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A REAL OPTIONS APPROACH TO FDIS AND TAX COMPETITION

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

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Abstract

This paper explores how taxes on corporate income are set when countries compete to attract foreign direct investments (FDIs), and multinationals can shift profit as well as decide on the timing of their FDIs. Central to the analysis is the Bad News Principle which is used to analyze the effect of tighter economic integration on tax policy. A deepening of the integration process is interpreted as more firms undertake FDIs (increased foreign market openness) or/and as profits become more variable and volatile. We show that increased volatility lowers equilibrium tax rates and tax revenue and leads to a fall in welfare. In contrast, a rise in foreign market openness implies higher tax rates and tax revenue and improves welfare.

JEL classification: H25.

Keywords: Corporate taxation, irreversibility, MNE, real options and uncertainty.

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1 Introduction

There is mounting evidence suggesting that the globalization process has made the world economy less predictable and more variable. The increase in variability has been attributed to increased international mobility of factors and goods; the deregulation of national capital controls and creation of new financial markets; the entry of new countries in international trade, international outsourcing of production on a large scale and, finally, the formidable rise in the use of skill-biased technology (e.g., computers, the internet, biotechnology, etc.).[1] Skill-biased technology proceeds at an uneven and unpredictable pace and interacts with the factors above in ways that often are hard to predict. The globalization process as outlined above is especially relevant for multinational enterprises (MNEs) because the defining activity of MNEs is foreign direct investments (FDI). If globalization means more volatility one would expect this to affect the flow of FDIs and/or how FDIs are undertaken (greenfield investments versus Mergers and Acquisitions).

There has been substantial interest in MNEs since the flows of FDI have grown at substantial rates the last two decades, outstripping the rate of growth of both world output and international trade. Increased capital mobility and the ability to use skill-biased technology in almost any country have lead countries to compete to attract FDIs. In recent years an extensive body of theoretical literature has appeared, which almost unanimously concludes that high taxes have a significantly negative effect on the likelihood of a country attracting FDI.[2] In principle, there are two types of capital tax competition to attract FDIs: competition for physical capital and competition for (paper) profits (see Devereaux (1992)). A multinational firm can exploit this by locating capital in the country which offers the most favorable capital investment scheme. Later, once it starts to generate profits, it can shift some of its taxable profits to a country that offers low statutory tax rates. This two-step strategy means that a multinational firm can save tax payments relative to domestic firms, but it also has the implication that national tax bases become more tax sensitive.

The starting point of the theoretical literature on tax competition is that opening up the world economy to capital mobility introduces competition among countries

[1] See Heckman (2003).

[2] See Hines (1999) for a survey of US MNE behavior and Haufler (2001) for European MNEs.

for internationally mobile capital. A country that cuts its capital tax rate to attract FDI or portfolio investments typically ignores the resulting fall in tax revenue in other countries.[3] The negative fiscal externality arising from such behavior leads to too low taxes and underprovision of public goods in a Nash equilibrium. It is worth pointing out that increased globalization in the standard literature is taken to imply that more countries compete to attract capital and this aggravates the underprovision result. An underlying premise in all these studies is that capital investment is fully reversible or, alternatively, that capital investment is irreversible but characterized by exogenous investment timing.[4] 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*".

In this paper we argue that the description above by Dixit and Pindyck 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.[5] Thus, managers behave as if they owned option-rights thereby computing the optimal investment (exercise) timing. In slight abuse of language, in what follows we will sometimes refer to the situation when managers have the option to delay their FDIs as the now-or-later case, whilst the situation where managers cannot time their decisions is labelled the now-or-never case.

The paper uses 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, 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

[3] See Zodrow and Mieszkowski (1986) and Wilson (1986), and the survey by Wilson (1999).

[4] Surveys of this literature are given in Wilson (1999) and Wilson and Wildasin (2004).

[5] 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.

factors in the domestic economy. Second, in line with the discussion above we allow firms to time their FDI decisions. Waiting to undertake an investment entails an option that - as will become clear later - 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.

Firms can either undertake FDI at time 0 or, alternatively, they can wait and decide whether to invest at time 1. Waiting entails an option and our *first research objective* is to use real-option theory to analyze how the ability to postpone FDI decisions affects firm behavior under taxation[6]. This topic has been examined in a small but emerging literature on the theory of entry of a new firm under taxation[7]. With a few exceptions[8], however, the effects of taxation in an international setting have been disregarded by this literature.

Our *second research objective* is to examine the outcome of tax competition among countries when FDIs are risky and firms can time their FDIs. From the tax competition literature it is well known that competition to attract mobile capital results in too low taxes, underprovision of public goods and lower welfare, and the issue at heart here is if these results carry over if firms can delay their risky FDIs decisions.

