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Unintended technology-bias in corporate income taxation: The case of electricity generation in the low-carbon transition

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Unintended technology-bias in corporate income taxation – the case of electricity generation in the low-carbon transition

Abstract

This paper shows that corporate income tax (CIT) provisions can lead to different effective tax rates for different technologies producing the same output but having different cost structures, under otherwise identical CIT provisions. The paper develops a framework for analysing the sources of the differences in effective tax rates and adapts existing models to calculate and compare forward-looking average effective tax rates for carbon-neutral and carbon-intensive electricity generation technologies.

Considering CIT provisions for cost recovery in 36 OECD and partner economies, it finds that most tax systems calibrate the treatment of capital costs in a way that produces technology-neutral results when investments are debt-financed. This is because most tax systems offset the fact that deductions for capital costs are based on nominal (rather than real) capital costs by allowing deductibility for the full nominal (rather than real) cost of debt. In contrast, when an investment is equity-financed, the capital cost deduction may effectively be seen to be inadequate in the typical circumstance where the cost of equity is not deductible.

As a consequence, immediate deductibility of variable costs but not of capital costs implies that average effective tax rates are relatively high for capital-cost-intensive electricity generation when investment is financed via equity. Since low carbon electricity generation tends to be relatively capital-intensive, this result can be seen as a form of unintentional misalignment of the CIT system with decarbonisation objectives. Whether or not there is an overall bias against carbon-neutral technologies in the CIT system, abstracting from technology-specific tax incentives, depends on several other parameters, such as country-specific fiscal depreciation schedules and the sources of finance.

Fiscalité des sociétés et biais technologique involontaire – le cas de la production d'électricité en phase de transition vers une économie bas carbone

Résumé

Ce document décrit comment un même système d'impôt sur les bénéfices des sociétés peut aboutir à des taux d'imposition effectifs différents pour des technologies produisant le même produit mais dont les structures de coûts varient. Il propose un cadre permettant de déterminer l'origine de ces différences de taux d'imposition effectifs et procède à une adaptation des modèles existants afin de calculer et de comparer les taux d'imposition moyens effectifs prospectifs des technologies de production d'électricité à faible et à forte intensité de carbone.

Si l'on examine les règles relatives au recouvrement des coûts dans 36 pays de l'OCDE et économies partenaires, il ressort que la plupart des systèmes fiscaux prévoient un traitement spécifique des coûts d'investissement débouchant à la neutralité technologique lorsque les investissements sont financés par l'emprunt. En effet, le régime fiscal typique compense le fait que les déductions au titre des coûts d'investissement sont calculées sur la base des coûts nominaux (plutôt que réels) en autorisant la déductibilité du coût nominal total (plutôt que réel) de l'emprunt. En revanche, lorsqu'un investissement est financé sur fonds propres, la déduction des coûts d'investissement peut de facto être considérée comme inappropriée dans le cas habituel où le coût des fonds propres n'est pas déductible.

Il s'ensuit que la déductibilité immédiate des coûts variables mais pas des coûts d'investissement se traduit par des taux d'imposition effectifs moyens relativement élevés pour les technologies de production d'électricité nécessitant de fortes dépenses en capital lorsque celles-ci sont financées sur fonds propres. Comme la production d'électricité à faible émission de carbone a tendance à être relativement intense en capital, ce résultat peut être perçu comme une forme de décalage involontaire du régime de l'impôt sur les bénéfices des sociétés par rapport aux objectifs de décarbonisation. Déterminer si un régime induit ou non un biais général préjudiciable aux technologies à faible intensité de carbone, abstraction faite des incitations fiscales en faveur d'une technologie donnée, dépend de plusieurs autres paramètres, tels que les barèmes d'amortissement propres à chaque pays et les sources de financement.

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1. Introduction

This paper investigates the impact that corporate income tax (CIT) rules for cost recovery can have on investment decisions, more specifically on the choice between technologies. It adopts an investment project evaluation perspective to show that, when cost structures differ between substitute technologies, the CIT system can result in different effective tax rates (ETRs) across technologies, thereby potentially affecting technology choice. Typically, CIT systems allow variable costs to be immediately fully deducted from taxable income, whereas capital costs are not immediately deducted but depreciated over the lifetime of an depreciated over the lifetime of an asset, following country-specific fiscal depreciation rules. This differential treatment of costs can result in different tax liabilities for technologies producing similar outputs but exhibiting different cost structures. In this sense, the treatment of costs can interfere with the technology-neutrality of CIT systems. It is one of the central findings of the optimal taxation literature (Diamond and Mirrlees, 1971[1]) that a neutral tax system that does not distort decisions is optimal.

There are several situations where investment projects are faced with a choice between technologies with different cost structures. For example, electricity generation technologies using renewable sources of energy, such as wind and solar, feature relatively high capital costs and low variable costs per unit of output, as they do not incur substantial fuel costs. In contrast, variable costs for technologies relying on conventional sources of energy, such as coal or gas, are higher, as they include the market price of fuel. Outside the electricity market, business models using data driven services and technologies resulting from digitalisation tend to have lower variable costs. For example, in the manufacturing sector, traditional production processes compete with 3D printing and robotics, and in the transport sector, logistics companies will increasingly be able to rely on automated processes, including driverless trucks.

The contribution of this paper is threefold. First, it illustrates that current CIT rules are not neutral across equity-financed investments in substitute technologies with different cost structures, even if fiscal depreciation rules follow an asset's useful life. In the same setting, rules may be neutral if investments are financed by debt. Second, on methodology, the paper clarifies which ETR indicator to use when evaluating the impact of corporate tax rules on technology choice in a framework where cost structures of technologies differ. Third, in an empirical illustration, the paper investigates the extent to which the immediate deduction of variable costs but not of capital costs, and the country-specific depreciation of capital costs, affect ETRs for electricity generation technologies across 36 OECD and selected partner economies.[1]

Regarding the first contribution, the main finding of the analysis is that corporate tax rules for cost recovery are not neutral across substitute technologies with identical or strongly similar outputs and identical pre-tax profits, but different cost structures. Generally speaking, this result is due to differences in the Net Present Value (NPV) of tax deductions associated with the two investment projects. The larger the share of total costs that can be deducted from revenues and the earlier the deductions occur, the higher their NPV and, consequently, the lower the ETR on investment in a specific technology.

The paper identifies two channels through which corporate tax rules affect the NPV of capital allowances: the degree to which capital allowances compensate for the time value of money (compensation effect) and accelerated depreciation of capital costs (fiscal depreciation effect). These channels can reinforce or oppose each other and the direction of the combined effect depends on other parameters, including the financing

[1] The 36 countries included in the analysis are Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Costa Rica, Czech Republic, Denmark, Finland, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Luxembourg, Mexico, Netherlands, Norway, Poland, Portugal, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, United Kingdom and the United States.

structure of an investment. However, in order to provide an intuitive explanation of the processes at work, the following two paragraphs consider both channels separately, keeping everything else equal.

First, in standard corporate tax systems, capital allowances compensate for nominal capital costs but do not account for the time value of money. The degree of compensation – or lack thereof – depends on the financing structure of an investment. Consider the case where tax depreciation is aligned with economic depreciation; if investment projects are financed by equity, most tax systems do not account for the opportunity cost of equity finance, so they provide inadequate capital allowances in economic terms. This feature of CIT penalizes capital-cost-intensive technologies compared to variable-cost-intensive technologies, everything else equal. However, if the investment is financed by debt, nominal interest payments can be deducted from taxable income implying that the cost of debt finance is compensated. Assuming that leverage ratios are constant throughout the project lifetime, financing costs are fully compensated and corporate taxation is neutral across technologies with different capital-cost-intensities.

Second, a tax system that grants accelerated depreciation of capital costs favours capital-cost-intensive technologies compared to variable-cost-intensive technologies, everything else equal.[2] Accelerated depreciation enables taxpayers to deduct a higher share of an asset's capital costs from taxable profits during the early years of the asset's lifetime compared to economic depreciation. Technologies characterised by a high share of capital costs per unit of output therefore gain more in terms of freed-up cash flow via the same level of acceleration than technologies characterised by a smaller share of capital costs per unit of output produced over the lifetime of the technology.

Regarding the second contribution, to gauge the effect of CIT provisions on technology choice, the paper calculates and compares forward-looking effective average tax rates (EATRs) for two investment projects that differ in their cost structures while producing the same output. ETRs differ from statutory tax rates in that they account for the definition of the tax base, including for example information about tax depreciation rules and tax exemptions. More specifically, EATRs measure the percentage of an investment project's discounted lifetime profit that is paid in CIT given the tax base. As such, EATRs summarise the effect of taxation on the decision to invest in mutually exclusive projects, assuming that investment projects earn non-zero economic profits.

More specifically, the present analysis contributes to the literature by highlighting the characteristics of two different types of EATRs, clarifying their respective applicability and the advantages and disadvantages associated with each concept. The paper finds that only one of the concepts – the EATR-R – is a suitable indicator when analysing technologies with different cost structures.[3] The EATR-R relates an investment's tax liability to the investment's pre-tax economic profit, so that it captures both the effect of depreciation of capital costs and additional effects deriving from the different capital-cost-intensities of two investment projects. Previous studies have often used a definition of the EATR that relates an investment's tax liability to the investment's net income as opposed to pre-tax economic profit. While this measure has some advantages, which are discussed in the paper, it does not capture the effects of differences between investment projects in the capital intensity per unit of output produced over the lifetime of the investment, a crucial element of the present analysis.

A well-established methodology exists to calculate different types of forward-looking ETRs on the basis of prospective, or hypothetical, investment projects. The standard approach was developed by Devereux and Griffith (1999[2]; 2003[3]) and more recently applied in ETR databases maintained by the Oxford Centre

2 This holds even if the same level of acceleration is granted across technologies in the sense that the NPV of capital allowances is the same multiple of the NPV of economic depreciation for investments in substitute technologies.

3 Following Devereux and Griffith (2003[2]), the additional qualification "-R" indicates that an investment's *pre-tax economic profit* (denoted *R* in the analysis) is used as a denominator when calculating effective tax rates.

for Business Taxation (Bilicka and Devereux, 2012[4]) and the Centre for European Economic Research (Spengel and et al., 2016[5]) as well as in several OECD publications focusing on investments in knowledge-based capital (OECD, 2013[6]; Modica and Neubig, 2016[7]). The literature often focusses on effective marginal tax rates (EMTRs) and as such analyses incentives to expand existing investment at the margin (intensive margin). The present paper takes the average – instead of the marginal – rate as the indicator, thereby focusing on incentives to invest in mutually exclusive projects (extensive margin) which earn non-zero economic profits.

Studies applying forward-looking ETRs in the context of electricity generation and a low-carbon transition are scarce. A notable exception is Metcalf (2010[8]), who calculates EMTRs for different energy capital investments under US tax code provisions, including depreciation rules and technology-specific tax incentives. He finds that EMTRs vary widely across investment types: amongst all energy capital, investment in wind and solar power is most heavily subsidised by the tax code, while investment in nuclear power is strongly subsidised as well. Metcalf identifies production and investment tax credits as the major source for these subsidies. Metcalf's focus on marginal rates is likely to produce an upper bound of the CIT system's impact on ETRs, because it studies projects that do not earn economic profits. Since economic profits are always taxed at the statutory tax rate (STR), whereas normal returns are taxed at the EMTR, tax allowances weigh more heavily when no economic profits occur. The present analysis calculates average rates for given levels of economic profits and shows that assumptions about a project's profitability, determined by the pre-tax rate of return on capital, affect the extent (but not the direction) of the two channels through which corporate tax rules affect the NPV of capital allowances.

Regarding the third contribution, analysing corporate tax rules and their effect on incentives to invest in carbon-neutral but capital-cost-intensive electricity generation technologies is particularly important in the context of the low-carbon transition. In the 2015 Paris Agreement,[4] governments around the world agreed to limit the increase in global temperatures to less than two degrees Celsius and to reach zero net carbon emissions by the second half of the 21th century. This requires steering investment away from carbon-intensive assets and transitioning towards low-carbon alternatives (OECD, 2017[9]).

Electricity generation plays a crucial role in a low-carbon transition as electricity consumption is projected to rise due to the anticipated electrification, partially or wholly, of sectors currently relying heavily on fossil fuels, in particular in heating and transport. Corporate tax rules that imply dis-incentives to invest in carbon-neutral electricity generation technology due to their capital-cost intensity can be considered as misaligned with a low-carbon transition. This bias is not intentional in the sense that the differential treatment of variable and capital costs does not derive from a policy intention to advantage or disadvantage specific technologies. The present analysis abstracts from intentional, technology-specific tax provisions and other forms of support, e.g. for feeding electricity into the grid, focussing on the unintentional effects only.[5] The remainder of the paper therefore refers to the "unintended technology-bias" of the CIT system.

An empirical application of the EATR-R concept that considers the current CIT treatment of electricity generation technologies across 36 OECD and selected partner economies shows that tax systems affect discrete investment choices when two comparable projects have different cost structures, and that the direction of this unintended bias depends on the financing structure of the investment. If both investment projects are equity-financed, inadequate compensation for the time value of money on capital costs induces

4 The Paris Agreement was adopted by 195 countries in December 2015 at the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC).

5 In many countries, technology-specific tax incentives encourage investment in carbon-neutral electricity generation technologies, as do other direct support measures e.g., in the form of feed-in tariffs or, in the case of carbon-intensive generation, fossil fuel support measures (OECD, 2015[15]). These are not covered by the present analysis. Analysing the *intended* incentives from technology-specific incentives is a promising avenue for future research.

a bias against investments in renewable technologies, as they feature relatively high capital costs per unit of output. This bias is reduced in countries that provide more generous acceleration of capital costs. However, results show that, in all but two countries, the technology-bias against renewables from not compensating for the cost of equity finance dominates the counteracting effect from accelerated depreciation. If both investment projects are debt-financed, the technology-bias against renewables can be compensated or even overturned by the deductibility of interest payments.

