast, if firms collaborate, firm $i$'s R&D effort is increasing in the subsidies offered by the two governments; ${d\hat{x}_i^c}/{ds_i} > 0$ and ${d\hat{x}_i^c}/{ds_j} > 0$. This has important implications for the equilibrium outcome that we discuss later on.

Taking the firms' equilibrium subsidies as given, in stage 2, the two firms make the R&D collaboration decision. Firm $i$'s choice is determined by a simple comparison between the profits that it earns if it collaborates and those that it would earn if it didn't. Thus, firm $i$ collaborates iff $\hat{\Pi}_i^c > \hat{\Pi}_i^n$.

Anticipating the firms' R&D investment and output choices, in stage 1, governments simultaneously and independently make their subsidy offers. These are determined in such a way that they maximise their countries' welfare; which is here defined as $\hat{W}_i = \hat{V}_i + \hat{\Pi}_i - s_i\hat{x}_i$, where $\hat{V}_i = \frac{1}{2}\left(1 - \hat{P}_i^*\right)\hat{Q}_i^*$ is country $i$'s consumer surplus. We

[11]See Appendix 4.4.1 for the two firms' R&D reaction functions for the case with R&D subsidies.

can thus solve for ${}^{d\hat{W}_i}/_{ds_i} = 0$ to obtain the equilibrium R&D subsidies:[12]

$$s_i^{n*} = \frac{2\gamma\left(1 - C - {}^{t}/_{2}\right)}{9\gamma - 18}$$
$$s_i^{c*} = \frac{4\left(4 + 9\gamma\right)\left(1 - C - {}^{t}/_{2}\right)}{9\left(9\gamma - 20\right)} \tag{4.8}$$

where $s_i^{k*}$ is the equilibrium subsidy paid by government $i$ in collaboration case $k \in \{n, c\}$. We make three observations about this result. First, irrespective of the anticipated collaboration decision taken by the two firms in stage 1, the subsidies paid by the two governments are positive, $s_i^* > 0$.

Second, the subsidy paid by the two governments is bigger if they anticipate collaboration in R&D, $s_i^c > s_i^n$. To understand what drives this result, it is worth noting the differing aspects that incentivise governments to subsidise R&D in the 'no collaboration' and 'collaboration' cases. In the case where firms do not collaborate, subsidies are (partly) incentivised by a business stealing motive that results from the strategic substitutability between the competing firms' R&D efforts (see Appendix 4.4.1).[13] Specifically, each government has an incentive to subsidise its indigenous firm to make it more efficient relative to its competitor, such that it captures a bigger share of the market(s). However, if firms collaborate (and fully share their investment in R&D), the business stealing motive vanishes as the two firms' R&D efforts become strategic complements.[14] This suggests that if firms collaborate, governments' incentive to subsidise R&D diminishes.

However, that is only part of the story as governments also care about the welfare of their consumers. The consumer surplus motive for subsiding R&D is positive in

[12]In the model with R&D subsidies, we assume $\gamma > \frac{1}{18}\left(41 + \sqrt{241}\right) \approx 3.14$ to ensure that the second order condition for subsidy choices is satisfied. This suffices to also ensure that the second order condition for R&D choice is satisfied.

[13]An increase in $s_i$ reduces $x_j$ that, in turn, increases firm $i$'s output and profits. See, for example, Haaland and Kind (2008) for a similar argument.

[14]An increase in $s_i$ increases $x_j$ that, in turn, increases firm $i$'s output and profits. Qui and Tao (1998) make a similar observation for cases where there is "full" collaboration.

both the 'no collaboration' and 'collaboration' cases. In the 'no collaboration' case government $i$'s subsidy reduces firm $i$'s marginal cost and thus lowers the market price to the benefit of its consumers. But if firms collaborate, the consumer surplus effect is amplified because government $i$'s subsidy reduces the marginal cost of both indigenous firm $i$ and exporting firm $j$ such that the impact on consumer surplus is bigger than it would be if firms do not collaborate. This enhanced consumer surplus motive under collaboration more than makes up for the "disappearance" of the business stealing motive; such that $s_i^c > s_i^n$ (see Appendix 4.4.2).

