To Invest or not to Invest: A Real Options Approach to FDIs and Tax Competition

Paolo M. Panteghini

University of Brescia and CESifo

Guttorm Schjelderup

Norwegian School of Economics and Business Administration and CESifo

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Abstract

Foreign investment decisions of firms are often charaterized by investment irreversibility, uncertainty, and the ability to choose the optimal timing of foreign investments. We embed these charataristics into a real option theory framework to analyze international competition among countries to attract mobile investments when firms after the investment is sunk, can shift profit to low tax countries by transfer pricing. We find that an increase in the uncertainty of profit income reduces the equilibrium tax rates, whilst lower investment costs or larger profits, counteracts the negative fiscal externality of tax competition leading to higher equilibrium tax rates.

JEL classification: H25.

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1

1 Introduction

This paper argues that the foreign investment decisions of firms are often character-ized by investment irreversibility, uncertainty, and the ability to choose the optimal timing of foreign investments. We embed these characteristics into a real option theory framework and analyze international competition among countries to attract mobile investments when firms after the investment is sunk can shift profit to low tax countries by transfer pricing. We find that an increase in the uncertainty of profit income from foreign investments leads to lower equilibrium tax rates. In con-trast, a reduction in FDI investment costs and/or larger profits from FDI activities, counteracts the negative fiscal externality of tax competition and raises equilibrium tax rates.

Our results are obtained by using a two-period model where firms can either invest at time 0 or time 1. As in the traditional tax competition literature we allow capital to be mobile internationally,[1] but we add several new dimensions to the analysis. First, we make the reasonable assumption that expanding production in the home country is less costly than investing abroad due to the firm's familiarity with the legal and cultural factors in the domestic economy. Second, we allow firms to time their FDI decisions. Waiting to undertake an investment entails an option that affects the behavior of the firm as well as the conduction of tax policy. Third, we introduce risk in the sense that FDIs may be affected by either good or bad news. Good news means that the profit from FDI is higher than what was initially expected, while bad news implies losses. A final feature of our model is that we allow multinationals to shift profit to low tax countries by transfer pricing. The shifting of profit is well documented as an ongoing activity in multinationals.[2] It is therefore of interest to examine how transfer pricing affects the volume and timing of investment decisions, as well as the change in the tax sensitivity of mobile investments (and thus the equilibrium tax rate) [3]

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[1] See Zodrow and Mieszkowski (1986), Wilson (1986), as well as surveys by Wilson (1999) and Wilson and Wildasin (2004).

[2] For surveys on transfer pricing and multinationals see Hines (1999) and Gresik (2001).

[3] In recent years a body of theoretical literature has appeared, which tries to assess how sensitive capital is to taxation. Since taxes are not the sole determinant of firm behavior, the outcome of these studies differ in the extent to which they allow for other factors to influence firm's behavior. A general assessment of the literature, however, is that it provides evidence for that taxes affect

The model we use is related to the standard tax competition model, but distinguishes itself from it in fundamental ways. An underlying premise in the standard theoretical tax competition literature is that capital investment is fully reversible or, alternatively, that capital investment is irreversible but characterized by exogenous investment timing. As argued by Dixit and Pindyck (1994, p.3), however; *"Most investment decisions share three important characteristics; investment irreversibility, uncertainty, and the ability to choose the optimal timing of investment"*. We argue that this description is especially relevant for foreign direct investments (FDIs). FDIs usually entail the payment of sunk costs making them at least partially irreversible. Moreover, imperfect information concerning market conditions and national rules and regulations means that there is uncertainty related to the true costs of FDIs and their payoff. Finally managers are aware that investments present opportunities and are not an obligation and that irreversible choices reduce the flexibility of their strategy.[4] Thus, managers behave as if they owned option-rights thereby computing the optimal investment (exercise) timing.

Our paper relates to an emerging literature that analyzes uncertainty and the ability of firms to choose when to invest. It is well known in this literature that if the future is uncertain (and in the absence of taxation), it is optimal for a firm to choose a rather high premium in terms of expected rents (profit) relative to the immediate cost of entry (see e.g. McDonald and Siegel, 1986). Under taxation, Mackie-Mason (1990) studies the effects on investment and asset values of the U.S. percentage depletion allowance, and finds that it is a subsidy that in some cases may discourage investments. More recently Alvarez and Kanniainen (1997) analyze the tax effects on a potential firm with an irreversible entry option and risky post-entry profit. Neither of these two papers model openness explicitly.

The structure of the analysis is as follows. Section 2 outlines the basic principles used to analyze the timing of investments. Section 3 models the investment strategy of a firm considering whether or not to undertake FDIs. Section 4 uses a two-country model to investigate how taxes are affected by competition between countries over

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firm's location and investment decisions, but that no single elasticity measure can be obtained on the impact of taxation on cross-border flows of capital (see Devereux and Griffith (1998, 2002).

[4]Graham and Harvey (2001) show that about 25% of the US companies they surveyed always or almost always incorporate real options when evaluating a project. Furhermore, McDonald (2000) argues that even when firms apply standard techniques, it is possible that they adopt ad hoc rules of thumb which proxy for optimal timing behaviour.

FDI. Finally, section 5 concludes.

2   Some Preliminaries

In this section we introduce a two-period model describing FDIs by an MNE. For simplicity we employ a model with two symmetric countries called A and B. Let $PDV_{0,A}$ be the net present value of additional profits (i.e., profits above those derived from home investments) earned in country B by a multinational with its headquarters (HQ) in country A at time 0. Define $T_{0,A}$ as the present discounted value of tax payments when investment is undertaken at time 0 by a firm located in country A. The after-tax expected net present value of profits is then $NPV_{0,A} \equiv PDV_{0,A} - T_{0,A}$, and if $NPV_{0,A} > 0$, investing abroad is profitable and vice versa. Without any opportunity to delay irreversible investment, the firm decides whether to undertake an investment according to the standard net-present-value rule

$$\max \{NPV_{0,A}, 0\}. \tag{1}$$

As commonly argued in the literature on investment decisions (see e.g. Trigeorgis, 1996), managers are well aware that any decision to undertake irreversible investment reduces the flexibility of their strategy. Investment opportunities, therefore, are not obligations, but option-rights. If firms can postpone irreversible investments, they will choose the optimal exercise timing, and the rule given in (1) changes to take into account the option to delay. To see the implication, suppose the firm can delay investment abroad until time 1. If the firm invests immediately, it will enjoy the profit stream between time 0 and time 1. If it waits until time 1, it has the possibility of acquiring new information, which may emerge in the form of good news (profits) or bad news (losses). Therefore, investing at time 0 implies the exercise of the option to delay and entails paying an opportunity cost for the flexibility lost in the firm's strategy.[5] To decide when to invest, the firm compares $NPV_{0,A}$ with the expected net of tax present value of the investment opportunity at time 1, $NPV_{1,A} \equiv PDV_{1,A} - T_{1,A}$, where $PDV_{1,A}$ is the net present value of the investment opportunity at time 1, and $T_{1,A}$ is the present value of tax payments

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[5]McDonald and Siegel (1986) show that the opportunity to invest is analogous to a call option.

