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This paper explores the economic consequences of proposed EU reforms for a common consolidated corporate tax base. The reforms replace separate accounting with formula apportionment as a way to allocate corporate tax bases across countries. To assess the economic implications, we use a numerical CGE model for Europe. It encompasses several decision margins of firms such as marginal investment, FDI decisions, and multinational profit shifting. The simulations suggest that consolidation does not yield substantial welfare gains for Europe. The variation of effects across countries is large and depends on the choice of the apportionment formula. Consolidation with formula apportionment does not weaken incentives for tax competition. Tax competition instead offers a rationale for rate harmonisation, in addition to base harmonisation.

Key words: Corporate Tax Harmonisation; Common Consolidated Corporate Tax Base; Applied General Equilibrium; European Union
JEL Codes: C68; F23; H25

Abstract in Dutch

Dit artikel onderzoekt de economische gevolgen van EU-voorstellen voor een hervorming van de vennootschapsbelasting met een gemeenschappelijke geconsolideerde grondslag. In het huidige Vpb-systeem hanteert elke lidstaat een eigen grondslag en een eigen tarief. In het nieuwe systeem komt er een Europese grondslag, dat met een verdeelsleutel wordt toegerekend naar de lidstaten, waarop zij elk hun eigen tarief mogen hanteren. We gebruiken een toegepast algemeen evenwichtsmodel om de economische gevolgen van deze hervorming te analyseren. Het model bevat een aantal beslispunten van bedrijven, over hun uitbreidingsinvesteringen, directe buitenlandse investeringen en internationale winstverschuiving. De simulaties laten zien dat voor de EU geen grote welvaartswinsten verwacht mogen worden van deze hervorming. De variatie van deze effecten tussen landen is groot en bovendien sterk afhankelijk van de gehanteerde verdeelsleutel. Bovendien leidt deze Vpb-hervorming niet tot een vermindering van belastingconcurrentie. De enige oplossing hiervoor is een uniform tarief, in aanvulling op de grondslagharmonisatie.

Steekwoorden: Vennootschapsbelasting, Common Consolidated Corporate Tax Base; Toegepast algemeen evenwichtsmodel, Europese Unie

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Corporate tax harmonization in the EU[1]

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Abstract

This paper explores the economic consequences of proposed EU reforms for a common consolidated corporate tax base. The reforms replace separate accounting with formula apportionment as a way to allocate corporate tax bases across countries. To assess the economic implications, we use a numerical CGE model for Europe. It encompasses several decision margins of firms such as marginal investment, FDI decisions, and multinational profit shifting. The simulations suggest that consolidation does not yield substantial welfare gains for Europe. The variation of effects across countries is large and depends on the choice of the apportionment formula. Consolidation with formula apportionment does not weaken incentives for tax competition. Tax competition instead offers a rationale for rate harmonisation, in addition to base harmonisation.

[1] Paper presented at the 50th Economic Policy panel meeting in Tilburg.

1. Introduction

The European Commission claims that existing corporate tax systems in Europe are highly inefficient (European Commission, 2001). This is partly due to the principle of separate accounting under which multinational firms file separate accounts in each country where they operate. Indeed, determining the exact source of profits is often difficult and arbitrary. It leaves opportunities for multinationals to engage in profit shifting to low-tax jurisdictions and causes disputes among governments and firms on the appropriate transfer prices for intra-company transactions. To reduce these inefficiencies, the European Commission (2004) proposes an alternative system based on consolidation with formula apportionment. Under that regime, also used in the United States and Canada, each multinational computes its EU-wide consolidated profits. These are allocated to Member States on the basis of an apportionment formula containing e.g. employment, payroll, assets, and/or sales. Each member state can then tax the allocated profits at its own tax rate. In determining the consolidated tax base, the European Commission aims at a common definition of the tax base and one single formula. The proposal is labelled CCCTB: common consolidated corporate tax base.

This paper explores various margins which might be considered inefficient under the existing system, and which might be affected by such a reform, including profit shifting, factor reallocations and loss consolidation. We do this by using a computable general equilibrium model for the EU-27. The model has been designed to analyse corporate tax policy in the EU. It encompasses several behavioural distortions associated with corporation taxes, such as the debt/equity choice, marginal investment decisions, discrete location choices and profit shifting. The last two of these incorporate international spillovers. The model captures detailed aspects of the corporate tax systems of all member states like statutory rates, fiscal depreciation schemes and nominal interest deductibility. Data from company financial reports are used to calibrate country-specific parameters such as debt-equity ratios and economic depreciation rates. The model allows for company losses in order to explore the impact of loss consolidation.

Only a few examples of relevant general equilibrium simulations are available in the literature. Edmiston (2002) applies a CGE model to strategic formula apportionment policies in the US. Sørensen (2004b) simulates with a CGE model for the OECD the welfare gains from a complete CIT rate and base harmonization in the EU. He does not consider the consolidation of the tax base with formula apportionment.

In principle, the CCCTB could reduce compliance costs as multinationals can reap economies of scale and scope in accounting practices. Moreover, multinationals no longer have to determine transfer prices for complicated intra-company transactions. The European Commission (2001) estimates the costs related to transfer pricing in multinational companies at 3% of the revenues they generate. However, it is difficult to determine the proportion of these costs that can be actually reduced via the CCCTB. For instance, transfer pricing vis à vis third countries will remain when consolidation is limited to the EU. Given this uncertainty we abstract from a change in compliance costs in the simulations of the CCCTB.

In simulating the CCCTB reform, we assume revenue neutrality in each country by an adjustment of other taxes, such as labour taxes, corporate tax rates or lump-sum taxes. The simulations suggest that the CCCTB does not yield substantial welfare gains, especially if other distortionary taxes are used to balance the government budget. This is because distortions in the current system are replaced by equally large new distortions induced by the formula. The introduction of loss consolidation can be welfare improving (Weiner, 2002; Devereux, 2004; Nicodème, 2007). However, this welfare gain disappears if the decline in tax revenue is compensated by higher labour or corporate tax rates. More substantial than the aggregate EU-wide economic effects are the economic consequences for individual countries. Indeed we find that the distribution of corporate tax revenue, as well as country-specific welfare effects, is diverse. Moreover, they depend strongly on the choice of the apportionment formula. By considering alternative formulas, we assess which countries gain or lose from consolidation under alternative designs of the CCCTB. The openness of an economy, the statutory tax rate and in particular the capital intensity are shown to determine the distribution of gains and losses under alternative formulas.

The paper explores how the introduction of the CCCTB would affect behaviour by firms and governments. Under the current system of separate accounting, multinational assets and profits respond to differences in (effective) tax rates across countries. These effects tend to induce governments to compete for tax bases by lowering their tax rates. Under full consolidation of the tax base, profit shifting within the EU is no longer feasible. However, multinationals can still respond to tax rate differentials: by relocating factors to low-tax countries, they change the weights in the apportionment formula and thus reduce their overall tax liability (Hellerstein and McLure, 2004; Martens-Weiner, 2006). Hence, tax competition does not disappear under consolidation but will take a different form. In this paper we explore whether tax competition between governments would be likely to be more or less intense with consolidation with formula apportionment, and which countries would gain and lose. By simulating unilateral corporate tax cuts under both separate accounting and consolidation, we show that consolidation does not make tax cuts less beneficial for governments. Rather, low-tax countries benefit more from a unilateral tax cut than under separate accounting. This implies that consolidation with formula apportionment may cause further competition in tax rates in the EU, thereby exacerbating distortions in the allocation of capital. It offers an argument that tax base consolidation should be accompanied with rate harmonisation. Indeed, our simulations suggest that rate harmonisation produces modest welfare gains for the EU.

The debate on the CCCTB raises several fundamental questions that require consideration when assessing its attractiveness for the EU. One relevant question is the role of corporate taxation in European systems under a CCCTB. For instance, how should the CCCTB affect the integration of the corporate tax with personal taxes on capital income in Europe? Moreover, what principle should underlie corporate tax systems under a CCCTB, i.e. source, residence or destination. This paper does not discuss these issues in detail; see e.g. Fuest (2008) for a discussion.

The rest of this paper is organised as follows. Section 2 elaborates on the EU debate on tax consolidation and the experiences in the US and Canada. Section 3 describes our CGE model. Section 4 demonstrates the outcomes for the CCCTB reform. Section 5 considers a range of alternative apportionment formulas. Section 6 looks at incentives for tax competition by comparing unilateral rate

changes under separate accounting and consolidation. It also explores the impact of rate harmonisation. Section 7 contains a sensitivity analysis of a number of simulations to show the robustness of our findings. Finally, Section 8 concludes.

2. The EU debate, and lessons from elsewhere

2.1. EU debate on corporate tax consolidation

Proposals to harmonize taxes in the European Union are not a new phenomenon. While the treaty articles have generated progress in the case of indirect taxation, the harmonization of corporate taxation is driven by the commitment to create a single market. This implies that the unanimity principle applies which, in combination with widely diverging interests of the individual member states, complicates the harmonization process. As a result, corporate tax harmonization efforts have not been very successful, despite many proposals having been made. The ongoing debate has had the important side effect of creating EU-level think tanks such as the 'Stockholm group' or the Centre for European Policy Studies (CEPS).[2]

Partly influenced by the business community, the focus of the current corporate tax harmonization debate has shifted to the removal of obstacles for cross-border investment and the difficulty of dealing with numerous different tax laws. While there has been progress in the removal of cross border investment, e.g. the parent-subsidiary directive abolished withholding taxes on dividend flow between associated companies, the harmonization process has been sluggish. In 2004, member states considered four methods of harmonizing corporate tax:

i.) a EU corporate tax rate (with full harmonization of rates and bases),
ii.) a compulsory harmonized method to compute the tax base,
iii.) the same harmonized method to compute tax bases but made optional, and
iv.) a system of Home State Taxation (subsidiaries are taxed according to the headquarter country's tax law).

