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Working Paper

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EconPol Working Paper, No. 18

Provided in Cooperation with:

EconPol Europe – European Network for Economic and Fiscal Policy Research

Suggested Citation: Kari, Seppo; Laitila, Jussi; Ropponen, Olli (2018) : Investment Incentives and Tax Competition under the Allowance for Growth and Investment (AGI), EconPol Working Paper, No. 18, ifo Institute - Leibniz Institute for Economic Research at the University of Munich, Munich

This Version is available at:

<https://hdl.handle.net/10419/219480>

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ifo INSTITUTE

Leibniz Institute for Economic Research
at the University of Munich



EconPol WORKING PAPER
A publication of EconPol Europe
European Network of Economic and Fiscal Policy Research

Publisher and distributor: ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 89 9224-0, Telefax +49 89 9224-1462, Email Dolls@ifo.de
Editors: Mathias Dolls, Clemens Fuest
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19 October 2018

Abstract

We employ a dynamic investment model to study the investment incentives of the Allowance for Growth and Investment (AGI) proposed by the European Commission in its two-step approach towards the Common Consolidated Corporate Tax Base (CCCTB). We show that the AGI strengthens investment incentives in high-tax countries and decreases the CCCTB-induced investment push towards low-tax countries. Furthermore, we show that the AGI decreases tax competition and that a sufficiently generous AGI reduces tax competition between countries when introduced with the CCCTB. We also provide new results for the standard Allowance for Corporate Equity (ACE) discussed intensively in the literature. In particular, we show that the ACE reduces the CCCTB-induced investment push towards low-tax countries and that the ACE reduces tax competition between countries. Despite the positive implications of the AGI for investment incentives and tax competition, the ACE performs slightly better in both respects. In addition the ACE also offers better neutrality properties. On the other hand, the ACE is criticized for its possible inherent tax revenue losses; with AGI these losses would be smaller. However, the trade-off between better incentives and higher revenue loss also appears to persist with the AGI.

JEL classification: F21, F23, H25, H32

Keywords: Corporate Income Tax, Investments, Tax Competition, Allowance for Growth and Investment (AGI), Allowance for Corporate Equity (ACE), Common Corporate Tax Base (CCTB), Common Consolidated Corporate Tax Base (CCCTB), Formula Apportionment (FA)

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1. Introduction

The European Union (EU) has taken an active role in the fight against the tax avoidance behavior of multinational enterprises (MNEs). One major specific proposal designed to restrain this activity¹ was made by the European Commission (EC) on 25 October 2016.² This proposal concerns a move to a Common Consolidated Corporate Tax Base (CCCTB), where the tax base definitions are aligned within the European countries and the allocation of each corporate group-level tax base is made across countries by a formulary apportionment, which in turn is based on three factors (labor, assets, sales) that are considered to reflect the location where the corporate activity actually takes place. The CCCTB is a variant of formula apportionment (FA), which has been used for decades in several federal states such as Canada, Germany and the USA, but not at the EU level.³ The CCCTB proposal comes with two specific features designed to boost the European economy: an allowance for growth and investment (AGI) and a super deduction for research and development (R&D) expenses, which are included in the first step towards CCCTB, the CCTB.⁴ We focus in this paper on the implications of the AGI allowance. In more detail, we study the effects of an allowance for corporate equity as an element in an FA system, with the AGI being a special case of this. To our knowledge this is the first detailed study on the effects of the AGI.

The AGI, which is specified in the first step towards the CCCTB, can be considered a modification of the well-known Allowance for Corporate Equity (ACE), where not only the debt expenses but also the notional costs related to the equity of a company are deductible for tax purposes.⁵ An important benefit of the ACE is that it removes the debt-equity bias (or debt bias), which refers to asymmetric tax treatment between investments made by debt-financing versus those made by equity-financing.⁶ However, unlike an ACE, which provides the allowance based on the overall equity stock of a company, the AGI allowance is based on the equity accumulated over the last 10 years only.⁷ Due to its incremental nature and the limited base accumulation period, the AGI may receive wider support from the EU member states than the ACE, which has been criticized for its large tax revenue losses, which may have to be financed by corporate tax rate increases.⁸ In our study we

¹ Another objective of the proposal is to strengthen the single market.

² See EC (2016 a,b).

³ See e.g. Eichner and Runkel (2008).

⁴ According to the EC proposals, the CCCTB will be implemented in two steps, where the CCCTB proposal is preceded by a proposal for a Common Corporate Tax Base (CCTB). For details, see EC (2016a, b). These proposals are based on an earlier EC proposal on the CCCTB, which did not include the AGI, see EC (2011).

⁵ The ACE was developed by the IFS working group (1991) and later on it was included in the tax reform proposal by the Mirrlees Review (2011).

⁶ The literature acknowledges that the debt bias increases the ability of MNEs to shift profits, distorts the financial choice of investments, and increases systemic risk (see e.g. Fatica et al. 2012). De Mooij and Devereux (2009, 2011) and Brekke et al. (2017) provide comparisons between the ACE and the other competing solution for the debt-equity bias, the Comprehensive Business Income Tax (CBIT).

⁷ The two common types of ACE implementations (implemented in Belgium and Italy) are compared in Zangari (2014). Whereas the Belgian implementation grants an allowance for the entire existing stock of equity, the Italian (incremental) implementation grants an allowance only for equity accumulated after the reform.

⁸ For the early discussion on the need for corporate tax rate increases to compensate the tax revenue loss arising from introduction of the ACE, see Bond (2000). The more recent discussion in the Mirrlees Review (Ch. 10; Griffith et al. 2010) argues that there is no need for tax rate increases after the introduction of the ACE in the long run, the reason being increased domestic and inbound investments. It also argues that in the short and medium term the tax revenue losses would remain small if the ACE allowance were granted only for additions to the equity base, and not to existing equity accumulated before the reform (i.e. no windfalls). In

consider the differences between the AGI and the ACE. The main features of the AGI are given in Box 1.

Box 1. The Allowance for Growth and Investment (AGI) in a nutshell

The Allowance for Growth and Investment (AGI) is defined in the Proposal for a Council Directive on a Common Corporate Tax Base, COM(2016) 685 final, Strasbourg, 25.10.2016 (EC 2016a). According to the proposal, the aim of the allowance is to tackle the debt bias, which refers to an advantage in favor of financing through debt as opposed to equity. The allowance is granted to companies according to increases or decreases in their equity within the last 10 years (see paragraph 4 in Article 11 in the proposal, given below). The equity is defined to include, for the purpose of the Article, the 'capital and reserves' defined in EU legislation and the 'equity' defined in International Financial Reporting Standards (see paragraph 2 below). The defined yield (AGI rate) is defined to be the yield of the euro area 10-year government benchmark bond increased by a risk premium of two percentage points, but at least two per cent (see paragraphs 3 and 5).

Article 11

Allowance for growth and investment ('AGI')

"1. For the purposes of this Article, 'AGI equity base' means, in a given tax year, the difference between the equity of a taxpayer and the tax value of its participation in the capital of associated enterprises as referred to in Article 56."

"2. For the purposes of this Article, 'equity' means any of the following:

- (a) 'capital and reserves', as described in letter A., under 'Capital, reserves and liabilities' in Annex III to Directive 2013/34/EU of the European Parliament and of the Council ²⁴.
- (b) 'capital and reserves', as described in letter L. in Annex IV to Directive 2013/34/EU;
- (c) 'equity', as defined in the International Financial Reporting Standards which are adopted and used in the Union pursuant to Regulation (EC) No 1606/2002 of the European Parliament and of the Council ²⁵."

"3. An amount equal to the defined yield on the AGI equity base increases shall be deductible from the taxable base of a taxpayer according to paragraphs 1 to 6. If there is an AGI equity base decrease, an amount equal to the defined yield on the AGI equity base decrease shall become taxable."

"4. AGI equity base increases or decreases shall be calculated, for the first ten tax years that a taxpayer is subject to the rules of this Directive, as the difference between its AGI equity base at the end of the relevant tax year and its AGI equity base on the first day of the first tax year under the rules of this Directive. After the first ten tax years, the reference to the amount of AGI equity base that shall be deductible against the AGI equity base at the end of the relevant tax year shall annually be moved forward by one tax year."

"5. The defined yield referred to in paragraph 3 shall be equal to the yield of the euro area 10-year government benchmark bond in December of the year preceding the relevant tax year, as published by the European Central Bank, increased by a risk premium of two percentage points. A floor of two per cent shall apply where the curve of the annual yield is negative."

"6. ..."

Tax systems where the local profits of a multinational enterprise are first pooled and then allocated to jurisdictions according to a given formula - FA tax systems - have been studied quite intensively. This literature has shown that while FA eliminates the opportunities for

addition to this incremental transition rule, the AGI also includes a 10-year time limit for the accumulation of the base for the allowance. This limit is likely to further reduce the need for tax rate compensation due to possible tax revenue losses.

profit-shifting between countries participating in an FA system, it provides incentives to choose strategically the allocation of factors determining the apportionment.⁹ Thus FA may favor low-tax jurisdictions at the expense of high-tax jurisdictions. Regarding tax competition, the literature acknowledges that FA provides incentives to lower corporate tax rates, and that the intensity of tax competition depends on the mobility of the factors determining the apportionment.¹⁰

To our knowledge, previous literature on the topics that we aim to address is very scarce. We have not found any previous academic papers modeling the effects of an AGI-type allowance.¹¹ Nor have we found any analyses on the implications of more general equity allowances (such as the ACE) as an element in an FA system. In our analysis we use a genuinely dynamic framework to study the effects of the AGI on the investment incentives of companies under FA. The previous literature on FA has mostly used a static framework.¹² With a few notable exceptions, the same applies to studies on the ACE.¹³ Our dynamic approach allows us to model the accumulation of a time-constrained AGI base and the interactions between the AGI and fiscal depreciation allowances, which would both remain beyond the scope of a static model.

In the first part of the paper, we derive the results concerning the investment effects of the AGI in the framework of both separate accounting (SA) and FA.¹⁴ The results allow for several types of comparisons: we compare the current CCCTB proposal with an AGI to the earlier CCCTB proposal introduced in 2011, which did not include any equity allowance. We compare the AGI to the ACE in the framework of an FA and, finally, we study the effects of the replacement of the CCTB (AGI in SA) with the CCCTB (AGI in FA).

We find that the introduction of the AGI, as specified in the CCCTB proposal, decreases the cost of capital in high-tax countries and hence makes the current CCCTB proposal more lucrative for investments in these countries than the earlier CCCTB proposal with no equity allowance. A comparison between the AGI and the ACE shows that they provide very similar investment incentives and the differences are quite small. However, even if the differences remain small, the ACE is able to deal with tax distortions better than the AGI, in which the cost of capital remains dependent on the parameter values, such as the rate of depreciation. Thus the AGI does not have the desirable neutrality properties, which are the key benefit of the ACE. The differences between the implications of the AGI and the ACE become even more pronounced if the accumulation period of the AGI base is less than

⁹ Under FA, a firm's tax payment to a given jurisdiction is based on how separate factors given in the formula for apportionment, like assets, labor and sales, are allocated to the jurisdiction relative to other jurisdictions within the FA. See McLure (1980), Gordon and Wilson (1986), Mintz and Weiner (2003) and Runkel and Schjelderup (2011).

¹⁰ See Gordon and Wilson (1986), Pethig and Wagener (2007), Wrede (2009) and Nielsen et al. (2010).