4

when investment is undertaken at time 1. The optimal decision entails choosing the maximum value:

$$\max \left\{ NPV_{0,A}, NPV_{1,A} \right\}. \tag{2}$$

Equation (2) shows that the firm chooses the optimal investment timing by comparing the two alternative policies. If the inequality $NPV_{0,A} > NPV_{1,A}$ holds, immediate investment is undertaken. If, instead, $NPV_{1,A} > NPV_{0,A}$, then waiting until time 1 is better. This rule can be interpreted as follows: if the firm receives good news (positive profits), it invests. If, instead, it faces losses, it does not invest. It is worth noting that delaying investment entails a postponement in the tax payment, since an increase in $(T_{0,A} - T_{1,A})$ raises the tax savings due to the delay of investment. Thus, the tax credit discourages immediate investment.[6]

As shown by Bernanke (1983), if the firm can postpone its investments, the investment decision depends on bad news, but is independent of good news. This result is often referred to as the *Bad News Principle (BNP)*, and states that uncertainty acts asymmetrically, since only unfavorable events affect the current propensity to invest. The implication of the BNP is that the worse the news, the higher is the return required to compensate for irreversibility, and the higher is the trigger point for when investment is profitable. In the following sections we use rules (1) and (2) to study FDI decisions and the outcome of competition among countries to attract FDI.

3 The model

We consider a representative firm that is initially located only in country A. The firm earns a certain net profit flow after tax equal to $(1 - \tau_A) \pi_A$, where τ_A is the statutory tax rate and π_A is gross profits. The firm has an opportunity to expand production and if it decides to invest in country B it incurs a sunk investment cost I. Let $(1 + j)\pi_B$ be gross profits in country B. At time 0, j is zero. At time 1, however, it will change: with probability q, it will be $j = u$ and with probability $(1 - q)$ it will be $j = -d$. Parameters u and d are positive and measure the upward and downward

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[6]For further details on the effects of taxation on the interactions between intertemporal decisions and discrete choices, see Panteghini (2003).

5

profit moves, respectively. At time 1, uncertainty vanishes due to the release of new information. For simplicity, gross profits will remain at the new level forever.[7] Risk is fully diversifiable and both countries are assumed to be small so that the interest rate r used to discount profits is fixed. Furthermore:

ASSUMPTION 1. *The shock is mean-preserving*

$$q(1 + u) + (1 - q)(1 - d) = 1. \tag{3}$$

Assumption 1 states that any change in one parameter is offset by changes in the other parameters. Hence, a change in volatility does not affect the expected value, which remains equal to the payoff faced by the firm at time 0. For simplicity we assume that the probability q is the same for both countries.[8]

Our model is one where the attractiveness of FDI is driven by the ease by which a firm can shift profit to low tax countries. After all, what matters for a firm is the after-tax profit it can harvest after the investment is sunk.[9] Foreign profits are taxed at the rate τ_B.[10]After investing abroad, the firm can save tax payments in the high tax country by shifting profits to the low tax country. We denote the percentage of profits shifted by $\beta \lessgtr 0$. In line with most of the literature on transfer pricing we make the realistic assumption that it is costly to shift profits for tax saving purposes, and the concealment (transaction) cost function is denoted by $\nu(\beta)$. The cost element may be interpreted as the hiring of lawyers or consultants to conceal

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[7]In line with Dixit and Pindyck (1994, Ch.2), we assume that the second period lasts to infinity. It is worth pointing out that the quality of results would not change if we assumed a finitely lived project. What matters is the relative weight of the two periods (namely the relevant discount factor) rather then their lenght.

[8]Thus, there are two shocks with the same characteristics. This does not entail any assumption on the correlation between the two shocks which ranges from -1 to +1. If the correlation is zero, shocks are fully country specific. If, instead, the correlation coefficient is 1 firms face the same shock.

[9]A model where the profit shifting motive is absent and where tax competition is over FDI per se, is not the focal point here. Such a model would necessitate a different model structure, but would probably not alter results. The reason is that models of profit shifting in the standard tax competition literature yield results in line with models where competition is over capital (see e.g., Haufler and Schjelderup (1999, 2000), and Kind et. al. (2005)).

[10]Although repatriated profits in principle are taxed in the country of residence, there is general agreement that due to deferral possibilities and limited credit rules, the source principle is effectively in operation for international investments (see. e.g. Keen, 1993).

the illegality of the transaction.[11]

The overall after-tax net operating profit of the firm (if it invests in B) is

$$\Pi_A^N (j) = (1 - \tau_A) \pi_A + (1 + j) [(1 - \tau_B) + \phi(\beta)] \pi_B, \qquad (4)$$

where $\phi(\beta) \equiv [(\tau_A - \tau_B) \beta - \nu(\beta)]$ measures the net tax savings arising from profit shifting. With no consequence for our results, we normalize overall tax savings with respect to π_B, and make the reasonable assumption that it is prohibitively costly to shift all profits to the low-tax country. The implication of the latter assumption is that

$$(1 - \tau_A) \pi_A + (1 + j)\phi(\beta) \pi_B > 0,$$
$$(1 + j) [(1 - \tau_B) + \phi(\beta)] \pi_B > 0,$$

which holds for a sufficiently low amount of profits shifted or for sufficiently high profit shifting costs. For simplicity, we will assume $\nu(\beta)$ to be quadratic, i.e.

$$\nu(\beta) = \frac{n}{2}\beta^2,$$

where $n \geq 0$ is a parameter that indicates how costly it is for the firm to shift profit. If n approaches zero, the firm can shift profit at no cost. If n goes to infinity, profit shifting is prohibitively costly.

Differentiating (4) with respect to the transfer pricing variable β, one obtains the optimal level of profit shifting

$$\beta_A^* = \frac{\tau_A - \tau_B}{n}. \qquad (5)$$

Equation (5) states that the firm shifts profits to the low-tax country. If $\tau_A < \tau_B$ $(\tau_A > \tau_B)$, then $\beta < 0$ $(\beta > 0)$. The optimal amount of profit shifting is reached when the marginal gain in terms of tax savings, here expressed by statutory tax rates $(\tau_A - \tau_B)$, is equal to the marginal cost of shifting profits. The fact that statutory tax rates are the only factor that matters for profit shifting decisions is supported by empirical findings.[12] In what follows we use the optimal profit shifting condition

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[11] These costs may or may not be tax deductible. Neither assumption has an impact on the qualitative results, but tax deductibility lowers the cost of profit shifting. See Haufler and Schjelderup (1999, 2000) for a more detailed discussion.

[12] See Hines (1999) for empirical results concerning transfer pricing. Note that β_A^* is not state-contingent due to our assumptions about the convexity of the cost function $\nu(\beta)$. If we relaxed this assumption so that one of the profit expressions could be zero, a corner solution would be obtained, and β_A^* would be state contingent.

(5) in the maximization problem, since the firm can decide up front on how much it wants to shift of the profits,

$$\Pi_A^N \left(j, \beta_A^*\right) \equiv \max_{\beta} \Pi_A^N \left(j\right).$$

Note that the ability to shift profits may have an effect on the timing of FDIs since it affects the net of tax profitability of FDIs. In the continuation we use * to denote the optimal values. Let us finally specify how one should interpret bad news:

ASSUMPTION 2. *If at time 1 the firm faces bad news, the present discounted value of future profits is less than the net discounted cost of investment, that is:*

$$\sum_{t=1}^{\infty} \frac{\Pi^N \left(-d, \beta_A^*\right)}{(1+r)^t} - \frac{1}{1+r} I < 0. \qquad (6)$$

Assumption 2 states that bad news inflicts a loss on the firm. If this were not the case, all news would be good in the sense that any news would generate positive profits and the BNP would not apply. The implication of (6) is that a rational firm does not invest at time 1 under the bad state.