A majority of member states agreed that a common harmonized tax base would be most desirable way forward.[3]

Consequently a working group chaired by the European Commission was established to work out the exact details of a proposal of a common consolidated corporate tax base (CCCTB). Currently the European Commission appears to be in favour of an optional CCCTB with a weighted formula (sales by destination, assets and employment) used for apportionment. There are no plans for harmonization of rates at the moment, as the Commission has repeatedly stressed.[4] The initial plan was to produce a legislative proposal by the end of 2008, but this has been delayed.

[2] See Radaelli and Kraemer (2008) for a detailed discussion of the actors in the EU tax policy.
[3] Nicodème (2007) provides a useful summary of the corporate tax harmonization debate in the European Union.
[4] See European Commission (2006).

The current system of corporate income taxation in the European Union (EU) is based on separate accounting. It means that the taxable income of a multinational enterprise is determined as the income generated in each jurisdiction, in principle with arms length prices used for intra-company transactions. Under the alternative system of consolidation, taxable income is aggregated over all member states to yield a single aggregate tax base for each company in the EU. In the United States, Canada and the proposed CCCTB system in the EU, the consolidated tax base is apportioned to individual states or countries via a formula. In the US, states may use their own formula. Factors used include sales, payroll and assets. States can apply their own rate to the apportioned part of the corporate tax base. In the EU discussion on the CCCTB, the intention is to use a single and common formula to allocate profits across the EU Member States. Countries could then apply their own rate to the apportioned share of the tax base.

2.2. Lessons from the US and Canada

The literature on formula apportionment concentrates on the distortions induced by the formula. The choice of the apportionment formula is important for two reasons. First, it determines the distribution of the tax base across jurisdictions. A state that is abundant in capital-intensive production will receive a relatively large share of profits if capital is used in the formula. A state with many consumers but no production facilities will gain more if sales are used to apportion the tax base. Hence, each country will have a different interest as to what apportionment factors are used. Second, formula apportionment imposes an implicit excise tax on the apportionment factor. Indeed, firms can influence their corporate tax liability by locating the factors that enter the formula in low-tax jurisdictions. As long as tax rates differ across states, the allocation of investment and employment will thus be influenced under formula apportionment. A well-developed empirical literature explores how the variation in the apportionment formulas and tax rates affects investment and employment by multinationals. The majority of these studies are for the US. They confirm the impact of the formula on factor allocation, see e.g. Weiner (1994), Klassen and Shackelford (1998), Gupta and Hofmann (2003) and Goolsbee and Maydew (2000). Canadian provinces use the same formula but differ in their tax rates. Multinationals can exploit these differences by reallocating factors to low-tax provinces. Mintz and Smart (2004) use Canadian administrative tax data and find that the elasticity of taxable income to tax rates is significantly higher for firms that engage in factor shifting. Also Weiner (1994) and Klassen and Shackelford (1998) find evidence for factor shifting to low-tax provinces.

3. The CORTAX model

This paper uses the CORTAX model to assess the economic impact of the CCCTB. CORTAX is an applied general equilibrium model describing the 27 countries of the European Union, the US and Japan. The model is designed to simulate the economic implications of unilateral and multilateral corporate tax policies. It concentrates on the long-run effects in the steady state. The structure of each country is the same and countries are linked via trade in goods and capital and via multinational firms. We set shares to replicate aggregates from national accounts data in 2005 and country averages from

data on firm accounts in the ORBIS database, a comprehensive set of over 9 million companies based on standardized balance sheet information. Parameters in CORTAX also replicate empirical elasticities found in the economic literature. CORTAX is heavily inspired by the OECDTAX-model of Sørensen (2001, 2004a). An earlier version was used for European tax policy analysis in Bettendorf et al. (2006, 2007), Van der Horst et al. (2007) and De Mooij and Devereux (2009). A detailed description of the structure and parameterisation of the model can be found in Bettendorf and Van der Horst (2008). Tables 1 and 2 summarize information about the calibration of key institutional, economic and behavioural parameters.

Government

The government does not optimize its policies. We simply modify tax and expenditure parameters exogenously. On the revenue-side of the government budget, we have indirect taxes on consumption and direct taxes on corporate income and labour income. The expenditure side features government consumption, interest payments on public debt and lump-sum transfers. In performing simulations, we keep the government budget balanced by adjusting one of the tax parameters endogenously. We always keep government consumption and public debt constant as a fraction of GDP. The initial labour and consumption tax rates are calibrated by using effective taxes from Eurostat (2007). Corporate tax systems are calibrated using legal data on taxes and depreciation allowances for 2005.[5] In the baseline, corporate tax changes in 2006 and 2007 are simulated so that reforms are considered relative to the systems in 2007. Hence, we include the Allowance for Corporate Equity that Belgium introduced in 2006. The values of statutory corporate tax rates, the net present value of depreciation allowances and the EMTR (average of debt and equity financed investment) are reported in Table 1. In computing the EMTR, we include personal income taxes applying to dividends and capital gains.

[5] In the calibration, we modify the tax base indicator for Estonia. In principle, the value of fiscal depreciation is zero in Estonia as no depreciation allowances are available. However, Estonia does not tax retained profits but only levies a 22% tax rate on profit distributions. Hence, corporate profits in Estonia go untaxed as long as they are not repatriated to the parent or distributed to shareholders. To bring the system more in line with other countries in the model, we modify the corporate tax base by assuming a positive allowance in Estonia so as to replicate its observed corporate-tax-to-gdp ratio. We maintain the Estonian corporate tax rate at 22%.

Table 1: Calibration of corporate taxation in CORTAX, data 2007

Country	CIT rate	NPV allowances	EMTR
	%	%	%
Austria	25	42	6
Belgium	34	58	-1
Bulgaria	10	46	3
Cyprus	10	46	3
Czech Republic	24	44	9
Denmark	25	59	5
Estonia	22	70	0
Germany	36	44	8
Finland	26	49	7
France	33	50	8
Greece	25	47	6
Hungary	16	41	5
Ireland	13	40	3
Italy	37	44	7
Latvia	15	62	3
Lithuania	18	69	3
Luxembourg	30	49	14
Malta	35	36	14
Netherlands	26	44	7
Poland	19	42	7
Portugal	27	50	5
Romania	16	64	3
Slovak Republic	19	51	5
Slovenia	23	55	6
Spain	33	39	11
Sweden	28	49	6
United Kingdom	30	48	4
Japan	41	42	15
United States	39	42	14

Source: European Commission and ORBIS database

Households

Following the overlapping generations model of Diamond, households live for two periods. One may interpret one period to cover 40 years. We express all variables in annual terms to facilitate the interpretation in terms of national accounts data. Behaviour within each 40-year period is assumed to be constant. Households make their decisions regarding work, consumption and saving by maximizing a life-time utility function subject to an intertemporal budget constraint. When young (i.e. the first period), households choose to allocate their time between leisure and work. When old (i.e. the second period) households do not work but only consume. Young households receive after-tax wage income and lump-sum transfers. This income at a young age is allocated over consumption and savings. Savings are

invested in a mix of bonds and stocks, which are assumed to be imperfect substitutes and which yield different rates of return. In the second period, households are retired. Consumption at old age is financed by the assets saved from the first period plus an after-tax rate of return and by lump-sum transfers. Moreover, the older generation is assumed to own the fixed factor used by firms.

Household optimization yields expressions for labour supply, consumption, savings and the optimal asset portfolio. Asset returns are determined on world markets. The most important distortion is related to the consumption/leisure choice. Labour supply behaviour in CORTAX is governed by the usual income and substitution effects. Most empirical studies suggest that substitution effects dominate income effects so that the uncompensated elasticity of labour supply is positive (see Evers et al., 2008). In CORTAX, we set for all countries the utility parameters so that we obtain a positive uncompensated elasticity of labour supply. Values differ due to country variation in hours worked, but on average the labour supply elasticity is 0.19.

Firms

In CORTAX, one representative domestic firm and one representative multinational headquarter is located in each country. The multinational owns a subsidiary in each foreign country. With 29 countries in CORTAX, we thus have 30 different firms operating in each country, namely the representative domestic firm, the representative headquarter and 28 subsidiaries that are owned by the headquarters in the other countries.

Each firm maximises its value – equal to the net present value of all future cash flows – subject to the accumulation constraints and a production function. The production function features three primary factors: labour, capital and a fixed factor. Labour is immobile across borders and wages are determined on national labour markets. Capital is assumed to be perfectly mobile internationally so that the return to capital (after corporate taxes) is given for each country on the world capital market. The fixed factor is location-specific (e.g. land) and supplied inelastically. The income from the fixed factor reflects an economic rent. The fixed factor may have a variety of interpretations. For instance, it may represent location-specific agglomeration caused by increasing returns to scale in production, as emphasised in the new economic geography literature (see e.g. Brakman et al., 2001). Alternatively, it may reflect land as a location-specific fixed factor of production. Another interpretation is that the fixed factor is not location specific but firm specific, e.g. due to managerial skills, a brand name or patents. In that case, the factor may become responsive to tax, a case that we discuss in more detail below.

In calibrating the model of the firm, capital and labour parameters are determined by national accounts data on labour- and capital income shares. The labour income share is approximately 0.7 on average in the EU and lies between 0.6 and 0.8 for different countries. Investment is determined by the cost of capital. The responsiveness of investment to the cost of capital depends on the substitution elasticity between labour and capital. Most general equilibrium models adopt values between 0.5 and 1.0. We use a value of 0.7 in the basic calibration. We have no direct information that we can use to calibrate the income share of the fixed factor in the model. We set it at 2.5% of value-added in each country. It is chosen such that CORTAX yields corporate tax-to-GDP ratios that fit observed values on average. A sensitivity analysis will shed light on the implications of this assumption.