¹¹ For papers discussing some aspects of the AGI, see Rose (2017), The Commission staff working document - the Impact Assessment - accompanying the CCCTB proposal (EC 2016c) and Petutschnig and Runger (2017): The latter paper studies empirically the effects of Austria's former equity allowance which had some similarities with the AGI.

¹² E.g. Mintz and Weiner (2003) and Nielsen et al. (2010).

¹³ The exceptions include Bond and Devereux (1995, 2003).

¹⁴ Note that the AGI in a SA corresponds to the CCTB tax system, which is the first step towards the CCCTB. Note also that it is possible that the CCTB might become effective before the CCCTB.

10 years, since in that case, for instance, depreciations would not erode the AGI base as much.

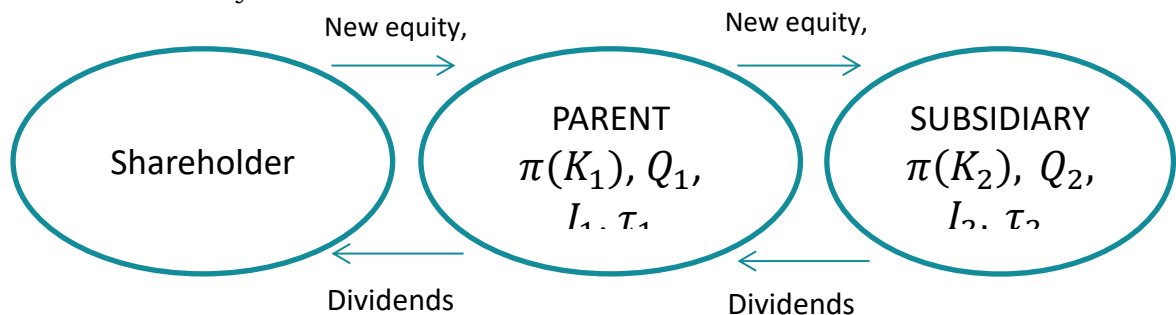
In the second part of the paper we study how the AGI affects the strategic responses by countries to other countries' decisions. We find that the AGI reduces tax competition between countries in FA. This reduction is, however, slightly smaller than what the ACE would imply. We also find that a replacement of the current SA with no allowance for corporate equity by a CCCTB system with an AGI might result in a reduction or an increase in tax competition. The sign of the effect depends on the generosity of the AGI allowance.

The paper proceeds as follows. The next section provides the details of our investment model and derives the optimality conditions for investment decisions. Section 3 illustrates the magnitudes of the investment incentives resulting from the AGI. It compares the investment incentives in FA between the AGI, the ACE and the case with no allowance for corporate equity, by providing calculations with varying parameter values. Section 4 studies the effects of the AGI on strategic interaction between countries. Section 5 provides a discussion. Section 6 concludes.

2. Modelling the AGI in a dynamic investment framework

This section employs a dynamic investment model to study the investment incentives provided by the AGI in both the CCTB/SA and CCCTB/FA¹⁵ tax systems.¹⁶ We employ a model where an MNE is composed of two companies, each of which operates in a small open economy. The parent company of the group is domiciled in country 1 (with corporate income tax rate τ_1) and its fully-owned subsidiary in country 2 (tax rate $\tau_2 \leq \tau_1$). Both companies have business operations only in their countries of domicile. The model is illustrated in Figure 1.

Figure 1: A Two-Country Investment Model



¹⁵ In the following sections dealing with investment incentives and tax competition we follow the terminology used in most of the earlier literature and stick to the terms SA and FA. However, note that we focus on an SA/FA that includes in particular the AGI, an essential feature of the CCTB/CCCTB. The results for the SA/FA without the AGI follow from our model as special cases.

¹⁶ We consider here a continuous-time model. Note that Article 11 in the draft directive employs discrete time (e.g. the equity included in the AGI base is determined at the end of each year). Therefore, our model does not take into account, for example, possible back-and-forth investments taking place within a year. Nor do we consider transition period issues, returns on own equity (equity transition from subsidiary to parent or from parent to shareholder), or debt-financing. We use the cost of capital as a measure for investment incentives. Other measures employed in the literature include the effective marginal tax rate (EMTR) and the effective average tax rate (EATR) (see Devereux and Griffith 2003 and references therein).

In the model a parent company uses its profits ($\pi(K_1)$), new equity from its shareholders (Q_1) and dividends from its subsidiary (D_2) to finance its investments (I_1), new equity for its subsidiary (Q_2), dividends to its shareholders (D_1) and taxes ($T_1(K_1, K_2, B_1, B_2)$). The budget constraint for the parent company is:¹⁷

$$\pi(K_1) + Q_1 + D_2 = I_1 + Q_2 + D_1 + T_1(K_1, K_2, B_1, B_2) \quad (1)$$

The budget constraint for the subsidiary is:

$$\pi(K_2) + Q_2 = I_2 + D_2 + T_2(K_2, K_1, B_1, B_2) \quad (2)$$

The stocks of capital (K_1 and K_2) depreciate at rate δ (economic depreciation):

$$\dot{K}_1 = I_1 - \delta K_1 \text{ and } \dot{K}_2 = I_2 - \delta K_2 \quad (3)$$

The accounting stocks of capital (B_1 and B_2) depreciate at rate γ (fiscal depreciation):

$$\dot{B}_1 = I_1 - \gamma B_1 \text{ and } \dot{B}_2 = I_2 - \gamma B_2 \quad (4)$$

The start-up stocks of capital at time $t = 0$ are $K_1(0) = B_1(0) = k_1$ and $K_2(0) = B_2(0) = k_2$.

The starting point for defining the AGI base is owners' equity in the company's balance sheet. As a basic accounting identity, this corresponds to the book value of capital (B_1) plus the value of shareholdings in other companies. However, as under the ACE, the latter item is deducted in order to avoid cascading, i.e. inappropriate accumulation of the allowance in ownership chains.¹⁸ This implies that, in our simple model, the relevant equity concept (adjusted equity) equals the book value of capital (B_1), the size of which depends on current and past investment and fiscal depreciation allowances (equation (4)).

The draft directive proposal defines the AGI base (A_1) as the sum of annual changes in adjusted equity over a period of ten years (see Box 1). Let v denote the length of the accumulation period. The AGI base is defined as the sum of net increases in investment for the last v years (from $t - v$ to t). Thus, in continuous time, we may write the AGI base A_1 as follows:

$$A_1(t) = \int_{\max\{0, t-v\}}^t e^{-\gamma(t-s)} I_1(s) ds \quad (5)$$

¹⁷ Capital is the only input in the production function in our model. Taxes depend on both the capital and the accounting stock of the capital of both the parent company and the subsidiary. For details, see especially equations 7 and 8 below. Country 1 applies an exemption method for within-group dividend payments in its taxation. We further assume that D_1, D_2, Q_1 and Q_2 are non-negative, and that π satisfies the usual Inada conditions.

¹⁸ The elimination of the cascading effect in the AGI is stipulated in paragraph 1 of Article 11 in the draft proposal (Box 1). For the discussions concerning cascading in the ACE, see IFS (1991), Devereux and Freeman (1991), Griffith et al. (2010), and Zangari (2014).

By using equation (4) and integrating, we get the more practical formula

$$A_1 = B_1 - R_1, \quad (6)$$

where $R_1(t) = e^{-\gamma t} k_1$ for $0 < t < v$ and $R_1(t) = e^{-\gamma v} B_1(t - v)$ for $t \geq v$.

The FA and SA differ only in terms of their definitions of taxes T_1 and T_2 . In FA, the parent company's taxes are¹⁹

$$T_1(K_1, K_2, B_1, B_2) = \tau_1 s_1(K_1, K_2) P(K_1, K_2, B_1, B_2), \quad (7)$$

where $P(K_1, K_2, B_1, B_2) = \pi(K_1) - \gamma B_1 - aA_1 + \pi(K_2) - \gamma B_2 - aA_2$ and $s_1(K_1, K_2) = \frac{\sigma_K K_1}{K_1 + K_2} + X_1$ is the tax base apportionment share of the parent company, with a constant weight $0 < \sigma_K < 1$ for the capital factor and an exogenous element, X_1 . The terms γB_1 and γB_2 are the depreciation allowances for taxation purposes and aA_1 and aA_2 are the AGI allowances, with a being the AGI rate.

Analogously, for the subsidiary the taxes are given by

$$T_2(K_1, K_2, B_1, B_2) = \tau_2 s_2(K_1, K_2) P(K_1, K_2, B_1, B_2), \quad (8)$$

where $s_2(K_1, K_2) = \frac{\sigma_K K_2}{K_1 + K_2} + X_2$.

In SA, each country taxes the profits of companies resident in its territory and no consolidation is made:

$$T_1(K_1, K_2, B_1, B_2) = \tau_1(\pi(K_1) - \gamma B_1 - aA_1) \text{ and } T_2(K_1, K_2, B_1, B_2) = \tau_2(\pi(K_2) - \gamma B_2 - aA_2) \quad (9)$$

The MNE's objective is now to maximize the value of its shares:

$$V = \int_0^{\infty} (D_1(t) - Q_1(t)) e^{-\rho t} dt \quad (10)$$

Here ρ is the time-invariant rate of interest at which the economic agents can borrow and lend in the international capital markets.²⁰

With the elements of the investment model given above, we can derive the equations for both the parent's and the subsidiary company's cost of capital under AGI. Note that this result also includes the ACE in the special case where $v \rightarrow \infty$ (when $e^{-\gamma v} \rightarrow 0$). For the statement of the result, we define the constant

¹⁹ In the CCCTB proposal the common tax base is constructed by pooling the company-specific tax bases, which are both determined by the company profits, the fiscal depreciation and the AGI. The apportionment is made according to an endogenous variable K_1 (and K_2) and an exogenous factor X_1 (and X_2). See also e.g. Pethig and Wagener (2007) and Nielsen et al. (2010).

²⁰ The derivation of the objective function is based on the net cash flow $Y = D_1 - Q_1$ and the no-arbitrage condition $Y + \dot{V} = \rho V$. See e.g. Auerbach (2002) and Sinn (1993).

$$C = \frac{a(1 - e^{-(\gamma+\rho)v}) + \gamma}{\rho + \gamma}, \quad (11)$$

which will be interpreted below as the present value of investment allowances. The proof of the following proposition and further technical assumptions are given in Appendix A.

Proposition 1: (i) *In the SA system, all optimal solutions of the problem (10) take constant values $K_i(t) = K_i^*$ for all t , where the numbers K_i^* are defined by*

$$\pi'(K_i^*) = \frac{1 - \tau_i C}{1 - \tau_i} (\rho + \delta), \quad (12)$$

for $i = 1, 2$.

(ii) *In the FA system, assuming that the maximization problem (10) admits a steady-state solution, the steady-state cost of capital of the parent company is:²¹*

$$\pi'(K_1) = \frac{1 - \bar{\tau}(K_1, K_2)C}{1 - \bar{\tau}(K_1, K_2)} (\rho + \delta) + \frac{\tau_1 - \tau_2}{1 - \bar{\tau}(K_1, K_2)} \frac{\sigma_K K_2}{(K_1 + K_2)^2} P^*(K_1, K_2), \quad (13)$$

where $\bar{\tau}$ is the average tax rate of the group $\bar{\tau}(K_1, K_2) = \sigma_K \frac{\tau_1 K_1 + \tau_2 K_2}{K_1 + K_2} + \tau_1 X_1 + \tau_2 X_2$ and $P^*(K_1, K_2) = \pi(K_1) + \pi(K_2) - (K_1 + K_2)\delta(a(1 - e^{-\gamma v})/\gamma + 1)$.