In what follows we start out by asking what level of profit (trigger point) is needed for foreign investments to occur at time 0 when the firm can delay its investments. In order to find this trigger point, we set $NPV_{0,A} - NPV_{1,A} = 0$, and solve for π_B. This yields (the full derivation is given in the Appendix)

$$\pi_B^* = \eta \frac{r}{1+r} \tilde{I}, \qquad \eta \equiv \frac{r + (1-q)}{r + (1-q)(1-d)} > 1, \qquad \tilde{I} \equiv \frac{1}{[1 - \tau_B + \phi(\beta)]} I. \qquad (7)$$

In order for the firm to invest abroad at time 0, profits must cover the effective sunk cost of investing abroad $\tilde{I}$ (net of the tax benefit of profit shifting) adjusted by the value of forgoing the opportunity to wait, that is, the value of exercise of the call option ($\eta > 1$). The wedge ($\eta - 1$) is positive due to the asymmetric effect of uncertainty. Recall that the BNP of Bernanke (1983) implies that the investment decision depends on the seriousness of the downward move, d, and its probability $(1 - q)$, but is independent of the parameter that leads to the upward move. A firm that invests either at time 0 or 1 and receives good news, will not regret its investment decisions, since it is profitable irrespective of the firm's timing. In contrast, timing is crucial if bad news is reported. To see this, say the firm waits until time 1 and then receives bad news. In this case it will not invest and the choice of waiting turns out to be a good choice. If, instead, it had invested at time 0, it would have regretted its

choice. Thus, bad news matters for the timing of investments, but good news does not.[13]

Assumption 1 means that the now-or-never case (which entails the absence of any option to delay) is equivalent to a deterministic setup and we can obtain it as a special case by setting $d = u = 0$. In this case, the opportunity cost of losing flexibility is zero, and the firm's trigger point is lower than when it can time its investment decision.[14] The opportunity to delay investments increases the profit level required to undertake FDI and the increase is equal to the opportunity cost (as given by the option).

We now turn to investigating the effect on the trigger point if volatility increases. Volatility may rise for several reasons, including increased risk of terrorism and political instability. We find that:

LEMMA 1. *An increase in volatility raises the trigger point π_B^* and vice versa.*

Proof. See the Appendix.

An increase in volatility means that good news gets better and bad news gets worse. However, from the BNP it follows that good news is immaterial. Thus, increased volatility affects profitability in an adverse way and must be compensated by higher profits. As a consequence, the firm requires a higher trigger point if it is to invest. LEMMA 1 is in line with empirical evidence, which shows a negative relationship between uncertainty and firms' propensity to undertake FDIs.[15]

4 Tax competition and FDI

In this section we investigate how taxes are set in order to attract FDI when firms can time their investment decisions and countries compete to attract FDIs. We

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[13] As stated by Bernanke (1983) "the impact of downside uncertainty on investment has nothing to do with preferences ... The negative effect of uncertainty is instead closely related to the search theory result that a greater dispersion of outcomes, by increasing the value of information, lengthens the optimal search time" [p. 93].

[14] For further details see a previous version of this article (Panteghini and Schjelderup, 2003).

[15] The negative impact of uncertainty on FDIs is investigated e.g by Chen and So (2002), who show that the 1997 Asian financial crisis (which caused an increase in exchange rate variability) undermined FDIs undertaken by U.S. MNEs. Further evidence can be found in Aizenman and Marion (2004), who focus on the foreign operations of U.S. MNEs since 1989.

model tax competition between two identical countries called A and B. In each country, there exists a continuum of firms that can invest abroad. Each firm is characterized by its own starting profit (π) arising from investing abroad. The firm-specific profits are distributed according to a linear density function $f(\pi)$ with $\pi \in [\underline{\pi}, \overline{\pi}]$. In equation (7) we showed that there existed a unique level of profit (trigger point) that made a representative firm indifferent between investing at time 0 and time 1. We assume that the lower bound for firm-specific profits ($\underline{\pi}$) is below the trigger point (π_i^*) in the sense that $\underline{\pi} < \pi_i^*$ $i = A, B$, and that $\underline{\pi} < \frac{r}{1+r}I < (1+u)\underline{\pi}$. These inequalities are introduced for two reasons: firstly they rule out the closed-economy case, which, if allowed, would always make firms incur a loss from their FDI activities.[16] Secondly, they imply that bad news entails a loss. Furthermore, in order to examine the outcome of tax competition in a setting where FDIs occur both at time 0 and time 1, we need to make an assumption that leads some firms to invest at time 0 irrespective of the option to delay. This amounts to assuming that the inequality $\overline{\pi} > \pi_i^*$ holds, that is, there exist high-income firms that invest abroad at time 0 irrespective of the existence of the option to delay.

In constructing the social welfare function for each country, note that since firms incur additional costs by investing abroad relative to home investments, firms exploit home investment opportunities at time 0. Furthermore, there are no economies of scale or scope in our model, so we can concentrate our attention on the sum of the extra producer surplus (profit) generated by FDIs stemming from home country firms plus tax revenue from foreign firms' FDI in the home country.[17] Thus, each government maximizes the welfare function,

$$\max_{\tau_i} W_i \qquad i = A, B \tag{8}$$

where W_i is the intertemporal sum of overall gross profits for home firms (i.e. multinationals with a home base in country i) plus tax revenues from subsidiaries located in i of multinationals with home base in country j. The maximization of (8) is part of a sequential game, where at stage 1 each government sets its tax rate; at stage 2 the firms in country A and B decide whether to invest at time 0 or at time 1. In solving this game we need to take into account that W_i is made up of four terms:

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[16]The limit case would be $I \to \infty$. In this case no opportunities to invest abroad would exist.

[17]With no loss of generality we thus disregard profits faced by home firms who never exploit FDI opportunities.

(I) The NPVs of home companies investing at time 0, net of tax revenues outflows caused by profit shifting

$$\int_{\pi_B^*}^{\overline{\pi}} \left\{ \frac{1+r}{r}\left[(1-\tau_B)+\phi\left(\beta_A^*\right)-\tau_A\beta_A^*\right]x - I \right\} f(x)dx =$$
$$= \frac{1+r}{r}\frac{\overline{\pi}^2-\pi_B^{*2}}{2(\overline{\pi}-\underline{\pi})}\left[(1-\tau_B)+\phi\left(\beta_A^*\right)-\tau_A\beta_A^*\right] - \left(\frac{\overline{\pi}-\pi_B^*}{\overline{\pi}-\underline{\pi}}\right)I.$$

(II) The net tax revenues raised from foreign companies who invest at time 0

$$\int_{\pi_A^*}^{\overline{\pi}} \left\{ \frac{1+r}{r}\tau_A\left(1+\beta_B^*\right)x \right\} f(x)dx = \frac{1+r}{r}\frac{\overline{\pi}^2-\pi_A^{*2}}{2\left(\overline{\pi}-\underline{\pi}\right)}\tau_A\left(1+\beta_B^*\right).$$

(III) The NPVs of home companies investing at time 1, net of profit shifting,

$$q\int_{\widetilde{\pi}_B}^{\pi_B^*} \left\{ \frac{(1+u)\left[(1-\tau_B)+\phi\left(\beta_A^*\right)-\tau_A\beta_A^*\right]x}{r} - \frac{I}{1+r} \right\} f(x)dx =$$
$$= \frac{q}{r}\left[\frac{\pi_B^{*2}-\widetilde{\pi}_B^2}{2(\overline{\pi}-\underline{\pi})}(1+u)\left[(1-\tau_B)+\phi\left(\beta_A^*\right)-\tau_A\beta_A^*\right] - \left(\frac{\pi_B^*-\widetilde{\pi}_B}{\overline{\pi}-\underline{\pi}}\right)\frac{r}{1+r}I\right].$$