The actual financing structure of an investment typically lies somewhere in between full equity and full debt financing and is likely not exogenous to the cost structure of an investment, nor to the tax system. The present analysis, however, does take the financing approach as exogenous, and considers the polar cases of full equity and full debt financing. Available data points towards renewable investments using relatively more debt than equity finance to cover capital costs in some countries, which somewhat mutes the bias against renewables when investments are equity-financed. However, given the limited data available no strong conclusion about financing patterns can be made at this stage. Questions relating to the interaction of CIT systems with the financing structure of investments are left for future research.

The remainder of the paper is structured as follows. Section 2 introduces the concepts of EATRs, showing that CIT systems can induce technology-bias in the presence of technologies with different cost structures even when same tax rules apply, and discussing the appropriateness of different EATR indicators when analysing the impact of cost recovery in corporate taxation. Section 3 applies the methodology to the electricity sector, contrasting EATRs of a carbon-neutral and a carbon-intensive generation technology. It presents stylised cost structures of both types of technologies and summarises the CIT provisions that apply to those assets across 36 OECD and selected partner economies. It then calculates the distribution of EATR differentials across the 36 countries and presents the unintended technology-bias in investment incentives arising from the interaction of differing cost structures of electricity generation technologies and current CIT rules for cost recovery. Section 4 concludes.

2. A framework to compare effective tax rates (ETRs) when cost structures of substitute technologies differ: the case for the EATR-R

2.1. Main concepts

In order to analyse whether corporate tax rules can inadvertently create a bias between investments in substitute technologies when cost structures differ, the present analysis uses forward-looking effective tax rates (ETRs). ETRs are tax policy measures that summarise country-specific CIT rules, such as statutory tax rates (STRs) and rules affecting the tax bases, for example tax depreciation rules, within a comparable framework. A well-established methodology (Devereux and Griffith, 2003[3]) exists to calculate forward-looking ETRs on the basis of prospective, or hypothetical, investment projects. In contrast to backward-looking ETRs, this approach does not rely on tax revenue or tax liability data and has the advantage of isolating the effects of tax systems on investment incentives. The impact of tax policy on investment behaviour has long been studied by economists. Starting with Hall and Jorgenson (1967[10]) the literature has produced convincing evidence for the empirical relevance of these impacts. Hassett and Hubbard (2002[11]) provide a survey of this literature.

Two types of forward-looking ETRs can be distinguished. First, effective marginal tax rates (EMTRs) measure the extent to which taxation increases the cost of capital, i.e., the pre-tax rate of return on capital required by investors to break even. EMTRs are used to analyse investment decisions at the intensive margin, that is, to assess how taxes affect the incentive to expand investment given that a production technology is already in place. Second, effective average tax rates (EATRs) measure the percentage of an investment's lifetime profit that is paid in taxes. EATRs are used to analyse investment decisions at the extensive margin, that is, discrete decisions between mutually exclusive investment projects.

EMTRs and EATRs are best understood as complementary tax policy metrics. While both are informative for policy analysis, their relative merits largely depend on the context. The aim of the present paper is to study how the treatment of costs in current corporate tax systems affects incentives to invest in one as opposed to another technology producing highly similar outputs. Given this focus, the EATR is the main tax policy metric of interest.

Current tax systems levy CIT on taxable income, where typically variable costs are immediately fully deducted, while capital costs are depreciated over the lifetime of an asset according to country-specific fiscal depreciation rules. To capture the differential treatment of costs in the ETR, the present analysis deviates from common practice and uses an definition of the EATR that was introduced by Devereux and Griffith (2003[3]) but is not often used in the literature, namely the EATR-R. The EATR-R is the difference between pre-tax and post-tax economic profits of an investment expressed as a share of the investment's pre-tax economic profit. Hence, it gives the percentage of economic profit that is "taxed away" under current tax rules. As such, the EATR-R captures both the effect of depreciation of capital costs and the effect of immediately deducting variable but not capital costs, a necessary property for the present analysis.[6]

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[6] Previous studies often analysed a different EATR type which relates the difference between pre-tax and post-tax economic profits *to the investment's net income* as opposed to pre-tax economic profit. This measure cannot capture the effect of differences in cost structures with variable costs being fully deductible contrary to capital costs, a crucial element of the analysis. It has the advantage to be closely related to an economy's STR and is therefore easily interpretable if the STR is the point of comparison. However, as EATRs are compared across technologies, instead of relating technology-specific EATRs to a country's STR, the EATR-R is the appropriate tax policy measure in the present set-up.

To identify how corporate tax rules regarding cost recovery affect investment incentives, the difference in EATR-Rs of two investment projects is calculated separately for the equity- and debt-financed cases. The definition of the two investment projects builds on the assumption that both technologies produce the same final good, but that each investment requires a different mix of variable and capital costs. Different cost structures can imply that the tax treatment is non-neutral across substitute technologies even if the same tax rules apply, in the sense that the rules result in different EATR-Rs.

EATR-Rs are calculated and compared for two mutually exclusive investment projects holding pre-tax economic profit constant. While projects based on the two different technologies may, in reality, not always deliver the same pre-tax economic profits, this approach allows us to isolate the effects of corporate tax rules on investment incentives. By construction, an investor is indifferent between two technologies before tax, because pre-tax economic profits are the same. Then, if the investor prefers one technology over the other after tax (i.e., post-tax economic profits differ because the tax system drives a wedge between the economic profits of the two investment projects), taxation is not neutral. Given the assumptions that both investments are identical in terms of output and profit, the wedge will be driven by the interaction between tax rules and the difference in cost structures associated with each of the two technologies. More generally, the tax system can change project rankings also in situations where pre-tax economic profits differ between technologies.

2.2. Modelling differing cost structures in the ETR framework

Adapting the ETR framework outlined by Devereux and Griffith (1999[2]), the analysis focusses on investment decisions at the project level and considers a profit-maximising investor facing a discrete choice between two investment projects, denoted by $i = \{c, d\}$. The investor chooses on the basis of revenues and costs that arise during the entire lifecycle of the investment project. Both projects produce the same output level but feature different cost structures. Each project is characterised by a fixed capital cost and a variable cost per unit of output. The Net Present Value (NPV) of total costs is fixed across projects and assumed to sum to one: $\overline{\mathrm{TC}} = \mathrm{F_c} + \mathrm{V_c} = \mathrm{F_d} + \mathrm{V_d} = 1$; where $\mathrm{F_i}$ denotes the initial capital costs and $\mathrm{V_i}$ the NPV of variable costs. It is assumed that capital costs under project c are higher than under project d; that is, $\mathrm{F_c} > \mathrm{F_d}$. Conversely, variable costs are lower under project c, such that $\mathrm{V_c} < \mathrm{V_d}$. For simplicity, it is assumed that both investments depreciate at the same rate.

The investor's choice is mutually exclusive between investments and both investments earn non-negative pre-tax economic profits, $\mathrm{R_i^*} \geq 0$. The analysis only requires the existence of profits whatever their source. To make the two projects comparable, pre-tax economic profits will be held constant across projects, $\mathrm{R_c^*} = \mathrm{R_d^*}$. Given the difference in capital costs, this assumption implies that throughout the analysis project c features a higher pre-tax rate of return on capital than project d.

The pre-tax economic profit, $\mathrm{R_i^*}$, is defined as the difference between the NPVs of gross revenue, G, and total costs, $\mathrm{V_i} + \mathrm{F_i}$. Assuming equal pre-tax economic profits and equal total costs across investment projects implies gross revenues being equal by construction as well.

$$R_i^* = G - V_i - F_i \geq 0 \tag{1}$$

The post-tax economic profit, $\mathrm{R_i}$, takes into account the impact of taxation on investment projects. To begin with assume that the project is fully equity-financed. As long as there is no allowance for corporate equity, this implies that firms do not obtain deductions for the opportunity cost of equity finance. Corporate income is taxed at rate τ and variable costs are fully deductible in the period in which they occur. Denoting the NPV of capital allowances per unit of investment by $\mathrm{A_i} \in [0; 1]$, the post-tax economic profit is derived as follows:

$$R_i = R_i^* - \tau(G - V_i - A_i F_i) \tag{2}$$

$$= (1-\tau)(G - V_i) - (1 - \tau A_i)F_i$$

The post-tax economic profit is equal to the pre-tax economic profit minus the NPV of what has to be paid in taxes. Tax liability is determined by multiplying the tax rate τ with taxable income, i.e., revenue G net of variable costs V_i and the absolute value of capital allowances which is obtained by multiplying the NPV of capital allowances per unit of investment with initial capital costs $(A_i F_i)$. Rearranging this expression shows that post-tax profit is equal to the NPV of after-tax income, $(1-\tau)(G - V_i)$, minus initial capital costs F_i net of the net-of-tax savings due to capital allowances, $\tau A_i F_i$. Annex A provides a set of worked-through calculations illustrating how profits and tax allowances are calculated based on per-period cash flows that are discounted based on the real interest rate.

In the present set-up, a profit-maximising investor chooses the project with the highest post-tax economic profit, R_i. Equation (2) shows how tax rules for cost recovery can affect post-tax economic profits for a given level of pre-tax economic profit and gross revenue when investments are fully equity-financed. Variable costs are immediately deducted from gross revenues and thus neutral across projects; capital costs, on the other hand, are deducted at rate A_i which depends on asset-specific corporate tax rules and economic depreciation. All else equal, tax allowances per unit of investment, A_i, are higher in tax systems providing more generous depreciation of capital costs. However, capital costs are typically deducted at their nominal value implying that, under equity finance, corporate tax systems do not compensate for the time value of money (unless they specifically include an allowance for corporate equity). As a consequence the NPV of tax allowances per unit of investment is below one, $A_i < 1$. The lack of compensation for the time value of money is stronger if future payments are more heavily discounted or project lifetimes are longer (i.e., where economic depreciation is lower).

A technology-bias occurs when the tax system affects the ranking of projects in terms of their post-tax economic profits. For example, a tax-related bias exists if the two investment projects c and d that generate the same output and therefore the same revenues[7] have the same pre-tax economic profit while post-tax economic profits differ. Assume a situation in which an investor is indifferent between both projects before tax, i.e., $R_c^* = R_d^*$. This pre-tax indifference implies that $R_c^* - R_d^* = (V_d - V_c) - (F_c - F_d) = 0$; the difference in variable costs across both technologies is compensated by the difference in capital costs, which is by construction always the case in this normalised setting. In the post-tax situation, however, $R_c - R_d = \tau(V_c - V_d) + \tau(A_c F_c - A_d F_d)$. As $V_c < V_d$ in the normalised setting, the tax code retains neutrality between technologies only if $(A_c F_c - A_d F_d)$ compensates precisely for the difference in variable costs.[8] This can only be the case if the NPV of capital allowances is sufficiently larger under project c (i.e., $A_c > A_d$), or if capital costs are fully compensated, including the time value of money (i.e., $A_c = A_d = 1$).

In a more general set-up, starting from a situation where there is no pre-tax indifference, i.e., when $R_c^* \neq R_d^*$, taxation affects ETRs in ways that can – but do not necessarily – affect project rankings.

Comparing the two investment projects outlined above shows that technology-bias may arise via two distinct effects. Both effects operate through their impact on the NPV of capital allowances per unit of investment, A_i, and therefore translate directly into differences in the absolute value of capital allowances, $A_i F_i$. First, capital allowances do not fully compensate for the cost of equity finance. Correspondingly, higher discount rates and lower economic depreciation rates (i.e., longer project lifetimes) reduce the NPV of capital allowances per unit of investment ($A_i < 1$). Everything else equal, this compensation effect implies that capital allowances in absolute terms will be lower for capital-cost-intensive investments, thereby leading to lower post-tax economic profits. Second, a counteracting effect

7 Holding gross revenues and pre-tax economic profits constant implies a different pre-tax rate of return on capital of different size: the project with higher capital costs features a lower pre-tax rate of return than the project with lower capital costs.

8 The normalisation of total costs implies that $V_c - V_d = F_d - F_c$.

arises, as capital-cost-intensive projects benefit relatively more from accelerated depreciation, even if economic depreciation is constant and the same level of acceleration is granted across investments in the sense that capital allowances per unit of investment are the same for both projects ($A_c = A_d$). For the same level of acceleration, capital-cost-intensive investments achieve higher tax allowances in absolute terms and therefore also higher post-tax economic profits everything else equal; in the following this effect is denoted the depreciation effect.

Taking both effects together, the compensation effect will dominate the depreciation effect, implying a bias against capital-cost-intensive projects, unless tax depreciation is significantly more accelerated for capital-cost-intensive investments or unless capital costs are fully compensated including for the time value of money. Therefore, accelerating the depreciation schedules for specific asset types, e.g., through fiscal depreciation or other tax incentives, can be seen as a way to reduce the tax bias against capital-cost-intensive investments. The more generous the fiscal depreciation schedule for these assets, the smaller the overall bias will be.

So far, the discussion only considers investment projects that are fully equity-financed; however, additional effects arise under debt finance. Typically, nominal interest payments on debt are deductible from corporate income tax bases implying that the cost of debt finance is compensated. As a consequence, interest deductibility induces additional effects on post-tax economic profits of projects with different cost structures.[9]

Assuming that investments are fully financed with debt and denoting D_i the NPV of interest deductions, post-tax economic profits are expressed as follows:

$$R_i = R_i^* - \tau[G - V_i - (A_i + D_i)F_i] \qquad (3)$$

As illustrated above, investment strategies, c and d, can be compared when the pre-tax economic profit is kept constant. To relate results under debt finance to results under equity finance, the project-specific pre-tax rate of return on capital is kept constant across financing scenarios, so that any difference in post-tax economic profits will solely be driven by the deductibility of interest payments. Given the corporate tax rate, the absolute value of interest deductions, $\tau\, D_i F_i$, is driven by the nominal interest rate, the size of the capital investment as well assumptions about the timing of debt repayments.

Comparing the two investment projects outlined above shows how interest deductibility can affect the two effects identified under equity financing. On the one hand, interest deductions have no direct implication on capital allowances and consequently on the depreciation effect that works in favour of capital-cost-intensive investments. On the other hand, interest deductions compensate the investor for the cost of debt finance, and more so for investments with larger capital costs. As a result, the compensation effect against capital-cost-intensive investments that prevails under equity finance is attenuated. To what extent interest deductions compensate for the cost of finance depends on how the firm structures its debt repayments. As shown in Annex B, the compensation effect is eliminated if repayments are such that the debt-to-asset ratio (i.e., leverage) is kept constant throughout the project lifetime. In this case $(A_i + D_i) = 1$ for both investment projects implying that post-tax economic profits are again equalised across investment project and no technology-bias occurs.