Third, equation (4.8) shows that the subsidies paid by the two governments are decreasing in trade costs, ${}^{ds_i}/_{dt} < 0$. This implies that in the case with R&D subsidies, the negative impact of trade costs on firms' profits does not only work through $x_i$ but also through $s_i$ (see equation [4.7]). The latter happens because an increase in $t$ reduces the quantity sold such that governments' incentive to subsidise R&D is reduced. Note too that $|{}^{ds_i^c}/_{dt}| > |{}^{ds_i^n}/_{dt}| > 0$. This means that as trade costs fall, the increase in the subsidies paid by the two governments is bigger if firms collaborate.

By substituting for $s_i$ and $s_j$ in equation (4.7) we get firm $i$'s equilibrium R&D effort:

$$\hat{x}_i^{n*} = \frac{2\,(5\gamma - 8)\,(1 - C - {}^{t}/_{2})}{(\gamma - 2)\,(9\gamma - 8)}$$

$$\hat{x}_i^{c*} = \frac{8\,(1 - C - {}^{t}/_{2})}{9\gamma - 20} \tag{4.9}$$

On the basis of equation (4.9), we can make the following proposition.

**Proposition 4.4.** *(i) The equilibrium R&D level in the case with subsidies, $\hat{x}_i^*$, is decreasing in trade costs irrespective of the firm's R&D collaboration decision. (ii) The negative impact of trade costs on firms' R&D effort is stronger in the case with subsidies than in the case without subsidies.*

*Proof.* (i) For any $\gamma > \frac{1}{18}\left(41 + \sqrt{241}\right)$, ${}^{d\hat{x}_i^n}/_{dt} = {}^{(8-5\gamma)}/_{(\gamma-2)(9\gamma-8)} < 0$ and ${}^{d\hat{x}_i^c}/_{dt} =$

$-4/(9\gamma-20) < 0$. (ii) $|d\hat{x}_i^*/dt| > |dx_i^*/dt| > 0$ follows from the proof of Proposition 4.1 and part (i) of the proof of Proposition 4.4. □

To understand part (i) of Proposition 4.4, note that if governments subsidise R&D, trade costs affect firms' R&D effort both directly and indirectly; the latter working through the impact that trade costs have on government subsidies. Specifically, the impact of $t$ on firm $i$'s equilibrium R&D investment, $\hat{x}_i^*$, can be expressed as follows:

$$\frac{d\hat{x}_i^*}{dt} = \underbrace{\frac{d\hat{x}_i}{dt}}_{<0} + \underbrace{\frac{d\hat{x}_i}{ds_i} \cdot \frac{ds_i}{dt}}_{<0} + \underbrace{\frac{d\hat{x}_i}{ds_j} \cdot \frac{ds_j}{dt}}_{\gtrless 0} \tag{4.10}$$

The first term on the right-hand side of equation (4.10) represents the direct effect of trade costs on firm $i$'s R&D effort. This is negative irrespective of firm $i$'s collaboration choice, $d\hat{x}_i/dt < 0$. The second term represents the impact of trade costs on firm $i$'s R&D effort through the subsidy it gets from its government, and is also negative. This follows from equations (4.7) and (4.8), where it is easy to see that $d\hat{x}_i/ds_i > 0$ and $ds_i/dt < 0$. Finally, the third term represents the impact of trade costs on firm $i$'s R&D effort through the subsidy its rival, firm $j$, gets from its own government. This may be either positive or negative, depending on whether firms collaborate in R&D. If firms collaborate, $d\hat{x}_i/ds_j > 0$, but otherwise $d\hat{x}_i/ds_j < 0$. Since $ds_j/dt < 0$, the third term is negative if firms collaborate and positive if they do not. Putting everything together, it follows that $d\hat{x}_i^*/dt < 0$ when firms collaborate. And even if firms do not collaborate, it can be shown that $t$ affects $\hat{x}_i^*$ negatively because the negative impact that works through $s_i$ outweighs the positive impact that works through $s_j$.[15]