Our *third and final research objective* is to analyze the impact of increased globalization on the outcome of tax competition. Tighter economic integration can be interpreted in at least two ways. First, it may imply that more firms undertake FDI, for a given level of volatility. We refer to this as an increase in foreign market openness. The second way of modeling tighter economic integration is to side with the evidence suggesting that the globalization process has made the world economy less predictable and more variable. In our setting this translates into more variable and

[6]If the future is uncertain and in the absence of taxation, it is well known from early contributions that it is optimal for a firm considering to invest, to choose a rather high premium in terms of expected rents (profit) relative to the immediate cost of entry (see e.g. McDonal and Siegel, 1986).

[7]See e.g. the pioneering article by Mackie-Mason (1990), who 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. Moreover, Alvarez and Kanniainen (1997) analyze the tax effects on a potential firm with an irreversible entry option and risky post-entry profit. For further details see the articles quoted in Panteghini (2001).

[8]See e.g. Panteghini (2003).

volatile profit for the firm.

To answer these questions we assume the existence of two countries. Each country plays host to a continuum of firms that must decide whether to undertake FDI in the first or the second period. Once an investment is undertaken the MNE can shift profits to the country with the lower level of profit taxes. Such profit shifting behavior is confirmed by many studies and these studies also find that the amount of profit shifted depends on the difference in statutory tax rates between countries.[9] Our model, as will become clear later, triggers profit shifting when statutory tax rates differ, and the amount of profit shifted depends on the difference between statutory tax rates as well as the cost of engaging in transfer pricing (which is illegal in most countries if the transfer price deviates from arm's length prices).

The structure of the article is as follows. Section 2 outlines the basic principles used in the analysis pertaining to 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 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

[9] It is well known in the tax competition literature that multinationals shift profits by way of transfer prices, and the role of statutory tax rates is documented in Hines (1999). For surveys on transfer pricing and multinationals see Hines (1999) and Gresik (2001).

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

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

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

Subtracting (1) from (2) yields the option to delay as $\max\left\{NPV_{1,A},0\right\}$. 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.[11]

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

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

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

Firms usually have the opportunity to expand production both at home and abroad. A reasonable assumption is 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 at play in the home country. In order to capture this difference we assume that expanding activity at home does not entail the payment of any sunk cost whereas FDIs do. Thus, home investment opportunities can be exploited without any delay. We also assume that there do not exist scale and/or scope economies so that home and foreign investment opportunities can be treated separately. This assumption allows us to focus on profits from FDIs.

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 negative $j=-d$. Parameters u and d are positive and measure the downward and upward 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.[12] Risk is fully diversifiable and both countries are assumed to be small so

[12] 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

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, the expected current payoff is equal to the payoff faced by the firm at time 0.

Foreign profits are taxed at the rate τ_B. 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).

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 $\beta \lesseqgtr 0$. 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 $v(\beta)$. The cost element may be interpreted as the hiring of lawyers or consultants to conceal the illegality of the transaction.[13]

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

$$\Pi_A^N(j)=(1-\tau_A)\pi_A+(1+j)\left[(1-\tau_B)+\phi(\beta)\right]\pi_B, \tag{4}$$

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

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

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 and of the

factor) rather then their lenght.

[13]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 (2000) for a more detailed discussion.

form $\nu(\beta) \equiv \beta^2/2$. Differentiating (4) with respect to the transfer pricing variable β, one obtains the optimal level of profit shifting

$$\beta_A^* = \beta \mid \nu'(\beta) = \tau_A - \tau_B. \tag{5}$$

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.[14] In what follows we use the optimal profit shifting condition (5) in the maximization problem, since the firm can decide up front on how much it wants to shift of the profits,

$$\Pi_A^N(j, \beta_A^*) \equiv \max_\beta \Pi_A^N(j).$$

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:*

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

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)

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

[14] 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 $v(\beta)$. 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.

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.[15]

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.[16] 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 many reasons. One may be the emerging threat of terrorism, another political instability, and a third liberalization of markets and the reduction of barriers to trade and foreign investments (as exemplified by WTO membership, say). Given the above assumption we can prove the following:

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

Proof. See the Appendix.

An increase in volatility means that good news gets better and bad news gets

[15] 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].

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

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 and thus leads to a higher trigger point.

A final comment pertains to effective sunk cost of investing abroad $\tilde{I}$. From the definition of $\tilde{I}$ it can be seen that the greater the net tax savings from profit shifting and transfer pricing (i.e., the higher ϕ), the lower is the sunk cost of investing $\tilde{I}$. The impact of $\tilde{I}$ on the firm's FDI decision does also depend on volatility. From LEMMA 1 we have that the higher the degree of volatility, the greater is the impact of a given percentage of profits shifted on the propensity to invest. The implication of LEMMA 1 is that in the deterministic case (no volatility), the 'subsidy' from profit shifting on FDI is at its lowest, and a rise in volatility increases the importance of profit shifting as a facilitator of FDI. It turns out that these properties are useful for results to follow.