Cases where leverage ratios vary over time may exist in reality but are not in the focus of the present analysis, which abstracts from strategic considerations related to increases in leverage. Annex B further investigates how different assumptions about debt repayment affect ETRs and resulting biases. It also provides a set of worked-through calculations illustrating the difference in calculating economic profits and tax allowances under both financing scenarios. More detailed discussions of the theoretical and

9 The analysis focuses only on the level of the corporation; taxes levied at shareholder level are not taken into account.

empirical literature on the debt-equity decision has been provided, e.g., by Auerbach (2002[12]) and Mirrlees and et al. (2011[13]).

2.3. The relationship between different ETR types

Devereux and Griffith (2003[3]) propose two different definitions of an EATR and discuss their properties in detail. The standard EATR definition, referred to as the EATR-I in the present analysis, is calculated as the difference in pre-tax and post-tax economic profits over the lifetime of an investment expressed as a share of pre-tax income net of variable costs and depreciation (equation (4)). EATR-I's are typically calculated for an exogenous pre-tax rate of return on capital (p).[10] Economic profits are calculated as the net present values (NPVs) of pre-tax and post-tax cash flows associated with a given project and are denoted by R^* and R, respectively. The NPV of pre-tax income is denoted by Y^* and is expressed net of variable costs and depreciation. Ignoring the effects of taxation at the personal level and setting inflation to zero, the investor is assumed to discount future payments on the basis of the real interest rate (r).

$$EATR\text{-}I(p, r, tax\ parameters) = \frac{R^*(p,r) - R(p,r,tax\ parameters)}{Y^*(p,r)} \quad (4)$$

Equation (4) shows that, holding tax parameters and discount rate constant, assumptions about p have an impact on the relative size of the profits and of income and thereby also on the EATR-I. However, p is bounded from below, because investment projects are profitable only if p is high enough to generate a non-negative post-tax economic profit. The cost of capital is equal to the minimum rate of return, $\tilde{p}$, which is such that the post-tax rate of return is zero and investors are indifferent between investing in the project and making an alternative investment.

The EMTR is a complementary measure to the EATR-I as it determines the impact of taxes on the minimum rate of return. It is defined as the difference between the cost of capital ($\tilde{p}$) and the shareholder's rate of return on alternative investments, given by the real interest rate (r), as a share of the cost of capital.

$$EMTR(\tilde{p}, r) = \frac{\tilde{p} - r}{\tilde{p}} \quad (5)$$

$$\text{where } \tilde{p} \text{ such that } R(\tilde{p}, r, tax\ parameters) = 0$$

The difference between EMTR and EATR-I is driven by the share of economic profits in total profits. For investing in a marginal project, where p is such that the post-tax rate of return is zero, investors earn only the normal return to capital and no economic profit. As a consequence, the EMTR and the EATR-I are the same. However, as p increases, economic profits arise and the EATR-I diverges from the EMTR. Because economic profits are always taxed at the STR whereas normal returns are taxed at the EMTR, increases in p imply that the share of total profits taxed at the EMTR decreases and the EATR-I approaches the STR.[11] Devereux and Griffith (2003[3]) show that the EATR-I can in fact be expressed as a weighted sum of the EMTR and the STR. Given the cost of capital, $\tilde{p}$, the weights in this equation are determined by the exogenous rate of return, p.

$$EATR\text{-}I(p) = \left(\frac{\tilde{p}}{p}\right) EMTR + \left(1 - \frac{\tilde{p}}{p}\right) STR \quad (6)$$

10 The pre-tax rate of return on capital expresses the pre-tax income net of depreciation as a share of the capital stock.

11 Under a cash flow tax, corporate taxes are levied only on economic profit and not on normal returns, so the EMTR would be equal to 0.

Devereux and Griffith (2003[3]) also propose an alternative definition of an EATR, referred to as EATR-R, which expresses the difference in pre-tax and post-tax economic profits over the lifetime of an investment as a share of the pre-tax economic profit.

$$EATR\text{-}R(p, r, tax\ parameters) = \frac{R^{*}(p,r) - R(p,r,tax\ parameters)}{R^{*}(p,r)} \tag{7}$$

The EATR-R might be a more intuitive measure than the EATR-I, but has received much less attention by researchers and policy analysts. Devereux and Griffith (2003[3]) discuss and compare the properties of both EATRs, the EATR-I and the EATR-R, noting several features. First, the EATR-R can be obtained by multiplying the EATR-I with the factor $p/(p-r)$. Second, unlike the EATR-I, the EATR-R does not necessarily coincide with the STR if fiscal depreciation follows economic depreciation. Third, the EATR-R is not defined when an investment is marginal in the absence of a tax, i.e., when pre-tax economic profit is zero, whereas the EATR-I is defined in such a case and is equal to the EMTR.

In the present setting, EATRs need to be compared across projects with different cost structures, keeping track of differences in the shares of capital costs and variable costs. The EATR-I is defined in relation to income net of variable costs and of depreciation and is an important measure to calculate the impact of fiscal depreciation schedules. However, it cannot capture the direct effect of immediate deductibility of variable costs, as the EATR-R does. (Annex A provides a set of worked-through calculations illustrating this difference.) The present analysis therefore makes use of the EATR-R, only. When focussing on the EATR-R, one loses comparability with the STR and the EMTR. However, this plays a minor role in the present context, given the objective of comparing the tax system's effect inter-technology, i.e., measuring EATR differentials across technologies. So, the point of comparison is neither the STR nor the EMTR.

The EATR-R – like the EATR-I – depends on assumptions about the profitability of an investment project. In the current framework, profitability, and thus also the economic profit associated with a project, is mainly determined through the exogenous rate of return on capital, p. When profitability increases, the EATR-R approaches the STR because tax allowances become less relevant when investments are very profitable; a more important factor is the rate at which income is taxed.

3. Application: effective tax rates for electricity generation technologies

Having derived the theoretical framework to analyse the effect of CIT systems on investment incentives when the distribution of costs varies across investment projects, this section provides an empirical application of these concepts for the case of electricity generation. In particular, it illustrates how different cost structures of electricity generation technologies interact with current corporate tax rules for cost recovery in 36 OECD and selected partner economies. Using the EATR-R framework derived in Section 2, it shows that this interaction may interfere with the technology-neutrality of CIT systems and lead to an unintended bias in favour of technologies with specific cost structures.

First, the section derives stylised cost structures for technologies that generate electricity from different energy sources. Technologies relying on carbon-intensive primary energy carriers are typically characterised by a relatively high share of variable costs per unit of output, whereas carbon-neutral technologies feature relatively high capital costs per unit of output. Second, it describes main features of corporate tax systems across the 36 OECD and selected partner economies, in particular country-specific statutory tax rates and fiscal depreciation rules that apply to carbon-intensive and carbon-neutral electricity generation technologies. Third, it presents the distribution of EATR-R differentials between both technologies across the 36 economies, showing whether and to what extent the percentage of economic profit that is taxed away under current CIT rules for cost recovery is higher for the carbon-neutral or the carbon-intensive technology.

3.1. Cost structures of electricity generation technologies

Electricity generation technologies, although producing a perfectly substitutable good,[12] differ strongly in how costs are distributed over their lifetimes depending on the energy source used in production. Typically, technologies based on renewable energy sources, such as wind and solar, feature higher capital costs than variable costs per unit of output. This feature of the renewable energy cost structure is mainly due to the near zero marginal costs of the energy source. For example, the wind blows and the sun shines without cost, driving the variable costs of producing electricity close to zero. During the production stage, only some costs for operating and maintaining the plant arise. Conversely, electricity generation technologies based on conventional sources of energy, such as coal and gas, exhibit a more evenly spread cost profile. The variable costs of producing electricity with conventional sources of energy reflect the market price of the underlying fuel that is purchased for production and may be further affected by other price components, such as carbon prices.

Evidence for varying cost structures across electricity generation technologies can be constructed on the basis of NEA/IEA/OECD (2016[14]) "Projected Costs of Generating Electricity 2015". The NEA/IEA/OECD report calculates the expected costs to generate 1 MWh of electricity for different generation technologies across countries, using cost data of plants that will be commissioned in the year 2020. Costs are reported by technology following a levelised cost[13] approach and are expressed as a NPV per unit of electricity produced over the average lifetime of the technology. The following cost types are

12 The present analysis treats electricity generation technologies as perfect substitutes, because it looks at investment projects from an investor perspective. An investor generally is not liable for costs that relate to differences of both technologies, such as energy system costs or the handling of variability in the renewable energy source.

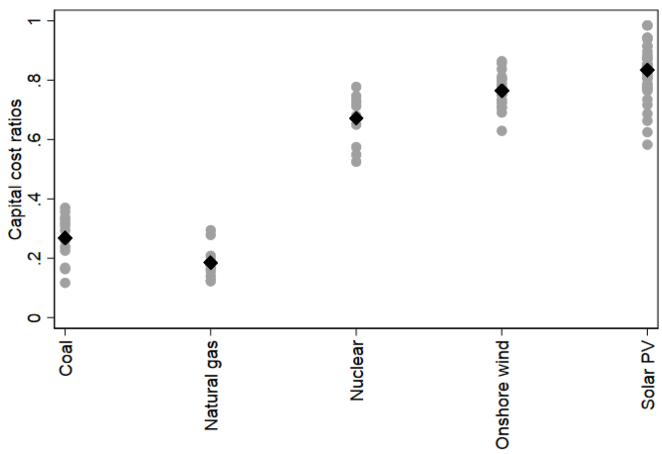
13 The levelised cost of electricity is the NPV of the cost, expressed per unit of electricity, of installing, operating and decommissioning a generating plant over its lifetime.

included in the NEA/IEA/OECD data: capital costs[14], operation and maintenance costs and fuel costs. They are calculated based on cost data at the plant level for 181 plants in 22 countries.[15]

Stylised cost structures for renewable and conventional electricity generation technologies are estimated based on NEA/IEA/OECD (2016[14]), by measuring the ratio of capital costs in total costs for different technologies and countries.[16] Given the levelised cost approach, these capital cost ratios are expressed per unit of electricity generated over the average lifetime of a plant. The "share of capital costs" that will be used throughout the analysis is calculated for each energy source as a cross-country average of these capital cost ratios. If several technology types are used to produce electricity from a specific energy source, averages are built across technologies.

Figure 3.1 presents the calculated ratios of capital costs in total costs for technologies using different energy sources to generate electricity: coal, natural gas, nuclear, onshore wind and solar. Grey dots represent the calculated capital costs ratio for each country included in the NEA/IEA/OECD data. Black diamonds represent cross-country averages and as such the "share of capital costs" used in the analysis. Table 3.1 summarises the share of capital costs in total costs (i.e., the diamonds) by energy source.

Figure 3.1. Share of capital costs in total costs for technologies using different energy sources



Source: OECD calculations based on NEA/IEA/OECD (2016[14]) "Projected Costs of Generating Electricity 2015", using a 7% discount rate and a carbon price of EUR 30 per tonne of CO_2.[17]

14 Capital costs include investment cost, interest during construction, as well as refurbishing and decommissioning of the plants (except for the solar technology, where refurbishing and decommissioning are included in the operation and maintenance costs according to NEA/IEA/OECD (2016[13]).

15 Nineteen OECD and three non-OECD countries are included in the dataset: Austria, Belgium, Denmark, Finland, Germany, Hungary, Italy, Japan, Korea, the Netherlands, New Zealand, Portugal, Slovak Republic, Spain, Switzerland, Turkey, the United Kingdom and the United States as well as Brazil, China and South Africa.

16 To calculate these shares, the capacity factors of the baseline scenario in NEA/IEA/OECD (2016[13]) are used, except when it comes to the CCGT technology, where a 50% capacity factor is assumed.

17 Annex C includes a brief sensitivity analysis using different discount rates and carbon prices.

Table 3.1. Share of capital costs in total costs by energy source, averages

	Coal	Natural gas	Nuclear	Onshore Wind	Solar PV
Estimated share of capital costs in total costs	0.27	0.18	0.67	0.76	0.83

Source: OECD calculations based on NEA/IEA/OECD (2016[14]) "Projected Costs of Generating Electricity 2015", using a 7% discount rate and a carbon price of EUR 30 per tonne of CO_2.

To invest in technologies that use renewable sources of energy, such as wind and solar, a significantly higher share of capital costs needs to be mobilised, for each unit of electricity generated over the lifetime of the asset. For example, looking at the distribution of total costs to build and run a solar power plant, on average, 83% are spent during investment, whereas this share reduces to 18% on average for a gas power plant. Similarly, on average 76% of total costs are spent during investment to produce electricity with an onshore windmill, as opposed to a coal plant that only spends 27% at the investment stage. The difference in cost structures can also lead to a different financing profile with often higher financing costs for renewables, which can reinforce the difference in cost structures. It likely also affects an investor's choice to finance a project via equity or via debt.

The stylised cost structures of electricity generation technologies depend on the underlying assumptions. First, high prices of conventional fuels, including carbon prices, will increase the weight of variable costs of carbon-intensive technologies, thereby reducing the importance of capital costs.[18] A discussion on how fuel costs affect cost structures can be found in Annex C. Second, the assumption whether a conventional power plant runs on base or peak load affects its capacity factor and therefore the distribution of costs over time. For example, whether a CCGT plant runs 50% or 85% of the time affects the produced electricity output per unit of investment. When capacity factors are lower, the share of capital costs in total costs becomes more important. Third, the stylised cost structures of nuclear generation technologies largely depend on how decommissioning and waste management costs are accounted for in the calculations. Given the high uncertainties related to these concepts, nuclear generation technologies are not included in the present analysis. Fourth, assumptions about how future payoffs are discounted will also affect the stylised cost structures. In particular, higher discount rates typically put more weight on costs incurred at an earlier stage of the investment, raising the share of capital costs in total costs. A discussion on how the discount rate affects the stylised cost structures can be found in Annex C.