(IV) Net tax revenues raised from foreign companies investing at time 1, net of profit shifting,

$$\frac{q}{r}\int_{\widetilde{\pi}_A}^{\pi_A^*} \tau_A(1+u)\left(1+\beta_B^*\right)xf(x)dx = \frac{q}{r}\frac{\pi_A^{*2}-\widetilde{\pi}_A^2}{2\left(\overline{\pi}-\underline{\pi}\right)}\tau_A(1+u)\left(1+\beta_B^*\right),$$

where

$$\widetilde{\pi}_i = \pi_i \left. \right|_{\frac{(1+u)\left[(1-\tau_i)+\phi\left(\beta_i^*\right)\right]\pi_i}{r}-\frac{I}{1+r}=0} \quad \text{for } i = A, B,$$

measures the threshold level of profit above which investing at time 1 is profitable, under the good state.

Solving this game it is straightforward to establish that

PROPOSITION 1. *There exists a unique symmetric Nash equilibrium tax rate* $\tau^* \in (0,1)$, *which equates at the margin the social cost of taxation to its social benefit, that is,*

$$f(\tau) = \kappa g(\tau), \tag{9}$$

where

$$f(\tau) \equiv \left(\frac{1}{2}-\frac{\tau}{n}\right), \qquad g(\tau) \equiv \left[\frac{\tau}{1-\tau}+f(\tau)\right]\frac{1}{(1-\tau)^2},$$

and

$$\kappa \equiv \left(\frac{r}{1+r}\right)^2\left[\left(1-\frac{q(1+u)}{1+r}\right)\eta^2 + \frac{q}{(1+r)}\frac{1}{(1+u)}\right]\left(\frac{I}{\overline{\pi}}\right)^2.$$

11

PROOF. See the Appendix.

In the Appendix it is seen that $g'(\tau) > 0$. From (9) it then follows that an increase in κ must be matched by a reduction in $g(\tau)$, that is, a fall in the equilibrium tax rate. From the definition of κ we see that it is affected by the number of firms that undertake FDI (i.e., the ratio $\frac{I}{\bar{\pi}}$), and the volatility of the return to FDI (as given by the parameters q, u, and η).

The ratio $\left(\frac{I}{\bar{\pi}}\right)$ is affected by the size of sunk investment cost I and the maximum expected return at time 0, i.e. $\bar{\pi}$. It is interesting that a fall in I may be related to globalization if tighter economic integration is characterized by a reduction in technical barriers such as national standards and other entry barriers that lower investment costs. A rise in profit income $\bar{\pi}$ may also be linked to globalization and more specifically to the formidable rise in skill-biased technology and information systems such as the Internet. In particular, information technology has allowed firms to outsource tasks to low costs suppliers and has improved communications (with HQs) and thus decision making. A reasonable assumption is that these factors should have a positive effect on profit income. A further argument that may link changes in the ratio $\left(\frac{I}{\bar{\pi}}\right)$ to globalization is that it follows from our analysis in section 3 that if I falls and/or the maximum expected return to investment ($\bar{\pi}$) rises, the number of firms that undertake FDI will go up. It is useful to note in this context that the liberalization of foreign exchange laws in most OECD countries in the mid and late 80s implied free mobility of capital. Empirical studies show that the period after foreign exchange liberalization laws coincide with a sharp rise in FDI and multinational firm activity.[18]

It follows from Proposition 1 that the effects of changes in $\left(\frac{I}{\bar{\pi}}\right)$ on the tax rate and tax revenue are:

Corollary 1 *For a given level of volatility:*

(a) *A decrease in I leads to a rise in the equilibrium tax rate τ^*, and an increase in tax revenue;*

(b) *An increase in $\bar{\pi}$ leads to a rise in the equilibrium tax rate τ^*, and, if $\bar{\pi}$ is high enough, an increase in tax revenue.*

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[18] See Markusen (ch. 1, 2002).

12

Proof. See the Appendix.

A rise in $\bar{\pi}$ and/or a decrease in I increases firms' average profitability, thereby encouraging FDI activities. This allows the two competing countries to set a higher tax without deterring FDIs. Moreover, as we have shown above, an increase in the number of multinational firms widens the overall tax base. Hence, higher tax rates combined with wider tax bases in both countries yield larger tax revenue.

We now turn to examine the effect of transfer pricing on the equilibrium tax rate. This pertains to the ease by which MNEs can shift profit (i.e., the size of the parameter n) and thus the intensity of tax competition. We find that,

Corollary 2 *An increase in the cost of shifting profit (rise in n) leads to an increase in the equilibrium tax rate, and, if $\bar{\pi}$ is high enough, a rise in tax revenues.*

Proof. See the Appendix.

It is straightforward to show based on Corollary 2 that intensified tax competition in the sense of a fall in n would further reduce the Nash-equilibrium tax rates.[19]

The effect of changes in the volatility parameters on κ is less clear cut than changes in profit or investment costs. It is seen from (9) that, ceteris paribus, a rise in η increases κ, whereas a rise in u (i.e. the seriousness of the good news) lowers κ. In contrast, a rise in q has an ambiguous impact on κ. Thus, taken together it is not clear how the interaction of the volatility parameters may affect the size of κ and thus the social marginal benefit of taxation and the equilibrium tax rate. It is, however, possible to show that the effect of a change in volatility on the tax equilibrium is

PROPOSITION 2: *Increased volatility (of profit income) lowers the equilibrium tax rate τ^*, and reduces tax revenue.*

Proof. See the Appendix.[20]

The intuition behind Proposition 2 is as follows. For given tax rates, an increase in volatility raises the investment trigger point, say from $\pi_{B_0}^*$ to $\pi_{B_1}^*$. This induces firms

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[19]A proof of this is obtainable from the authors upon request. Notice that when n goes to infinity tax competition vanishes, and tax revenue reaches its maximum.

[20]Notice that Proposition 2 holds irrespective of the starting values of u and d (these might be ≥ 0).

whose profits at time 0 are in the $\left(\pi^*_{B_0}, \pi^*_{B_1}\right)$ interval to delay. At time 1, however, only a fraction q of the firms who delayed will receive good news and then invest at time 1. The remaining firms decide not to invest. Therefore volatility reduces the overall number of firms involved in FDI activities and the policy response is to lower the tax rate in order to alleviate the negative impact of increased volatility. However, Corollary 1 shows that such a tax rate cut cannot compensate fully for the fall in FDI and profit. In turn, the reduction in the number of multinational firms entails a drop in the overall tax base, namely in the summation of all firms' tax bases. Therefore, both the reduced tax rate and the narrower overall tax base entails lower tax revenue.

Changing the uncertainty parameters amounts to introducing two country specific shocks: a shock faced by firm A investing in country B (and vice versa). The relevance of such shocks for real world policy depends obviously on the size of multinational activity in a country. There is empirical evidence showing that FDIs and multinational firms constitute significant fractions of economic output and investment in many countries.[21] Furthermore, Desai and Foley (2004) using U.S. data find empirical evidence for that shocks that occur in one part of the world is transmitted across borders as a consequence of multinational firm's worldwide network of subsidiaries. This is at least an indication of that such shocks transmitted through multinational activity is of interest from a policy point of view.