The result of Lemma 1 is in line with empirical evidence, which shows a negative relationship between uncertainty and firms' propensity to undertake FDIs.[17] In our model a lower propensity to invest is modelled with a rise in the trigger point.[18]

Our discussion so far has aimed at analyzing investment decisions when the firm makes both intertemporal and locational choices in a tax environment with profit shifting. The setup captures the main features of how multinationals act as well as the tax implications. In the next section we analyze the impact on tax rates if countries compete to attract investments from firms.

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[17] 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) fairly 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.

[18] One might argue that globalization reduces the impact of uncertainty on FDIs, by means of hedging activities in more integrated markets. However, Goetzman et al. (2002) have found that, in the last two decades, correlations of the major markets have substantially increased. Moreover, the benefits to international diversifications have been primarily ensured by small emerging capital markets, 'where the costs and risks of international investing are potentially high' (p.5). These factors undermined the beneficial effects of hedging activities.

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. We 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 necessary 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.[19] Secondly, they imply that bad news entails a loss.

In order to be able 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.

An interesting question is how globalization might affect FDI and how we can define globalization in our framework. Albuquerque et al. (2003) find that the huge increase in FDI activities is driven by *global factors* (such as the exploitation of economies of scale and lower transportation costs) as well as *local factors* (such as the relative abundance of skilled labour in low cost countries, local taxes, and country-specific risk). In line with Albuquerque et al. (2003), we define a decrease in I and/or an increase in $\overline{\pi}$ as an increase in the weight of global factors. We refer to this as an increase in foreign market openness. This may happen either if profit opportunities abroad become brighter, or if the sunk cost of FDI falls.

Changes in the tax rate and the bivariate shock of Assumption 1 are considered as local factors of the globalization process. This second way of modeling tighter economic integration is to side with the evidence that suggests that globalization has made the world economy less predictable and more variable (see e.g., Heckman

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

2003). More volatility would then be interpreted as a deepening of the globalization process. Volatility is related to the parameters d, u, and q, which affect the value of the firms' real options and thus the timing decision.

In what follows we analyze how both an increase in market access and volatility affect taxes, tax revenue and welfare, but before we do this we set up the social welfare function. Since firms incur additional costs by investing abroad relative to home investments, firms will 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.

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. [20] 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 the NPVs of home companies investing at time 0, net of tax-revenues outflows caused by profit shifting, that is,

$$\begin{aligned}&\int_{\pi_B^*}^{\overline{\pi}} \left\{ \tfrac{1+r}{r} \left[(1-\tau_B) + \phi\left(\beta_A^*\right) - \tau_A \beta_A^* \right] x - I \right\} f(x) dx = \\ &= \tfrac{1+r}{r} \tfrac{\overline{\pi}^2 - \pi_B^{*2}}{2(\overline{\pi} - \underline{\pi})} \left[(1-\tau_B) + \phi\left(\beta_A^*\right) - \tau_A \beta_A^* \right] - \left(\tfrac{\overline{\pi} - \pi_B^*}{\overline{\pi} - \underline{\pi}} \right) I,\end{aligned}$$

plus the summation of NPVs of home companies investing at time 1, net of tax-revenue outflows caused by profit shifting, i.e.,

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

plus the net tax revenue raised from foreign companies which invest at time 0, net

[20] The actual expressions and a more detailed description as well as the computations are given in the Appendix.

of tax-revenue outflows caused by profit shifting

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

and the net tax revenue raised from foreign companies which invested at time 1 net of tax-revenue outflows caused by profit shifting

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

where

$$\widetilde{\pi}_i = \pi_i \mid \frac{(1+u)\left[(1-\tau_B) + \phi\left(\beta\right)\right] \pi_B}{r} - \frac{I}{1+r} = 0 \text{ for } i = A, B,$$

measures the threshold level of profit above which investing at time 1 is profitable, under the good state. Collecting the above four terms and calculating the effects on these from policy yields the solution to the game.

Solving this game it is straightforward to establish that

PROPOSITION 1. *A unique symmetric Nash equilibrium tax rate $\tau^* \epsilon \ (0,1)$ exists, such that*

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

where

$$f(\tau) \equiv \frac{1}{2}\left(1-\tau\right), \quad \kappa \equiv \left(1-2\gamma\right) a^2 < 1, \qquad \gamma \equiv \left\{ \frac{q}{1+r} \frac{\left[1 - \left(\frac{1}{1+u}\frac{1}{\eta}\right)^2\right]}{2} (1+u) \right\},$$

$$a \equiv \frac{\eta \frac{r}{1+r} I}{\overline{\pi}}, \quad g\left(\tau\right) \equiv \left[\frac{\tau}{1-\tau} + f(\tau)\right] \frac{1}{\left(1-\tau\right)^2}.$$

PROOF. See the Appendix.