Finally, it should be noted that technological developments are likely to affect the cost structures in the future. For example, conventional technologies using carbon capture and storage (CCS) are likely to exhibit higher capital costs than the ones used in the calculation. This is in line with the conclusion that carbon-neutral technologies are associated with relatively high costs during the investment phase compared to their carbon-intensive counterpart. On the other hand, costs of renewable capacity have come down strongly over time and are likely to decrease further in the future, which will reduce the weight of capital costs in total costs, in particular for photovoltaic (PV) technologies. The IEA dataset partly accounts for such changes by applying learning rates when dealing with renewable sources of energy that are anticipated to be cheaper in 2020 than they are today.

18 The energy prices used in NEA/IEA/OECD (2016[13])were fixed before much of the decline in oil prices during the second half of 2014 and therefore may be high relative to expectations at the time of the publication.

3.2. CIT systems for electricity generation technologies

This section summarises country-specific CIT rules for 36 OECD and selected partner economies. In particular it describes statutory tax rates and fiscal depreciation rules for carbon-intensive and carbon-neutral electricity generation technologies.[19]

3.2.1. Main data sources and caveats

CIT rates have been collected from Hanappi (2017[15]) and the International Bureau of Fiscal Documentation (IBFD) database. They typically do not vary across technologies or sectors. Fiscal depreciation schedules, however, are often technology-specific and there is no exhaustive list summarising the treatment of electricity generation technologies across countries. Data on fiscal depreciation were constructed using information in Hanappi (2017[15]), the IBFD database and bilateral consultation with countries' Finance Ministries.

In particular, an OECD survey, conducted in 2016, collected comparable cross-country information on fiscal depreciation rules from Finance Ministries. Depreciation schedules have been reported for several predetermined assets, including an electric utility services asset and a photovoltaic module for solar power generation. Fiscal depreciation rules that Finance Ministries provided for the electric utility services asset were matched to the carbon-intensive technology, whereas responses for the photovoltaic module for solar power generation were matched to the carbon-neutral technology. This matching is necessary to produce comparable estimates of the CIT provisions that apply to the different electricity generation technologies across countries, but should be seen as an approximation for at least two reasons. On the one hand, an electric utility service is a very broad definition that may include services other than the generation of electricity as well as a combination of assets subject to different depreciation rates. It may not be limited to carbon-intensive technologies but can also include carbon-neutral ones. On the other hand, a photovoltaic module represents only one component of the photovoltaic (PV) technology which represents only one type of a carbon-neutral generation technology.

In spite of these limitations, there is some external validation supporting the match of the survey data to carbon-neutral and carbon-intensive electricity generation technologies: First, the German Ministry of Finance publishes official tables on the operating life of different economic assets that are used to calculate tax depreciation schedules.[20] In these tables, the entry related to the PV technology refers to PV systems (as opposed to PV modules). Nevertheless, Germany reports a tax depreciation schedule for PV modules in the OECD survey that is equivalent to the depreciation of PV systems reported in the official table.[21] This equivalence can be explained by the fact that while the survey provides specific examples for a given set of asset types, in practice many countries do not vary depreciation rules at such granular level. The equivalence between the survey and the official tables supports the approach to use data from the OECD survey for the carbon-neutral technology in the subsequent analysis.

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19 Large investments in renewables are needed to engage countries in a low-carbon transition. These investments likely attract large producers and investors, but the production of electricity with PV-modules is often also decentralized, where small private producers are taxable under the personal income tax.

20 www.bundesfinanzministerium.de/Content/DE/Standardartikel/Themen/Steuern/Weitere_Steuerthemen/Betriebspruefung/AfA-Tabellen/afa-tabellen.html

21 More precisely, the official table indicates 20 years of operating life for a PV system. Using a straight line (SL) depreciation rule, an asset's total value (100%) fully depreciating at a constant amount every year over these 20 years reaches a fiscal depreciation rate of 5% per year, which is equivalent to Germany's survey response on tax depreciation rates for PV modules.

A second external validation comes from Metcalf (2010[8]), who reports fiscal depreciation rules for energy-related assets in the United States. An electric utility that uses gas as its energy source is associated with a recovery period of 15 years and a depreciation method of 150% declining balance (DB), which equals the information that was provided by the United States in its reply to the 2016 OECD survey when asked about the electric utility services asset. Metcalf (2010[8]) does not report specific depreciation rules for the PV technology. However, for other renewable technologies (i.e., solar thermal and wind) he reports a 5 year recovery period at a 200% DB method, resulting in the same parameters reported for PV modules in the reply to the OECD survey received from the United States.

3.2.2. Fiscal depreciation and CIT rates across countries

Fiscal depreciation rules can encourage investment in certain assets if they allow depreciation in tax terms to be accelerated relative to the asset's depreciation in economic terms.[22] If fiscal depreciation is accelerated relative to the true decrease in value, taxpayers can claim a relatively higher amount of an asset's costs to be deducted at early years of the asset's lifetime. This leads to an ETR that is smaller than the statutory rate everything else equal.

When calculating EATRs for electricity generation technologies, data on economic depreciation rates come from the US Bureau of Economic Analysis (BEA) following Metcalf (2010[8]) who reports a rate of 3.03% for renewable energy technologies and a rate of 5.16% for electricity generation technologies using coal or gas. Put differently, according to BEA, carbon-neutral technologies used in electricity generation depreciate more slowly than carbon-intensive ones. For example, taking the same initial capital stock as a starting point for both projects, the carbon-neutral technology requires 96 periods until 95% are depleted while 56 periods are sufficient for the carbon-intensive asset to experience the same level of decay. Deviations between economic and fiscal depreciation rates may be explained by favorable tax regimes for the respective good.

Table 3.2 summarises CIT rates and fiscal depreciation schedules for all 36 OECD and selected partner economies included in the analysis as reported in the OECD survey or in the IBFD Database. Depreciation rates and recovery methods for carbon-neutral and carbon-intensive assets vary widely across the 36 countries.

[22] Broadly speaking, the incentives deriving from fiscal depreciation rules should be seen in the context of liquidity and interests. Incentives are less powerful in situations where liquidity is abundant, as a major benefit from generous depreciation is to improve a firm's liquidity. Incentives are also weakened in a situation where interest rates are low, which encourages the financing of any type of investment.

Table 3.2. Fiscal depreciation and CIT rates in OECD and selected partner economies

	Carbon-Neutral Technology		Carbon-Intensive Technology		CIT Rate
	Recovery Method	Depreciation Rate	Recovery Method	Depreciation Rate	
Argentina	SL	0.20	SL	0.10	0.35
Australia	DBSL	0.05	DBSL	0.05	0.30
Austria	SL	0.05	SL	0.07	0.25
Belgium	SL	0.10	SL	0.10	0.34
Brazil	SL	0.04	SL	0.04	0.34
Canada	DB	0.50	DB	0.08	0.27
Chile	SL	0.10	SL	0.10	0.24
China	DB	0.17	SL	0.10	0.25
Costa Rica	SL	0.07	SL	0.07	0.30
Czech Republic	SL	0.05	COEF	-	0.19
Denmark	SL	0.17	SL	0.17	0.22
Finland	DB	0.25	DB	0.25	0.20
Germany	SL	0.05	SL	0.07	0.30
Greece	SL	0.10	SL	0.10	0.29
Hungary	SL	0.15	SL	0.15	0.19
Iceland	DB	0.35	DB	0.35	0.20
India	DB	0.80	DB	0.15	0.41
Ireland	SL	0.13	SL	0.13	0.13
Israel	SL	0.25	SL	0.07	0.25
Italy	SL	0.04	SL	0.07	0.31
Japan	DB	0.12	DB	0.12	0.23
Luxembourg	SL	0.05	DB	0.07	0.29
Mexico	SL	1.00	SL	0.05	0.30
Netherlands	SL	0.20	SL	0.20	0.25
Norway	DB	0.10	DB	0.02	0.25
Poland	SL	0.18	SL	0.18	0.19
Portugal	SL	0.25	SL	0.05	0.28
Singapore	SL	0.33	SL	0.33	0.17
Slovak Republic	SL	0.17	SL	0.17	0.22
Slovenia	SL	0.20	SL	0.20	0.17
South Africa	SL	0.20	SL	0.20	0.28
Spain	SL	0.10	SL	0.05	0.25
Sweden	DB	0.30	DB	0.30	0.22
Switzerland	SL	0.40	DB	0.40	0.21
UK	DB	0.18	DB	0.18	0.20
USA	DBSL	0.40	DBSL	0.10	0.39

Note: Depreciation schedules of the carbon-neutral technology relate to country-specific rules for a photovoltaic module for solar power generation as reported in the OECD survey, those of the carbon-intensive technology to the electric utility services asset. If information was missing, data was collected from IBFD or via bilateral consultation with Finance Ministries. *Depreciation methods*: SL – straight line method; DB – declining balance method; DBSL – combined declining balance and straight line method; COEF – coefficient-based method.

The most common recovery methods are straight line (SL), assuming that the asset value depreciates at a constant amount every year, and declining balance (DB) depreciation, assuming that economic depreciation is equal to a fixed proportion of the remaining capital stock, which implies that the amount of depreciation is higher at earlier years in the life of an asset and approaches zero as the capital stock depletes. Some countries use a method that combines both the declining balance and straight line method (DBSL). Using this method, per period deductions as a proportion of the remaining value of the investment for tax purposes are determined as the product of a DBSL factor and the fiscal depreciation rate. For example, if the DBSL factor is 2 and the depreciation rate is 5%, a deduction of 10 units is granted on an investment with a remaining tax value of 100. As with DB depreciation, deductions decrease each period in line with reductions of the remaining tax value of the investment. However, a switch to straight line depreciation occurs in the period when the depreciation deduction falls below the deduction which would be granted on the basis of SL depreciation. This method can result in more or less acceleration than SL depreciation, depending on the choice of the DBSL factor (typically 1.5 or 2).

Apart from these methods there is also a coefficient-based depreciation method used in the Czech Republic which provides more acceleration than all other three methods (Hanappi, 2017[15]), for a detailed description). Two countries provide specific accelerated depreciation schedules. Switzerland depreciates carbon-neutral investments over just two periods, granting 50% of the investment value in both. For carbon-neutral technologies, South Africa provides allowances of 50% in the first, 30% in the second and 20% in the third year of the investment, whereas carbon-intensive technologies are subject to a 40% first-year allowance and can then be depreciated on a SL basis over the following three years.

A first comparison of the depreciation rates over the full set of countries shows that there is considerable variation. For carbon-neutral technologies, depreciation rates vary between 3% and full expensing (i.e., 100% depreciation in the first period). For carbon-intensive technologies, the rates vary between 2% and 40%. While these rates can give first indications about intended technology-biases, a more thorough analysis is needed to understand the combined impacts of these and other tax parameters on relative investment incentives. Forward-looking effective tax rates are tax policy measures that summarise country-specific tax rules within a comparable framework. This type of analysis will be presented in Section 3.

Finally, Table 3.2 also gives an overview of CIT rates in all countries considered in the analysis. The lowest rates apply in Ireland (13%) and Singapore and Slovenia (17%); whereas the highest rates are found in India and the United States (41% and 39%, respectively). The average CIT rate across all countries included in the analysis is 26%.

3.3. Results

This section presents and discusses the empirical results on the unintended technology-bias deriving from the interaction of tax rules for cost recovery with different cost structures of electricity generation technologies. It compares forward-looking ETRs across investments in a carbon-neutral and a carbon-intensive technology. Following the theoretical framework outlined in Section 2, the two investment projects differ only in the distribution of costs over time, but are otherwise identical. In particular, it is assumed that pre-tax economic profits are the same across investments and that investment is profitable throughout the whole period of the analysis. Based on the cost-structures derived in Subsection 3.1, EATR-Rs are calculated and compared for both investments in 36 OECD and selected partner economies given country-specific tax rules on expensing costs summarised in Subsection 3.2. A discount rate of 1% is assumed.

The main variable of interest is the difference in EATR-Rs between both technologies, the "EATR-R differential". EATR-R levels measure the percentage of economic profit that is "taxed away" under current tax rules for a given technology. EATR-R differentials compare the tax liability across technologies in percentage points and indicate whether a tax system favours investment in one technology over the other. The closer the differential is to zero, the smaller the tax-induced technology-bias. Positive values of the EATR-R differential indicate a bias in favour of carbon-intensive technologies in a specific country as relatively more economic profit is taxed away for investments in carbon-neutral as opposed to carbon-intensive technologies. For example, an EATR-R differential of 3 percentage points indicates that a country's tax rules on cost recovery favour carbon-intensive technologies in the sense that the EATR-R of the carbon-neutral technology is 3 percentage points higher. A negative differential points towards a tax system favouring the carbon-neutral technology.

There are two channels that may affect EATR-R differentials: the degree to which capital allowances compensate for the time value of money on capital costs (compensation effect) and accelerated depreciation of capital costs (fiscal depreciation effect). Three types of EATR-R differentials are presented: two that represent the isolated effect of each channel separately and a third one that captures their combined effect. The combined effect is calculated using the model outlined in Section 2 applying country-specific depreciation schedules and CIT rates. The effect on EATR-Rs of not compensating for the full cost of capital, including for the time value of money, is isolated using the same framework but setting fiscal depreciation schedules equal to economic depreciation in each country, as this eliminates the impact of depreciation rules on tax liabilities. The effect of accelerated depreciation of capital costs on EATR-Rs is calculated as the difference between the two other effects.

EATR-R differentials are derived for two financing scenarios, full equity and full debt financing, and three profitability scenarios. As discussed in Section 2, EATR-Rs depend on assumptions about the profitability of an investment project as determined by the pre-tax rate of return on capital, which in turn affects an investment's pre-tax economic profit. While it is beyond the scope of this paper to estimate rates of return, the present analysis reflects the fact that pre-tax economic profits of investment projects may differ by deriving results for different scenarios corresponding to different levels of profitability: low, moderate and high profitability. The following pre-tax rates of return for investments in the carbon-neutral technology are set: 1.7% (low economic profits), 5% (moderate economic profits) and 10% (high economic profits).[23] Given the main assumption that pre-tax economic profits are equal across both investment projects, the following pre-tax rates of return for investments in the carbon-intensive technology are derived: 6.7% (low economic profits), 35% (moderate economic profits) and 77% (high economic profits). Rates of return are kept constant across financing scenarios.