5 Conclusion

This paper has adopted a different view on FDI than most papers within the tax competition literature. We have argued that foreign investment decisions of firms are characterized by investment irreversibility, uncertainty, and the ability to choose the optimal timing of foreign investments. Our modeling framework allows us to analyze how an increase in volatility affects FDI behavior and the tax equilibrium. We show that increased volatility may lead to lower equilibrium tax rates.

A second result of our model is that a rise in FDI and multinational activity is triggered either by a reduction in investments costs, or a rise in the expected return to investment. In either case, the effect of these changes is to increase the

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[21]Evidence of this is given in Markusen (2002, ch1.) and in Desai and Foley (2004).

equilibrium tax rate. Thus, if a prominent feature of tighter economic integration is a fall in FDI cost (through a reduction in barriers to entry) or a rise in profit (due to information based technology and outsourcing), tax reforms in the future could roll back the significant reductions in statutory tax rates seen in the 80s and 90s. As a matter of fact, one example of such a development is the new Norwegian tax reform of 2005. It imposes a tax of 48.16 percent on dividends that exceed the normal return to capital. This is in contrast to the old regime, which entailed a full imputation system and a flat tax rate of 28 percent.

A final result in our model is to show that transfer pricing affects both the timing of investment decisions and taxes. Equilibrium taxes are lower, the easier it is (less costly) for MNEs to shift profit.

It is difficult to draw firm conclusions on how taxes, and tax revenue are affected if all parameters change simultaneously. In this case a more volatile world economy lowers taxes, and tax revenue, whilst a fall in investment costs or a rise in profit income has the opposite effect. Which of these two effects dominates depends on their relative magnitude. This is an issue that we have left for future research.

6 Appendix

6.1 Derivation of eq.(7)

Let us first compute the NPV of country A's companies when they invest at time 0:

$$NPV_{0,A} = [(1 - \tau_B) + \phi(\beta)] \frac{1+r}{r} \pi_B - (1 - \gamma_B \tau_B) I.$$

Next compute the NPV of country A's companies when they invest at time 1. Given Assumption 2 we obtain:

$$NPV_{1,A} = q \left\{ \frac{(1+u)[(1 - \tau_B) + \phi(\beta)] \pi_B}{r} - \frac{(1 - \gamma_B \tau_B) I}{1+r} \right\}.$$

Setting $NPV_{0,A} - NPV_{1,A} = 0$, and solving for π_B one obtains eq.(7).

6.2 Proof of Lemma 1

Let us recall Assumption 1. Rearranging (3) yields $d = \frac{q}{1-q} u$. Thus we have $\Delta d \propto \Delta u$, and, hence, $\frac{\Delta \eta}{\Delta d} \propto \frac{\Delta \eta}{\Delta u} > 0$, where the positive sign follows immediately from the definition of the variables r, d and q. Since $\frac{\partial \pi_B^*}{\partial \eta} > 0$, we can prove that an increase in volatility raises the trigger point π_B^*.∎

6.3 Proof of Proposition 1

Let us recall problem (8), and compute the first order condition

$$\frac{\partial W_i}{\partial \tau_i} = 0 \quad i = A, B. \tag{10}$$

Under symmetry ($\tau_A = \tau_B = \tau$) one obtains

$$\left(1 - 2\frac{\tau}{n}\right) \frac{\bar{\pi}^2 - \pi^{*2}}{2} - \frac{\tau}{1 - \tau} \pi^{*2} + \left\{ 2\gamma \frac{\tau}{1 - \tau} + \gamma \left[1 - 2\left(\frac{\tau}{n}\right)\right] \right\} \pi^{*2} = 0, \tag{11}$$

where

$$\pi^* = \frac{\eta \frac{r}{1+r} I}{1 - \tau}, \qquad \gamma \equiv \left\{ \frac{q}{1+r} \frac{\left[1 - \left(\frac{1}{1+u} \frac{1}{\eta}\right)^2\right]}{2} (1+u) \right\}.$$

Given Assumption 1 we have $q(1+u) < 1$. Moreover, both the inequalities $\frac{1}{1+r} < 1$ and $\left[1 - \left(\frac{1}{1+u}\frac{1}{\eta}\right)^2\right] < 1$ hold. Thus we have $\gamma < \frac{1}{2}$. Manipulating (11) yields

$$\left(\frac{1}{2} - \frac{\tau}{n}\right) = (1 - 2\gamma)\left[\frac{\tau}{1-\tau} + \left(\frac{1}{2} - \frac{\tau}{n}\right)\right]\frac{\pi^{*2}}{\bar{\pi}^2}. \qquad (12)$$

Let us now define $\kappa \equiv (1 - 2\gamma)a^2$, and $a \equiv \frac{\eta\frac{r}{1+r}I}{\bar{\pi}}$. Given the the inequality $\bar{\pi} > \pi^*$ we thus have $\frac{\pi^*}{\bar{\pi}} = \frac{a}{1-\tau} < 1$. This implies that $a < 1$ and, hence, $a^2 < 1$. As $(1 - 2\gamma) \in (0, 1)$, therefore, we have $\kappa < 1$. Using (12), rewriting κ as

$$\kappa = \left(\frac{r}{1+r}\right)^2 \left\{\left[1 - \frac{q(1+u)}{1+r}\right]\eta^2 + \frac{q}{1+r}\frac{1}{1+u}\right\}\left(\frac{I}{\bar{\pi}}\right)^2,$$

and defining

$$g(\tau) \equiv \left[\frac{\tau}{1-\tau} + f(\tau)\right]\frac{1}{(1-\tau)^2}, \qquad f(\tau) \equiv \left(\frac{1}{2} - \frac{\tau}{n}\right),$$

one obtains (9).

To prove the existence of an equilibrium tax rate it is necessary to study the properties of functions $g(\tau)$ and $f(\tau)$ in the $[0, 1)$ interval. It is straightforward to show that $\frac{1}{2} > \kappa g(0) = \frac{\kappa}{2}$, and that $g(\tau)$ is monotonically increasing in τ, with $\lim_{\tau \to 1} g(\tau) = +\infty$. Moreover, it is easy to ascertain that $f(\tau)$ is monotonically decreasing, and that $f(0) = \frac{1}{2} > \kappa g(0) = \frac{\kappa}{2}$, with $f(1) = \frac{1}{2} - \frac{1}{n} < \lim_{\tau \to 1} g(\tau) = +\infty$. Condition (9) can thus be represented by Fig. 1.

$$Fig.1$$

By applying the Fixed Point Theorem, we can conclude that, in the $[0, 1)$ interval, there exists one point such that equation (9) holds. Proposition 1 is thus proven.∎

6.4 Computation of tax revenues gathered from country A

The present discounted value of tax revenues T_A consists of five terms:

(I) the tax revenues for all the home firms

$$\frac{1+r}{r}\int_{\underline{\pi}}^{\bar{\pi}}\tau_A x f(x)dx = \frac{1+r}{r}\frac{\bar{\pi}^2 - \underline{\pi}^2}{2(\bar{\pi} - \underline{\pi})}\tau_A,$$

17

(II) the present value of home companies' tax benefits arising from profit shifting when FDI is undertaken at time 0

$$\int_{\pi_B^*}^{\overline{\pi}} \left\{ \frac{1+r}{r} \left[-\tau_A \beta_A^* \right] x \right\} f(x) dx = -\frac{1+r}{r} \frac{\overline{\pi}^2 - \pi_B^{*2}}{2 \left(\overline{\pi} - \underline{\pi} \right)} \left(\tau_A \beta_A^* \right),$$