Part (ii) of Proposition 4.4 follows from a comparison between equations (4.5) and (4.7). Note that $\hat{x}_i^* = x_i^*$ if $s_i = 0$, but $\hat{x}_i^* > x_i^*$ for any $s_i^* > 0$. And since $s_i^*$ is decreasing in $t$ (see equation [4.8]), it follows that the negative impact of trade costs

[15] From equation (4.7), we get $d\hat{x}_i/ds_i = 3(9\gamma-16)/(3\gamma-8)(9\gamma-8)$ and $d\hat{x}_i/ds_j = -24/(3\gamma-8)(9\gamma-8)$. It follows that $|d\hat{x}_i/ds_i| > |d\hat{x}_i/ds_j|$ for all $\gamma > \frac{1}{18}\left(41+\sqrt{241}\right)$.

on firms' R&D efforts is stronger in the case with subsidies than in the case without subsidies, $\left|\frac{d\hat{x}_i^*}{dt}\right| > \left|\frac{dx_i^*}{dt}\right|$. This brings us to the next proposition:

**Proposition 4.5.** *(i) Equilibrium collaborative R&D agreement in the case with subsidies. Let* $\hat{t}^*$ *be such that* $\hat{\Pi}_i^{c*} = \hat{\Pi}_i^{n*}$ *if* $t = \hat{t}^*$*; while* $\hat{\Pi}_i^{c*} > (<)\, \hat{\Pi}_i^{n*}$ *if* $t < (>)\, \hat{t}^*$*. Then firms collaborate if* $t < \hat{t}^*$*, but otherwise do not. (ii) Governments' R&D subsidies increase the collaboration threshold relative to the case without subsidies, i.e.* $\hat{t}^* > t^*$*.*

*Proof.* (i) By definition $\hat{\Pi}_i^{c*} - \hat{\Pi}_i^{n*} = 0$ if $t = \hat{t}^*$. Moreover $d\left(\hat{\Pi}_i^c - \hat{\Pi}_i^n\right)/dt = -\,(2 - 2c - t)$ $\left[(20480+\gamma(94208+3\gamma(-101440+27\gamma(3728+3\gamma(-524+81\gamma)))))/9(8-9\gamma)^2(20-9\gamma)^2(\gamma-2)^2\right] < 0$.[16] It follows that $\hat{\Pi}_i^{c*} > (<)\, \hat{\Pi}_i^{n*}$ if $t < (>)\, \hat{t}^*$. (ii) Noting that $2\hat{x}_i^{c*} > \hat{x}_i^{n*} > x_i^{n*} = 2x_i^{c*}$, it follows that $\hat{\Pi}_i^{c*} - \hat{\Pi}_i^{n*} > \Pi_i^{c*} - \Pi_i^{n*}$ such that $\hat{t}^* > t^*$. □

To understand part (i) of Proposition 4.5, recall that a reduction in trade costs increases $\hat{x}_i^*$; and that the reduction in firms' marginal cost due to R&D is $2\hat{x}_i^{c*}$ in case of collaboration and $\hat{x}_i^{n*}$ in case of 'no collaboration', where $2\hat{x}_i^{c*} > \hat{x}_i^{n*}$. Note too, from the proof of Proposition 4.3, that the impact of trade costs on $2\hat{x}_i^{c*}$ is stronger than on $\hat{x}_i^{n*}$. Since firms' output and profits are increasing in R&D, it follows that lower trade costs increase $\hat{\Pi}_i^c$ relative to $\hat{\Pi}_i^n$.