The distribution of EATR-R differentials across all 36 countries are shown in Figure 3.2 for the moderate economic profit scenario. Results in the left panel relate to a situation where investments are fully equity-financed, those in the right panel to investments being fully debt-financed. Both panels report three distributions summarising (i) on the left, the isolated effect on EATR-R differentials deriving from the degree to which capital allowances compensate for the cost of capital, (ii) at the centre, the isolated effect of country-specific depreciation of capital cost, and (iii) on the right, the combined effect of both channels. The rectangles are bordered at the 25th and 75th percentile of the EATR-R differential across all countries, with a black line drawn at the 50th percentile representing the median EATR-R differential. Lines extend from the rectangles to an upper and lower adjacent line, where the adjacent lines are calculated as the lowest value within the 1.5 interquartile range of the lower quartile, and the highest value within the 1.5 interquartile range of the upper quartile.[24] Outlying values are represented as dots.

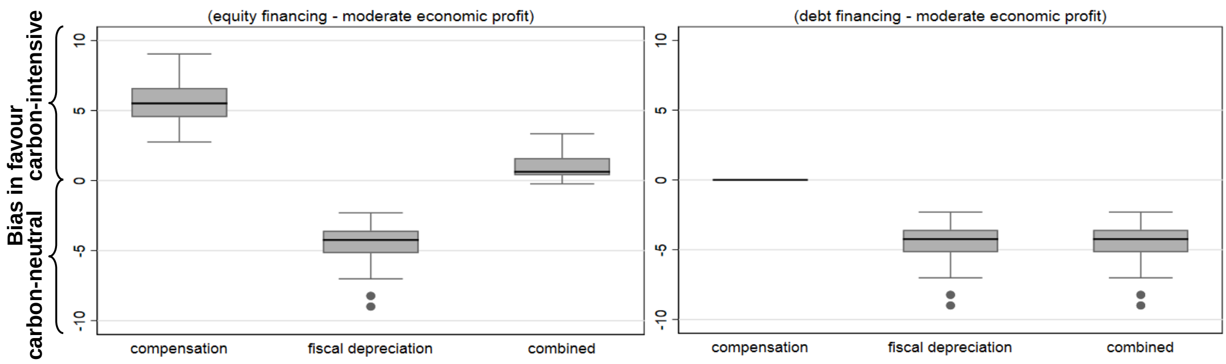
[23] The 1.7% rate is chosen such that the economic profit of the carbon-neutral technology in the country with the least favourable rules for cost recovery is equal to zero after taxes; in which case the EATR-R is equal to 1 ("all profit is taxed away") and thus equal to the EMTR. However, this implies that the post-tax economic profit will be above zero for countries with lower statutory rates or more generous tax depreciation rules, as these countries "leave" more economic profit to the investor instead of taxing it. Bearing this in mind, the low profitability scenario can be interpreted as an approximation to the EMTR.

[24] The interquartile range is a measure of statistical dispersion and equal to the difference between the 75th and the 25th percentile. For example, in a distribution where the first quartile equals 6, the median equals 8 and the third quartile equals 9, the rectangle would be bordered at 6 and 9 with lines extending to 1.5 and 13.5 respectively, i.e., $6 - 1.5 * (9 - 6)$ and $9 + 1.5 * (9 - 6)$.

Results under equity finance suggest that the lack of fully compensating for the time value of money on equity (left part in the left panel of Figure 3.2) favours carbon-intensive technologies, everything else equal, in every country considered in the analysis, although there is quite strong variation across countries. All data points lie above the zero line, meaning that in all 36 OECD and selected partner economies, tax liabilities derived via the EATR-R are higher for the carbon-neutral technology than for the carbon-intensive one. Capital allowances that compensate only for nominal capital costs, excluding the time value of money, penalize carbon-neutral investment projects as they feature higher capital costs than carbon-intensive technologies. This effect is also larger for investments with longer lifetimes, such as renewables. The median EATR-R differential amounts to 5.5 percentage points in the moderate economic profit scenario, indicating that the percentage of economic profit that is taxed away is higher by an amount of 5.5 percentage points for the carbon-neutral than the carbon-intensive technology in the median country. In the country with the lowest bias, the differential amounts to 2.8 percentage points, while it is of 9.0 percentage points in the country with the highest bias. Results are shown assuming a discount rate of 1%, higher discount rates imply that the bias against capital-cost intensive renewables deriving from this "compensation effect" will be stronger.

Figure 3.2. Distribution of EATR-R differentials across 36 countries

(in percentage points)



Note: The box plots represent the distribution of EATR-R differentials across 36 countries. Rectangles are bordered at the 25th and 75th percentile of the EATR-R differential across all countries, with a black line drawn at the 50th percentile representing the median EATR-R differential. Lines extend from the rectangles to an upper and lower adjacent line, where the adjacent lines are calculated as the lowest value within the 1.5 interquartile range of the lower quartile, and the highest value within the 1.5 interquartile range of the upper quartile. Outlying values are represented as dots.
Compensation represents the effect on EATR-R differentials from not compensating for the full cost of equity finance, including for the time value of money; *fiscal depreciation represents* the effect on EATR-R differentials from accelerated depreciation of capital costs; *combined* summarizes both effects.

Although the lack of capital allowances compensating for the full costs of equity, including for the time value of money, is the same in all 36 countries, EATR-R differentials differ across countries because STRs differ. A country's STR represents the costs that an investor would bear were costs not deducted, and as such indicates the value of capital cost deductibility in a country. It can be shown that the EATR-R differentials displayed in the leftmost box plot of the left panel in Figure 3.2 are directly proportional to countries' STR, i.e. countries with high STRs experience higher EATR-R differentials as a result of the lack in compensating for the cost of equity finance. The distribution captured in this leftmost plot therefore mirrors the distribution of STRs across countries. Because there are no outlying STRs in the group of countries considered in the analysis, no outliers in the distribution of EATR-R differentials arise.

Under full debt financing, assuming that the leverage ratio of both investment projects is stable over time, i.e. the repayment rule is such that the debt stock decreases at the same rate at which the asset value depreciates, the deductibility of interest payments on debt fully compensates for the cost of debt finance (cf. Annex B). Therefore, there is no compensation effect under debt finance (left part in the right panel of Figure 3.2).

Looking at country-specific rules to depreciate capital costs (centre in both panels of Figure 3.2), there is a bias in favour of carbon-neutral technologies everything else equal in all 36 countries considered by the analysis. All data points lie below the zero line, implying that fiscal depreciation patterns generate a higher tax liability for investments in the carbon-intensive technology compared to the carbon-neutral technology. However, the size of the bias differs strongly across countries. For example, in the moderate economic profit scenario, the EATR-R differential ranges from -2.3 percentage points in the country with the lowest bias to -9 percentage points in country with the highest bias. In the median country, the tax burden of investing in an electricity generation technology is 4.2 percentage points lower at the median for the carbon-neutral as opposed to the carbon-intensive technology.

The technology-bias that derives from the depreciation of capital costs across the 36 countries is independent of the financing scenario. Under full equity and full debt financing, the distribution of EATR-R differentials is the same. This is a plausible result given that the only difference between the two scenarios is the inclusion of interest deductions, which have no impact on the capital allowance that affects the EATR-Rs results and ranking displayed here.

Country differences in the magnitude of the bias from fiscal depreciation will depend on two country-specific features of the tax system. First, the level of a country's STR determines the value of capital allowances and as such the potential gain from accelerated depreciation. Second, the overall generosity of the fiscal depreciation rules will also affect the magnitude of the bias. The EATR-R differentials, displayed in the central plots of Figure 3.2, capture both effects. Although all countries allow accelerated depreciation for both technologies, the acceleration granted to renewables is more generous. The two countries ranking highest in terms of favourable treatment to carbon-neutral technologies provide particularly generous fiscal depreciation to carbon-neutral technologies and are characterised by high STRs.

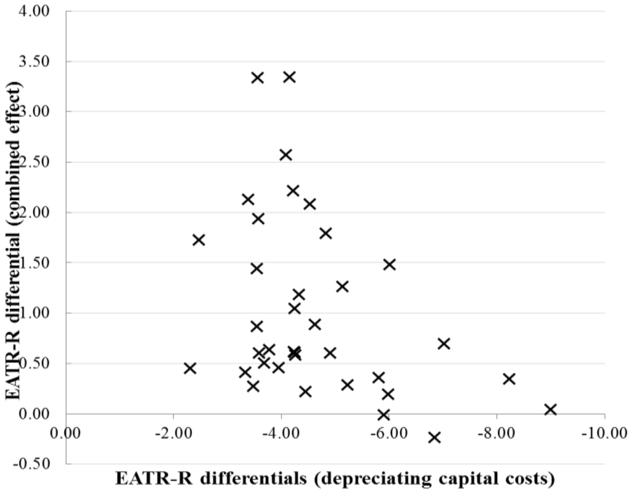
Whether the combination of both tax rules favours carbon-intensive or carbon-neutral technologies depends on the source of finance as well as on country-specific tax rules. The combined effect is driven by two counteracting effects. On the one hand, investments in capital-cost-intensive, renewable technologies are favoured by accelerated depreciation. This benefit arises when the same acceleration is granted across technologies (see Section 2), but also under country-specific depreciation schedules where technologies might receive differential treatment. On the other hand, capital allowances compensate only for nominal capital costs but do not account for the time value of money. The degree of compensation – or lack thereof – depends on the financing structure of an investment. If investment projects are financed via equity, capital-cost-intensive technologies are penalized compared to variable-cost-intensive technologies, because tax systems typically do not account for the full cost of equity. If projects are fully financed via debt and the leverage ratios of both investment projects is kept constant, this bias is eliminated as nominal interest payments fully compensate for the cost of debt finance.

When investments are fully equity-financed, the combined effect shows that tax rules for cost recovery favour carbon-intensive technologies in the majority of countries. EATR-R differentials are positive in nearly all countries as displayed on the right hand side in the left panel of Figure 3.2. For the median country, the EATR-R differential amounts to 0.6 percentage points in the moderate economic profit scenario. While only one country provides a slight preferential treatment to carbon-neutral technologies in this scenario, another country features hardly any overall bias. When investments are fully debt-financed, the combined bias reverses in favour of carbon-neutral technologies reflecting the benefit from accelerated depreciation.

In the equity case, countries that provide more generous depreciation schedules to carbon-neutral than to carbon-intensive technologies are able to reduce the bias against capital-cost-intensive, renewable technologies that derive from the lack in compensating for the full cost of equity finance, including for the time value of money, as can be seen in Figure 3.3. The vertical axis ranks countries according to the combined bias from immediate deductibility and fiscal depreciation, i.e., the EATR-R differentials in the rightmost box plots of Figure 3.2. On the horizontal axis, countries are displayed following the isolated effect from country-specific fiscal depreciation of capital costs, i.e., the distribution of EATR-R differentials in the central box plots of Figure 3.2; countries are ranked from left to right according to how much they favour carbon-neutral technologies. There is a negative correlation between generous depreciation schedules towards carbon-neutral electricity generation technologies (i.e., moving right on the horizontal axis) and the combined bias (i.e., moving down on the vertical axis).

Figure 3.3. Generously depreciating capital costs can counteract technology-bias from not compensating for the full cost of equity finance, including for the time value of money

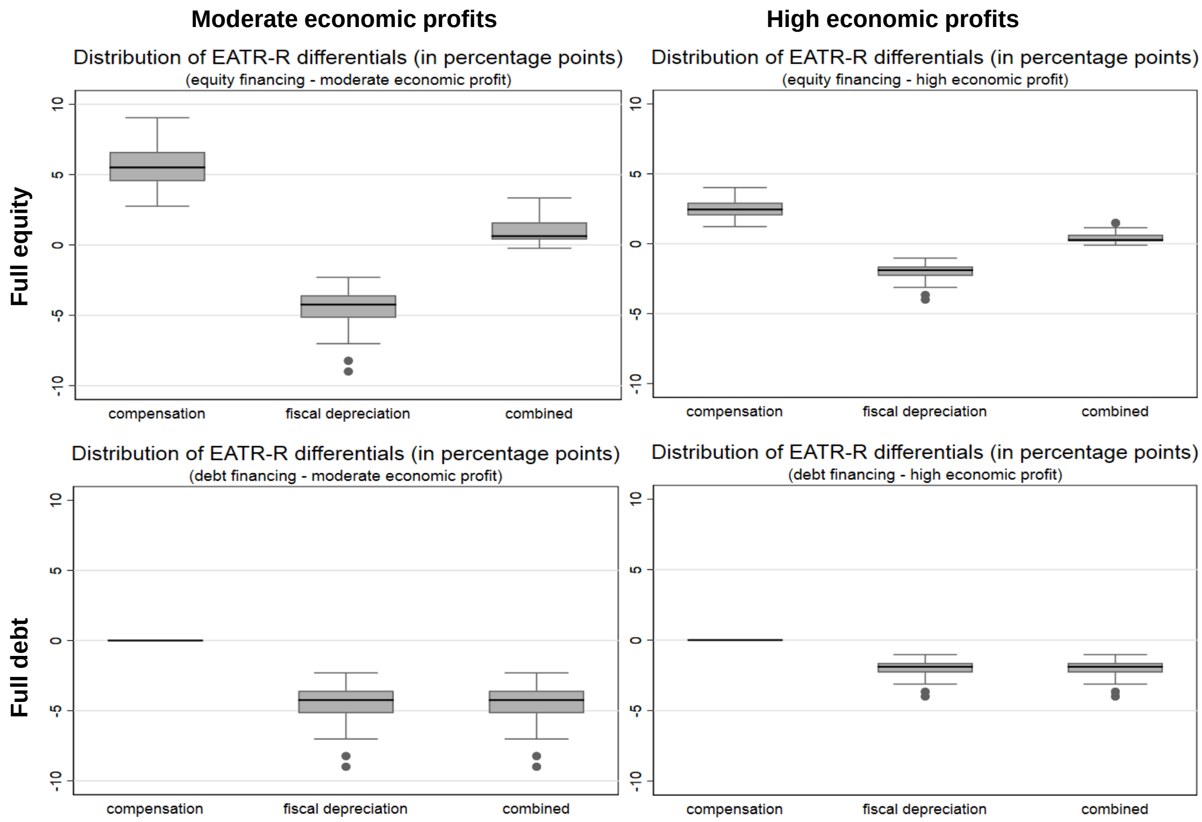
EATR-R differentials in percentage points
(by country, equity financing)



The magnitude of the technology-bias shown in Figure 3.2 critically depends on assumptions about the size of economic profit, while the direction of the bias is not affected by these assumptions. Figure 3.4 shows that the EATR-R differentials decrease but do not change sign, when economic profits are assumed to be higher under both financing scenarios. The moderate economic profit scenario reported in the left panels of Figure 3.4 is equivalent to what is presented in Figure 3.2.