Comparing the cost of capital in FA to that in SA shows us some important aspects of the tax systems. We observe that the cost of capital given in (13) includes two terms. The first term, $\frac{1 - \bar{\tau}(K_1, K_2)C}{1 - \bar{\tau}(K_1, K_2)} (\rho + \delta)$, can be interpreted as giving the pre-tax cost of marginal investment assuming a given tax rate, $\bar{\tau}$. It closely resembles the cost of capital under SA, $\frac{1 - \tau_i C}{1 - \tau_i} (\rho + \delta)$, but differs as the country-specific tax rate (τ_i) is replaced by the weighted average of the local tax rates of the corporate group ($\bar{\tau}$).²² This property of FA is familiar from earlier literature.²³

The second term on the right hand side of (13) reflects the effects via the average tax rate ($\bar{\tau}$)²⁴ on the cost of capital. The term includes the difference between corporate tax rates. In the special case of equal tax rates ($\tau_1 = \tau_2 \Rightarrow \tau_1 - \tau_2 = 0$ and $\tau_1 = \tau_2 = \bar{\tau}$), the second term vanishes and the first term becomes identical to the cost of capital in SA in (12). The second term of (13) is also familiar from previous FA literature.

Let us turn to the effects of the AGI allowance. We observe that in both (12) and (13) the present value of investment allowances, C , defined in (11) includes the AGI rate adjusted by the time restriction, $a(1 - e^{-(\gamma+\rho)v})$ (effective AGI rate). The intuition of this expression can be found by considering a one-unit investment financed from equity. This investment

²¹ For the subsidiary we get a similar expression, with indexes 1 and 2 being interchanged.

²² Note that if the tax rates are the same ($\tau_1 = \tau_2 \Rightarrow \tau_1 = \tau_2 = \bar{\tau}$), the equation for the cost of capital in FA becomes the same as in SA. Note also that the first term in (13) closely resembles the cost of capital in standard corporate income tax (CIT), but differs in two respects. In addition to the use of a weighted average, the present value of the investment allowances, C , differs from the standard results. See Devereux and Griffith, 2003.

²³ See, e.g. Mintz and Weiner 2003 and Pethig and Wagener 2007.

²⁴ Or, put differently, the effect via the apportionment shares.

provides the firm with a flow of equity allowances, the present value of which is $\int_0^t (ae^{-\gamma s})e^{-\rho s} ds$, where $e^{-\gamma s}$ is the book value of the investment (after fiscal depreciation) at time s and $e^{-\rho s}$ is the discount factor. The value of this integral is $\frac{1}{\gamma+\rho}a(1 - e^{-(\gamma+\rho)t})$. If there is no time limit (as under ACE), i.e. $t \rightarrow \infty$, then the present value of the allowance flow reduces to $\frac{1}{\gamma+\rho}a$. Instead, if there is an AGI-type time constraint ($t = v$), we obtain the expression above. Observe that in a properly designed ACE where the rate is set to $a^{ACE} = \rho$, we have $C^{ACE} = \frac{a^{ACE} + \gamma}{\rho + \gamma} = 1$.²⁵ In the AGI, $a(1 - e^{-(\gamma+\rho)v})$ may deviate from ρ depending particularly on the rate of fiscal depreciation γ and the time limit v . Therefore, $C^{AGI} \neq 1$, which implies that the AGI does not have equally favorable neutrality properties as the ACE.

One key feature of the second term of the cost of capital in FA, given in (13), is that it raises the cost of capital for a high-tax country ($\tau_1 - \tau_2 > 0$). In a low-tax country the outcome is the opposite. Together, these facts imply that FA distorts the location of investment in a multi-country setting where the tax rates differ.

The second term is further affected by the long-run taxable profit P^* .²⁶ This implies that all details of the definition of the taxable profit affect the size of the second term. For example, more generous tax allowances make the taxable profit smaller and reduce the distortions caused by FA.

Now we are able to identify the effects of the AGI on the cost of capital in an FA system. The presence of the AGI ($a > 0$) decreases the cost of capital both in high- and low-tax countries via the first term.²⁷ Compared to the ACE ($v = \infty$), the reduction in the cost of capital is smaller, however. The effect of the AGI through the second term depends on the relative magnitudes of the tax rates. The cost of capital in a high-tax country (the parent's home country in our model) decreases via this term due to the AGI. For the low-tax country the effect on the cost of capital is the opposite. Overall, the cost of capital unambiguously decreases due to the AGI for a company in the country with a higher tax rate, while for the company in the country with a lower tax rate, the effect of the AGI remains ambiguous and depends on the relative magnitudes of the two terms in equation (13). These observations lead to our Corollary 1.

Corollary 1: *The AGI decreases the cost of capital of companies in high-tax countries in an FA tax system. For companies in low-tax countries, the effect on the cost of capital remains ambiguous.*

The cost of capital given in Proposition 1 also demonstrates another issue. The AGI mitigates the difference in the cost of capital arising from the difference in tax rates in FA. To observe this, first note that the last term in equation (13) increases the cost of capital in the country with a higher tax rate and reduces it in the country with a lower tax rate,

²⁵ $C = 1$ implies that the cost of capital becomes independent of the taxes, which in turn implies that the tax system is neutral.

²⁶ $P^*(K_1, K_2)$ is just shorthand for the taxable profit $P(K_1, K_2, B_1, B_2)$ for large t ($t > v$) and with B replaced by its long-run value $(\delta/\gamma)K$.

²⁷ $1 - e^{-(\gamma+\rho)v} > 0$, $\bar{\tau}(K_1, K_2) > 0$, $\rho + \gamma > 0$, $\rho + \delta > 0$, $1 - \bar{\tau}(K_1, K_2) > 0$ and $a > 0$.

and therefore increases the cost of capital *gap* between countries with different tax rates. Thus, FA pushes investment towards low-tax countries, and therefore causes a distortion in the location of investment. This push is larger the larger the terms multiplying the tax rate difference ($\frac{\sigma_K K_2}{(K_1 + K_2)^2}$ and $P^*(K_1, K_2)$). As the AGI decreases one of these terms, it mitigates the cost of capital gap between companies in high-tax and low-tax countries, and therefore also mitigates the investment push towards low-tax countries. Corollary 2 summarizes this conclusion.

Corollary 2: *The AGI decreases the FA-induced investment push towards low-tax countries by decreasing the cost of capital gap between companies in high-tax and low-tax countries.*

In summary, we show via our dynamic investment model that the AGI affects investment incentives in FA. More specifically, we show that the AGI strengthens the investment incentives of companies in high-tax countries in the FA tax system. The AGI also reduces the distortion in the investment location decisions created by FA. However, the ACE would both increase the investment incentives and reduce the distortion more than the AGI.

3. Calculations on the Investment-Enhancing Effects of the AGI

In this section we employ the cost of capital expressions derived in the previous section to illustrate how the investment incentives change in FA due to the AGI. In our calculations we consider both the extent to which the investment incentives change and how the parameter values affect these incentives in different cases. Regarding the parameters, we consider the rate of economic depreciation (δ), accelerated fiscal depreciation ($\gamma > \delta$), the discount rate (ρ), the AGI rate (a) and the accumulation period of the AGI base (v). Let us first consider the dependence of the cost of capital on the depreciation rate in a case where the rate of economic depreciation (δ) and the rate of fiscal depreciation (γ) are the same. The assumption on the similarity of the depreciation rates will be relaxed later.

As our baseline, we consider a case where the tax-related parameters and economic parameters are chosen according to the first column in the upper panel of Table 1. In our baseline case, the corporate tax rate of both countries is 21.9%²⁸, the rate of economic depreciation is 25% per year, the rate of fiscal depreciation 25% per year, the discount rate 0.05, the AGI rate 5%, and the time the investment remains in the AGI base is 10 years. The other columns in the table consider cases where the rate of economic depreciation varies from the baseline of 25%.

The lower panel in Table 1 shows the cost of capital for the three separate cases: FA with no equity allowance, FA with AGI and FA with ACE.²⁹ Without an equity allowance, the (after-depreciation) cost of capital is 0.0640 in the baseline case.³⁰ For the AGI, it is clearly

²⁸ The EU average top rate of tax on corporate income was 21.9% in 2017 (EC 2017). In the baseline case there are no tax rate differences ($\tau_1 = \tau_2$).

²⁹ The cost of capital refers to the minimum yield after depreciation has been taken into account ($\pi'_1(K_1) - \delta$).

³⁰ In the calculations we make the following assumptions: $X_1 = X_2 = 0$, $\sigma_K = 1$ and $\pi(K) = \sqrt{K}$.

lower, 0.0507. Compared to the case with no allowance for corporate equity, the AGI reduces the cost of capital by 20.8%. However, the ACE also increases the investment incentives. Compared to the case without an equity allowance, the ACE decreases the cost of capital slightly more than the AGI, by 21.9% in the baseline case (from 0.0640 to 0.0500). Thus, the difference between the AGI and the ACE in increasing the investment incentives is not large, with the increase in the cost of capital being roughly one fifth for both allowances. The implied increases for the capital levels of the AGI and the ACE in our model are 9.1% and 9.6% respectively. The result for the AGI remains close to that for the ACE, because the difference between them results only from investments made more than 10 years ago, which therefore become heavily discounted.³¹

Table 1. Cost of Capital: Rate of Economic Depreciation

Tax Parameters and Economic Parameters		(1 BASE)	(2)	(3)	(4)
Corporate Tax Rate in Country 1	τ_1	0.219	0.219	0.219	0.219
Corporate Tax Rate in Country 2	τ_2	0.219	0.219	0.219	0.219
Rate of Economic Depreciation	δ	0.25	0.15	0.10	0.05
Rate of Fiscal Depreciation	γ	0.25	0.15	0.10	0.05
Discount Rate	ρ	0.05	0.05	0.05	0.05
AGI Rate	a	0.05	0.05	0.05	0.05
Duration of Investment in AGI	v	10	10	10	10
Cost of Capital					
FA, No Equity Allowance		0.0640	0.0640	0.0640	0.0640
AGI		0.0507	0.0519	0.0531	0.0552
ACE		0.0500	0.0500	0.0500	0.0500

In the other columns of the table we vary the rate of economic depreciation to take the values 0.15, 0.10 and 0.05. We observe that the cost of capital varies according to the depreciation rate only in the presence of AGI, whereas for the ACE and the case without an equity allowance they remain intact.

The observations from Table 1 show us a few things. First, compared to the case with no allowance the AGI and the ACE decrease the cost of capital. Second, the reduction is larger in the ACE. Third, in the ACE the reduction remains independent of the depreciation rate, whereas for the AGI the reduction is larger and closer to that of the ACE the higher the depreciation rate. Thus the cost of capital in the AGI remains dependent on the parameter values and therefore it does not have the same neutrality properties as the ACE.

The ways in which investment incentives depend on other parameters are studied in Appendix B. The results show that the cost of capital in the AGI remains dependent on the parameter values, whereas in the ACE it is more often independent of the parameter values. The ACE also provides better investment incentives than the AGI.