It is less straightforward to understand part (ii) of Proposition 4.5. Recall that in the case without R&D subsidies, the reduction in the marginal cost of production is the same irrespective of whether firms collaborate, i.e. $c_i^c = c_i^n$ because $2x_i^{c*} = x_i^{n*}$. In contrast, in the case with R&D subsidies, the reduction in the marginal cost due to investment in R&D is bigger if firms collaborate because they invest more in R&D, i.e. $\hat{c}_i^c < \hat{c}_i^n$ because $2\hat{x}_i^{c*} > \hat{x}_i^{n*}$. And since firms' profits are increasing in R&D, it follows that $\hat{\Pi}_i^{c*} - \hat{\Pi}_i^{n*} > \Pi_i^{c*} - \Pi_i^{n*}$. This implies that the level of trade costs that leaves firms indifferent between 'collaborating' and 'not collaborating' in the case with R&D subsidies is higher than in the case without subsidies, i.e. $\hat{t}^* > t^*$.

Finally, we turn to the welfare impact of collaboration in the case with government subsidies for R&D:

[16] For illustrative purposes note that if $\gamma = 10/3$, $d\left(\hat{\Pi}_i^c - \hat{\Pi}_i^n\right)/dt \approx -4/3\,(1 - c - t/2) < 0$.

Table 4.1: World Welfare Impact of R&D Subsidies

| Trade cost level | Collaboration choice | | World welfare impact |
|---|---|---|---|
| | without subsidies | with subsidies | |
| $t < t^* < \hat{t}^*$ | Yes | Yes | + |
| $t^* < t < \hat{t}^*$ | No | Yes | + |
| $t^* < \hat{t}^* < t$ | No | No | - |

**Proposition 4.6.** *Let world welfare be the sum of the welfare of the two countries, $\sum_i \hat{W}_i$. Then if R&D collaboration arises in equilibrium, it improves world welfare, i.e. $\sum_i \hat{W}_i^c > \sum_i \hat{W}_i^n$ for all $t < \hat{t}^*$, but otherwise does not.*

To understand this result we consider firms' collaboration decisions for various levels of trade costs. These are summarised in Table 4.1.[17] Note that if $t < t^*$, then firms choose to collaborate even in the absence of subsidies. However, by incentivising firms to invest more in R&D, government subsidies have the effect of improving both consumer surplus and firms' profits such that world welfare increases. The impact of subsidies on welfare is also positive for $t \in [t^*, \hat{t}^*]$. At this intermediate level of trade costs, subsidies incentivise collaboration (that otherwise wouldn't take place) between the competing firms. Thus, their positive impact on world welfare is not only the result of higher R&D effort that improves both firms' profits and consumer surplus, but also of the elimination of duplication of effort. At $t > \hat{t}^*$, subsidies fail to incentivise collaboration; and although they have the effect of increasing both consumer surplus and firms' profits, they come at the cost of incentivising over-investment in R&D. Putting everything together, we conclude that subsidies are world-welfare-improving as long as firms choose to collaborate; but otherwise governments end up in a subsidy war that causes world welfare to decline.

[17] These results are based on extensive numerical simulations that are available from the authors upon request.

## 4.3 Conclusion

This chapter studies the effect of trade costs on firms' R&D investment and collaboration choices in a symmetric international duopoly setup. We consider the cases 'with' and 'without' government subsidies for R&D, and we draw several conclusions. First, in line with Haaland and Kind (2008) and Ghosh and Lim (2013), we show that lower trade costs increase the quantity sold, and thereby incentivise firms to invest more in R&D.

Second, we show that firms engage in international R&D collaboration with their competitor(s) if trade costs are sufficiently low. This is in line with the trends observed in Figure 4.1, where the significant increase in the number international inter-firm R&D collaborations is shown to coincide with significant reductions in world trade costs. We also show that the collaboration threshold in the case with R&D subsidies, $\hat{t}^*$, is higher than that in the case without government subsidies, $t^*$. Thus, in a model where trade costs provide a degree of market separation that may discourage international inter-firm R&D collaboration, governments may subsidise R&D to encourage collaboration.