Table 2: Key elasticities in CORTAX

Elasticities of substitution		
Intertemporal		0.5
Intratemporal (consumption - leisure)		1.0
Capital - labour		0.7
Income share of location specific capital		2.5%
Income share intermediate inputs (of subsidiaries)		10.0%
Implied semi-elasticities	Min	Max
Labour supply to wage	0.08	0.31
Savings to interest rate	0.41	0.81
Capital stock to statutory CIT	-0.09	-0.64
Incoming FDI to statutory CIT	-0.10	-2.71
Debt share to statutory CIT	0.17	0.35
Incoming transfer price to statutory CIT	-0.69	-1.88

Source: Authors' calculations

The impact of the corporate tax on the cost of capital depends on the initial corporate tax system and is measured by the effective marginal tax rate (EMTR). Table 1 offers insight in corporate tax systems by showing rates and the net present value of depreciation allowances in percentage of the purchase price. It also shows the EMTR which is computed as a weighted average of an investment financed by debt and equity. The EMTR ranges from – 1% in Belgium (which has an allowance for corporate equity in place) to 14% in Malta. The higher is the initial EMTR, the more responsive is investment to changes in the corporate tax rate. Table 2 shows that the tax-rate elasticity of investment to the corporate tax rate ranges between – 0.1 and – 0.6.

Firms finance their investment by issuing bonds and by retaining earnings (issuing new shares is excluded). The optimal financial structure depends on the difference between the after-tax cost of debt and equity. Along the lines of the trade-off theory, we include a financial distress cost associated with high debt positions. The marginal cost of debt finance increases in the debt share. In CORTAX, the convexity of the financial distress cost determines the impact of corporate taxation on a firms' financial policy. We set the parameters in this function so as to obtain a semi-elasticity of the debt share with respect to the corporate tax rate between 0.2 and 0.4, which is consistent with recent empirical studies (see Weichenrieder and Klautke, 2008).

The size of corporate tax distortions in CORTAX can be assessed by simulating a system that is neutral with respect to investment and financing decisions. De Mooij and Devereux (2009) explore an allowance for corporate equity (ACE) with CORTAX, which is known to be neutral with respect to financing and investment decisions. They report that an ACE financed by a lump-sum tax yields a welfare gain of 0.6% of GDP, on average in the EU. This welfare gain ranges from 0.3% of GDP in countries with small corporate tax distortions to more than 1% of GDP for countries with high effective marginal tax rates. This welfare gain is approximately one third of the revenues raised by corporate taxes. Hence, corporate tax systems impose a sizeable excess burden via investment and financial distortions.

Multinationals

In maximising the value of the firm, multinationals take the sum of the values in the headquarter and the subsidiaries. In addition to choices on investment and financial structure, multinationals decide about the location of investment across subsidiaries (denoted as foreign direct investment, FDI) and the allocation of profits. CORTAX assumes that the multinational owns a given fixed factor in each country which it can only use to produce via the subsidiary. The size of the fixed factor in each country is determined by data on bilateral foreign direct investment (FDI) stocks. These stocks differ considerably between countries in the EU. Stocks are generally small in Central and Eastern Europe, especially the outward stocks. They are large in some small Western EU countries, like the Netherlands, Belgium and Ireland. Luxembourg stands out with a sum of the inward and outward FDI stock of more than 10 times its GDP.[6] Given the fixed factor in each location, the multinational decides how much capital and labour to employ in each foreign subsidiary. The cost of capital determines the amount of capital the multinational is willing to invest. Thus, changes in inward FDI is governed by the EMTR in each location. The implied elasticity of FDI to the statutory rate ranges between − 0.1 and − 2.7, depending on the initial distortion of the corporate tax system.

Recent empirical studies emphasise that multinationals not only respond to changes in the cost of capital, but also to effective average tax rates (see e.g. Devereux and Griffith, 1998; Devereux and Lockwood, 2006). Hence, inframarginal choices regarding profitable discrete investment locations depend on corporate taxes. In terms of our model, we may interpret this as if rents from the fixed factor are firm-specific, implying that the location of these rents can move across borders. Modelling this location choice from microeconomic principles within the context of CORTAX is difficult. Yet, a simple ad-hoc extension of CORTAX is to make the size of the fixed factor dependent of the corporate tax rate. In a sensitivity analysis, we consider how this extension affects our results. Thereby, we set the response of the fixed factor in subsidiaries such that CORTAX replicates an aggregate semi-elasticity of FDI to the effective average tax rate of – 6.0. This equals the consensus estimate obtained in a recently updated meta analysis by De Mooij and Ederveen (2008). In the extended model, we assume that location choices are responsive only to tax differences within the EU, not between the EU and other world regions.

In CORTAX, foreign subsidiaries need intermediate inputs to produce output. These are supplied by the parent company. As there is only one homogeneous good in the model, the arms-length price for this intermediate input is equal to the market price determined on world markets. However, the parent company can charge a transfer price for intra-company deliveries that deviates from this arms-length price. In particular, a headquarter company has an incentive to set an artificially low (high) transfer price for supplies to subsidiaries in countries that feature a lower (higher) statutory corporate tax rate. In this way, the multinational shifts profits from high to low-tax countries, thereby reducing its overall tax liability. The benefits from profit shifting thus rise linearly in the tax difference between countries. We specify a convex cost function to capture the costs associated with manipulated transfer pricing, e.g. due to fines imposed by governments. Hence, profit shifting to countries with very low corporate tax rates becomes increasingly costly at the margin. The elasticity of transfer pricing with respect to the corporate

[6] Throughout the article, we do not present outcomes for Luxembourg which is a severe outlier due to its exceptional position in terms of foreign direct investment. Hence, we report effects for only 26 European countries.

tax rate is determined by the parameters in the cost function and is set to obtain a tax elasticity of transfer pricing of around − 1.4 on average over all countries. The tax elasticity ranges between − 0.8 in low-tax countries and − 2 in high-tax countries. To compare this to the empirical evidence on profit shifting, we translate it into a semi-elasticity of the corporate tax base. This depends on the share of intrafirm trade which, in CORTAX, is proportional to bilateral FDI stocks. The tax-rate elasticity of the corporate tax base has an average value of − 0.23, implying that the corporate tax base shrinks by 0.23% due to profit shifting if the corporate tax rate is increased by 1%-point. The majority of countries feature a smaller elasticity as their multinational sector is small. This holds for most Central and Eastern European countries. For countries with a large multinational sector, elasticities are larger. In the Netherlands, a 1%-point higher corporate tax rate reduces the tax base via profit shifting by 0.8%.

Losses and loss carry forward

To be able to simulate the impact of loss consolidation, CORTAX contains a simple but straightforward modelling of aggregate losses by firms. We introduce random shocks in output or, equivalently, in the value of sales. Sales are high in the good outcome which generates positive profits. However, profitability is negative in the bad outcome with limited sales. Hence, ex-post there are both profit making firms and loss making firms. We assume that firms are risk neutral. They decide on their optimal levels of investment, employment, debt, and transfer prices before knowing whether they are subject to a negative shock. Hence, they base their input decisions on expected sales and expected marginal productivities. The probabilities of profit and loss are assumed to be independent and not correlated between years. Table A1 in appendix A shows ORBIS micro data about loss probabilities and the ratio of loss/profit in EU countries. The average loss probability is approximately 0.2, i.e. 20% of all firms with unconsolidated accounts make a loss each year. The average ratio of loss/profit equals approximately one. In the simulations, we use these averages to assess the impact of loss consolidation. In section 7.2, we consider a sensitivity analysis and pay attention to country-specific variations.

In today's corporate tax regimes in Europe, losses can be carried forward and offset against future profits within the same country. Yet, losses are generally treated asymmetrically from profits in two respects. First, there are several limitations to loss offset: losses can usually only be set off against taxable profits within the same income category; some countries put a cap on losses that can be offset each year; if a loss making companies were taken over, restrictions to loss carry forwards would apply; and the number of years for which losses can be carried forward is usually restricted. These limitations imply that some losses dry up and cannot be used. Second, firms can only carry forward nominal losses, i.e. without indexation. Due to discounting, its value declines over time.

In CORTAX, we adopt a simple first-order approach to capture the limitations to loss offset in current systems. In particular, we assume that losses can be carried forward only one year. If the company makes a loss in two consecutive years, the first-year loss dries up and cannot be offset against profits in the future. This is obviously not a proper reflection of the complex and diverse treatment of losses in EU tax systems. On the one hand, it may overstate restrictions to loss offset since the period of loss carry forward is generally longer while some countries also allow loss carry backward. On the other hand, it may underestimate the restrictions to loss offset as loss probabilities in consecutive years may be correlated, which increases the probability of dry up. What matters in the CORTAX simulations is the

quantitative size of the restrictions to loss offset. As we may either under or overestimate this, section 7 performs a sensitivity analysis to our assumptions.

Equilibrium and welfare

Equilibrium must hold on each market. On the goods market, a homogenous good is traded on a perfectly competitive world market. Thereby, countries cannot exert market power so that the terms of trade is fixed. On asset markets, bonds and equity of different origins are perfect substitutes and are freely traded on world markets so that returns are fixed for individual countries. Debt and equity are imperfect substitutes. The current account matches the change in the net foreign asset position for each country (including rest of the world), due to Walras law. As labour is immobile internationally, wages are determined nationally on competitive labour markets.

We compute the compensating variation to measure the welfare effects of policy changes. It is equal to the transfer that should be provided to households to maintain their utility at the pre-reform level. A positive compensating variation implies a welfare loss. In presenting the welfare effects of reforms, we put a minus for the compensating variation so that a positive value denotes an increase in welfare. We express the welfare effect in terms of GDP.