When profitability is lower, the technology-bias deriving from tax rules for cost recovery is relatively stronger, because cost recovery has a relatively more important effect on total profits. As discussed in Subsection 2.3, in current tax systems, the portion of total profits reflecting "normal returns" benefits from tax allowances, while those reflecting economic profits will be taxed at the STR. As a consequence, when economic profits are lower, the share of total profits that is taxed at the STR decreases which increases the importance of tax rules for cost recovery. It follows that the benefit that increasing importance of tax rules for cost recovery drives up the bias when moving from the high to the moderate economic profit scenario.

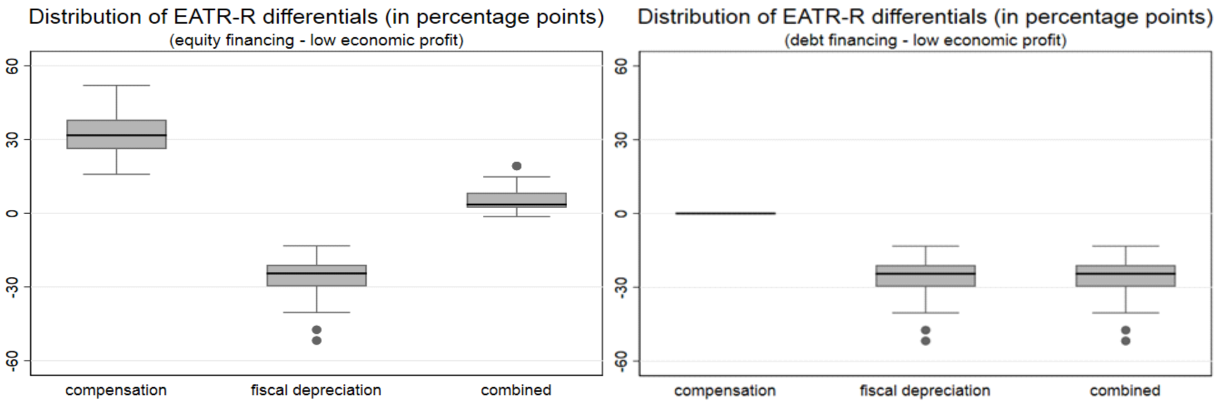
Figure 3.4. The impact of the level of economic profits on the unintended technology bias



Note: The box plots represent the distribution of EATR-R differentials across 36 countries. Rectangles are bordered at the 25th and 75th percentile of the EATR-R differential across all countries, with a black line drawn at the 50th percentile representing the median EATR-R differential. Lines extend from the rectangles to an upper and lower adjacent line, where the adjacent lines are calculated as the lowest value within the 1.5 interquartile range of the lower quartile, and the highest value within the 1.5 interquartile range of the upper quartile. Outlying values are represented as dots.
Compensation represents the effect on EATR-R differentials from not compensating for the full cost of equity finance, including for the time value of money; *fiscal depreciation* represents the effect on EATR-R differentials from accelerated depreciation of capital costs; *combined* summarizes both effects.

Specific assumptions on the profitability of both investments make it possible to calculate an upper bound of the technology-bias deriving from cost recovery across the 36 countries analysed. Figure 3.5 displays results in a low economic rents scenario, which approximates the case when an investment is marginal after tax, i.e., when all economic profit is taxed away. The less economic rent is earned, the more weight is attributed to the tax system's impact on profits. Consequently, the effect of tax rules for cost recovery is highest in the low economic rents scenario. The upper bound of the combined bias when investments are equity-financed amounts to an EATR-R differential of 3.6 percentage points for the median country. The country with the highest overall bias in favour of carbon-intensive technologies displays an EATR-R differential of 19 percentage points in the low profitability scenario. When investments are debt-financed, the overall bias in favour of carbon-neutral technologies at the median amounts to an EATR-R differential of 24.5 percentage points in the low profitability scenario.

Figure 3.5. An estimated upper bound of the unintended technology-bias



Note: The box plots represent the distribution of EATR-R differentials across 36 countries. Rectangles are bordered at the 25th and 75th percentile of the EATR-R differential across all countries, with a black line drawn at the 50th percentile representing the median EATR-R differential. Lines extend from the rectangles to an upper and lower adjacent line, where the adjacent lines are calculated as the lowest value within the 1.5 interquartile range of the lower quartile, and the highest value within the 1.5 interquartile range of the upper quartile. Outlying values are represented as dots.
Compensation represents the effect on EATR-R differentials from not compensating for the full cost of equity finance, including for the time value of money; *fiscal depreciation* represents the effect on EATR-R differentials from accelerated depreciation of capital costs; *combined* summarizes both effects.

3.4. Discussion of results

Investments in electricity generation in 36 OECD countries or partner economies feature capital allowances that do not fully compensate for the cost of equity finance, including the time value of money. This biases against renewable generation technologies, given their relatively high capital-cost-intensity. In countries that grant very generous fiscal depreciation to renewable technologies, this bias is reduced or even reversed, depending on country-specific depreciation schedules.

A relatively higher tax liability of renewable technologies under equity finance interferes with the technology-neutrality of CIT systems. It can be seen as a source of misalignment of CIT with a low-carbon transition, in the sense that tendencies towards higher effective tax rates for renewable electricity resulting from their specific cost structure can slow down the transition by steering investors in the direction of fossil-fuel-based technologies. However, there is no obvious solution on how to address this bias: Implementing more generous fiscal depreciation or technology-specific tax incentives in favour of capital-cost-intensive renewables can counteract the bias from not fully compensating for the cost of equity finance. However, fiscal measures which differentiate taxpayers, sectors and technologies instead of favouring system-wide solutions may risk creating additional complexity in the tax system. In particular, while acceleration of capital allowances could reduce the technology-bias for equity-financed investments, it would create the opposite effect for debt-financed investments. Another approach to address the bias could be to change the treatment of equity costs, e.g., through the introduction of an allowance for corporate equity, but this would also increase the complexity of corporate tax systems and raise further challenges which are outside the scope of this paper.

The focus of the present analysis is deliberately narrow, to allow studying the impact of specific tax provisions on ETRs in isolation. It follows, of course, that the results reported above might be affected when considering a broader set of CIT system characteristics. The next paragraphs point to three issues in particular.

First, the technology-bias against renewables derived within this narrow approach should not be interpreted as a bias in the overall tax system, but rather as underlining that a specific aspect of current tax systems, namely not fully compensating for the full costs of equity, including for the time value of money, disfavours capital-cost-intensive investments such as renewables. Evaluating and contrasting the overall tax-driven technology support for carbon-neutral versus carbon-intensive technologies within a country calls for a broader approach, one that includes technology-specific tax incentives and other direct support mechanisms towards carbon-intensive and carbon-neutral sources of electricity. The analytical framework of ETRs derived in the present paper (Section 2) provides a framework for incorporating such broader considerations. This narrow approach also abstracts from other, non-tax types of support, e.g. feed-in tariffs, feed-in premiums and contract-for-differences that provide stable and predictable revenue streams, or, in the case of carbon-intensive generation, fossil fuel support measures (OECD, 2015[16]).

Second, whether accelerated depreciation in favour of renewable investment can overcome the bias against renewables from not fully compensating for the full costs of capital depends on country-specific fiscal rules and the financing scenario. When investments are fully equity-financed, the combined bias goes in favour of carbon-intensive technologies for the median country. When investments are fully debt-financed, interest deductibility compensates for the time value of money, so that only the intended bias from accelerated depreciation in favour of carbon-neutral technologies remains for all countries. The reality will likely be somewhere in between the two boundary cases. Since this is ultimately an empirical question, future analyses should ideally build on firm-level data of financing sources. Further examining the empirical relevance of these findings, i.e., the impact of capital-intensities on the mix of debt and equity financing in various sectors, is a potential area for follow-on research based on firm- or sector-level data.

The present analysis takes an approach where the financing source of investments is exogenous and presents results either under full equity or full debt finance. However, when financing is endogenous and given interest deductibility, effective tax rates on the corporate level will be lower under debt than under equity finance everything else equal. Since capital costs are higher for carbon-neutral investments, this effect will be larger for these types of investments. More generally, debt may be an important source of financing in electricity production due to the relative stability of income flows from energy projects. This effect may be stronger in the case of renewable energy, where there is higher cost certainty due to the greater relative importance of upfront capital costs, as opposed to less certain ongoing fuel costs in fossil fuel projects, making the former more attractive for debt holders. NEA/IEA/OECD (2016[14]), DiaCore (2016[17]) and NETL (2008[18]) indeed report that debt is an important source of finance in the energy sector and that, in some countries, renewable investments use relatively more debt than equity finance to cover capital costs, but given the limited data available, no strong conclusion about financing patterns can be made at this stage. Further research at the micro-level would allow a more precise understanding of the complexities on financing sources and possibly also their interaction with CIT systems.

Third, loss carryover provisions are an essential part of corporate tax systems, ensuring that taxation does not distort investment decisions across projects with different risk profiles. However, they are not considered in the present analysis. In tax systems that do not restrict carryovers, taxpayers can deduct accumulated tax losses against future (or past) profits, implying that the expected returns on both projects are aligned. If intertemporal loss offsets are not allowed, profits and losses are treated asymmetrically for tax purposes, which may reduce the profitability of investments. In particular, riskier projects will deliver lower expected post-tax returns because profits are taxed but losses receive no tax relief, while larger more diversified firms may be less affected. In such a system and assuming risk-neutral investors, investment decisions will be distorted towards less risky projects.

Restrictions to loss carryovers are relatively common in current tax systems[25] and their effect on technology choice is not straightforward. Restricted carryovers may disadvantage technologies with a high share of capital costs, such as renewables, in the sense that these are more vulnerable to market and general economic shocks. Carbon-neutral technologies yield higher tax allowances compared with technologies characterised by a smaller share of capital costs. As a result, the amount of accumulated tax deductions will likely be higher. Everything else equal, restrictions to carryover will have larger impacts on investments in carbon-neutral technologies. This effect may be particularly relevant in the case of young, innovative firms, which often have limited access to external finance and which are relatively likely to incur losses during the start-up phase. In such situations, restricted loss carryovers imply that tax allowances are lost and technologies with relatively high allowances are disadvantaged.

25 Many countries restrict intertemporal loss offsets through limitations of the time periods for which losses can be carried forward or restrictions to the amount that can be deducted in a given fiscal period. Additionally, the large majority of countries do not index accumulated tax losses to inflation, implying a further loss of value to the taxpayer. The main rationales to implement such restrictions are revenue and anti-tax avoidance reasons (Hanappi, 2017[21]).

4. Conclusions

This paper has shown that the immediate deduction of variable but not of capital costs implies deviations from technology-neutrality in corporate income taxation, in the sense of disadvantaging or favouring technologies depending on their specific cost structure. Standard corporate tax provisions can affect the choice of technology for producing a particular good and thus create an unintended bias. In the case of electricity generation, the analysis shows that capital-cost-intensive, low-carbon technologies may be subject to higher effective tax rates due to their cost structure when investments are financed by equity. This represents a form of misalignment of the tax system with the objective of decarbonising electricity production. When investments are financed by debt, the effect can be reversed. While the empirical application focusses on one specific sector, namely electricity generation, the digitalisation of our economies and the associated tendencies towards low variable cost technologies and services suggest that the conclusions of the present analysis become increasingly relevant for other goods and sectors.

The tax provisions that were studied have opposing effects on investment incentives and it remains for empirical analysis to determine which effect dominates. First, accelerated depreciation favours investment projects characterised by a high share of capital costs per unit of output, everything else equal, even when the same levels of acceleration are provided across both technologies. Second, for equity-financed investments capital allowances typically do not compensate for the full cost of finance, including for the time value of money. As a consequence, investment that feature a relatively high share of capital costs per unit of output, or investments that live longer, are penalized, everything else equal. For debt-financed investment, this effect can be compensated or even reversed due to the deductibility of interest payments.

Empirical analysis across 36 OECD and selected partner economies in the context of electricity generation shows that, when investment projects are fully equity-financed, the lack of full compensation for the cost of capital favours investments in carbon-intensive technologies, which are characterised by a relatively high share of total costs on fuels and consequently a low share of capital costs per unit of output. This bias against renewables under equity finance can be seen as a misalignment with a low-carbon transition. However, all 36 countries provide more generous acceleration to renewables, reducing the tax burden relatively more for renewables and counteracting the bias in favour of carbon-intensive technologies. Taking both together, the bias in favour of carbon-intensive technologies dominates in all but two countries. The strength of both effects (but not their sign) depends on the profitability level of the investments and will be highest when profitability is low. When investments are fully debt-financed, the deductibility of interest compensates for the cost of debt finance so that the bias in favour of carbon-neutral technologies prevails.

This analysis has shown that a specific feature of substitute technologies, namely their difference in cost structures, can affect investment incentives and can lead to unintended technology-bias under current corporate tax rules. However, determining the overall technology-bias of a tax system calls for further analysis as it will depend on additional features, e.g., the tax treatment of losses, the exact mix of debt and equity finance, debt repayment schedules, and the existence of technology-specific tax incentives or other direct support measures.