The implicit optimal tax formula in equation (9) equates at the margin the social cost of taxation, $f(\tau)$, to its social benefit, i.e. $[(1-2\gamma)\, a^2]\, g\,(\tau)$. A high tax reduces profits of domestic firms, but increases tax revenue from foreign firms. Equation (9) shows that the marginal benefit of taxation depends on both the number of firms that undertake FDI and the volatility of the return to FDI. In particular, the term γ measures the overall effect of volatility on the marginal benefit from FDI. The term

$\frac{1}{a}$ is a proxy for foreign market openness: *coeteris paribus*, the lower is the $\frac{I}{\overline{\pi}}$ ratio (i.e. the sunk cost I on the maximum expected return at time 0, i.e. $\overline{\pi}$), the greater is the number of firms which can invest abroad. Put differently, more firms invest abroad if profits abroad rise ($\overline{\pi}$ goes up) or if it becomes less costly to invest abroad (I falls).

We now turn to investigating how a deepening of the globalization process affects taxes, tax revenue and welfare. An enhanced globalization process could either imply more volatility, or that the foreign market becomes more attractive. Our next result pertains to the first interpretation. We have:

PROPOSITION 2: *Increased volatility of profit income lowers the equilibrium tax rate τ^*, reduces tax revenue, and leads to lower welfare.*

Proof. See the Appendix.

The intuition behind Proposition 2 is straightforward.[21] For given tax rates, an increase in volatility raises the investment trigger point. This induces more firms to delay their investment. On the one hand, therefore, the number of firms investing at time 0 decreases. On the other hand, only a fraction of firms will receive good news and then invest at time 1. This entails that not all the firms that found it optimal to delay FDI because of increased volatility will actually invest at time 1. For this reason, an increase in volatility reduces the overall number of firms involved in FDI activities.

The policy response is to lower the tax rate in order to alleviate the negative impact of increased volatility. However, Proposition 2 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.

Let us finally focus on the welfare effect. As we have seen, the rise in the trigger point means that, on the one hand, fewer firms will find it profitable to invest at time 0. On the other hand, the number of firms investing in period 1 increases. As we have pointed out, however, an increase in volatility reduces the overall number of multinational firms, and the overall amount of profits, thereby making the negative

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

effect of period 0 outweigh the positive effect of period 1. Hence, an increase in volatility is welfare deteriorating.

Let us next turn to the effects of market openness. We can prove the following:

PROPOSITION 3: *For a given level of volatility, an increase in market openness (caused by either an increase in $\overline{\pi}$ or a decrease in I) leads to a rise in the equilibrium tax rate τ^*, an increase in tax revenue, and higher welfare.*

Proof. See the Appendix.

The interpretation of Proposition 3 is as follows. A rise in foreign market openness - through a rise in $\overline{\pi}$ 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, an increase in the number of multinational firms widens the overall tax base. Hence, both higher tax rates and wider tax bases have a positive effect on tax revenue.

Finally, an increase in average profitability raises the number of multinational firms. This means more profit from FDI and, subsequently, an increase in welfare.

5 Conclusion

We have discussed two different interpretations of intensified globalization (increased volatility and foreign attractiveness). It may be the case that both these effects are present at the same time. Our analysis shows that it may then be very difficult to draw firm conclusions on how taxes, tax revenue and welfare are affected. A more volatile world economy lowers taxes, tax revenue and welfare, while increased foreign attractiveness has the opposite effect. Which of these two effects dominates depends on their relative magnitude. Different from the standard tax competition literature, then, is our insight that if globalization means that the foreign market becomes more attractive (so more firms invest), we arrive at the conclusion that welfare rises and taxes go up. Our result here is similar in nature to trade theory where it is well known that a reduction in trade barriers is welfare enhancing. It should be noted that our scenario of globalization where FDIs become more attractive is perhaps the one which is close to the standard tax competition where intensified globalization means that more countries compete. In our setting more firms are investing while the number of countries is fixed. One insight is then that the conclusions are qualitatively different; the standard tax competition ends up with a fall in taxes, tax revenue and welfare, whilst we can obtain the opposite.