Finally, we show that the use of government subsidies for R&D will be world-welfare-improving as long as firms choose to collaborate; otherwise governments end up in a 'subsidy war' that causes world welfare to decline.

The model considered here is admittedly a special case of a very complex problem; and one could think of several variations to our baseline model. For example, alternative ways of modelling R&D cooperation between firms are what Kamien et al. (1992) call 'R&D cartelization', which refers to cases where firms coordinate their R&D effort by maximizing joint profits, and 'RJV cartelization', which refers to cases where in addition to the coordination of firms' efforts to maximize their joint profits, they also share their R&D. We have studied both these modes of cooperation for the case without government subsidies. The results are intuitively appealing: if cooperation between firms takes the form of R&D cartelization, such that firms coordinate their R&D efforts to maximise joint profits, the critical trade cost threshold is higher than in the case of RJV competition, where countries simply share their R&D (our base case). And if addition to the coordination of R&D effort to maximise joint profits, the firms also share their R&D knowledge, the critical trade cost threshold is even higher as coordination and sharing of R&D incentivizes firms to increase their investment.[18]

Finally, we note that there are several closely related questions that this model leaves unanswered. For example, it would be interesting to analyse the effect of trade costs on a firm's incentive to engage in international R&D collaboration if it is given a collaboration choice between a local competitor and a foreign competitor; or how trade costs affect (world) welfare in case of coordinated R&D policy between the governments of different countries. We leave these for future research.

## 4.4 Appendix

### 4.4.1 R&D reaction functions (case with R&D subsidies)

Substituting for $c_i$ in equation (4.6), there exist unique solutions for ${d\hat{\Pi}_i}/{d\hat{x}_i} = 0$, from which we obtain firm $i$'s R&D reaction functions for the 'no collaboration' and 'collaboration' cases:

$$\begin{aligned} \hat{x}_i^n\left(\hat{x}_j^n\right) =& \frac{8\left(1 - C - {t}/{2} - x_j^n\right) + 9s_i^n}{9\gamma - 16} \\ \hat{x}_i^c\left(\hat{x}_j^c\right) =& \frac{4\left(1 - C - {t}/{2} + x_j^c\right) + 9s_i^n}{9\gamma - 4} \end{aligned} \tag{4.11}$$

As in the case without government subsidies for R&D, the two firms' R&D efforts

[18]As an illustrative case, note that if cooperation takes the form of RJV cartelization, then firm $i$'s R&D effort is $x_i^* = 8{\left(1-C-\frac{1}{2}t\right)}/{(9\gamma-16)}$, compared to $x_i^* = 4{\left(1-C-\frac{1}{2}t\right)}/{(9\gamma-8)}$ when cooperation takes the form of RJV competition (our base case). The cooperation condition changes from $12\gamma\left({(2-2C-t)}/{(9\gamma-8)}\right)^2 > F$ in case of the latter to $36\gamma^2\left({(2-2C-t)^2}/{(9\gamma-8)(9\gamma-16)}\right) > F$ in case of the former. It follows that the critical trade cost threshold for cooperation is higher under RJV cartelization than it is under RJV Competition.

are strategic substitutes in they do not collaborate, but strategic complements if they do.

### 4.4.2 Equilibrium R&D subsidies

To understand why $s_i^c > s_i^n$, we analyse how subsidies affect the two components of the welfare function, i.e. the indigenous firm's profits and consumer surplus. Suppose, for the time being, that government $i$'s objective is to maximise its indigenous firms' profits net of subsidies, i.e. $d(\hat{\Pi}_i - s_i\hat{x}_i)/ds_i = 0$. Then, the equilibrium subsidies paid by government $i$ are:

$$s_i^{n*} = \frac{16\gamma\,(2 - 2C - t)}{96 + 27\gamma\,(3\gamma - 8)}$$
$$s_i^{c*} = \frac{8\,(2 - 2C - t)}{27\,(3\gamma - 4)} \tag{4.12}$$

Thus, if governments' objectives are to maximise their indigenous firms' (net-of-subsidy) profits, the equilibrium subsidy paid in case of 'no collaboration' is higher than that that is paid if they do, $s_i^n > s_i^c$. This happens because if firms do not collaborate, governments have an incentive to subsidise their indigenous firms to make them more efficient than their competitor. This has been termed in the literature as the 'business stealing effect'. But if firms collaborate, the business stealing motive vanishes because both firms fully benefit from each others investments in R&D. This contrasts with what we get in equation (4.8), $s_i^n < s_i^c$.