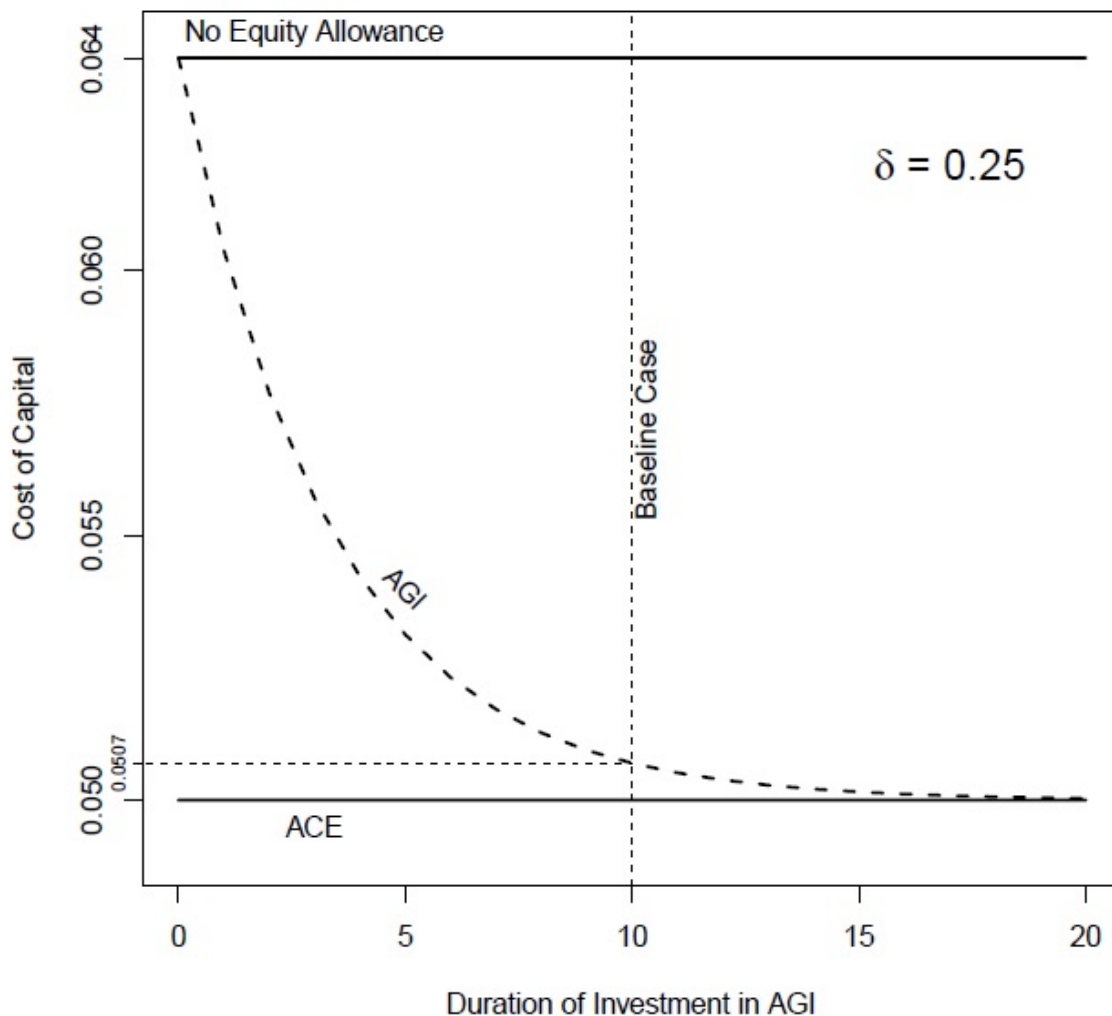
A particularly interesting feature of the AGI is how its base accumulates. This is also the thing that makes the AGI differ from the ACE. Figure 2 focuses on how the cost of capital in the AGI depends on the number of years that are included in the AGI base. When the

³¹ Observe that the value of the allowance is discounted at the rate of $\rho + \gamma$, which may be high particularly if the rate of depreciation is high, see definition of C in Proposition 1.

number of years is zero, the cost of capital in the AGI coincides with the case without an equity allowance (the cost of capital is 0.064). However, when the number of years increases the cost of capital in the AGI decreases and converges to the cost of capital in the ACE (0.05). It is also worth noting that with an accumulation period of 10 years it is already very close to that of the ACE (0.0507). Moreover, we observe in the figure that the cost of capital in the AGI is close to mid-way between those for the case without an equity allowance and the ACE already with a duration of about 2 years.

We also study how the length of the accumulation period of the AGI base affects the cost of capital when the depreciation rates vary. Figure 3 in Appendix B illustrates this issue. The results are qualitatively the same as in Figure 2: when the AGI base is determined according to few years only the cost of capital in the AGI remains close to that without an equity allowance, whereas when the number of years increases the cost of capital in the AGI converges to that in the ACE. The cost of capital in the AGI thus remains heavily dependent on the accumulation period.

Figure 2: Cost of Capital and Duration of Investment in AGI



4. Tax Competition

In this section we consider the effects of the AGI on tax competition between countries.³² We employ a simpler model than in section 2 and consider two symmetric countries, in each of which resides an MNE whose subsidiary resides in the other country.³³ The model includes two choices: first, the corporate groups G and \tilde{G} choose their capital levels in countries 1 (K_1, \tilde{K}_1) and 2 (K_2, \tilde{K}_2), and second, the countries choose their tax rates (τ_1, τ_2).

The corporate group maximizes its net-of-tax profits:³⁴

$$\Pi^{FA,AGI} = [\pi(K_1) + \pi(K_2) - \rho K] - \bar{\tau} \underbrace{[\pi(K_1) + \pi(K_2) - \rho A]}_{= P^{FA}(K_1, K_2)} \quad (14)$$

Here the first term represents the corporate group's pre-tax profit and the latter one its taxes. $A = A_1 + A_2$ is the AGI base, which is defined to be the capital accumulated over the last 10 years³⁵ and ρ stands for the AGI rate. $\bar{\tau}$ is the capital-weighted average tax rate, $\bar{\tau} = \frac{K_1}{K} \tau_1 + \frac{K_2}{K} \tau_2$. The optimality condition is (see Appendix C):

$$\frac{\partial \Pi^{FA,AGI}}{\partial K_1} = (1 - \bar{\tau})[\pi'(K_1) - \pi'(K_2)] - \frac{1}{K}(\tau_1 - \tau_2)[\pi(K_1) + \pi(K_2) - \rho A] = 0 \quad (15)$$

Second, each country maximizes its national welfare, $W^{FA,AGI}$, which is defined as a combination of its tax revenue $T^{FA,AGI}$ and the MNE's net-of-tax profits, $\Pi^{FA,AGI}$, weighted by λ .³⁶ The taxes to be paid to country 1 are defined by three factors: the consolidated tax bases ($P^{FA}(K_1, K_2)$ and $P^{FA}(\tilde{K}_1, \tilde{K}_2)$) are apportioned by the apportionment factors ($\frac{K_1}{K}$ and $\frac{\tilde{K}_1}{\tilde{K}}$) and the tax rate (τ_1) is then applied to the apportioned tax bases, $T_1^{FA,AGI} = \tau_1 \frac{K_1}{K} P^{FA}(K_1, K_2) + \tau_1 \frac{\tilde{K}_1}{\tilde{K}} P^{FA}(\tilde{K}_1, \tilde{K}_2)$. The national welfare of country 1 thus reads as follows:

$$W_1^{FA,AGI} = T_1^{FA,AGI} + \lambda \Pi^{FA,AGI} \quad (16)$$

In a symmetric equilibrium the optimal tax rate of country 1 is given by the equation given in Proposition 2. The proof is given in Appendix C.

³² Our approach has common features with Devereux et al. (2008) and section 4.5 in Keen and Konrad (2013). As in the earlier literature, tax competition is measured by the level of the optimal equilibrium tax rate.

³³ Compared to the above we consider a case where the capital does not depreciate ($\delta = \gamma = 0$), the AGI rate is aligned with the discount rate ($a = \rho$) and capital is the only element in the formulary apportionment (no exogenous variables, like X above). The overall capital stocks for both MNEs are fixed, $K = K_1 + K_2$ for an MNE (G) residing in country 1 and $\tilde{K} = \tilde{K}_1 + \tilde{K}_2$ for an MNE (\tilde{G}) residing in country 2. Subindex 1 refers to location in country 1. For example \tilde{K}_1 corresponds to the capital level of a subsidiary located in country 1 (whose parent is located in country 2). The production technologies are considered to be the same both within an MNE and across MNEs (the production function π is the same for all four companies in our model).

³⁴ The other corporate group similarly maximizes its net-of-profits $\bar{\Pi}^{FA,AGI} = [\pi(\tilde{K}_1) + \pi(\tilde{K}_2) - \rho \tilde{K}] - \hat{\tau} \underbrace{[\pi(\tilde{K}_1) + \pi(\tilde{K}_2) - \rho \tilde{A}]}_{= P^{FA}(\tilde{K}_1, \tilde{K}_2)}$, where $\hat{\tau} = \frac{\tilde{K}_1}{\tilde{K}} \tau_1 + \frac{\tilde{K}_2}{\tilde{K}} \tau_2$.

³⁵ Note that in the steady-state $A < K$, where K is the overall capital stock, by Proposition 1 (ii).

³⁶ $\lambda \in [0,1]$ is a relative weight on the profit component, where the case $\lambda = 0$ refers to a tax revenue-maximizing government (Leviathan government).

Proposition 2: *The optimal tax rate of country 1 in a symmetric tax competition model with the FA tax system and the AGI is determined by the following equation:*³⁷

$$\frac{\tau_1^{FA,AGI}}{1 - \tau_1^{FA,AGI}} = -\frac{(2 - \lambda)K_1^2\pi''(K_1)}{\pi(K_1) - \rho A_1} (> 0) \quad (17)$$

Without the AGI, $A_1 = 0$ and thus the condition for the optimal tax rate without an equity allowance (noEA) reduces to $\frac{\tau_1^{FA,noEA}}{1 - \tau_1^{FA,noEA}} = -\frac{(2 - \lambda)K_1^2\pi''(K_1)}{\pi(K_1)}$. Because the left-hand side of the equation increases with the tax rate, the optimal tax rate is lower without the AGI than with it ($\tau_A^{FA,noEA} < \tau_A^{FA,AGI}$). Thus without the AGI, the tax competition between countries remains tougher. This conclusion is given in Corollary 3.

Corollary 3: *The AGI reduces tax competition between countries in FA*

We also observe from equation (17) that the tax rate decreases with the welfare weight for company profits (λ). Thus in the FA tax system a pure tax revenue-maximizing government ($\lambda = 0$) retains the tax competition between countries less intense than one that also takes company profits into account in its welfare.

The optimal tax rate under the ACE differs from that for the AGI as the base for the allowance is now the whole capital stock (K_1), not just that accumulated over the last 10 years only (A_1):

$$\frac{\tau_1^{FA,ACE}}{1 - \tau_1^{FA,ACE}} = -\frac{(2 - \lambda)K_1^2\pi''(K_1)}{\pi(K_1) - \rho K_1} \quad (18)$$

Because $A_1 < K_1$, the ACE reduces tax competition even more than the AGI by leaving tax rates at higher levels. This conclusion is given in Corollary 4.