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Annex A. Illustrative example of calculating effective tax rates

The following example illustrates the calculation of EATR-Rs and EATR-Is for investment projects as discussed in Section 2 when investments are fully equity financed. (Please refer to Annex B for the calculations under debt finance.) It also shows that the EATR-R is the appropriate measure when both characteristics of CIT systems, the immediate deductibility of variable cost and specific depreciation schedules of capital costs, need to be accounted for. Throughout the example it is assumed that corporate income is taxed at 30% and fiscal depreciation completely follows economic depreciation at a rate of 10% declining balance. Total project costs to produce a unit of output are 100 units under both strategies, c and *d*, but the distribution of costs differs over time, such that $F_c > F_d$ and $V_c < V_d$. More precisely, it is assumed that investment strategy *c* requires a fixed capital cost of 90 units whereas strategy *d* requires 50 units The NPV of the variable costs occurring over the entire lifetime of the projects is 10 units under strategy *c* and 50 units under strategy *d*. Table A.1 summarises the main assumptions about investment strategies *c* and *d*.

Table A.1. Definition of Investment Strategies *c* and *d*

		Strategy C	Strategy D
Economic Depreciation	*delta*	0.10	0.10
Rate of Return	*p*	0.05	0.08
Corporate Tax Rate	*tau*	0.30	0.30
Recovery Method	-	DB	DB
Capital Allowance Rate	*phi*	0.10	0.10
NPV Fixed Cost	*F*	0.90	0.50
NPV Variable Cost	*V*	0.10	0.50
NPV Total Cost	*TC*	1.00	1.00

In order to compare ETRs across these two investment strategies both projects need to be equivalent in terms of their pre-tax economic profit, $R^* = G - V_C - F_C = G - V_D - F_D \equiv \overline{R^*} > 0$. The lower variable costs under strategy *c* imply a higher pre-tax income net of variable costs and economic depreciation. As a consequence, the pre-tax rate of return on a unit of capital, *p*, is higher for type-*d* projects (8%) compared to type-*c* projects (5%).

Table A.2. Investment Strategy *c*: High Capital and Low Variable Costs

	Capital	Gross Revenue	Variable Costs	Revenue	Pre-Tax Net Income	Capital Allowance	Taxable Income	Taxes	Pre-Tax Cash Flows	Post-Tax Cash Flows
		G	*V*		*Y*				R^*	*R*
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.90	-0.90
1	0.90	0.15	0.01	0.14	0.05	0.09	0.05	0.01	0.14	0.12
2	0.81	0.13	0.01	0.12	0.04	0.08	0.04	0.01	0.12	0.11
3	0.73	0.12	0.01	0.11	0.04	0.07	0.04	0.01	0.11	0.10
4	0.66	0.11	0.01	0.10	0.03	0.07	0.03	0.01	0.10	0.09
5	0.59	0.10	0.01	0.09	0.03	0.06	0.03	0.01	0.09	0.08
6	0.53	0.09	0.01	0.08	0.03	0.05	0.03	0.01	0.08	0.07
7	0.48	0.08	0.01	0.07	0.02	0.05	0.02	0.01	0.07	0.06
8	0.43	0.07	0.01	0.06	0.02	0.04	0.02	0.01	0.06	0.06
9	0.39	0.06	0.00	0.06	0.02	0.04	0.02	0.01	0.06	0.05
10	0.35	0.06	0.00	0.05	0.02	0.03	0.02	0.01	0.05	0.05
NPV		**1.33**	**0.10**	**1.23**	**0.41**			**0.12**	**0.33**	**0.20**

Table A.3. Investment Strategy *d*: Equal Share of Capital and Variable Costs

	Capital	Gross Revenue	Variable Costs	Revenue	Pre-Tax Net Income	Capital Allowance	Taxable Income	Taxes	Pre-Tax Cash Flows	Post-Tax Cash Flows
		G	*V*		*Y*				R^*	*R*
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.50	-0.50
1	0.50	0.15	0.05	0.09	0.04	0.05	0.04	0.01	0.09	0.08
2	0.45	0.13	0.05	0.08	0.04	0.05	0.04	0.01	0.08	0.07
3	0.41	0.12	0.04	0.07	0.03	0.04	0.03	0.01	0.07	0.06
4	0.36	0.11	0.04	0.07	0.03	0.04	0.03	0.01	0.07	0.06
5	0.33	0.10	0.04	0.06	0.03	0.03	0.03	0.01	0.06	0.05
6	0.30	0.09	0.03	0.05	0.02	0.03	0.02	0.01	0.05	0.05
7	0.27	0.08	0.03	0.05	0.02	0.03	0.02	0.01	0.05	0.04
8	0.24	0.07	0.03	0.04	0.02	0.02	0.02	0.01	0.04	0.04
9	0.22	0.06	0.02	0.04	0.02	0.02	0.02	0.01	0.04	0.03
10	0.19	0.06	0.02	0.04	0.02	0.02	0.02	0.00	0.04	0.03
NPV		**1.33**	**0.50**	**0.83**	**0.37**			**0.11**	**0.33**	**0.22**

Table A.2 and Table A.3 illustrate the calculation procedures used to derive the NPVs for each of the relevant variables. For both investments the initial capital stock is equal to the share of capital cost in total costs which has to be paid in period zero. In subsequent periods this capital stock depreciates following a declining balance schedule with a 10% rate. To calculate the NPVs of each variable period-by-period values are discounted at a real interest rate of 1%. For simplicity, it is assumed that fiscal depreciation follows the same schedule in this example. Given the assumption that pre-tax economic profits and total costs are equal across both investment projects, gross revenues, G, are the same by construction (see Subsection 2.2). Variable costs, V, are so as to satisfy the assumptions set out in Table A.1 and are proportional to the remaining capital stock in each period. Pre-tax net income, Y, equals gross revenue minus variable costs and real economic depreciation. Taxable income is calculated by subtracting tax deductible variable costs and capital allowances from gross revenue. Pre-tax and post-tax economic profits are then determined on the basis of the respective cash-flows.

Table A.4. Calculating EATRs for both Investment Projects under Equity Finance

		Strategy *c*	Strategy *d*
NPV Gross Revenue	*G*	1.33	1.33
NPV Revenue	-	1.23	0.83
NPV Net Income	*Y*	0.41	0.37
NPV Tax Allowances	*A*	0.91	0.91
Pre-tax Economic Rent	R^*	0.33	0.33
Post-tax Economic Rent	*R*	0.20	0.22
Effective Average Tax Rates	***EATR-I***	0.30	0.30
	EATR-R	0.38	0.34

Table A.4 summarises the NPVs as derived from the period-by-period calculations reported in Table A.2 and Table A.3 and calculates the EATRs based on the definition presented in Section 2. As highlighted above, the economic profit before taxes is held constant across the two strategies (0.33).

Although project d earns higher post-tax economic profits, the EATR-I is equal across both projects and does not allow us to identify the full effect of tax rules for cost recovery on investment incentives when cost structures of investment projects differ. As expected, the EATR-Is for both technologies are equal to the STR, which is in line with the assumption that fiscal depreciation follows economic depreciation in this example. However, this simple calculation shows that the EATR-I does not capture the effect of immediate deductibility of variable costs. As highlighted in Section 2, the denominator of the EATR-I, pre-tax net income, varies across investment projects due to differences in the share of variable to capital costs. As a result, differences in the post-tax economic profit (0.20 to 0.22) are neutralised in this example as the EATR-I equals the STR. While this is a useful property of the EATR-I when the objective is to analyse the impact of fiscal depreciation on investment incentives, it does not capture the difference in variable costs across projects and the fact that investors will ultimately choose to invest in the project with highest post-tax economic profits.

The EATR-R, on the other hand, incorporates the effect of the difference in variable costs across investment project as it uses the pre-tax economic profit as a denominator (see Equation (7) in Section 2). As can be seen in Table A.4, comparing EATR-Rs across investment projects indicates a higher tax liability of strategy c, so strategy d will be preferred by an investor from a tax point of view. The EATR-R accurately captures the overall effects of corporate tax rules on cost recovery on investment decisions when investment projects differ in the distribution of costs over time. However, with the EATR-R it is not possible to isolate the effects of fiscal depreciation on investment decisions, while this is possible with the EATR-I.

Annex B. Calculating EATR-Rs under different financing scenarios

While Annex A illustrates the per-period calculations on the basis of two equity-financed investment strategies to illustrate differences between the EATR-I and the EATR-R, Annex B takes the same two investment strategies as starting point to outline how interest deductibility is captured in the calculations of EATRs when investments are fully debt-financed. Accordingly, the two investment strategies c and d still follow the assumptions described in Table A.1. In fact, Table B.1 and Table B.3, illustrating the calculation procedures used to derive the NPVs for each of the relevant variables for an equity-financed investment, contain exactly the same results as Table A.2 and Table A.3; they are reported again only for ease of comparison. In these two cases it is assumed that the initial investment, 0.9 under strategy c and 0.5 under strategy d, is financed through equity. As mentioned in the main body of the text, the analysis does not explicitly model dividend payments or repurchases of shares issued to finance the investments. Focusing only on the level of the corporation, taxes levied at shareholder level are not taken into account either.

An additional assumption has to be taken to calculate EATRs for the two debt-financed cases depicted in Table B.2 and Table B.4. As suggested by Klemm (2008[19]), it is assumed that the firm repays principal so as to keep a stable debt-to-asset ratio; that is to say, in each period debt repayments are equal to the value of capital that is lost due to economic depreciation. Interest payments are determined by multiplying each period's debt stock with the nominal interest rate (1%); debt stocks and interest payments are depicted in columns 2 and 3 of the tables. While variable costs, revenues and capital allowances are the same as under equity finance, interest can now be deducted from revenues to arrive at taxable income (reported in column 9). As a result, tax liabilities, shown in column 10, are lower under debt-finance compared to the corresponding equity-finance case. More precisely, comparing Table B.1 and Table B.2 it can be seen that tax liabilities are 0.02 smaller for investment strategy c when investments are debt-financed and interest deductibility is included. Similarly, Table B.3 and Table B.4 show that this effect is slightly lower, around 0.01, for investment strategy d.

Smaller tax liabilities, in turn, carry through to EATRs summarised in Table B.5. Interest deductibility leads to stronger reductions in tax liabilities for investments with larger capital costs implying that the bias towards strategy d under equity finance, which was identified in Table A.4 of Annex A, is completely eliminated. This result therefore confirms that, given the assumption about debt repayments, interest deductions compensate precisely for the cost of finance irrespective of the size of the initial investment costs associated with the two projects. Correspondingly, Table B.5 also shows that in this case the sum of the NPVs of capital allowances and interest deductions (which are both measured per unit of investment) is equal to one (i.e., $\mathrm{A_c} + \mathrm{D_c} = \mathrm{A_d} + \mathrm{D_d} = 1$).

This result is driven by the assumption that debt repayments follow the depreciation of the capital stock such that the debt-to-asset ratio is constant. Other repayment rules may exist in reality. If, for example, the firm decides to pay only interest and no principal during the lifetime of the project, the debt stock would stay constant throughout the entire project lifetime and interest payments would be considerably higher, especially for projects with larger initial capital costs ($D_c > D_d$). As a consequence of not paying the principal, the debt-to-asset ratio increases over time. Given this repayment rule, the EATR-R would then be lower under strategy c, implying that the direction of the bias is overturned if leverage ratios are allowed to increase over time. However, as pointed out by Klemm (2008[19]) such a repayment rule corresponds to a situation where the firm postpones debt repayment so as to generate tax benefits which are effectively unrelated to the investment and not in the focus of the present analysis. More detailed discussions of the theoretical and empirical literature on the debt-equity decision has been provided, e.g., by Auerbach (2002[12]) and Mirrlees and et al. (2011[13]). Boadway and Bruce (1979[20]) have investigated cases similar to the one outlined above and concluded that borrowing constraints would need to be introduced in order to restrict this type of arbitrage opportunity. If, on the other hand, firms decide to repay their debt as soon as post-tax cash flows allow, leverage ratios would decrease over time and the bias against projects with larger initial capital costs could still prevail.

Table B.1. Investment strategy *c*: Equity Finance

	Debt	Interest	Capital	Gross Revenue	Variable Costs	Revenue	Capital Allowance	Taxable Income	Taxes	Pre-Tax Cash Flows	Post-Tax Cash Flows
										R^*	R
0	0.00	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	-0.90	-0.90
1	0.00	0.000	0.90	0.146	0.011	0.135	0.090	0.045	0.014	0.14	0.12
2	0.00	0.000	0.81	0.131	0.010	0.122	0.081	0.041	0.012	0.12	0.11
3	0.00	0.000	0.73	0.118	0.009	0.109	0.073	0.036	0.011	0.11	0.10
4	0.00	0.000	0.66	0.106	0.008	0.098	0.066	0.033	0.010	0.10	0.09
5	0.00	0.000	0.59	0.096	0.007	0.089	0.059	0.030	0.009	0.09	0.08
6	0.00	0.000	0.53	0.086	0.006	0.080	0.053	0.027	0.008	0.08	0.07
7	0.00	0.000	0.48	0.078	0.006	0.072	0.048	0.024	0.007	0.07	0.06
8	0.00	0.000	0.43	0.070	0.005	0.065	0.043	0.022	0.006	0.06	0.06
9	0.00	0.000	0.39	0.063	0.005	0.058	0.039	0.019	0.006	0.06	0.05
10	0.00	0.000	0.35	0.057	0.004	0.052	0.035	0.017	0.005	0.05	0.05
NPV				**1.33**	**0.10**	**1.23**			**0.12**	**0.33**	**0.20**