The difference arises because equation (4.8) is derived on the assumption that governments also care about consumer surplus. In that case, if firms do not collaborate, the subsidy paid by government $i$ enhances firm $i$'s efficiency such that it also has the effect of improving consumer surplus, $\hat{V}_i$:

$$\frac{d\hat{V}_i^n}{ds_i^n} = \frac{9\left(2\gamma\,(1 - C - t/2) + s_i^n + s_j^n\right)}{(9\gamma - 8)^2} \tag{4.13}$$

But if firms collaborate, then the subsidy paid by government $i$ enhances the efficiency of both firm $i$ and firm $j$ such that the impact on $\hat{V}_i$ is bigger:

$$\frac{d\hat{V}_i^c}{ds_i^c} = \frac{18\left(2\gamma\left(1 - C - t/2\right) + 2s_i^c + 2s_j^c\right)}{\left(9\gamma - 8\right)^2} \tag{4.14}$$

Consequently, the impact of subsidies on consumer surplus is "amplified" if firms collaborate, ${dCS_i^c}/{ds_i^c} > {dCS_i^n}/{ds_i^n} > 0$; and this amplification effect more than makes up for the disappearance of the business stealing motive, such that $s_i^c > s_i^n$.

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# Conclusion

In Chapter 1 we study the location choice of a multinational firm in a world with two countries where governments compete in taxes and subsidies to host the multinational firm. The model brings together two important theoretical studies in the field of tax competition for Foreign Direct Investment (FDI): Fumagalli's (2003) consideration of countries' differing capacity to absorb (beneficial) knowledge spillovers from the multinational firm, and Bjorvatn and Eckel's (2006) consideration of imperfectly competitive markets.

The motivation for this setup is Bjorvatn and Eckel's theoretical prediction that the government of the country with an indigenous firm loses the auction for the MNE because it takes account of the harm that inward investment has on its indigenous firm's profits. This result is at odds with empirical cases where governments frequently appear to be keen to attract inward FDI for its perceived benefits to indigenous industry.

We show that the decision of multinational firms to locate in the proximity of indigenous firms may be the result of the provision of government incentives that aim to capitalise on the potential for knowledge spillovers to indigenous industry. Somewhat different but complementary to Fumagalli (2003), we also show that fiscal competition may increase the welfare of both winning and losing countries in the auction for the multinational firm when it leads to the relocation of multinationals away from countries that do not have the potential to benefit from knowledge spillovers to countries that do. As trade costs fall and the potential for knowledge spillovers increases, both outcomes become more likely in equilibrium.

Turning to Chapter 2, we analyse the impact of policies aiming to curb tax avoidance through profit shifting in a model with two countries that compete, first, for an MNE's plant via subsidies, and then for its profits via proportional tax rates. The study is motivated by the concern of a number of national and international institutions about highly profitable multinationals firms that pay very little corporate tax in their home countries. The model returns a number of basic results that are in line with those obtained from variants of standard models of international tax competition. First, similar to Haufler and Wooton (1999), who consider competition between two countries for a foreign owned monopolist, the larger country hosts the MNE's plant if trade costs are positive. Second, in line with Keen and Konrad (2013), we show that in equilibrium the larger country sets the higher tax rate on profits. And third, in line with Gordon and MacKie-Mason (1995) and Haufler and Schjelderup (2000), we show that profit shifting exerts downward pressure on competing countries' tax rates.