Corollary 4: *The ACE reduces tax competition between countries more than the AGI*

Let us next compare the tax competition in the current SA-based international corporate tax system to that in FA. For SA the group-level profits are:

$$\Pi^{SA} = (1 - \tau_1)\pi(K_1) + (1 - \tau_2)\pi(K_2) - \rho(K_1 + K_2) \quad (19)$$

And the optimal tax rate is (see Appendix C):

$$\frac{\tau_1^{SA}}{1 - \tau_1^{SA}} = -\frac{(2 - \lambda)\pi(K_1)\pi''(K_1)}{\pi'(K_1)^2} \quad (20)$$

First, we observe that as with FA, the tax rate decreases with the welfare weight for company profits (λ) in SA. Thus in SA a pure tax revenue-maximizing government ($\lambda = 0$) reduces the tax competition between countries compared to one that also takes company profits into account in its welfare.

³⁷ Note that the higher the right-hand side of the equation, the higher the optimal tax rate $\tau_1^{FA,AGI}$.

The introduction of FA without an equity allowance intensifies tax competition by lowering tax rates and the effect is larger the larger the relative weight of tax revenue (i.e. the smaller the λ), because:

$$\frac{\tau_1^{FA,noEA}}{1 - \tau_1^{FA,noEA}} - \frac{\tau_1^{SA}}{1 - \tau_1^{SA}} = \frac{(2 - \lambda)\pi''(K_1)}{\pi'(K_1)^2\pi(K_1)} [\pi(K_1)^2 - (\pi'(K_1)K_1)^2] < 0 \quad (21)$$

Introducing FA together with the AGI affects tax competition, but the sign of the effects remains ambiguous:

$$\frac{\tau_1^{FA,AGI}}{1 - \tau_1^{FA,AGI}} - \frac{\tau_1^{SA}}{1 - \tau_1^{SA}} = \frac{(2 - \lambda)\pi''(K_1)}{\pi'(K_1)^2(\pi(K_1) - \rho A_1)} \{\pi(K_1)^2 - (\pi'(K_1)K_1)^2 - \rho A_1\pi(K_1)\} \quad (22)$$

From equation (22) we see that tax competition decreases when $\rho A_1\pi(K_1) > \pi(K_1)^2 - (\pi'(K_1)K_1)^2$. This means that tax competition decreases with a sufficiently generous AGI allowance. This observation is provided in Corollary 5.

Corollary 5: *With a sufficiently generous AGI allowance, a replacement of the SA tax system by the FA system with the AGI reduces tax competition between countries.*

Let us next illustrate the effects of the AGI in decreasing tax competition between countries by employing the formulas derived in the above. One important factor affecting the calculations is the AGI rate. Table 2 shows the results for optimal tax rates³⁸ with the AGI rate varying between 0.02 and 0.07.³⁹

Table 2. Optimal Tax Rates

AGI Rate ($a = \rho$)		0.02	0.03	0.04	0.05	0.06	0.07
Tax Rate	$\tau_1^{FA,noEA}$	33.3 %	33.3 %	33.3 %	33.3 %	33.3 %	33.3 %
	$\tau_1^{FA,AGI}$	33.8 %	34.1 %	34.4 %	34.6 %	34.9 %	35.2 %
	$\tau_1^{FA,ACE}$	34.4 %	34.9 %	35.4 %	36.0 %	36.6 %	37.2 %

The first column in the table shows that with the smallest possible AGI rate, 0.02, tax competition would be reduced by the AGI, because the tax rate would remain 0.5 percentage points higher in the presence of the AGI compared to the case without an equity allowance. For the ACE, the tax competition would in this case decrease even more: by 1.1 percentage points. The other columns of the table show that the larger the AGI rate, the larger the reduction in the tax competition. We also observe that the tax rate increases from the case without an equity allowance to the ACE are roughly twice the size of the increase from the case with no equity allowance to the AGI. For an AGI rate of 0.07, the tax rate increase is 1.9 percentage points for the AGI and 3.9 percentage points for the ACE.

³⁸ In our calculations we have chosen the production function to be $\pi(K) = \sqrt{K}$, the overall capital level $K = 10$, the government is Leviathan ($\lambda = 0$) and half of the capital is considered to be accumulated over the last ten years.

³⁹ Note that according to the draft directive (EC 2016a), the AGI rate is at least 2 percentage points.

5. Discussion

The main focus in our study has been on the AGI, which may be considered as a variant of the ACE, where not only the debt-related costs but also the notional costs of equity are tax-deductible. In order to compare implications of these for investment incentives and tax competition we have given the results for both the AGI and the ACE, making our paper the first to study the properties of the AGI. The results show that even if the ACE seems to broadly achieve its main original targets - removal of the debt bias and the investment neutrality within the tax system - the AGI does not achieve these properties. However, in line with the targets of the draft proposal, the AGI still increases investment incentives (and is thus likely to boost the economy) and decreases the debt bias. Regarding tax competition, the AGI also makes an improvement compared to an FA tax system without an equity allowance by decreasing tax competition. However, the ACE outperforms the AGI also in this respect. Therefore, if the investment incentives and tax competition implications of the two equity allowances were the only measures determining their ranking, the ACE would be the number one choice. However, taking into account the other side of the story also, the possible tax revenue losses – a critique made of the ACE – might change the ranking. Given that there is a trade-off between incentives and tax revenue, and that the only thing that differentiates the AGI and the ACE is the accumulation period of the AGI allowance, a desirable balance is likely to be found by choosing the accumulation period of the AGI in a desirable way.

Our results add some new aspects to earlier contributions that have excluded the detailed properties of the AGI from their scope. Whereas the calculations in the Impact Assessment (EC 2016c; IA) accompanying the CCCTB proposal assume the AGI to be a fixed fraction (20%) of the ACE, we show that (in terms of investment incentives and tax competition) their relationship cannot be captured by a single number, but the dependence is non-linear. Moreover, in light of our results the fraction employed in the IA seems to be estimated too low (see Table 1 and Figure 2).

There are also a few important aspects regarding the AGI that remain beyond our study, and are left for future studies. First, given that the AGI is supposed to be implemented as part of the CCCTB proposed for the EU countries, it changes the taxation in these countries relative to third countries that do not feature changes in their cost of capital, like the US or tax havens. Therefore, as the AGI increases investment incentives, it makes the EU countries more lucrative for foreign investments. Thus one could also consider the AGI to be a tax competition tool in this respect.⁴⁰ Second, our study does not include direct investments in foreign countries, and in our model all overseas investments are channeled via the subsidiary. Including direct investments by the parent company in foreign countries could provide additional insight by affecting the allocation of the tax base across countries. Third, our model does not include debt-financing, which could also provide additional insight into the implications of the AGI.

⁴⁰ Hebous and Ruf (2017) make the point that the ACE opens the door for international tax-planning regarding profit-shifting. We show that the equity allowance (both AGI and ACE) may provide tax-planning incentives not only regarding profit-shifting, but also the real activity.

6. Conclusions

We have studied how the Allowance for Growth and Investment (AGI) proposed in the European Commission proposal for the Common Consolidated Corporate Tax Base (CCCTB) affects the investment incentives of companies and tax competition between countries. Our paper, which is the first to study the properties of the AGI, shows some intriguing results. Compared to a CCCTB without any allowances for corporate equity, we find that a corresponding tax system with the AGI increases investment incentives in high-tax countries. We also find that while the CCCTB pushes investments towards low-tax countries by increasing the cost of capital gap between countries with different tax rates, the AGI reduces the gap and therefore also the push of investments towards low-tax countries. However, we also find that the AGI distorts the allocation of capital with respect to several dimensions, like economic depreciation, and in the presence of accelerated depreciation. Regarding the strategic interaction between countries, we find that the AGI reduces tax competition in a consolidated tax system. Also, while a replacement of the current separate accounting (SA) tax system by a CCCTB without an equity allowance would intensify tax competition between countries, the introduction of a CCCTB with the AGI might result in a reduction in tax competition. The sign of the effect depends on the generosity of the AGI allowance.

We also provide new results for the standard Allowance for Corporate Equity (ACE) discussed intensively in the literature. We first show that the ACE reduces the FA-induced investment push towards low-tax countries. Regarding the strategic responses to other countries' decisions, we show that the ACE reduces tax competition between countries. Regarding the comparison between the two equity allowances being studied (AGI and ACE), we find that even if the AGI both increases investment incentives and reduces tax competition, the ACE would perform better regarding these aspects. In addition, unlike the AGI, the ACE removes the debt bias completely and does not distort the investment incentives under accelerated depreciation schedules. The ACE has therefore better neutrality properties than the AGI. However, it has been argued that the ACE induces large tax revenue losses, which may require tax rate increases in order to finance them (see Bond 2000 and Griffith et al. 2010).

Acknowledgements

We gratefully acknowledge the seminar participants of the XL Annual Meeting of the Finnish Economic Association in Turku, the Finnish Economic Researchers' Summer Seminar in Jyväskylä, the 2018 ZEW Public Finance Conference in Mannheim, and the 74th Annual Congress of the International Institute of Public Finance in Tampere.

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Appendix A: Proof of Proposition 1.

In this Appendix we present a proof of Proposition 1. We state and prove the result in two separate parts, Proposition A.1 and Proposition A.2, for SA and FA, respectively. We first restate the problem with all necessary assumptions. Let $\mathbb{R}_+ = [0, \infty)$ and denote by Ω the set of functions f on \mathbb{R}_+ such that f is almost everywhere continuous and $\int_0^\infty |f(t)|e^{-\rho t} dt < \infty$.⁴¹ Let $k_i \geq 0$, $a \geq 1$, $\delta > 0$, $\rho > 0$, $0 \leq \tau_1, \tau_2 < 1$, $v \geq 0$, $X_i > 0$ be constants, abbreviate $j = e^{-\gamma v}$ and define $R_1(t) = e^{-\gamma t}k_1$ for $0 < t < v$ and $R_1(t) = jB_1(t - v)$ for $t \geq v$. The objective is to find a policy $(D_1, Q_1, D_2, Q_2) \in \Omega^4$ which maximizes

$$\int_0^\infty (D_1(t) - Q_1(t))e^{-\rho t} dt \quad (\text{A.1})$$

subject to

$$\pi(K_1) + Q_1 + D_2 = I_1 + Q_2 + D_1 + T_1(K_1, K_2, B_1, B_2),$$

$$\pi(K_2) + Q_2 = I_2 + D_2 + T_2(K_1, K_2, B_1, B_2),$$

$$\dot{K}_i = I_i - \delta K_i \quad \text{a. e. on } \mathbb{R}_+, \quad i = 1, 2,$$

$$\dot{B}_i = I_i - \gamma B_i \quad \text{a. e. on } \mathbb{R}_+, \quad i = 1, 2,$$

$$A_i = B_i - R_i, \quad i = 1, 2,$$

$$B_i(0) = K_i(0) = k_i \geq 0,$$

$$D_1 \geq 0, D_2 \geq 0, Q_1 \geq 0, Q_2 \geq 0,$$

where (i) K_i and B_i are continuous and almost everywhere differentiable on \mathbb{R}_+ , (ii) $\pi(K_i)$, B_i and $T_i(K_1, K_2, B_1, B_2)$ belong to Ω , (iii) $\lim_{t \rightarrow \infty} K_i(t)E(t) = 0$, and (iv) $\pi: \mathbb{R}_+ \rightarrow \mathbb{R}_+$ satisfies the usual Inada conditions. Further, in FA,

$$T_1(K_1, K_2, B_1, B_2) = \tau_1 s_1(K_1, K_2)(\pi(K_1) - \gamma B_1 - aA_1 + \pi(K_2) - \gamma B_2 - aA_2),$$

$$T_2(K_2, K_1, B_1, B_2) = \tau_2 s_2(K_2, K_1)(\pi(K_1) - \gamma B_1 - aA_1 + \pi(K_2) - \gamma B_2 - aA_2),$$

$$s_i(K_i, K_j) = \sigma_K \frac{K_i}{K_i + K_j} + X_i, \quad i = 1, 2.$$

In SA,

$$T_1(K_1, K_2, B_1, B_2) = \tau_1(\pi(K_1) - \gamma B_1 - aA_1) \text{ and } T_2(K_2, K_1, B_1, B_2) = \tau_2(\pi(K_2) - \gamma B_2 - aA_2).$$

⁴¹ A function f is almost everywhere (a.e.) continuous (respectively differentiable) on \mathbb{R}_+ if for every finite subinterval of \mathbb{R}_+ there is a finite number of points where f is not continuous (respectively differentiable). This assumption could be relaxed, but it allows a suitable generality of our main result.