Values and limitations of our approach

CORTAX is valuable for economic policy analysis as it combines three vital properties: theoretical rigour, empirical validity and institutional detail of corporate tax systems. Theoretical rigour implies that behavioural margins of firms and households are derived from microeconomic optimisation. This allows for easy interpretation of the results. The general equilibrium setting implies that feedback effects of policies through market responses are included, such as via the labour market. Exploring policies in such a comprehensive and consistent framework offers potentially important insights for policy makers. The empirical validation is reflected in share parameters that make the model replicate true economic data in the EU. This adds to the realism of the model. Moreover, by using available empirical evidence on behavioural responses, the model assesses the relative strength of various effects to tax reforms and, therefore, their economic and welfare effects. By quantifying different sides of relevant trade-offs, CORTAX is particularly relevant for policy makers.

Yet, the CGE approach also suffers from limitations. Although assumptions in the model are based on the best-possible empirical information and widely accepted economic theories, it is still a simplified description of the real world. For instance, CORTAX ignores certain economic mechanisms, includes specifications that are not undisputed, and cannot take away the uncertainty about the strength of certain behavioural effects to tax policies.

We discuss four features of CORTAX that are particularly important to keep in mind when interpreting the outcomes. The first issue is the treatment of risk. The model distinguishes between debt and equity and assumes different rates of return for these two assets, which is consistent with ex-post returns in real world observations. The equity returns contain a risk premium, however, which forms a compensation for the higher uncertainty of equity stakes as compared to risk-free government bonds. CORTAX does not explicitly model risk and thus ignores the uncertainty cost of holding equity. In fact, the CES function for the asset portfolio of households is an imperfect shortcut to obtain an interior solution for household asset portfolios, but does not account for the cost of risk taking.

Second, CORTAX does not consider distributional concerns. While various taxes in the model cause distortions in investment and labour supply, there is no explicit underlying distributional reason why the government does this. Indeed, the optimal tax structure in the model would be to simply raise lump-sum taxes and eliminate all other taxes. One therefore needs to be careful in interpreting simulations where the tax burden is shifted from distortionary taxes to lump-sum taxes, or between different distortionary taxes, as this may have distributional implications which are overlooked.

Third, CORTAX assumes one homogenous good. The price of this good is determined on a competitive world market on which no country can exert market power. Therefore, the terms of trade is fixed for all countries. Reforms may well affect world markets, especially when the EU implements reforms jointly.

Finally, CORTAX assumes a competitive labour market. This is an unrealistic description of European labour-markets, which are characterised by equilibrium unemployment. Bettendorf et al. (2009) explore how labour-market imperfections modify the impact of corporate tax changes on the economy via its effect on structural unemployment. They find that the cost of capital is an important determinant of the equilibrium unemployment rate. Therefore, policies that reduce the cost of capital can help to fight European unemployment. It magnifies the positive welfare impact of these policies. However, there is considerable uncertainty about the parameters determining the impact on equilibrium unemployment. In light of this uncertainty, we decided to assume a competitive labour market in our analysis.

Such caveats make us aware of the limitations of the CGE model. Yet, the consistency of the CORTAX framework offers common ground for a structured discussion about both the assumptions and the economic implications of corporate tax reforms. Sensitivity analysis further facilitates this by offering insight in how changes in certain assumptions affect the conclusions.

4. A common consolidated corporate tax base

The European Commission proposal for a CCCTB consists of two parts: a common corporate tax base (CCTB) and consolidation with formula apportionment (CFA). This section analyses the economic implications of both parts. Extensive results for individual countries are reported in tables in the Appendix. In the text, we summarise the main findings.

4.1. A common corporate tax base

We first consider the impact of a common corporate tax base in the EU (CCTB). It consists of a common set of rules regarding fiscal depreciation, loss offset and tax incentives. In our simulations, we consider common rules that produce a tax base equal to the aggregate base generated by the regimes currently in place.[7] Hence, some countries broaden their tax base while others narrow it. The common base applies to both multinationals and domestic firms. If tax revenues change in a country due to changes in the corporate tax base we adjust, respectively, lump-sum transfers, corporate tax rates or labour taxes to balance the government budget. Table 3 shows the aggregate economic impact of the CCTB for the EU as whole. The welfare effects for individual countries under lump sum revenue

[7] This choice of the common base differs from the proposal by the European Commission, which involves a net broadening of the corporate tax bases in Europe in combination with a reduction in corporate tax rates (see e.g. CCCTB Working Group, 2007; Spengel and Oestreicher, 2007).

recycling are presented in Figure 1. Figure 2 compares these outcomes to those under the alternative balanced budget rules.

Table 3: Economic effects for the EU of a common corporate tax base

	Lump-sum transfers	Corporate tax rate	Labour tax rate
Corporate tax-to-gdp ratio	0.00	-0.03	0.00
Cost of capital	-0.01	-0.01	-0.01
Investment	0.22	0.20	0.19
Wage	0.10	0.08	0.10
Employment	0.03	0.03	0.00
GDP	0.09	0.10	0.07
Welfare	0.01	0.01	0.01

Source: Authors' calculations

We see from Table 3 that the aggregate welfare effect of the common base is small under each balanced budget rule: welfare in Europe rises by a mere 0.01% of EU27-GDP. The small welfare gain is due to a smaller variation of effective marginal tax rates across countries. Indeed, the coefficient of variation of EMTRs declines from 0.63 today to 0.50 under the CCTB. The smaller dispersion of EMTRs reduces distortions in the allocation of mobile capital across countries. Intuitively, capital mobility equalises after-tax rates of return. If EMTRs differ across countries, this implies that before-tax rates of return must differ. It reflects the distortion in capital export neutrality. Convergence of marginal effective tax rates mitigates this distortion as capital relocates from countries with a low before-tax return to countries with a high before-tax return.

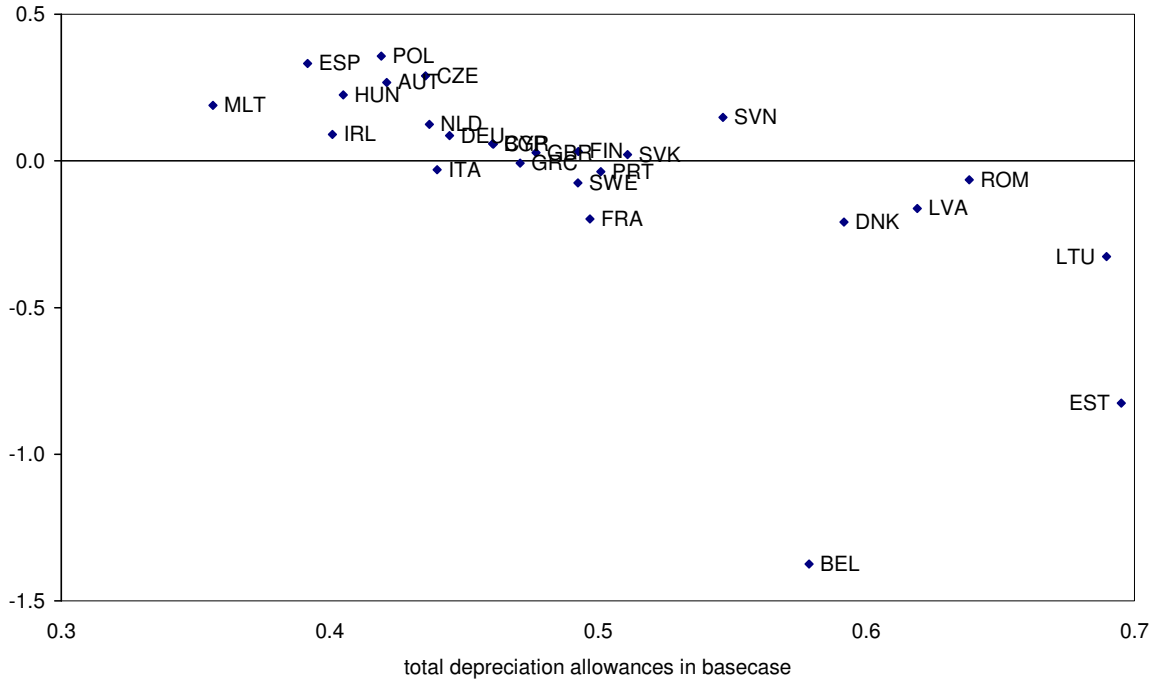

Figure 1: Welfare effects of a common corporate tax base, lump sum balanced budget rule

Figure 1 shows that the welfare implications of the CCTB differ considerably across countries. On the horizontal axis is the initial net present value of depreciation allowances, expressed as a share of the purchase price of an investment. Hence, countries with a broad initial base are positioned left in the Figure and countries with a narrow base right. On the vertical axis is the welfare effect induced by the introduction of the common European base. Figure 1 reveals that countries that narrow their tax base by means of more generous depreciation allowances under the common base rules experience a welfare gain. This is because the narrower tax base reduces the cost of capital so that investment expands. More investment raises the productivity of labour and is accompanied by higher wages. This encourages labour supply so that employment expands. The increase in investment and employment lead to a higher level of GDP. Due to smaller distortions in investment and labour supply, welfare ultimately increases up to almost 0.4% of GDP in Poland and Spain. Countries that gain in the top-left corner of Figure 1 include also Ireland, Hungary, Malta, Austria and Czech Republic. In contrast, countries that broaden their base via less generous allowances for investment experience opposite effects. This applies to Estonia, Lithuania, Denmark and France among others. Belgium is an outlier in Figure 1. It loses considerably due to the abolition of its ACE system, which raises the cost of capital substantially. Its welfare falls by 1.4% of GDP.