The empirical evidence on taxes and tax revenue is quite clear. On the one hand, statutory tax rates for large samples of countries in general show a declining trend, although it is possible to find countries where the tax on capital has risen.[22] On the other hand, tax revenues on corporate income as proportion of GDP have remained stable or even gone up for some countries since the early 1960s.[23] The fall in tax rates fits with the interpretation that the globalization process has lead to increased volatility. However, the hypothesis that profits have become more volatile leads to a fall in tax revenue and thus fails to explain the empirical findings of stable tax revenue over time (as does the entire tax competition literature). Such stability may be due to the second possible explanation we offer, namely the fall in trade barriers, which resembles our second interpretation of globalization. As pointed out in Proposition 3, the foreign market opens up in the sense that more firms undertake FDI. This may offset the increase in volatility and make the net effect on tax revenue close to zero.

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:

$$NPV_0 = \left[(1-\tau_B) + \phi(\beta)\right]\frac{1+r}{r}\pi_B - I.$$

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

[22] For empirical facts related to capital mobility and taxation see e.g., Devereaux, Griffith and Klemm (2002).

[23] An example of this is Finland, which has become significantly more integrated with the world economy after the collapse of the Soviet Union. Finland set the tax on capital at an initial low level of 25 percent, but has later increased it to 29 percent. For further details, see Devereaux and Griffith (1998).

$$NPV_1 = q\left\{\frac{(1+u)\left[(1-\tau_B)+\phi(\beta)\right]\pi_B}{r} - \frac{I}{1+r}\right\}.$$

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

$$d = \frac{q}{1-q}u. \tag{10}$$

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

$$\frac{\partial W_A}{\partial \tau_A} = 0. \tag{11}$$

Dividing by $(\overline{\pi} - \underline{\pi})$ and assuming symmetry ($\tau_A = \tau_B = \tau$) one obtains

$$\begin{aligned}(\overline{\pi} - \underline{\pi})^{-1}\frac{\partial W_A}{\partial \tau_A} &= -\tau\frac{1+r}{r}\frac{\overline{\pi}^2-(\pi^*)^2}{4} + \frac{1+r}{r}\left[-\frac{\tau}{1-\tau}(\pi^*)^2 + \frac{\overline{\pi}^2-(\pi^*)^2}{2}\left(1-\frac{\tau}{2}\right)\right] - \\ &-\gamma\left\langle\left(\frac{\tau}{2}\right) - \left\{2\frac{\tau}{1-\tau} + \left[1-\left(\frac{\tau}{2}\right)\right]\right\}\right\rangle(\pi^*)^2 = 0\end{aligned} \tag{12}$$

where

$$\pi^* = \frac{\eta\frac{r}{1+r}I}{1-\tau},$$

and

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

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 $\gamma < \frac{1}{2}$ always holds. Dividing (12) by $\frac{1+r}{r}$, and collecting the terms with $(\pi^*)^2$ yields

$$\frac{1}{2}(1-\tau)\overline{\pi}^2 + \left\{-(1-2\gamma)\frac{\tau}{1-\tau} - (1-\tau)\left(\frac{1}{2}-\gamma\right)\right\}(\pi^*)^2 = 0 \tag{13}$$

Let us recall that $a \equiv \frac{\eta \frac{r}{1+r} I}{\overline{\pi}}$. Given **Assumption 3** we thus have $\frac{\pi^*}{\overline{\pi}} = \frac{a}{1-\tau}$,which implies that $a < 1$. Define $\kappa \equiv (1-2\gamma)\, a^2$. Notice that $(1-2\gamma) \in (0,1)$. Moreover, given Assumption 2, we have $a^2 < 1$. Therefore, we obtain $\kappa \in (0,1)$.

Next divide both (13) by $\overline{\pi}^2$ so as to obtain (9).

Let us next study the functions

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

in the $[0,1)$ interval. It is straightforward to show that:

1. $f(\tau)$ is monotonically decreasing with $f(0) = \frac{1}{2} > \kappa g(0) = \frac{\kappa}{2}$, and $f(1) = 0$,
2. and that $g(\tau)$ is monotonically increasing, i.e. $\frac{\partial g(\tau)}{\partial \tau} = \frac{1}{(1-\tau)^3}\left[\frac{(2+\tau)-\frac{1}{2}\left(1-\tau^2\right)}{(1-\tau)}\right] > 0$ with $g(0) = \frac{1}{2}$ and $\lim_{\tau \to 1} g(\tau) = +\infty$.

Next compare the LHS and the RHS of (9) in Fig. 1.