A policy (D_1, Q_1, D_2, Q_2) is said to be admissible if it satisfies all of the above conditions. We denote the set of all admissible policies by Γ .

We first consider SA only.

Let the numbers K_i^* be given by the equations

$$\pi'(K_i^*) = \frac{\left(1 - \tau_i \frac{a(1 - e^{-(\gamma+\rho)v}) + \gamma}{\rho + \gamma}\right)}{1 - \tau_i} (\rho + \delta). \quad (\text{A.2})$$

We assume the constants $\tau_i, \rho, \delta, a, \gamma, v$ chosen so that the right-hand side of (A.2) is positive.

Proposition 1.(i) is contained in the following result. Note that due to the delayed terms R_i this is a non-standard version of an optimal control problem. Problems with delayed response can be solved with the help of a suitable form of the Pontryagin maximum principle (see, for example; Kamien & Schwartz, 2012). However, as our model is slightly more complex, we below present a complete proof of Proposition A.1 along the lines of the argument given in Section 19 of Kamien & Schwartz (2012).

Proposition A.1: *Consider SA. A policy $(D_1, Q_1, D_2, Q_2) \in \Gamma$ maximizes the objective function in (A.1) if and only if $K_i(t) = K_i^*$ for all t , for $i = 1, 2$. In particular, the optimal levels of cost of capital in countries 1 and 2 are $\pi'(K_1^*)$ and $\pi'(K_2^*)$ for all t .*

Proof of Proposition A.1: Abbreviate $c = e^{-\rho v}$ and $E(t) = e^{-\rho t}$. Let $(D_1, Q_1, D_2, Q_2) \in \Gamma$ be such that $K_i(t) = K_i^*$ for all t and $i = 1, 2$. Define the constants (or costate variables) λ_i and μ_i ($i = 1, 2$) as

$$\lambda_i = (1 - \tau_i) \frac{\pi'(K_i^*)}{(\rho + \delta)} = 1 - \tau_i \frac{a(1 - e^{-(\gamma+\rho)v}) + \gamma}{\rho + \gamma}$$

$$\mu_i = 1 - (1 - \tau_i) \frac{\pi'(K_i^*)}{(\rho + \delta)} = \tau_i \frac{a(1 - e^{-(\gamma+\rho)v}) + \gamma}{\rho + \gamma}.$$

Then $\lambda_i + \mu_i = 1$ and $0 < \lambda_i, \mu_i < 1$ for $i = 1, 2$. Let $(D'_1, Q'_1, D'_2, Q'_2) \in \Gamma$ be any admissible solution which does not satisfy $K_i(t) = K_i^*$ for all t and $i = 1, 2$. Then $K_i'(t') \neq K_i^*$ for some $t' > 0$ and $i = 1$ or 2 . Without loss of generality, we may assume that this holds for $i = 1$. Consider the differences $\tilde{D}_i = D_i - D'_i$ and $\tilde{Q}_i = Q_i - Q'_i$. Since (D'_1, Q'_1, D'_2, Q'_2) is chosen arbitrarily, the proof of Proposition A.1 is completed once we show that

$$\Delta := \int_0^{\infty} (\tilde{D}_1 - \tilde{Q}_1) E dt > 0.$$

It follows from the constraints of the problem that

$$\tilde{D}_1 - \tilde{Q}_1 = \sum_{i=1}^2 (1 - \tau_i) (\pi(K_i) - \pi(K'_i)) + \tau_i \gamma \tilde{B}_i + \tau_i a (\tilde{B}_i - \tilde{R}_i) + \lambda_i (-\delta \tilde{K}_i - \tilde{K}'_i) + \mu_i (-\gamma \tilde{B}_i - \tilde{B}'_i),$$

where $\tilde{K}_i = \dot{K}_i - \dot{K}'_i$ and $\tilde{B}_i = \dot{B}_i - \dot{B}'_i$.

We apply the following three facts: First, by the concavity of π and the identity $K_i = K_i^*$,

$$(1 - \tau_i)(\pi(K_i) - \pi(K'_i)) \geq (1 - \tau_i)\pi'(K_i)(K_i - K'_i) = \lambda_i(\rho + \delta)\tilde{K}_i. \quad (\text{A.3})$$

Second, since $\tilde{R}_i(t) = 0$, for $t < v$, we get by a change of variables,

$$\int_0^\infty \tilde{R}_i E dt = \int_v^\infty \tilde{R}_i E dt = j \int_v^\infty \tilde{B}_i(t - v)E(t) dt = j \int_0^\infty \tilde{B}_i(t)E(t + v) dt = cj \int_0^\infty \tilde{B}_i E dt. \quad (\text{A.4})$$

Third, by the definition of μ_i ,

$$\tau_i \gamma + \tau_i a(1 - cj) = \mu_i(\rho + \gamma).$$

Inserting these facts to Δ yields us the lower estimate

$$\begin{aligned} \Delta &= \int_0^\infty (\tilde{D}_1 - \tilde{Q}_1)E dt \geq \int_0^\infty \left(\sum_{i=1}^2 \lambda_i(\rho + \delta)\tilde{K}_i + \mu_i(\rho + \gamma)\tilde{B}_i + \lambda_i(-\delta\tilde{K}_i - \dot{\tilde{K}}_i) + \mu_i(-\gamma\tilde{B}_i - \dot{\tilde{B}}_i) \right) E dt \\ &= \int_0^\infty \left(\sum_{i=1}^2 \lambda_i(\rho\tilde{K}_i - \dot{\tilde{K}}_i) + \mu_i(\rho\tilde{B}_i - \dot{\tilde{B}}_i) \right) E dt = \sum_{i=1}^2 \lambda_i \int_0^\infty -(\tilde{K}_i E)' dt + \mu_i \int_0^\infty -(\tilde{B}_i E)' dt \\ &= \sum_{i=1}^2 \lambda_i \tilde{K}_i(0) + \mu_i \tilde{B}_i(0) = 0, \end{aligned}$$

where the last steps employed the assumption $\lim_{t \rightarrow \infty} K_i(t)E(t) = 0$ as well as the identities $\tilde{K}_i(0) = \tilde{B}_i(0) = 0$ and $\lambda_i + \mu_i = 1$.

Because $K'_1(t') \neq K_1^*$ for some $t' > 0$ and K'_1 is continuous, $K'_1 \neq K_1^*$ holds on some open interval S . On this interval the inequality (A.3) is strict, by the strict concavity of π . This implies that the conclusion $\Delta \geq 0$ also holds as a strict inequality, $\Delta > 0$. This shows that the condition $K_i = K_i^*$ ($i = 1, 2$) determines the optimal policies uniquely. This completes the proof of Proposition A.1.

We next consider FA and concentrate on the long-run (steady-state) solution only.

Let

$$\bar{\tau}(K_1, K_2) = \tau_1 s_1(K_1, K_2) + \tau_2 s_2(K_2, K_1)$$

and

$$P(K_1, K_2, B_1, B_2, R_1, R_2) = \pi(K_1) + \pi(K_2) - (\gamma + a)(B_1 + B_2) + a(R_1 + R_2).$$

Let K_i^* and B_i^* and the (costate) variables λ_i and μ_i be defined by the state equations, the equations

$$\dot{\lambda}_1 = (\rho + \delta)\lambda_1 - (1 - \bar{\tau}(K_1^*, K_2^*))\pi'(K_1) + \frac{\sigma_K K_2^* (\tau_1 - \tau_2)}{(K_1^* + K_2)^2} P(K_1^*, K_2^*, B_1^*, B_2^*, R_1^*, R_2^*), \quad (\text{A.5})$$

$$\dot{\mu}_1 = (\rho + \gamma)\mu_1 - (\gamma + a)\bar{\tau}(K_1^*, K_2^*) + caj\bar{\tau}(K_1^*, K_2^*)^\nu, \quad (\text{A.6})$$

analogous equations for λ_2 and μ_2 with indices 1 and 2 interchanged, and the condition $\lambda_1 + \mu_1 = 1$. Above the notation $f^\nu(t)$ means $f(t + \nu)$.

We assume that the function

$$G(K_1, K_2, B_1, B_2, R_1, R_2) = (1 - \bar{\tau}(K_1, K_2))(\pi(K_1) + \pi(K_2)) + \bar{\tau}(K_1, K_2)((\gamma + a)(B_1 + B_2) - a(R_1 + R_2)).$$

is concave and strictly concave wrt. K_1 and K_2 . We also assume that admissible solutions satisfy $\lim_{t \rightarrow \infty} (\lambda_i K_i E)(t) = \lim_{t \rightarrow \infty} (\mu_i B_i E)(t) = 0$. The following result contains Proposition 1.(ii).

Proposition A.2: Consider FA. A policy $(D_1, Q_1, D_2, Q_2) \in \Gamma$ maximizes the objective function in (A.1) if and only if $K_i = K_i^*$ and $B_i = B_i^*$ as defined above ((A.5) and (A.6)), for $i = 1, 2$. Assuming a steady-state solution, the numbers $K_i^{**} = \lim_{t \rightarrow \infty} K_i^*(t)$ satisfy

$$(1 - \bar{\tau}(K_1^{**}, K_2^{**}))\pi'(K_1^{**}) = (\rho + \delta) \left(1 - \frac{(\gamma + a(1 - cj)\bar{\tau}(K_1^{**}, K_2^{**}))}{\rho + \gamma} \right) + \frac{\sigma_K K_2^{**} (\tau_1 - \tau_2)}{(K_1^{**} + K_2^{**})^2} P^*(K_1^{**}, K_2^{**}), \quad (\text{A.7})$$

where

$$P^*(K_1^{**}, K_2^{**}) = \pi(K_1^{**}) + \pi(K_2^{**}) - \frac{(\gamma + a + aj)\delta}{\gamma} (K_1^{**} + K_2^{**}).$$

An analogous equation holds with indices 1 and 2 interchanged.