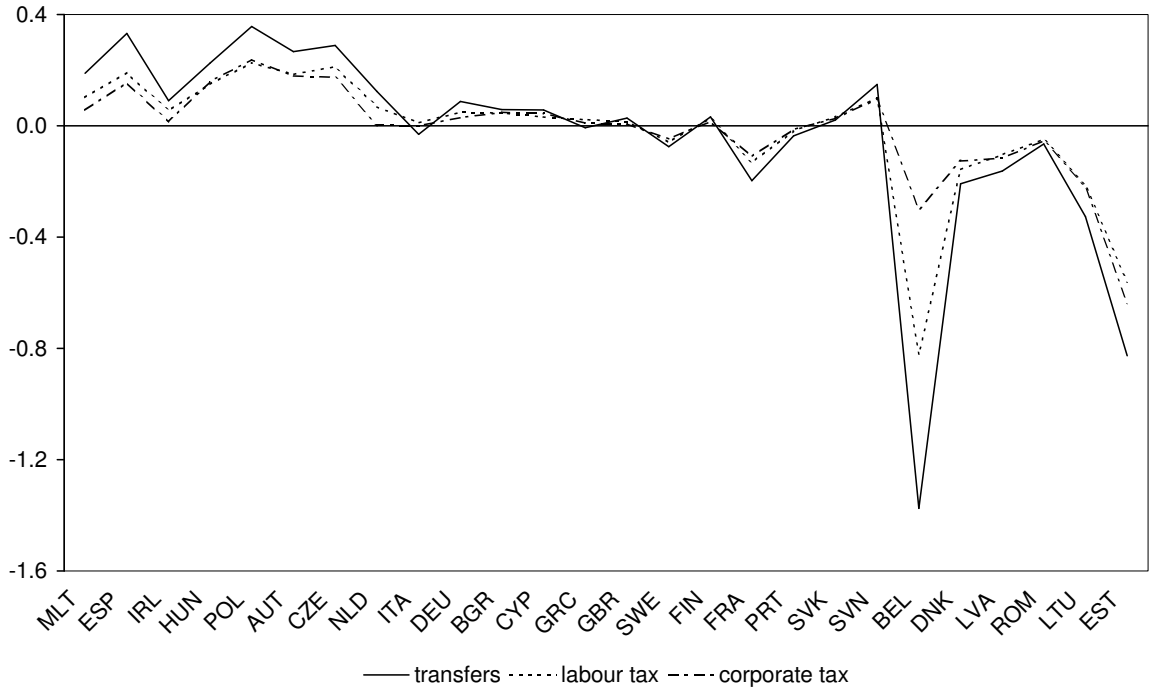

Figure 2: Welfare effects of a common corporate tax base, alternative balanced budget rules

Figure 2 shows how the welfare effects for countries change if governments use distortionary taxes on labour or corporate income to balance their budget, instead of lump sum taxes. Thereby, countries are ranked according to the value of their depreciation allowances for tax purposes (from low on the left to

high on the right). In the figure, points are linked through lines to facilitate comparison between the three simulations. Figure 2 shows that the adjustment via distortionary taxes does not change the sign of the effect for individual countries, but it results in a flattening of the effects of the CCTB. Hence, countries that narrow their base still benefit from the reduction in the cost of capital. Yet, the welfare effects are smaller due to higher distortionary taxes which are necessary after the narrowing of the corporate tax base. Countries broadening their base use the extra funds to cut distortionary taxes. This mitigates the adverse implications of the higher cost of capital induced by base broadening.

4.2. Consolidation with formula apportionment

To avoid mixing-up the welfare effects of a common tax base and the welfare effect of consolidation with formula apportionment (CFA), this subsection takes the common base as a starting point. The effects of CFA are thus assessed relative to a European common corporate tax base. As in the previous simulation, we assume that governments adjust lump-sum transfers, corporate tax rates or labour taxes to balance their budget if revenues change due to the reform.

CFA means for a multinational that the tax bases of the parent and its subsidiaries are added into one aggregate. This tax base is apportioned to the participating countries by using a prescribed formula. In particular, the share of the tax base of firm *i* allocated to country *j* equals:

$$\omega_{ij} = w^L \frac{L_{ij}}{L_i} + w^K \frac{K_{ij}}{K_i} + w^Y \frac{Y_{ij}}{Y_i} \qquad (1)$$

where w^L, w^K, and w^Y denote the formula factors adding up to one: $w^L + w^K + w^Y = 1$. X_{ij} denotes the share of multinational i's factor X_i that is operational in country j, where $X = L, K, Y$ reflect, respectively, employment, assets and sales. In our simulations, we consider the origin of the sales (i.e. in the jurisdiction in which the good or service is produced) as we have no information to identify the destination of final sales (where the final consumer resides: see section 5 for a discussion). The weights in the formula are fixed for all countries and determined at the supranational level. This section shows the impact of CFA with a formula of 1/3 for employment, assets and output. The apportioned profits are taxed at national corporate tax rates. These rates remain unchanged as compared to the situation in 2007, unless indicated otherwise.

CFA exerts a direct effect on the distribution of the corporate tax base between countries, i.e. even without behavioural responses by firms. We first discuss these direct revenue effects. Subsequently, we explore the behavioural consequences of CFA and the corresponding economic effects.

4.2.1. Direct effects on corporate tax revenue

The introduction of CFA affects corporate tax revenue in European countries for two reasons: reallocation and loss consolidation. First, CFA modifies the distribution of the European corporate tax base between Member States. A number of studies assess these distributional effects by using micro data

from firm accounts (see e.g. Fuest et al., 2007; Devereux and Loretz, 2008). They report a substantial reallocation of revenue, depending on the choice of the apportionment formula. In CORTAX, the direct reallocation of the corporate tax base is governed by national accounts data from Eurostat, which determine country-specific shares in the formula.

Second, loss consolidation affects the tax burden of multinationals. There are a number of considerations when comparing a system of loss-carry forward within each country to a system with immediate cross-border loss offset. To completely model the different treatment of losses one would need to simulate a number of periods with different potential outcomes. Further, it would be necessary to consider each possible outcome in each country simultaneously. For example, if there are even only two possible outcomes in each period (profit or loss), across 27 EU Member states in which each individual company is active, we would need to consider 2^{27} different states in each period. However, we can consider the basic mechanisms in a two-country framework with two – one positive and one negative – outcomes. To understand the impact of a switch to a cross-border loss consolidation system it is useful first to consider the impact of uncertainty on the expected tax burden under a loss carry-forward system. For simplicity, consider a firm with an investment with two possible outcomes: with probability p it creates a profit of g and with the probability $(1-p)$ it creates a loss of $b<0$. Hence the expected profit is $E= pg+ (1-p)b$. In the event of a profit, the firm faces a tax liability of tg. In the event of a loss, it generally cannot claim an immediate tax rebate, but must carry forward the loss to set against profits in a subsequent period. Given a discount factor of $0<d<1$, the present value of the reduction in tax due to the loss is tbd. We can define an "effective expected tax liability" under this system as $T = t[pg + (1-p)bd]$. Dividing by expected profit yields an "effective expected tax rate", $y=T/E$. Given that $b<0$ and $d<1$, then $y>t$: the effective tax rate exceeds the statutory rate. This is true as long as there is some possibility of a loss which would not receive an immediate tax rebate ($p<1$). The extent by which y exceeds t increases the further into the future that the loss must be carried forward. The extent to which y exceeds t represents a greater disincentive to investment relative to the case of a symmetric tax system (in which $y=t$). For a given level of uncertainty, an increase in profitability tends to increase T, but lower y. For example a smaller b, holding p and g constant, implies that a smaller taxable loss would need to be carried forward in the event of a loss. Further, given a level of expected profit, higher uncertainty is associated with a larger y. For example, an increase in g with an equal but offsetting reduction in b, holding p constant so that E is unchanged, would result in a higher T and a higher y.

Now consider the case of a system of loss consolidation between two countries, i and j, where each country hosts a similar investment which may make a profit or loss. Assume for simplicity that each country has an equal apportionment, so that the effective statutory rate is $t^*=0.5(t_i+t_j)$. If we assume that $g>b$ in each country, then the probability that aggregate taxable profit is negative is $p^*=(1-p_i)(1-p_j)$: this implies that there is a lower probability of a taxable loss which would need to be carried forward than in the case without loss consolidation. This implies that the disincentive to investment arising form the asymmetric treatment of profit and loss is lower than in the case without loss consolidation. These observations imply two effects of an introduction of a loss consolidation system. First, for a given expected profit, since the country with the more uncertain outcome gains more in expected tax revenues in the absence of consolidation, it would lose more than the other country if loss consolidation were

introduced. Second, for given levels of uncertainty, the country with the higher profit would lose more revenue when consolidated with the profits or losses in the other country. The effect on the distortion to investment also depends on tax rates. If tax rates differ across countries, it is possible that offsetting losses in a high tax country against profit in a low tax country may increase the effective tax liability on the firm. This is because is because it is possible that the present value of losses carried forward (say $t_i b_i d$ if the loss is incurred in country i) exceeds the value of losses immediately offset under formula apportionment ($t^* b_i$).

In our simulations, we make a first-order approximation of the impact of loss consolidation on revenues by assuming that all losses that occur in European subsidiaries can be offset by profits elsewhere under consolidation. Under loss carry forward, firms that make a loss in two consecutive periods cannot offset the loss of the first period. Moreover, losses that can be offset are discounted one period. Hence, loss consolidation in CORTAX will always reduce the tax burden of the multinational relative to loss carry forward. To illustrate the underlying mechanism, the following example shows the impact of loss consolidation on the corporate tax base in CORTAX. Suppose there are 100 firms. Among them, 80 make a profit of 1000 and 20 make a loss of 1000. The total taxable base of profit making firms is therefore 80 000 if the losses cannot be offset and 60 000 if losses are offset immediately. Under loss consolidation, the tax base is thus 25% smaller. As the tax reduction applies only to multinational firms, we multiply this by the share of multinationals in the economy, which is approximately 60% in Europe. Consolidation would then reduce the corporate tax burden by 15%.[8] In the steady state equilibrium of CORTAX, the reduction in the tax base is smaller due to losses carried forward from the past. In CORTAX, 80% of the previous-period losses (i.e. the probability of profit) can be offset against profits in the next period. In our example, this equals a loss compensation of 16 000. Yet, this compensation needs to be discounted at, say 5% interest, which reduces its current value to 15200. Compared to immediate loss offset under consolidation of 20 000, the value of losses decreases by 4 800. It implies a reduction of the corporate tax base by 4 800 / 64 800 = 7.5% when moving from loss carry forward to loss consolidation. Assuming a share of multinationals of 60% of all companies, the aggregate decline in the tax base in the steady state would be 4.5%.