$Fig.1$

By applying the Fixed Point Theorem, therefore, 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:

1. the present value of tax revenues paid by all the home (country A's) firms

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

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

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

3. tax revenues raised from those foreign companies (placed in country B) who invested at time 0, net of tax-revenue outflows due to profit shifting:
$$\int_{\pi_A^{**}}^{\overline{\pi}} \left\{ \frac{1+r}{r} \tau_A \left(1+\beta_B^*\right) x \right\} f(x)dx = \frac{1+r}{r} \frac{\overline{\pi}^2 - \pi_A^{*2}}{2\left(\overline{\pi} - \underline{\pi}\right)} \tau_A \left(1+\beta_B^*\right),$$

4. home companies' tax benefits due to profit shifting, when investment is undertaken abroad at time 1, net of tax-revenue outflows caused by profit shifting:
$$q \int_{\widetilde{\pi}_B}^{\pi_B^{**}} \left\{ \frac{(1+u)\left[-\tau_A \beta_A^*\right] x}{r} \right\} f(x)dx = -\frac{q}{r} \left[\frac{\pi_B^{*2} - \widetilde{\pi}_B^2}{2\left(\overline{\pi} - \underline{\pi}\right)} (1+u)\left(\tau_A \beta_A^*\right) \right],$$

5. tax revenues raised from foreign companies investing at time 1, net of tax-revenue outflows due to profit shifting:

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

Collecting the above terms yields country A's present value of tax revenues:

$$\begin{aligned} T_A\left(\tau_A, \tau_B\right) = \tau_A \Big\{ & \tfrac{1+r}{r} \tfrac{\overline{\pi}^2 - \underline{\pi}^2}{2(\overline{\pi} - \underline{\pi})} - \tfrac{1+r}{r} \tfrac{\overline{\pi}^2 - \pi_B^{*2}}{2(\overline{\pi} - \underline{\pi})} \beta_A^* + \\ + \tfrac{1+r}{r} \tfrac{\overline{\pi}^2 - \pi_A^{*2}}{2(\overline{\pi} - \underline{\pi})} \left(1+\beta_B^*\right) - \tfrac{q}{r} & \left[\tfrac{\pi_B^{*2} - \widetilde{\pi}_B^2}{2(\overline{\pi} - \underline{\pi})} (1+u)\beta_A^* \right] + \tfrac{q}{r} \tfrac{\pi_A^{*2} - \widetilde{\pi}_A^2}{2(\overline{\pi} - \underline{\pi})} (1+u)\left(1+\beta_B^*\right) \Big\}. \end{aligned} \tag{14}$$

The same procedure is followed to compute $T_B\left(\tau_A, \tau_B\right)$.

6.5 Proof of Proposition 2

Recall Lemma 1. Using (10) and differentiating with respect to u yields $\frac{\Delta\kappa}{\Delta u} > 0$. This entails that κ can be used as a proxy of volatility. As shown in Fig.2,

Fig. 2

an increase in κ leads to an upward shift of RHS of (9). This causes a decrease in the equilibrium tax rate τ^*.

Let us then analyze the effect of volatility on tax revenues. Under symmetry (14) reduces to

$$\begin{aligned} T(\tau^*) &= \tfrac{1+r}{r} \tfrac{\tau^*}{2(\overline{\pi} - \underline{\pi})} \left[\left(\overline{\pi}^2 - \underline{\pi}^2\right) + \left(\overline{\pi}^2 - {\pi^*}^2\right) + 2\gamma {\pi^*}^2 \right] = \\ &= \tau^* \left\{ \tfrac{1+r}{r} \tfrac{\overline{\pi}^2}{2(\overline{\pi} - \underline{\pi})} \left[\left(2 - \tfrac{\underline{\pi}^2}{\overline{\pi}^2}\right) - \kappa \left(\tfrac{1}{1-\tau^*}\right)^2 \right] \right\}. \end{aligned} \tag{15}$$

Let us now compute the derivative $\frac{dT(\tau^*)}{d\kappa}$. It is easy to ascertain that

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

where

$$\begin{gathered}\frac{d\left\{\tau^*\left[\left(2-\frac{\pi^2}{\overline{\pi}^2}\right)-\kappa{\pi^*}^2\right]\right\}}{d\kappa} = \left[\left(2-\frac{\pi^2}{\overline{\pi}^2}\right)-\kappa\left(\frac{1}{1-\tau^*}\right)^2\right]\frac{d\tau^*}{d\kappa}- \\ -\tau^*\left[\left(\frac{1}{1-\tau^*}\right)^2+2\kappa\left(\frac{1}{1-\tau^*}\right)^3\frac{d\tau^*}{d\kappa}\right],\end{gathered} \tag{16}$$

where the former term in the RHS is the direct effect on the tax rate and the latter one is effect on the tax base. Derivative (16) can rewritten as

$$\begin{gathered}\frac{d\left\{\tau^*\left[\left(2-\frac{\pi^2}{\overline{\pi}^2}\right)-\kappa\left(\frac{1}{1-\tau^*}\right)^2\right]\right\}}{d\kappa} = \\ = \left[\left(2-\frac{\pi^2}{\overline{\pi}^2}\right)-\kappa\left(\frac{1}{1-\tau^*}\right)^2\left(1+\frac{2\tau^*}{1-\tau^*}\right)\right]\frac{d\tau^*}{d\kappa}-\tau^*\left(\frac{1}{1-\tau^*}\right)^2.\end{gathered} \tag{17}$$