Proof of Proposition A.2: Using a similar notation as in the proof of Proposition A.1 and assuming that $K_i = K_i^*$ and $B_i = B_i^*$ for $i = 1, 2$, the aim is to show that

$$\Delta := \int_0^\infty (\tilde{D}_1 - \tilde{Q}_1)E dt \geq 0.$$

The constraints of the problem imply

$$\begin{aligned} \tilde{D}_1 - \tilde{Q}_1 &= G(K_1, K_2, B_1, B_2, R_1, R_2) - G(K_1', K_2', B_1', B_2', R_1', R_2') - \lambda_i \left(\sum_{i=1}^2 \dot{K}_i + \delta \tilde{K}_i \right) \\ &\quad - \mu_i \left(\sum_{i=1}^2 \dot{B}_i + \gamma \tilde{B}_i \right). \end{aligned}$$

Since G is assumed to be concave, we get, by writing $x = (K_1, K_2, B_1, B_2, R_1, R_2)$, that

$$\begin{aligned}
G(x) - G(x') &\geq \nabla G(x)^T (x - x') \\
&= \tilde{K}_1 \left((1 - \bar{\tau}(K_1, K_2))\pi'(K_1) - \sigma_K \frac{(\tau_1 - \tau_2)K_2}{(K_1 + K_2)^2} P(K_1, K_2, B_1, B_2, R_1, R_2) \right) \\
&\quad + \tilde{K}_2 \left((1 - \bar{\tau}(K_1, K_2))\pi'(K_2) - \sigma_K \frac{(\tau_2 - \tau_1)K_1}{(K_1 + K_2)^2} P(K_1, K_2, B_1, B_2, R_1, R_2) \right) \\
&\quad + (\tilde{B}_1 + \tilde{B}_2)(\gamma + a)\bar{\tau}(K_1, K_2) - (\tilde{R}_1 + \tilde{R}_2)aj\bar{\tau}(K_1, K_2).
\end{aligned}$$

Integrating and applying a change of variables as in (A.4), yields the lower estimate

$$\begin{aligned}
\Delta &\geq \int_0^\infty \left(\tilde{K}_1 \left((1 - \bar{\tau}(K_1, K_2))\pi'(K_1) - \sigma_K \frac{(\tau_1 - \tau_2)K_2}{(K_1 + K_2)^2} P(K_1, K_2, B_1, B_2, R_1, R_2) \right) \right. \\
&\quad \left. + \tilde{K}_2 \left((1 - \bar{\tau}(K_1, K_2))\pi'(K_2) - \sigma_K \frac{(\tau_2 - \tau_1)K_1}{(K_1 + K_2)^2} P(K_1, K_2, B_1, B_2, R_1, R_2) \right) \right. \\
&\quad \left. + (\tilde{B}_1 + \tilde{B}_2)[(\gamma + a)\bar{\tau}(K_1, K_2) - caj\bar{\tau}(K_1, K_2)^v] \right) E dt.
\end{aligned}$$

Using the definitions of λ_i and μ_i , this yields

$$\Delta \geq \int_0^\infty \left(\sum_{i=1}^2 \tilde{K}_i(\rho\lambda_i - \dot{\lambda}_i) - \lambda_i \dot{\tilde{K}}_i + \tilde{B}_i(\rho\mu_i - \dot{\mu}_i) - \mu_i \dot{\tilde{B}}_i \right) E dt = \sum_{i=1}^2 - \int_0^\infty (\lambda_i \tilde{K}_i E)' dt - \int_0^\infty (\mu_i \tilde{B}_i E)' dt = 0,$$

which shows that K_i and B_i are optimal. The uniqueness of the solutions $K_i = K_i^*$ and $B_i = B_i^*$ ($i = 1, 2$) (i.e. the strict inequality $\Delta > 0$) is proved similarly as in the proof of Proposition A.1 using the continuity of K_i and the strict concavity of G with respect to K_i .

Equations (A.5) and (A.6) and the fact $\lambda_1 + \mu_1 = 1$ imply the relation

$$\begin{aligned}
\lambda_1 \left(\frac{\gamma - \delta}{\rho + \gamma} \right) + (1 - \bar{\tau}(K_1, K_2))\pi'(K_1) \\
= (\rho + \delta) \left(1 - \frac{(\gamma + a)\bar{\tau}(K_1, K_2) - caj\bar{\tau}(K_1, K_2)^v}{\rho + \gamma} \right) \\
+ \frac{\sigma_K K_2 (\tau_1 - \tau_2)}{(K_1 + K_2)^2} P(K_1, K_2, B_1, B_2, R_1, R_2).
\end{aligned}$$

Assuming now a steady-state solution, where $\lim_{t \rightarrow \infty} \dot{\lambda}_i(t) = \lim_{t \rightarrow \infty} \dot{\mu}_i(t) = 0$ and where

$\lim_{t \rightarrow \infty} K_i(t) =: K_i^{**}$ and $\lim_{t \rightarrow \infty} B_i(t) =: B_i^{**}$ exist for $i = 1, 2$, we have $\lim_{t \rightarrow \infty} \bar{\tau}(K_1(t), K_2(t))^v = \bar{\tau}(K_1^*, K_2^*)$

and, solving from the state equations, $\lim_{t \rightarrow \infty} B_i(t) = (\delta/\gamma)K_i^*$. The above relation now implies

(A.7).

Appendix B: Investment-Enhancing Effects of AGI

$(\gamma > \delta; \rho; a \neq \rho; v)$

Accelerated Fiscal Depreciation ($\gamma > \delta$)

In Table 1 we considered cases where the book value of the capital stock evolves exactly like the real value of the stock of capital. Let us next consider cases where we allow for the accelerated rate of fiscal depreciation to be higher than the rate of economic depreciation. The results are given in Table 3.

The first column in Table 3 again shows the baseline case. In column 2 we consider a case which is otherwise like the baseline case, but where the accounting stock of capital depreciates at double the speed of the economic depreciation ($\gamma = 2 * \delta$). In this case, the cost of capital of the case with no allowance decreases from 0.0640 to 0.0576 and for the AGI from 0.0507 to 0.0500. Therefore, in the presence of accelerated depreciation, the introduction of the AGI reduces the cost of capital by 13.2%, which is less than without accelerated depreciation (20.8%). This follows, however, mostly from the reduction in the cost of capital taking place in the case with no allowance. Compared to the ACE, two things are observed. First, the cost of capital in the AGI becomes extremely close to that for the ACE (with four-decimal accuracy they become indistinguishable from each other). Second, the cost of capital in the ACE is not affected by accelerated depreciation, whereas the investment incentives in the AGI depend on accelerated depreciation.

Columns 3 and 4 consider accelerated depreciation in cases where the depreciation rate is lower than in columns 1 and 2. Again, accelerated depreciation mutes the increase in the investment incentive following from the AGI. The cost of capital in the ACE remains intact in this case also.

Table 3. Cost of Capital: Accelerated Fiscal Depreciation

Tax Parameters and Economic Parameters		(1 BASE)	(2)	(3)	(4)
Corporate Tax Rate in Country 1	τ_1	0.219	0.219	0.219	0.219
Corporate Tax Rate in Country 2	τ_2	0.219	0.219	0.219	0.219
Rate of Economic Depreciation	δ	0.25	0.25	0.05	0.05
Rate of Fiscal Depreciation	γ	0.25	0.50	0.05	0.10
Discount Rate	ρ	0.05	0.05	0.05	0.05
AGI Rate	a	0.05	0.05	0.05	0.05
Duration of Investment in AGI	v	10	10	10	10
Cost of Capital					
FA, No Equity Allowance		0.0640	0.0576	0.0640	0.0593
AGI		0.0507	0.0500	0.0552	0.0521
ACE		0.0500	0.0500	0.0500	0.0500

In summary, the AGI and ACE decrease the cost of capital compared to the case with no allowance and with accelerated depreciation. However, the reductions are smaller in relative terms in the presence of accelerated depreciation than without it. However, the cost of capital in the ACE is neither affected by the differences in the depreciation rate nor by accelerated depreciation, whereas the cost of capital for both the AGI and the case with no allowance remain dependent on the parameter values.

Discount Rate (ρ)

In Table 4 we study the investment incentives using varying discount rates. We observe that whereas for the case with no equity allowance the change in the discount rate seems to scale the cost of capital, for the ACE the cost of capital remains exactly at the level of the discount rate. For the AGI the cost of capital is neither a pure scaling nor a pure shift, but the discount rate affects the cost of capital non-linearly. Compared to the above cases the cost of capital in the ACE is no longer a constant, but depends on the discount rate.

Table 4. Cost of Capital: AGI Rate

Tax Parameters and Economic Parameters		(1 BASE)	(2)	(3)	(4)
Corporate Tax Rate in Country 1	τ_1	0.219	0.219	0.219	0.219
Corporate Tax Rate in Country 2	τ_2	0.219	0.219	0.219	0.219
Rate of Economic Depreciation	δ	0.25	0.25	0.25	0.25
Rate of Fiscal Depreciation	γ	0.25	0.25	0.25	0.25
Discount Rate	ρ	0.05	0.10	0.15	0.025
AGI Rate	a	0.05	0.10	0.15	0.025
Duration of Investment in AGI	v	10	10	10	10
Cost of Capital					
FA, No Equity Allowance		0.0640	0.1280	0.1921	0.0320
AGI		0.0507	0.1008	0.1508	0.0254
ACE		0.0500	0.1000	0.1500	0.0250

AGI Rate ($a \neq \rho$)

Let us next consider how the AGI rate affects investment incentives. Table 5 shows the parameter specifications and the cost of capital calculations for the cases where we vary the AGI rate (a), and in particular make it differ from the discount rate (ρ). We first observe that now the cost of capital varies according to the parameter values in both the AGI and the ACE, but remains intact for the case with no equity allowance (as it does not depend on the AGI rate). Second, compared to the above cases where the AGI rate is aligned with the discount rate, now the cost of capital in the ACE differs from the discount rate. Third, we also observe that the higher AGI rate lowers the cost of capital for both the AGI and the ACE, and that the differences between the AGI and the ACE remain small.