Figure 3 shows the direct impact of CFA with the 1/3 formula on corporate tax-to-GDP ratios according to CORTAX. Countries are ranked according to their capital/labour ratio from left (lowest) to right (highest). This capital/labour ratio explains part of the country differences (see below). On aggregate for the EU, the reduction in corporate tax revenue is 0.17% of GDP (see the dotted line in Figure 3) or nearly 5% of corporate tax revenues, which is due to loss consolidation. The effect for individual countries is partly the result of a differential impact of loss consolidation. In particular, the reduction in revenue due to loss consolidation is larger for countries featuring a high corporate tax rate and a large multinational sector.

The redistribution effect of formula apportionment depends on three factors. First, the capital/labour ratio determines the extent to which the asset factor relative to the employment factor influences the division of the corporate tax base across countries. Figure 3 shows that labour-intensive countries (on

[8] Fuest, et al (2007) estimate this impact and find a decline in the tax base of 20% using data on German multinationals. ORBIS suggests that the share of multinationals in Germany is 70%. It would imply a direct reduction of 17.5% in Germany.

the left-hand side of Figure 3) are more likely to gain from CFA under the 1/3 formula than the capital-intensive countries (on the right-hand side). For instance, Portugal gains because of its high labour intensity of production, while Germany loses due to its capital-intensive production. Second, the current corporate tax rate determines whether a country initially benefits or loses from profit shifting. In particular, low-tax countries like Ireland initially gain and high-tax countries like Belgium initially lose. Eliminating profit shifting takes away these benefits or losses. Third, CFA matters only for multinationals. Hence, countries with a large multinational sector are affected more than countries with a small multinational sector. The Netherlands and Ireland lose between 0.4% and 0.5% of GDP because they combine a large multinational sector with a relatively low tax rate and a high capital/labour ratio. Belgium gains due to its high tax rate in combination with a large multinational sector.

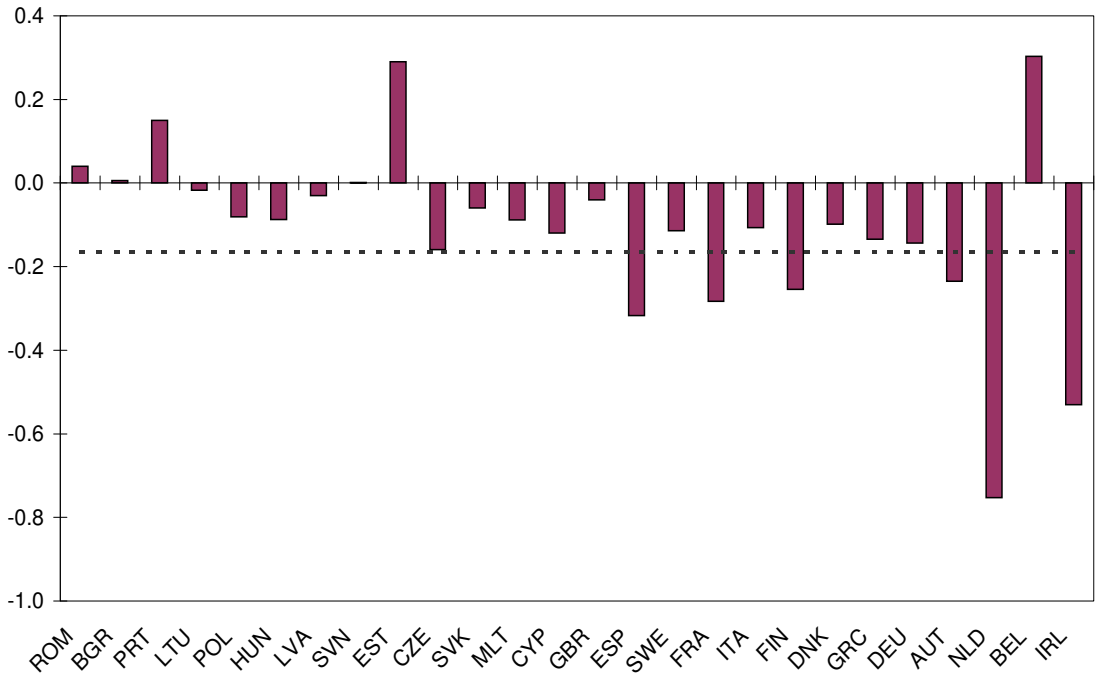

Figure 3: Direct impact of CFA (with ⅓ formula) on corporate tax-to-gdp ratios

4.2.2. Economic effects

CFA affects economic behaviour in CORTAX through four main channels. First, multinationals can no longer shift profits to subsidiaries within Europe. Indeed, profits are consolidated so that transfer prices are no longer needed. The elimination of profit shifting reduces corporate tax revenue in low-tax countries that currently benefit from it and raises revenue in high-tax countries (see Figure 2). However, profit shifting is not a zero-sum game in CORTAX (see also Hong and Smart, 2007). The reason is that profit shifting allows multinationals to reduce their overall tax burden. This reduces the cost of capital, encourages investment and boosts GDP. Taking away this opportunity effectively raises the tax burden for multinationals and exerts opposite effects on the economy. Note that profit shifting vis a vis the US and Japan remains as it is, i.e. based on separate accounting. In determining transfer prices,

multinationals take the weighted average European rate into account (see eq. (2) below) as the relevant tax rate applying to profits allocated in the EU.

The second effect of CFA involves the EMTR or cost of capital. With separate accounting, national corporate tax rates based on the source principle affect the cost of capital for subsidiaries in countries where they operate. Under consolidation, however, the cost of capital is not directly influenced by national tax rates. The reason is that the income generated by a multinational is summed up to a consolidated base. The location of investment thus does not matter for the tax base of the multinational. The tax rate applying to the profit of the multinational under CFA (τ_i^{cfa}) can be written as a weighted average of the tax rates applied by the participating jurisdictions (τ_j) according to:

$$\tau_i^{cfa} = \sum_j \omega_{ij} \tau_j \qquad (2)$$

where firm-specific weights ω_{ij} are determined by expression (1). CFA thus effectively means an equalisation of EMTRs. Countries with a low EMTR thus lose their competitive advantage in attracting mobile capital compared to countries with a high EMTR.

But CFA does cause distortions in factor allocation. This third effect is opposite to the second. In particular, under CFA, multinationals can change the shares ω_{ij} in expression (2), thereby affecting the tax burden applying to the entire multinational profit. Indeed, by relocating inputs appearing in formula (1) from high-tax to low-tax countries, firms reduce the weight of high-countries and increase the weight of low-tax countries. This reduces the tax burden τ_i^{cfa}. Hence, formula apportionment induces new behavioural distortions as long as corporate tax rates differ across countries. Effectively, statutory corporate tax rates become excises on the factors that appear in the formula. Thus, formula apportionment replaces the current distortion in capital and profit allocation by a new distortion that depends on the formula factors. CORTAX sheds light on whether this improves allocative efficiency or not and which countries benefit and lose.

Box: Incentives under loss consolidation and loss carry forward

Assume a firm that produces output by combining labour and capital. Ex-ante, firms are equal. Ex-post, they may suffer a random shock in the value of sales. In the good outcome, the revenue from sales equals Y_t^g. In the bad outcome, there is a lower value Y_t^b, such that profits are negative. Ex-post, a share of q firms obtain a good outcome and a share $1-q$ obtains a bad outcome. Assuming risk neutrality, firms consider the expected output value when determining their demand for inputs.

Under loss carry forward, firms cannot immediately offset losses. We assume they carry forward their loss one year and then offset it against a possible profit. The expected tax base is determined by profitable firms minus the taxable loss they carry from the previous year (Λ_t)

$$E(\Pi_t^L) = q[Y_t^g - wL_t - \phi I_t + (1-q)\Lambda_t] \quad \text{where} \quad \Lambda_t = \frac{1}{1+r}(Y_t^b - wL_t - \phi I_t) < 0 \qquad (3)$$

where wL_t denote labour costs, I_t is investment and ϕ stands for an investment tax credit.

Under loss consolidation, we assume that all losses can be immediately offset against profits elsewhere in the multinational group. The expected aggregate corporate tax base is

$$E(\Pi_t^C) = qY_t^g + (1-q)Y_t^b - wL_t - \phi I_t \qquad (4)$$

The difference in tax bases between consolidation and loss carry forward is:

$$E(\Pi_t^C) - E(\Pi_t^L) = (1-\theta)[Y_t^b - wL_t - \phi I_t] < 0 \qquad (5)$$

where $\theta = q\left[1+(1-q)/(1+r)\right] \leq 1$. Hence, the tax base is unambiguously smaller under consolidation.