Notice that $\frac{d\tau^*}{d\kappa}<0$ (see the proof of Proposition 2) and $-\tau^*\left(\frac{1}{1-\tau^*}\right)^2<0$. To show that $\frac{dT(\tau^*)}{d\kappa}<0$, therefore, it is sufficient to prove that the first term of (17) is negative, or equivalently that

$$\left[\left(2-\frac{\pi^2}{\overline{\pi}^2}\right)-\kappa\left(\frac{1}{1-\tau^*}\right)^2\left(1+\frac{2\tau^*}{1-\tau^*}\right)\right]>0. \tag{18}$$

Rewrite (9) as

$$\frac{1-\tau^*}{2}=\kappa\left[\frac{\tau^*}{1-\tau^*}+\frac{1-\tau^*}{2}\right]\frac{1}{(1-\tau^*)^2}. \tag{19}$$

Multiply (19) by 2 and rewrite it as

$$\frac{\kappa}{(1-\tau^*)^2}\left(1+\frac{2\tau^*}{1-\tau^*}\right)=(1-\tau^*)+\frac{\kappa\tau^*}{(1-\tau^*)^2}. \tag{20}$$

Substituting (20) into (18) yields

$$\frac{\overline{\pi}^2-\underline{\pi}^2}{\overline{\pi}^2}+\tau^*\left[1-\frac{\kappa}{(1-\tau^*)^2}\right]>0.$$

According to Assumption 3, we have $\overline{\pi}^2>{\pi^*}^2$. This inequality entails that $\left(\frac{\pi^*}{\overline{\pi}}\right)^2=\left(\frac{a}{1-\tau^{**}}\right)^2<1$. Since $(1-2\gamma)<1$ for $u>0$, we obtain $\frac{(1-2\gamma)a^2}{(1-\tau^*)^2}=\frac{\kappa}{(1-\tau^*)^2}<\left(\frac{a}{1-\tau^*}\right)^2<1$. Therefore the term $\left[1-\frac{\kappa}{(1-\tau^*)^2}\right]$ is positive. Therefore the inequality

$$\frac{\overline{\pi}^2-\underline{\pi}^2}{\overline{\pi}^2}+\tau^*\left[1-\frac{\kappa}{(1-\tau^*)^2}\right]>0 \tag{21}$$

always holds. Inequality (21) is sufficient to state that

$$\frac{dT(\tau^*)}{d\kappa} \propto \frac{d\left\{\tau^*\left[\left(2-\frac{\pi^2}{\overline{\pi}^2}\right)-\kappa\left(\frac{1}{1-\tau^*}\right)^2\right]\right\}}{d\kappa} < 0. \tag{22}$$

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 $g(\tau)$, thereby leading to a higher tax rate and, hence, to an increase in tax revenues.

Let us finally analyze the effect of volatility on welfare. Under symmetry, the welfare function (8) reduces to $W_i|_{\tau_A=\tau_B=\tau} \equiv W$, where

$$\begin{aligned} W = \tfrac{1+r}{r}\tfrac{\overline{\pi}^2-\pi^{*2}}{2} - \left(\overline{\pi}-\pi^*\right)I + \\ -\tfrac{q}{r}\left[\left(1-\tfrac{1}{1+u}\tfrac{1}{\eta}\right)\pi^*\tfrac{r}{1+r}I\right] + \tfrac{q}{r}(1+u)\tfrac{\left[\left(1-\frac{1}{1+u}\frac{1}{\eta}\right)\pi^*\right]^2}{2} = \end{aligned} \tag{23}$$

which can be rewritten as

$$W = A - \left(\frac{\frac{r}{1+r}}{1-\tau}\right) I^2 \left\langle \frac{1}{2}\frac{j(u)}{1-\tau} - 1 + \frac{q}{1+r}\eta\left(1-\frac{1}{1+u}\frac{1}{\eta}\right)\right\rangle \tag{24}$$

where $A \equiv \left(\frac{1+r}{r}\frac{\overline{\pi}^2}{2} - \overline{\pi}I\right)$, and

$$j(u) \equiv \eta^2\left\{1 - \frac{q(1+u)}{1+r}\left[1-\left(\frac{1}{1+u}\frac{1}{\eta}\right)^2\right]\right\} \tag{25}$$