(III) tax revenues raised from foreign companies investing at time 0, net of profit shifting, i.e.

$$\int_{\pi_A^*}^{\overline{\pi}} \left\{ \frac{1+r}{r} \tau_A \left(1 + \beta_B^* \right) x \right\} f(x) dx = \frac{1+r}{r} \frac{\overline{\pi}^2 - \pi_A^{*2}}{2 \left(\overline{\pi} - \underline{\pi} \right)} \tau_A \left(1 + \beta_B^* \right),$$

(IV) the present value of home companies' tax benefits due to profit shifting, when FDI is undertaken at time 1, i.e.

$$q \int_{\widetilde{\pi}_B}^{\pi_B^*} \left\{ \frac{(1+u) \left[-\tau_A \beta_A^* \right] x}{r} \right\} f(x) dx = -\frac{q}{r} \left[\frac{\pi_B^{*2} - \widetilde{\pi}_B^2}{2 \left(\overline{\pi} - \underline{\pi} \right)} (1+u) \left(\tau_A \beta_A^* \right) \right],$$

(V) tax revenues raised from foreign companies investing at time 1, net of profit shifting, i.e.

$$\frac{q}{r} \int_{\widetilde{\pi}_A}^{\pi_A^*} \tau_A (1+u) \left(1 + \beta_B^* \right) x f(x) dx = \frac{q}{r} \frac{\pi_A^{*2} - \widetilde{\pi}_A^2}{2 \left(\overline{\pi} - \underline{\pi} \right)} \tau_A (1+u) \left(1 + \beta_B^* \right).$$

Collecting the above terms yields country A's present value of tax revenues, T_A. The same procedure can be followed to compute T_B.

6.5 Proof of Corollary 1

Differentiating (9) with respect to κ yields

$$\frac{d\tau^*}{d\kappa} = -\frac{1}{(1-\tau^*)^2} \left\{ \frac{2\kappa}{(1-\tau^*)^3} + \frac{\left(\frac{1}{2} - \frac{\tau^{*2}}{n} \right)}{\left[\tau^* + (1-\tau^*) \left(\frac{1}{2} - \frac{\tau^*}{n} \right) \right]^2} \right\}^{-1} < 0$$

Moreover we have $\frac{d\kappa}{dI} > 0 > \frac{d\kappa}{d\overline{\pi}}$. Therefore we have $\frac{d\tau^*}{dI} = \frac{d\tau^*}{d\kappa} \frac{d\kappa}{dI} < 0$, and $\frac{d\tau^*}{d\overline{\pi}} = \frac{d\tau^*}{d\kappa} \frac{d\kappa}{d\overline{\pi}} > 0$. Namely an increase in the $I/\overline{\pi}$ ratio reduces the equilibrium tax rate.

Let us next turn to tax revenues. In equilibrium, overall tax revenues are equal to:

$$T(\tau^*) = \left(\frac{1+r}{2r} \right) \tau^* \left\{ \overline{\pi} + \underline{\pi} + \frac{\overline{\pi}^2}{(\overline{\pi} - \underline{\pi})} \left[1 - \kappa \left(\frac{1}{1-\tau^*} \right)^2 \right] \right\}. \tag{13}$$

18

Differentiating $T(\tau^*)$ with respect to I yields

$$\frac{dT(\tau^*)}{dI} = \underbrace{\frac{d\tau^*}{dI} \cdot \frac{T(\tau^*)}{\tau^*}}_{<0} - \tau^* \left[\frac{1+r}{r} \frac{\overline{\pi}^2}{2(\overline{\pi}-\underline{\pi})} \right] \cdot \left\{ \left(\frac{1}{1-\tau^*} \right)^2 + \frac{2\kappa}{(1-\tau^*)^3} \cdot \underbrace{\frac{d\tau^*}{d\kappa}}_{<0} \right\} \cdot \underbrace{\frac{d\kappa}{dI}}_{>0}.$$

Since

$$\left\{ \left(\frac{1}{1-\tau^*} \right)^2 + \frac{2\kappa}{(1-\tau^*)^3} \cdot \underbrace{\frac{d\tau^*}{d\kappa}}_{<0} \right\} = \frac{1}{(1-\tau^*)^2} \left\langle 1 - \left\{ \frac{\frac{2\kappa}{(1-\tau^*)^3}}{\frac{2\kappa}{(1-\tau^*)^3} + \frac{\left(\frac{1}{2}-\frac{\tau^{*2}}{n}\right)}{\left[\tau^*+(1-\tau^*)\left(\frac{1}{2}-\frac{\tau^*}{n}\right)\right]^2}} \right\} \right\rangle > 0,$$

we have $\frac{dT(\tau^*)}{dI} < 0$.

Let us next analyze the sign of $\frac{dT(\tau^*)}{d\overline{\pi}}$. Differentiating (13) with respect to $\overline{\pi}$ yields

$$\frac{dT(\tau^*)}{d\overline{\pi}} = \underbrace{\underbrace{\frac{\partial\tau^*}{\partial\overline{\pi}}}_{>0} \cdot \frac{T(\tau^*)}{\tau^*} + \left(\frac{1+r}{2r}\right)\tau^* \left\{ 1 + \left[\frac{\overline{\pi}^2-2\overline{\pi}\frac{\pi}{2}}{(\overline{\pi}-\underline{\pi})^2}\right]\left[1 - \kappa\left(\frac{1}{1-\tau^*}\right)^2\right] \right\}}_{>0}$$

$$- \tau^* \left[\frac{1+r}{r} \frac{\overline{\pi}^2}{2(\overline{\pi}-\underline{\pi})} \right] \underbrace{\left\{ \left(\frac{1}{1-\tau^*} \right)^2 + \frac{2\kappa}{(1-\tau^*)^3}\frac{d\tau^*}{d\kappa} \right\}}_{>0} \cdot \underbrace{\frac{d\kappa}{d\overline{\pi}}}_{<0}$$

Therefore, it is sufficient that $\overline{\pi}$ is high enough to have $\left\{ 1 + \left[\frac{\overline{\pi}^2-2\overline{\pi}\frac{\pi}{2}}{(\overline{\pi}-\underline{\pi})^2}\right]\left[1 - \kappa\left(\frac{1}{1-\tau^*}\right)^2\right] \right\} > 0$, and hence $\frac{dT(\tau^*)}{d\overline{\pi}} > 0$. The Proposition is thus proven.∎

6.6 Proof of Corollary 2

Rewriting the equilibrium condition (9) as

$$1 = \frac{\kappa}{(1-\tau^*)^2} - \frac{\tau^*}{\tau^* + (1-\tau^*)\left(\frac{1}{2}-\frac{\tau^*}{n}\right)} \tag{14}$$

and differentiating (14) yields

$$0 = \frac{\partial\left[\frac{\tau^*}{\tau^*+(1-\tau^*)\left(\frac{1}{2}-\frac{\tau^*}{n}\right)}\right]}{\partial\tau^*} d\tau + \frac{\partial\left[\frac{\kappa}{(1-\tau^*)^2}\right]}{\partial\tau^*} d\tau + \frac{\partial\left[\frac{\tau^*}{\tau^*+(1-\tau^*)\left(\frac{1}{2}-\frac{\tau^*}{n}\right)}\right]}{\partial n} dn,$$

where

$$\frac{\partial\left[\frac{\tau^*}{\tau^*+(1-\tau^*)\left(\frac{1}{2}-\frac{\tau^*}{n}\right)}\right]}{\partial n} = -\frac{(1-\tau^*)\left(\frac{\tau^*}{n}\right)^2}{\left[\tau^*+(1-\tau^*)\left(\frac{1}{2}-\frac{\tau^*}{n}\right)\right]^2} < 0,$$

$$\frac{\partial\left[\frac{\kappa}{(1-\tau^*)^2}\right]}{\partial\tau^*} = \frac{2\kappa}{(1-\tau^*)^3} > 0,$$

$$\frac{\partial\left[\frac{\tau^*}{\tau^*+(1-\tau^*)\left(\frac{1}{2}-\frac{\tau^*}{n}\right)}\right]}{\partial\tau^*} = \frac{\frac{1}{2}-\frac{\tau^{*2}}{n}}{\left[\tau^*+(1-\tau^*)\left(\frac{1}{2}-\frac{\tau^*}{n}\right)\right]^2}.$$