The first-order conditions for capital and labour demand under loss carry forward are:

$$qY_K^g + (1-q)Y_K^b = \frac{1-\phi\tau}{1-\tau}r + \frac{\tau}{1-\tau}\xi\left(\phi r - Y_K^b\right) \qquad (6)$$

$$qY_L^g + (1-q)Y_L^b = w + \frac{\tau}{1-\tau}\xi\left(w - Y_L^b\right) \qquad (7)$$

where subscripts denote marginal productivities, r is the return to equity, τ is the corporate tax rate and $\xi = (1-q)\left(1-q/(1+r)\right) \leq 1$. Under immediate loss offset, the first-order conditions are:

$$qY_K^g + (1-q)Y_K^b = \frac{1-\phi\tau}{1-\tau}r \qquad (8)$$

$$qY_L^g + (1-q)Y_L^b = w \qquad (9)$$

Expressions (6) to (9) show that firms set the expected marginal productivity of capital and labour equal to their respective prices. According to (8), the corporate tax raises the cost of capital as long as investment is not fully deductible, i.e. $\phi<1$. The first-order conditions in (6) and (7) differ from (8) and (9) due to the second term on the RHS in (6) and (7). Comparing (7) and (9) shows that consolidation unambiguously reduces labour costs, because $w > Y_L^b$. Intuitively, limited loss offset implies that part of labour costs cannot be deducted if a firm makes a loss in two consecutive bad years. Comparing (6) and (8) shows that consolidation may raise or reduce the cost of capital as compared to loss carry forward. This depends on the corporate tax system: if only a small share of investments are deductible (i.e. if ϕ is small), the reduced taxation of production in bad outcomes Y_K^b implies a reduction in the cost of capital. If ϕ is larger, consolidation raises the cost of capital because returns in consecutive bad outcomes will be untaxed as well.

The fourth effect of CFA is due to loss consolidation. The box 'Incentives under loss consolidation and loss carry forward' demonstrates how loss consolidation affects relative prices in CORTAX. It suggests that loss consolidation reduces the effective labour costs. This is because wages are always directly deductible from the multinationals´ corporate tax bill in the CFA-regime, which is not the case under loss carry forward. Loss consolidation does not necessarily reduce the cost of capital though. On the one hand, deductible capital costs become more valuable under consolidation as such costs can be deducted earlier and always. On the other hand, any positive *marginal* returns on investment are taxed immediately and cannot be postponed or waved in case of a loss. This increases the cost of capital. The CORTAX simulations reveal how in different countries the costs of labour and capital are affected. This drives the impact on employment and investment.

Table 4 shows the balance of these four effects according to CORTAX under three balanced budget rules: lump-sum taxes, corporate taxes and labour taxes. The first column of Table 4 shows that CFA improves welfare in Europe by 0.08% of GDP under lump sum adjustment. The cost of capital falls by 0.05%-point and investment rises by 0.38%. Employment and GDP expand by 0.17% and 0.18%, respectively. The aggregate welfare gain from CFA in the first column of Table 4 is mainly driven by loss consolidation. Indeed, the lower tax burden implies a reduction in labour costs and the cost of capital. As this is financed by lump-sum taxation, it creates a net welfare gain.

However, if other distortionary taxes are used to balance the government budget, the second and third columns of Table 4 show that the positive economic effects of CFA are smaller. Higher corporate tax rates are particularly harmful for investment as they raise the cost of capital. Higher labour taxes especially hurt labour supply incentives and reduce employment. The welfare gain of CFA drops under both simulations.

Table 4: Economic effects for the EU of consolidation with formula apportionment

	Lump-sum transfers	Corporate tax rate	Labour tax rate
Corporate tax-to-gdp ratio	-0.29	-0.11	-0.30
Cost of capital	-0.05	-0.02	-0.05
Investment	0.38	-0.13	0.23
Wage	0.41	0.20	0.42
Employment	0.17	0.09	0.02
GDP	0.18	-0.06	0.03
Welfare	0.08	0.02	-0.03

Source: Authors' calculations

Figure 4 shows the welfare effects for individual countries under lump sum adjustment. The horizontal axis shows the initial capital/labour ratio in CORTAX. We see that welfare increases in most countries. Hence, while a number of countries face a direct reduction in corporate tax revenue (see Figure 3), the resulting welfare effects are more favourable. For instance, we see that Ireland realises a small welfare gain, despite that corporate tax revenue falls substantially due to the abolition of profit shifting. Intuitively, Ireland's low corporate income tax now attracts substantial capital instead of paper profits. The opposite occurs in Belgium where the high corporate tax rate mitigates the benefits from

consolidation. For other countries, the balance of the two offsetting mechanisms depends on the economic structure, country-specific elasticities and the level of corporate tax rates. Eastern European countries with small capital/labour ratios gain most from consolidation and formula apportionment. Capital-intensive countries in Western Europe gain less.

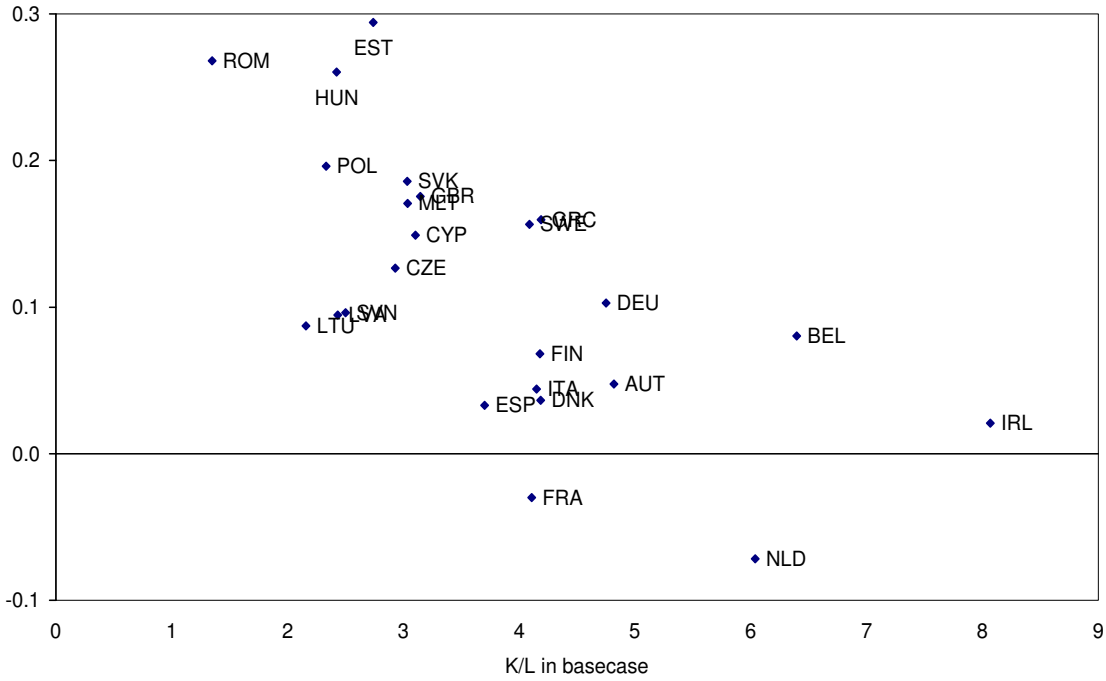

Figure 4 Welfare effect of CFA for different countries

The gains and losses are more dispersed if governments adjust distortionary taxes on labour or capital income instead of lump-sum transfers, see figure 5. Capital-intensive countries need to raise tax rates more to compensate their revenue loss induced by loss consolidation. This reduces their welfare. Labour-intensive countries are more likely to reduce tax rates, as they gain revenue under CFA. Hence, they experience larger welfare gains if distortionary taxes are reduced.

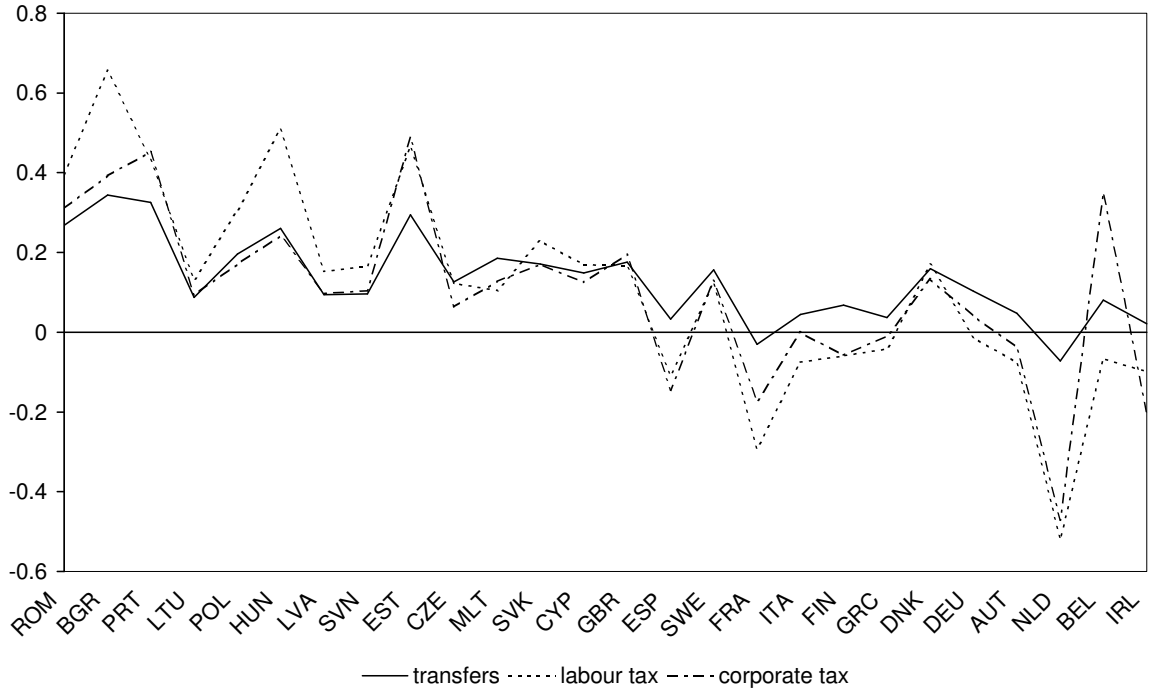

Figure 5 Welfare effect of CFA for different countries, alternative balanced budget rules

5. Choice of the apportionment formula

The direct distributional and economic effects of CFA depend on the choice of the apportionment formula. This section shows this by exploring the effects of CFA under four pure formulas, based on employment, payroll, assets or output. As in the previous section, we assess the impact of CFA relative to a scenario with a CCTB in the EU. If revenues change due to a CFA reform, we assume that a country adjusts corporate tax rates to balance its budget. The relative performance of different formulas does not change if we adopt alternative balanced budget rules. The outcomes for individual countries are given in the appendix. Table 5 summarises the economic effects for the EU as a whole.