Table 5. Cost of Capital: AGI Rate

Tax Parameters and Economic Parameters		(1 BASE)	(2)	(3)	(4)
Corporate Tax Rate in Country 1	τ_1	0.219	0.219	0.219	0.219
Corporate Tax Rate in Country 2	τ_2	0.219	0.219	0.219	0.219
Rate of Economic Depreciation	δ	0.25	0.25	0.25	0.25
Rate of Fiscal Depreciation	γ	0.25	0.25	0.25	0.25
Discount Rate	ρ	0.05	0.05	0.05	0.05
AGI Rate	a	0.05	0.10	0.15	0.025
Duration of Investment in AGI	v	10	10	10	10
Cost of Capital					
FA, No Equity Allowance		0.0640	0.0640	0.0640	0.0640
AGI		0.0507	0.0374	0.0241	0.0574
ACE		0.0500	0.0360	0.0220	0.0570

AGI Base Accumulation Period (v)

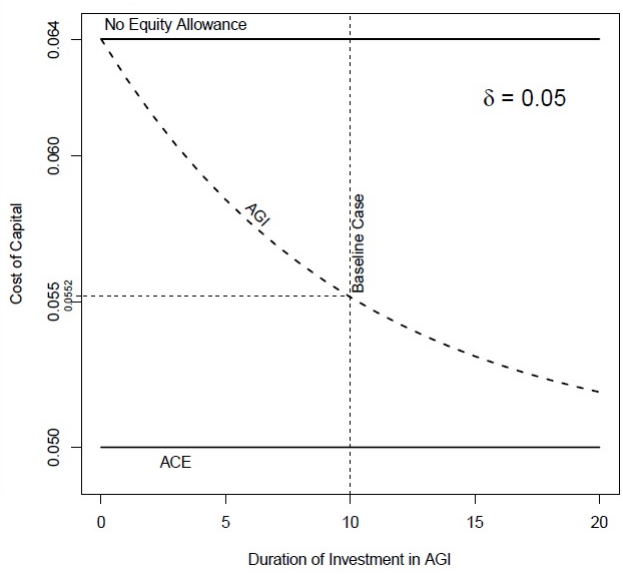
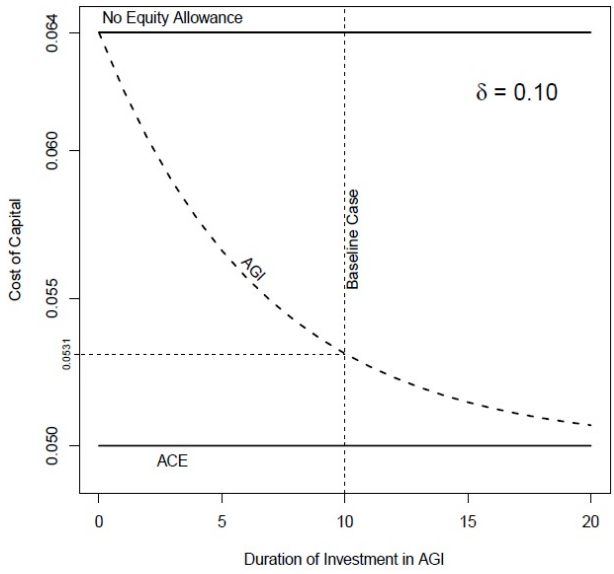
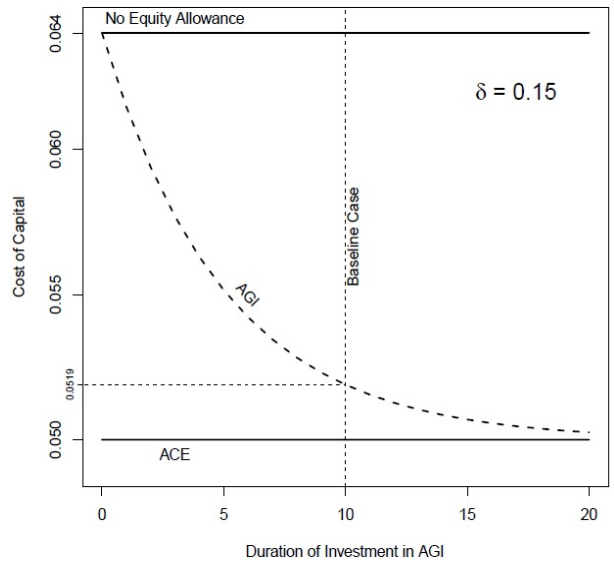
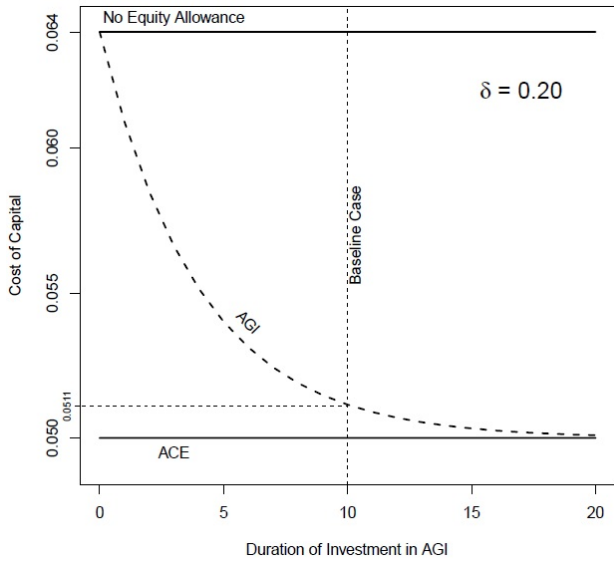
A particularly interesting feature of the AGI is how its base accumulates. This is also the thing that makes the AGI differ from the ACE. In Table 6 we study how the duration of the AGI accumulation period affects the cost of capital in our three cases. Compared to the baseline case, where a new investment remains in the AGI base for the next 10 years, in columns 2-4 it remains in it for 3, 5 or 15 years respectively. The table shows that whereas the cost of capital in the case with no equity allowance and for the ACE remain constant, the cost of capital in the AGI decreases non-linearly and quite rapidly in the first accumulation years, while the later years seem to be much less important for the cost of capital.

Table 6. Cost of Capital: AGI Base Accumulation Period

Tax Parameters and Economic Parameters		(1 BASE)	(2)	(3)	(4)
Corporate Tax Rate in Country 1	τ_1	0.219	0.219	0.219	0.219
Corporate Tax Rate in Country 2	τ_2	0.219	0.219	0.219	0.219
Rate of Economic Depreciation	δ	0.25	0.25	0.25	0.25
Rate of Fiscal Depreciation	γ	0.25	0.25	0.25	0.25
Discount Rate	ρ	0.05	0.05	0.05	0.05
AGI Rate	a	0.05	0.05	0.05	0.05
Duration of Investment in AGI	v	10	3	5	15
Cost of Capital					
FA, No Equity Allowance		0.0640	0.0640	0.0640	0.0640
AGI		0.0507	0.0557	0.0531	0.0502
ACE		0.0500	0.0500	0.0500	0.0500

We study this issue in more detail in Figure 3, which focuses on how the cost of capital in the AGI depends on the number of years that are counted in for the AGI base. Motivated by Table 1, which showed the differences in the cost of capital with respect to the depreciation rate, δ , we study this issue by considering in Figure 3 how the length of the accumulation period of the AGI base affects the cost of capital when the depreciation rates vary. Compared to Figure 2, where the depreciation rate is 0.25, in Figure 3 we consider lower rates ranging from 0.20 to 0.05. We find a similar pattern in each of the graphs in Figure 3: the cost of capital in the AGI coincides with that for the case with no equity allowance when $a = 0$ and converges to that of the ACE as a increases. The rate of the convergence depends on the depreciation rate. A higher depreciation rate is related to faster convergence. We also observe that with other than very low depreciation rates, the cost of capital in the AGI remains closer to that for the ACE than that of the case with no equity allowance, when the AGI base is based on a 10-year history. For the 10-year duration the cost of capital in the AGI is decreased by between 13.8% and 20.8% in Figures 2 and 3. For the ACE the decrease is 21.9% in each case. So the effects of the AGI seem to be quite close to those of the ACE, but do depend on the parameter values, unlike those of the ACE.

Figure 3: Cost of Capital and Duration of Investment in AGI, varying depreciation rates



Appendix C: Proof of Proposition 2

Proposition 2: *The optimal tax rate of country 1 in a symmetric tax competition model with the FA tax system and the AGI is determined by the following equation:*

$$\frac{\tau_1^{FA,AGI}}{1 - \tau_1^{FA,AGI}} = - \frac{(2 - \lambda)K_1^2 \pi''(K_1)}{\pi(K_1) - \rho A_1} \quad (\text{A.8})$$

For the case without an equity allowance, the ACE and the SA, the corresponding optimal tax rates are given by equations (A.9) – (A.11)

$$\frac{\tau_1^{FA,noEA}}{1 - \tau_1^{FA,noEA}} = - \frac{(2 - \lambda)K_1^2 \pi''(K_1)}{\pi(K_1)} \quad (\text{A.9})$$

$$\frac{\tau_1^{FA,ACE}}{1 - \tau_1^{FA,ACE}} = - \frac{(2 - \lambda)K_1^2 \pi''(K_1)}{\pi(K_1) - \rho K_1} \quad (\text{A.10})$$

$$\frac{\tau_1^{SA}}{1 - \tau_1^{SA}} = - \frac{(2 - \lambda)\pi(K_1)\pi''(K_1)}{\pi'(K_1)^2} \quad (\text{A.11})$$

Proof of Proposition 2:

We first prove (A.8). The company chooses its capital levels K_1 and K_2 optimally by maximizing the net-of-tax profits. For FA with the AGI the net-of-tax profits for a company are

$$\Pi^{FA,AGI} = [\pi(K_1) + \pi(K_2) - \rho K] - \bar{\tau} \underbrace{[\pi(K_1) + \pi(K_2) - \rho A]}_{= P^{FA}(K_1, K_2)}$$

where $\bar{\tau} = \frac{K_1}{K} \tau_1 + \frac{K_2}{K} \tau_2$, $K = K_1 + K_2$ and $A = A_1 + A_2$ with K and A being constants. Taking the derivative w.r.t K_1 gives us the following condition

$$\frac{\partial \Pi^{FA,AGI}}{\partial K_1} = (1 - \bar{\tau})[\pi'(K_1) - \pi'(K_2)] - \frac{1}{K}(\tau_1 - \tau_2)[\pi(K_1) + \pi(K_2) - \rho A] = 0$$

Differentiating this optimal condition w.r.t. τ_1 and using the symmetry ($\tau_1 = \tau_2 = \bar{\tau}$, $K_1 = K_2 = \frac{1}{2}K$ and $A_1 = A_2 = \frac{1}{2}A$) gives us the following equation (which will be used below):

$$\frac{\partial K_1}{\partial \tau_1} = \frac{\pi(K_1) - \rho A_1}{2(1 - \tau_1)\pi''(K_1)K_1} \quad (\text{A.12})$$

Next the country takes the company choices as given and chooses its tax rate by maximizing its welfare, where the welfare is now composed of tax revenue and the net-of-tax revenue of the corporate group, with the latter being multiplied by λ :

$$W_1^{FA,AGI} = T_1^{FA,AGI} + \lambda \Pi^{FA,AGI}$$

Here $T_1^{FA,AGI} = \tau_1 \frac{K_1}{K} P^{FA}(K_1, K_2) + \tau_1 \frac{\tilde{K}_1}{\tilde{K}} P^{FA}(\tilde{K}_1, \tilde{K}_2)$. Taking the derivative w.r.t. τ_1 , using the symmetry ($\tau_1 = \tau_2$, $K_1 = K_2 = \tilde{K}_1 = \tilde{K}_2$) and equation (A.12) gives us the following:

$$\frac{\partial W_1^{FA,AGI}}{\partial \tau_1} = \frac{\pi(K_1) - \rho A_1}{(1 - \tau_1)\pi''(K_1)K_1^2} [(2 - \lambda)\pi''(K_1)(1 - \tau_1)K_1^2 + \tau_1(\pi(K_1) - \rho A_1)] = 0$$

As the first term is considered to be greater than zero, the condition implies that the term in the square bracket has to be zero in the optimum. Thus we get the expression in equations (A.8) and (17) in Proposition 2.

The result in equation (A.9) for the case without an equity allowance (noEA) follows from (A.8) by choosing the AGI rate to be zero ($\rho = 0$). The proof of the ACE result in (18) and (A.10) follows exactly the same steps as above, but replacing A with K in each step.

For the SA tax system the proof of equation (20) and (A.11) also goes as above, but with an objective function $W_1^{SA} = T_1^{SA} + \lambda \Pi^{SA}$, where $T_1^{SA} = \tau_1 \pi(K_1) + \tau_1 \pi(\tilde{K}_1)$ and $\Pi^{SA} = (1 - \tau_1)\pi(K_1) + (1 - \tau_2)\pi(K_2) - \rho K$.

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