It is worth noting that condition (9) entails that $f(\tau^*) = \left(\frac{1}{2} - \frac{\tau^*}{n}\right) > 0$. This implies that $\left(\frac{1}{2} - \frac{\tau^{*2}}{n}\right) > 0$, and thus $\frac{\partial\left[\frac{\tau^*}{\tau^*+(1-\tau^*)\left(\frac{1}{2}-\frac{\tau^*}{n}\right)}\right]}{\partial\tau^*} > 0$. Given the above results, it is straightforward to show that $\frac{d\tau^*}{dn} > 0$. This concludes the proof of the first part of Corollary 2.

Let us next analyze the impact of n on $T(\tau^*)$. Differentiating (13) with respect to n yields

$$\frac{dT(\tau^*)}{dn} = \left[\frac{T(\tau^*)}{\tau^*} - \left(\frac{1+r}{2r}\right)\tau^*\frac{2\kappa}{(1-\tau^*)^3}\right]\cdot\underbrace{\frac{d\tau^*}{dn}}_{>0}. \qquad (15)$$

Substituting (13) into (15) one obtains

$$\frac{dT(\tau^*)}{dn} = \left(\frac{1+r}{2r}\right)\left\{\overline{\pi}+\underline{\pi}+\frac{\overline{\pi}^2}{(\overline{\pi}-\underline{\pi})}\cdot\left[1-\kappa\left(\frac{1}{1-\tau^*}\right)^2\right] - \frac{2\kappa}{(1-\tau^*)^3}\right\}\cdot\underbrace{\frac{d\tau^*}{dn}}_{>0}.$$

A sufficient condition for $\frac{dT(\tau^*)}{dn}$ to be positive is that $\overline{\pi}$ is high enough. This proves the second part of Corollary 2.∎

6.7 Proof of Proposition 2

Notice that κ embodies the overall effect of volatility, under the mean-preserving condition. Moreover recall that Lemma 1 shows that, under Assumption 1, an increase in volatility can be modelled as an increase in either u or d. Thus differentiating κ with respect to u yields $\frac{d\kappa}{du} > 0$. As shown in Corollary 1, we have $\frac{d\tau^*}{d\kappa} < 0$. This implies that $\frac{d\tau^*}{du} < 0$: namely an increase in volatility (or, equivalently, in u) leads a decrease in the equilibrium tax rate.

Let us then analyze the effect of volatility on tax revenues. Using (13) one easily

obtains

$$\frac{dT(\tau^*)}{d\kappa} \propto \frac{d\left\{\tau^*\left[\left(2-\frac{\pi^2}{\pi^2}\right)-\kappa\left(\frac{1}{1-\tau^*}\right)^2\right]\right\}}{d\kappa} =$$

$$= \left[\left(2-\frac{\pi^2}{\pi^2}\right)-\kappa\left(\frac{1}{1-\tau^*}\right)^2\left(\frac{1+\tau^*}{1-\tau^*}\right)\right]\cdot\underbrace{\frac{d\tau^*}{d\kappa}}_{<0} - \underbrace{\left[\tau^*\left(\frac{1}{1-\tau^*}\right)^2\right]}_{>0}. \tag{16}$$

As previously shown, we have $\frac{d\tau^*}{d\kappa} < 0$. Moreover we have $\left[\tau^*\left(\frac{1}{1-\tau^*}\right)^2\right] > 0$. If, therefore,

$$\left[\left(2-\frac{\pi^2}{\pi^2}\right)-\kappa\left(\frac{1}{1-\tau^*}\right)^2\frac{1+\tau^*}{1-\tau^*}\right] > 0, \tag{17}$$

then we have $\frac{dT(\tau^*)}{d\kappa} < 0$. Manipulating condition (9) one obtains

$$\frac{\kappa}{(1-\tau^*)^2} = \frac{\left(\frac{1}{2}-\frac{\tau^*}{n}\right)}{\frac{\tau^*}{1-\tau^*}+\left(\frac{1}{2}-\frac{\tau^*}{n}\right)} = \frac{(1-\tau^*)\left(\frac{1}{2}-\frac{\tau^*}{n}\right)}{\tau^*+(1-\tau^*)\left(\frac{1}{2}-\frac{\tau^*}{n}\right)} \in (0,1). \tag{18}$$

Moreover, notice that for $\tau^* > 0$ we have $\left(\frac{1}{2}-\frac{\tau^*}{n}\right) \in \left(0,\frac{1}{2}\right)$. Therefore, substituting (18) into (17) yields

$$2-\frac{\pi^2}{\pi^2}-\left[\frac{(1-\tau^*)\left(\frac{1}{2}-\frac{\tau^*}{n}\right)}{\tau^*+(1-\tau^*)\left(\frac{1}{2}-\frac{\tau^*}{n}\right)}\right]\frac{1+\tau^*}{1-\tau^*} = 2-\underbrace{\left(\frac{\pi^2}{\pi^2}\right)}_{<1}-\underbrace{\frac{\left(\frac{1}{2}-\frac{\tau^*}{n}\right)+\tau^*\left(\frac{1}{2}-\frac{\tau^*}{n}\right)}{\left(\frac{1}{2}-\frac{\tau^*}{n}\right)+\tau^*\left[1-\left(\frac{1}{2}-\frac{\tau^*}{n}\right)\right]}}_{<1} > 0.$$

This implies that $\frac{dT(\tau^*)}{d\kappa} < 0$.

Finally, notice that a shift from a stochastic context to a deterministic one (i.e. with $d = u = 0$) causes a downward shift of function $\kappa g(\tau)$, thereby leading to a higher tax rate and, hence, to an increase in tax revenues. This completes the proof of Proposition 2.∎

References

[1] Aizenman, J. and N. Marion (2004), The Merits of Horizontal versus Vertical FDI in the Presence of Uncertainty, *Journal of International Economics*, 62, pp. 125-148.

[2] Alvarez, L.H.R and V. Kanniainen (1997), Valuation of Irreversible Entry Options under Uncertainty and Taxation, CESifo working paper no. 144.

[3] Bernanke, B.S. (1983), Irreversibility, Uncertainty, and Cyclical Investment, *Quarterly Journal of Economics*, 98, pp. 85-103.

[4] Chen, C. and R.W. So (2002), Exchange Rate Variability and the Riskiness of US Multinational Firms: Evidence from the Asian Financial Turmoil, *Journal of Multinational Financial Management*, 12, pp. 411-428.

[5] Desai, A.M. and F.C. Foley (2004), The Comovement of Returns and Investment within the Multinational Firm, NEBR Working paper series No. 10785.