However, the key insight of the chapter is that the positive impact of anti-tax avoidance policies on host countries' tax revenues may be smaller than "anticipated" because they also intensify the competition for real capital. In our model, more costly profit shifting makes the profit tax base less mobile, enabling the host country government to earn higher tax revenues. This relative immobility of profits increases governments' valuation of the FDI project such that they are willing to bid more in the auction for the plant. Consequently, any gains in the host government's tax revenues that result from more costly profit shifting will be partly offset by higher subsidies. The difference in the size of competing countries turns out to be key in determining whether the higher costs of profit shifting intensify competition for real capital.

Motivated by empirical evidence that profit shifting to tax havens may be particularly problematic for less developed regions (IMF, 2014), in Chapter 3 we study its effects on a developed and a developing country that compete to host a multinational's plant in a sequential tax-setting game. The two governments cannot tax discriminate between the MNE and their indigenous firms. Consequently, by lowering their statutory tax rates, revenue-maximisng governments make their countries a more attractive location for the MNE, but that comes at the cost of losing tax revenues from indigenous firms.

We draw two major conclusions. The first is that the opportunity to shift profits to tax havens works against developing countries in their bid to attract FDI because it reduces the importance of tax rate differences between developed and developing countries in the eyes of MNEs. Second, in cases where less developed countries do host MNEs' plants, profit shifting opportunities have the effect of reducing their governments' revenues. It follows that profit shifting opportunities favour more developed countries in their bid host MNEs' plants. However, the impact of profit shifting on the tax revenues of developed countries may be either positive or negative, depending on the order of moves of the game.

If the developed country's government 'follows' in the tax-setting stage of the game, the tax rate set by the developed country's government is unaffected by profit shifting; but its tax revenues fall because the unchanged tax rate is applied to a smaller tax base. On the other hand, if the government of the developed country 'leads' in the tax setting stage of the game, profit shifting increases its revenues because the negative impact of the shrinking tax base is more than made up for by a higher tax rate. The latter result is similar to that reported in Hong and Smart (2010) who argue that tax havens could be beneficial to host countries because it allows them to set "high" tax rates on the profits of domestic (immobile) firms without driving away (mobile) MNEs. However, the conclusions drawn from our model suggest that the reasoning of Hong and Smart does not apply when it is developing countries that host the MNE. Rather, we show that tax havens put downward pressure on the developing country's tax rate. This is closer to the arguments put forward by Slemrod and Wilson (2009) who argue the tax havens "worsen" tax competition. Thus, by allowing for asymmetry between countries, we are able to distinguish between cases where tax havens have a positive impact and cases where they have a negative impact.

Finally, in Chapter 4 we study the effect of trade costs on firms' incentive to invest and collaborate (internationally) in R&D in a simple model with two same-size countries, each hosting one firm. The two firms may collaborate by sharing their cost-reducing R&D, but are assumed to act independently in deciding how much to invest in R&D and how much to produce for their home market and the foreign market (*à* la d'Aspremont and Jacquemin, 1988). Because R&D subsidies play a key role in strategic trade policy, we analyse the cases 'with' and 'without' government R&D subsidies to indigenous firms.

We draw the following conclusions. First, similar to Haaland and Kind (2008) and Ghosh and Lim (2013), we show that lower trade costs increase the quantity sold, and thereby incentivise firms to invest more in R&D. Second, in line with the observed trends of increasing international inter-firm R&D collaborations and reductions in world trade costs, we show that firms engage in international R&D collaboration with their competitor(s) if trade costs are sufficiently low; and that this threshold is higher if governments subsidise the R&D of their indigenous firms. Thus, in a model where trade costs provide a degree of market segmentation that may discourage international inter-firm R&D collaboration, governments may subsidise R&D to encourage collaboration. It turns out that the use of government subsidies for R&D will be world-welfare-improving as long as firms choose to collaborate; otherwise governments end up in a 'subsidy war' that causes world welfare to decline.

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