Table B.2. Investment Strategy *c*: Debt Finance

	Debt	Interest	Capital	Gross Revenue	Variable Costs	Revenue	Capital Allowance	Taxable Income	Taxes	Pre-Tax Cash Flows	Post-Tax Cash Flows
										R^*	R
0	0.00	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	-0.90	-0.90
1	0.90	0.009	0.90	0.146	0.011	0.135	0.090	0.036	0.011	0.14	0.12
2	0.81	0.008	0.81	0.131	0.010	0.122	0.081	0.032	0.010	0.12	0.11
3	0.73	0.007	0.73	0.118	0.009	0.109	0.073	0.029	0.009	0.11	0.10
4	0.66	0.007	0.66	0.106	0.008	0.098	0.066	0.026	0.008	0.10	0.09
5	0.59	0.006	0.59	0.096	0.007	0.089	0.059	0.024	0.007	0.09	0.08
6	0.53	0.005	0.53	0.086	0.006	0.080	0.053	0.021	0.006	0.08	0.07
7	0.48	0.005	0.48	0.078	0.006	0.072	0.048	0.019	0.006	0.07	0.07
8	0.43	0.004	0.43	0.070	0.005	0.065	0.043	0.017	0.005	0.06	0.06
9	0.39	0.004	0.39	0.063	0.005	0.058	0.039	0.015	0.005	0.06	0.05
10	0.35	0.003	0.35	0.057	0.004	0.052	0.035	0.014	0.004	0.05	0.05
NPV				**1.33**	**0.10**	**1.23**			**0.10**	**0.33**	**0.23**

Table B.3. Investment strategy *d*: Equity Finance

	Debt	Interest	Capital	Gross Revenue	Variable Costs	Revenue	Capital Allowance	Taxable Income	Taxes	Pre-Tax Cash Flows	Post-Tax Cash Flows
										R^*	R
0	0.00	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	-0.50	-0.50
1	0.50	0.005	0.50	0.146	0.055	0.091	0.050	0.036	0.011	0.09	0.08
2	0.45	0.005	0.45	0.131	0.050	0.082	0.045	0.032	0.010	0.08	0.07
3	0.41	0.004	0.41	0.118	0.045	0.074	0.041	0.029	0.009	0.07	0.06
4	0.36	0.004	0.36	0.106	0.040	0.066	0.036	0.026	0.008	0.07	0.06
5	0.33	0.003	0.33	0.096	0.036	0.060	0.033	0.024	0.007	0.06	0.05
6	0.30	0.003	0.30	0.086	0.032	0.054	0.030	0.021	0.006	0.05	0.05
7	0.27	0.003	0.27	0.078	0.029	0.048	0.027	0.019	0.006	0.05	0.04
8	0.24	0.002	0.24	0.070	0.026	0.044	0.024	0.017	0.005	0.04	0.04
9	0.22	0.002	0.22	0.063	0.024	0.039	0.022	0.015	0.005	0.04	0.03
10	0.19	0.002	0.19	0.057	0.021	0.035	0.019	0.014	0.004	0.04	0.03
NPV				**1.33**	**0.50**	**0.83**			**0.10**	**0.33**	**0.23**

Table B.4. Investment strategy *d*: Debt Finance

	Debt	Interest	Capital	Gross Revenue	Variable Costs	Revenue	Capital Allowance	Taxable Income	Taxes	Pre-Tax Cash Flows	Post-Tax Cash Flows
										R^*	R
0	0.00	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	-0.50	-0.50
1	0.50	0.005	0.50	0.146	0.055	0.091	0.050	0.036	0.011	0.09	0.08
2	0.45	0.005	0.45	0.131	0.050	0.082	0.045	0.032	0.010	0.08	0.07
3	0.41	0.004	0.41	0.118	0.045	0.074	0.041	0.029	0.009	0.07	0.06
4	0.36	0.004	0.36	0.106	0.040	0.066	0.036	0.026	0.008	0.07	0.06
5	0.33	0.003	0.33	0.096	0.036	0.060	0.033	0.024	0.007	0.06	0.05
6	0.30	0.003	0.30	0.086	0.032	0.054	0.030	0.021	0.006	0.05	0.05
7	0.27	0.003	0.27	0.078	0.029	0.048	0.027	0.019	0.006	0.05	0.04
8	0.24	0.002	0.24	0.070	0.026	0.044	0.024	0.017	0.005	0.04	0.04
9	0.22	0.002	0.22	0.063	0.024	0.039	0.022	0.015	0.005	0.04	0.03
10	0.19	0.002	0.19	0.057	0.021	0.035	0.019	0.014	0.004	0.04	0.03
NPV				**1.33**	**0.50**	**0.83**			**0.10**	**0.33**	**0.23**

Table B.5. EATR-R and EATR-I under Debt-Finance

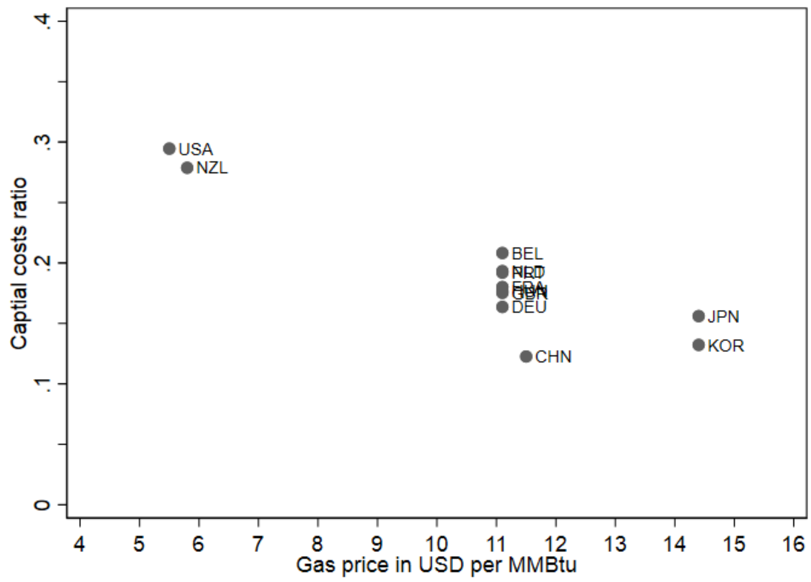
		Strategy *c*	Strategy *d*
NPV Gross Revenue	*G*	1.33	1.33
NPV Revenue	-	1.23	0.83
NPV Net Income	*Y*	0.41	0.37
NPV Tax Allowances	*A*	0.91	0.91
NPV Interest Deductions	*D*	0.09	0.09
Pre-tax Economic Rent	R^*	0.33	0.33
Post-tax Economic Rent	*R*	0.23	0.23
Effective Average Tax Rates	***EATR-I***	**0.24**	**0.26**
	EATR-R	**0.30**	**0.30**

Annex C. The impact of fuel costs on cost structures of electricity generation technologies

Fuel costs are driving cost structures of carbon-intensive electricity generation technologies. Renewable sources of energy, such as wind and solar, require virtually no fuel costs, whereas natural gas and coal powered electricity generation requires that considerable ongoing fuel costs are incurred. Fuel prices, however, differ largely across energy source, world region and time. Also fiscal policies that price the carbon content of fuels, for example excise taxes or carbon taxes affect the cost structures of technologies using carbon-intensive energy sources. Higher carbon prices will increase the importance of fuel costs and decrease the importance of capital costs per unit of output for carbon-intensive technologies.

First, the important role of fuel prices in determining cost structures of electricity generation technologies is demonstrated in Figure C.1. Share of capital costs in total costs versus gas price by country – CCGT, which plots the share of capital costs for a CCGT across countries against the regional gas price assumed in NEA/IEA/OECD (2016[14]). Two conclusions emerge: Capital costs never exceed 30% of total costs, but the share varies largely across countries. Between 12% in China and 30% in the United States of costs are used in the investment stage when electricity is generated using a CCGT. Furthermore, the relationship between gas prices and the share of capital costs is negative: countries in regions with low gas prices tend to exhibit higher shares of capital costs in total costs.

Figure C.1. Share of capital costs in total costs versus gas price by country – CCGT

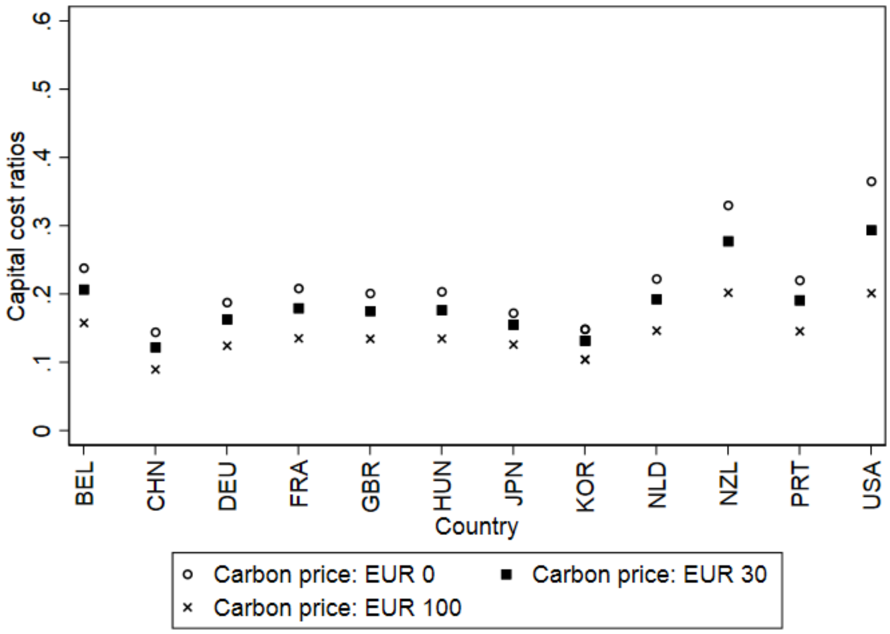


Source: OECD calculations based on NEA/IEA/OECD (2016[14]) "Projected Costs of Generating Electricity 2015", using a 7% discount rate and a carbon price of EUR 30 per tonne of CO_2.

Second, fuel costs are also driven by the carbon price in a country. For comparability, the NEA/IEA/OECD (2016[14]) data uses a carbon price of EUR 30 per tonne of CO2 across all countries which represents a low-end estimate of the climate costs from emitting one tonne of CO2. However, most countries considered in the analysis currently apply much lower carbon prices to electricity generation. OECD (2016[21]) gives an overview on current carbon price levels across countries. On the other hand, future carbon prices might increase well above the EUR 30 per tonne level if policies become more stringent. These developments will affect the cost structures of electricity generation technologies. Lower carbon prices decrease the fuel costs of carbon-intensive energy sources, thereby increasing the relative importance of capital costs per unit of electricity output. If carbon prices are to increase, the share of capital costs needed to generate one unit of electricity with a carbon-intensive technology will decrease. [26]

The composition of costs of course depends on various assumptions and prices, e.g., fuel prices and carbon prices. To illustrate, Figure C.2 shows results of a simulation that applies different carbon prices to the NEA/IEA/OECD (2016[14]) data.27 Circles represent the share of capital costs when no carbon price is applied; black crosses when a carbon price of EUR 100 per tonne of CO_2 is implemented. The black squares show shares as presented in the main text, assuming a carbon price of EUR 30 per tonne of CO_2.

Figure C.2. Simulated share of capital costs for different carbon prices by country – CCGT



Source: OECD calculations based on NEA/IEA/OECD (2016[14]) "Projected Costs of Generating Electricity 2015" using a 7% discount rate.

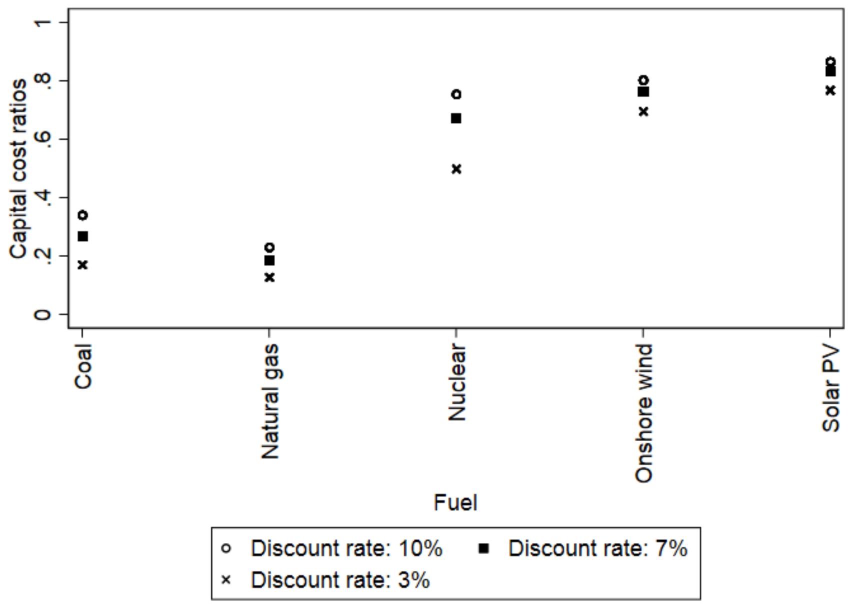
The simulated shares reported in Figure C.2 indicate that implementing a carbon price to reflect the climate costs of an energy source amplifies the difference in cost structures across carbon-neutral and carbon-intensive technologies. Whereas the cost distribution over time of carbon-neutral technologies is not directly affected by a carbon price, the importance of capital costs further reduces for the carbon-intensive technology. The higher the carbon price, the higher the difference will be.

26 It pays to acknowledge that an increase in the carbon price (either through a tax or an emissions trading system), however, does increase prices for carbon-intensive technologies which is likely to have an (non-CIT induced) impact on investment decisions.

27 The simulation assumes that producing 1 MWh of electricity from natural gas results in 0.5 tonnes of CO2.

Finally, the stylised cost structures used in the present analysis are also affected by assumptions about how future payoffs are discounted. Following NEA/IEA/OECD (2016[14]), a discount rate of 7% is used in the calculations of capital cost shares since this rate corresponds "approximately to the market rate in deregulated or restructured markets". Figure C.3 shows the sensitivity of discounted cost structures to the discount rate, by plotting capital cost ratios for different discount rates incorporated in the IEA dataset: the 7% baseline rate as well as a 3% rate "corresponding approximately to the social cost of capital" and a 10% rate "corresponding approximately to an investment in a high-risk environment". As expected, higher levels of discount rates increase the capital cost ratios for all technologies as a higher rate corresponds to assuming an investor puts more weight on current costs

Figure C.3. Share of capital costs in discounted total costs for different discount rates



Source: OECD calculations based on NEA/IEA/OECD (2016[14]) "Projected Costs of Generating Electricity 2015" using a carbon price of EUR 30 per tonne of CO_2.