[6] Devereux, M.P. and R. Griffith (1998), Taxes and the Location of Production: Evidence from a Panel of US Multinationals, *Journal of Public Economics*, 68, pp. 335-367.

[7] Devereux, M.P. and R. Griffith (2002), The Impact of Corporate Taxation on the Location of Capital: A Review. *Swedish Economic Policy Review* 9 (1), pp. 79-102.

[8] Dixit, A. and R.S. Pindyck (1994), *Investment under Uncertainty*, Princeton University Press.

[9] Graham, J.R. and C.R. Harvey (2001), The Theory and Practice of Corporate Finance: Evidence from the Field, *Journal of Financial Economics*, 60, pp. 187-243.

[10] Gresik, T. (2001), The Taxing Task of Taxing Transnationals, *Journal of Economic Literature*, 39, pp. 800-838.

[11] Haufler, A. and G. Schjelderup (1999), Corporate Taxation, Profit Shifting and the Efficiency of Public Input Provision, *FinanzArchiv*, 56 (3/4), pp. 481-499.

[12] Haufler, A. and G. Schjelderup (2000), Corporate Tax Systems and Cross Country Profit Shifting, *Oxford Economic Papers*, 52, pp. 306-325.

[13] Hines, J.R. (1999), Lessons from Behavioral Responses to International Taxation, *National Tax Journal*, 52, pp. 304-322.

[14] Keen, M. (1993), The Welfare Economics of Tax Co-ordination in the European Community: A Survey. *Fiscal Studies* 14, pp. 15-36.

22

[15] Kind, H.J., K. H. Midelfart, and G. Schjelderup (2005). Corporate Tax Systems, Multinational Enterprises, and Economic Integration. *Journal of International Economics*, 65, pp. 507-521.

[16] Mackie-Mason, J.K. (1990), Some Nonlinear Tax Effects on Asset Values and Investment Decisions under Uncertainty. *Journal of Public Economics* 42, pp. 301-327.

[17] Markusen, J. (2002), *Multinational Firms and the Theory of International Trade*, MIT Press, Cambridge.

[18] McDonald, R. (2000), Real Options and Rules of Thumb in Capital Budgeting, in M.J. Brennan and L. Trigeorgis (editors), *Project Flexibility, Agency, and Competition, New Developments in the Theory and Application of Real Options*, Oxford University Press.

[19] McDonald, R. and D. Siegel (1986), The Value of Waiting to Invest, *Quarterly Journal of Economics*, 101, pp. 707-728.

[20] Panteghini, P.M. (2003), A Dynamic Measure of the Effective Tax Rate, *Economics Bulletin*, 8, No. 15, pp. 1-7.

[21] Panteghini, P.M. and G. Schjelderup (2003), Competing for Foreign Direct Investments: A Real Options Approach, CESifo Working Paper No. 929.

[22] Trigeorgis, L. (1996), *Real Options, Managerial Flexibility and Strategy in Resource Allocation*, The MIT Press.

[23] Wilson, J.D. (1986), A Theory of Interregional Tax Competition, *Journal of Urban Economics* 19, pp. 296-315.

[24] Wilson, J.D. (1999), Theories of Tax Competition, *National Tax Journal*, 52, pp. 269-304.

[25] Wilson, J.D. and D.E. Wildasin (2004), Capital Tax Competition: Bane or Boon?, *Journal of Public Economics*, 88, pp. 1065-1091.

[26] Zodrow, G and P. Mieszkowski (1986), Pigou, Tiebout, Property Taxation and the Underprovision of Local Public Goods, *Journal of Urban Economics*, 19, pp. 356-370.
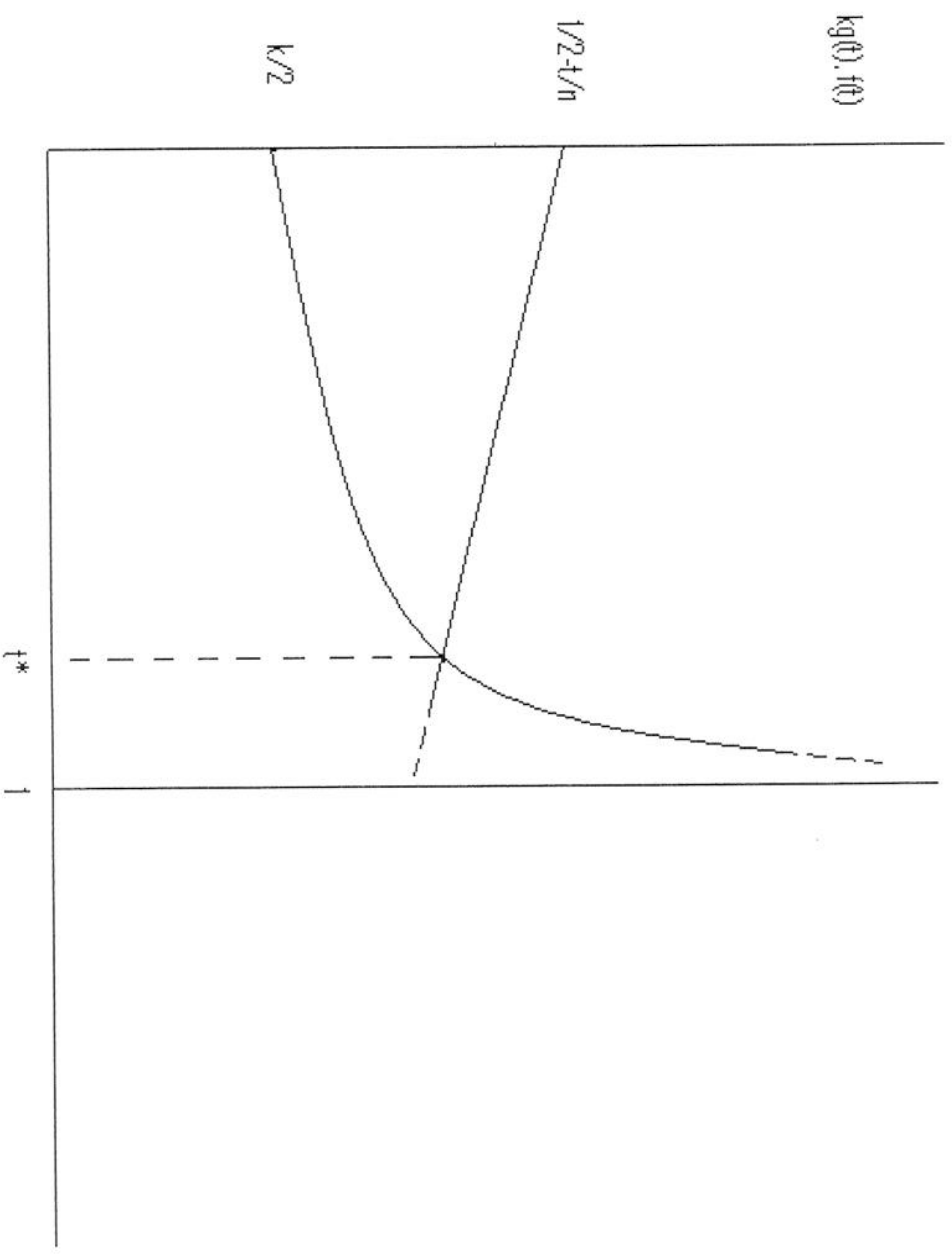
Figure 1: The equilibrium condition (9)

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