Let us then use Assumption 1 and rewrite $\eta = \frac{r+1-q}{r+1-q(1+u)}$. Substituting is into (25) one obtains

$$j(u) = \frac{(r+1-q)^2}{(1+r)\left[r+1-q(1+u)\right]} + \frac{q}{(1+u)(1+r)}$$

Using (10), differentiating (24) with respect to u and applying the Envelope Theorem yields

$$\frac{dW}{du} = \frac{dW}{du} + \frac{\partial W}{\partial \eta}\frac{d\eta}{du} \tag{26}$$

Notice that $\frac{\partial\left[\eta\left(1-\frac{1}{1+u}\frac{1}{\eta}\right)\right]}{\partial u} > 0$. Thus it is sufficient to show that $\frac{\partial j(u)}{\partial u} > 0$ for $\frac{dW}{du}$ to be negative. Differentiating $j(u)$ with respect to u yields

$$\frac{\partial j(u)}{\partial u} = \frac{q}{1+r}\cdot\left\{\underbrace{\frac{(r+1-q)^2}{\left[r+1-q(1+u)\right]^2}}_{>1} - \underbrace{\frac{1}{(1+u)^2}}_{<1}\right\} > 0.$$

The above inequality is sufficient to state that $\frac{dW}{du} < 0$. The Proposition is thus proven.■

6.6 Proof of Proposition 3

Using (9), it is straightforward to show that $\frac{\partial\kappa}{\partial a} > 0$. Moreover we have $\frac{d\tau^*}{d\kappa} > 0$ and $\frac{\partial\kappa}{\partial a} < 0$ (see the proof of Proposition 2). Thus we obtain $\frac{d\tau^*}{d\kappa}\frac{\partial\kappa}{\partial a} < 0$. Moreover, given inequality (22), we can show that $\frac{dT(\tau^*)}{d\kappa}\frac{\partial\kappa}{\partial a} < 0$. Therefore an increase in the degree of openness (i.e. a decrease in a), which may be caused by either an increase in $\overline{\pi}$ or a decrease in I, raises both τ^* and $T(\tau^*)$.

Let us next turn to the effect of market openness on welfare. Differentiating (24) with respect to $\overline{\pi}$, and applying the Envelope Theorem yields

$$\frac{dW}{d\overline{\pi}} = \frac{1+r}{r}\left(\overline{\pi} - \frac{r}{1+r}I\right).$$

Recall that $a = \left(\frac{\eta\frac{r}{1+r}I}{\overline{\pi}}\right) < 1$ with $\eta > 1$. This entails that $\left(\frac{\frac{r}{1+r}I}{\overline{\pi}}\right) < 1$. Therefore, we have $\frac{dW}{d\overline{\pi}} > 0$. An increase in $\overline{\pi}$ is thus welfare improving.

Let us finally differentiate (24) with respect to I. Applying the Envelope Theorem yields

$$\frac{dW}{dI} = -\overline{\pi}n\left(u\right) \propto -n\left(u\right)$$

where

$$n\left(u\right) = 1 + \frac{a}{1-\tau}\left\{\left(\frac{1}{1-\tau}\right)j\left(u\right) - 2\left[1 - \frac{q}{1+r}\left(1 - \frac{1}{1+u}\frac{1}{\eta}\right)\right]\right\}.$$

Notice that $\frac{dW}{dI} \propto -n\left(u\right)$, which entails that $\frac{dW}{dI}$ is always negative if

$$n\left(u\right) > 0 \tag{27}$$

To show that inequality (27) always holds notice that, given $\frac{\partial j(u)}{\partial u} > 0$,we have

$$\frac{\partial n\left(u\right)}{\partial u} > 0.$$

To prove that $\frac{dW}{dI} < 0\ \forall u$, therefore it is sufficient to show that (27) holds for $u = 0$. Setting $u = 0$ in (27) yields

$$n\left(u\right)|_{u=0} = 1 + \frac{a}{1-\tau}\left(\frac{1}{1-\tau} - 2\right)$$

If therefore $\frac{1}{1-\tau} - 2 > 0$, then $n\left(u\right)|_{u=0} > 0$. If $\frac{1}{1-\tau} - 2 < 0$, we know that $\frac{\pi^*}{\overline{\pi}} = \frac{a}{1-\tau} < 1$ and that, given $\frac{1}{1-\tau} > 1$, the inequality $2 - \frac{1}{1-\tau} < 1$ holds. Thus it is straightforward to obtain $1 > \frac{a}{1-\tau}\left(2 - \frac{1}{1-\tau}\right) > 0$. This is sufficient to have $n\left(u\right)|_{u=0} > 0$. A fortiori, $n\left(u\right)$ will be positive for $u > 0$. This implies that $\frac{dW}{dI} < 0\ \forall u$. The Proposition is thus proven. ■

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