Table 5: Economic effects of CFA for the EU under alternative formulas, corporate tax rate adjustment

	employment	payroll	capital	production	equal shares
CIT revenues	-0.15	-0.10	-0.11	-0.10	-0.11
Cost of capital	-0.05	-0.02	-0.01	-0.01	-0.02
Investment	-0.11	-0.15	-0.13	-0.19	-0.13
Wage	0.30	0.19	0.17	0.16	0.20
Employment	0.09	0.11	0.09	0.09	0.09
GDP	-0.15	-0.04	-0.05	-0.06	-0.06
Welfare	0.00	0.02	0.01	0.02	0.02

Source: Authors' calculations

Table 5 suggests that the choice of the formula matters marginally for aggregate welfare in Europe. The reason is that the economic effects are driven primarily by the tax relief associated with loss consolidation. This is on average independent of the formula choice. What we see is that the welfare gains are slightly larger under the pure payroll and production formulas as compared to the pure employment and capital formulas. The reason is that wages and the value of production both depend on the size of the fixed factor. This part of the apportionment formula is non-distortionary and, therefore, formulas based on it are less distortionary. Employment and assets do not directly depend on the fixed factor. Hence, these formulas are slightly more distortionary and yield smaller welfare gains.

5.1. Employment formula

Figure 6 presents the direct impact of CFA under a pure employment formula on the corporate-tax-to-gdp ratio (dotted line) and the general-equilibrium impact on welfare (solid line) in different countries if corporate tax rates are used to balance the budget. The figure reveals a negative correlation of the welfare effects with the initial capital/labour ratio (on the horizontal axis). Hence, poor labour-intensive countries in Central and Eastern Europe benefit more from CFA than the rich capital-intensive countries in Western Europe.[9] First, the initial redistribution of the tax base is more favourable as a large share is apportioned to labour-intensive countries. Second, low tax rates are more effective in attracting multinational activity if the formula is determined by the relatively abundant factor. Especially Bulgaria and Romania benefit, as they combine a labour-intensive production structure with relatively low corporate tax rates. The most capital-intensive countries, Belgium, Ireland and the Netherlands, suffer a welfare loss.

[9] This is in line with the findings of Devereux and Loretz (2008).

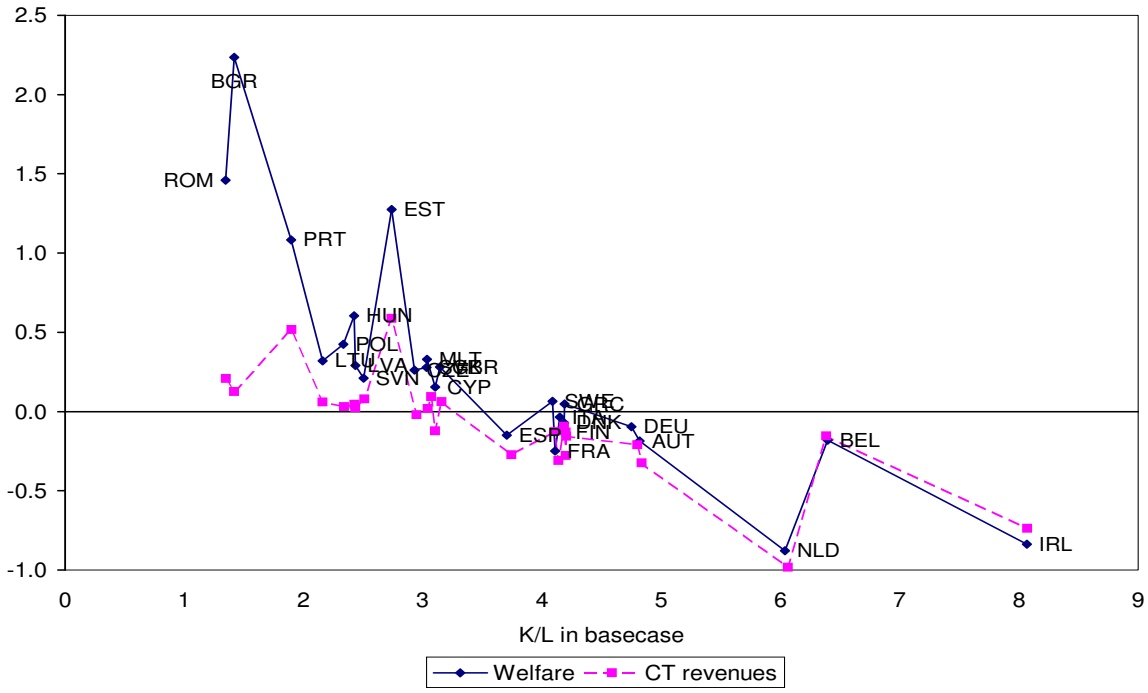

Figure 6 Effect on corporate tax-to-gdp ratio and welfare of CFA with a pure employment formula

5.2. Asset formula

Figure 7 demonstrates the effects of CFA under a pure asset formula. It reveals the direct impact on the corporate-tax-to-gdp ratio (dotted line) and general-equilibrium change in welfare (solid line) under corporate tax rate adjustment. Under a pure asset formula, capital-intensive countries benefit from receiving a relatively large share of the European tax base of multinationals. Moreover, a pure asset formula implies that the corporate tax rate has a relatively large effect on the asset allocation of multinationals. Capital-intensive countries with a low corporate tax rate therefore benefit most from CFA with the asset formula and labour-intensive countries with high tax rates lose. Figure 7 shows the positive correlation between the welfare effect of CFA and the initial capital/labour ratio. Interesting is that Ireland and the Netherlands experience a lower corporate tax-to-gdp ratio due to the abolition of profit shifting, although this effect is smaller than under the 1/3 formula. Yet, the welfare effect in these countries is positive because multinationals relocate their assets due to relatively low corporate tax rates.

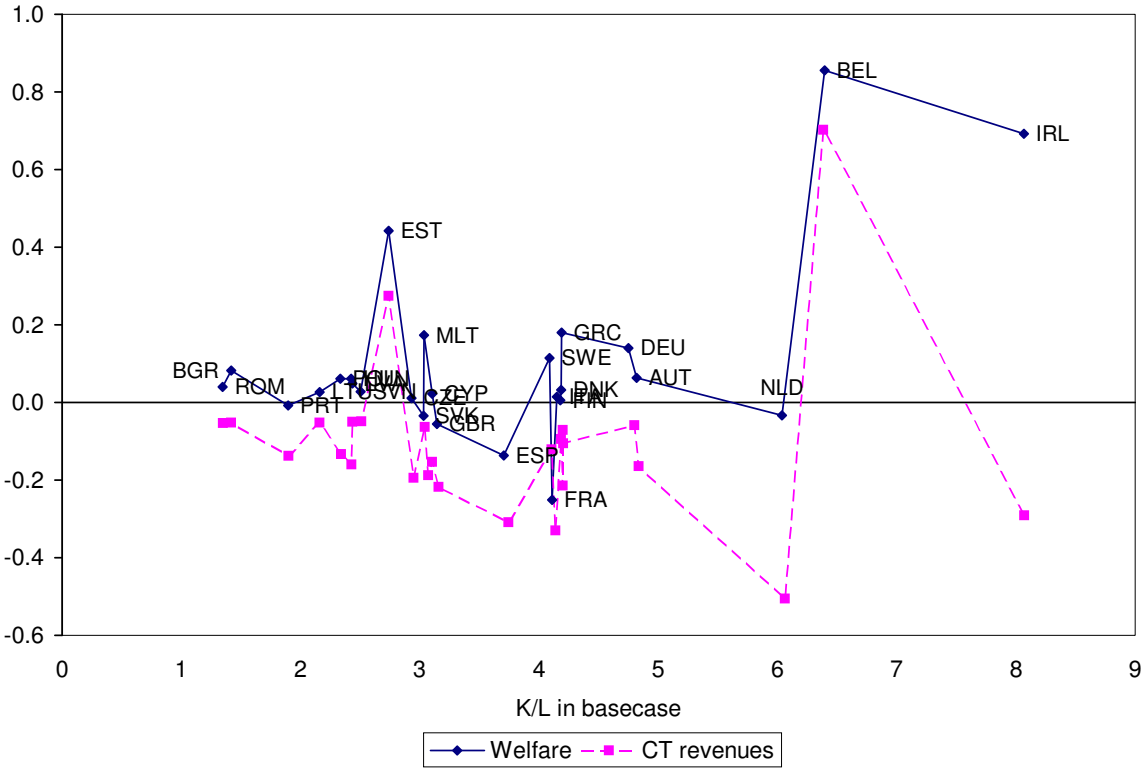

Figure 7 Effect on corporate tax-to-gdp ratio and welfare of CFA with a pure asset formula

When comparing Figures 6 and 7, we see that the variation of the welfare effects across countries is larger under the employment formula than under the asset formula (compare the scale of the vertical axis). The reason is that distortions induced by the current corporate tax systems are more similar to the distortions under CFA with a pure asset formula. Under a pure employment formula, distortions in response to the formula are more different as employment multinationals is more weakly linked to the current distribution of profits. Given the uneven distribution of labour, abundant in low-wage countries but scarce in high-wage countries, the effects for individual countries vary more under the employment formula than under the asset formula.

5.3. Payroll, production and sales formulas

Applying the source principle of taxation is difficult in practice, both under separate accounting and under consolidation with formula apportionment. This is due to the complex structures of multinational activities, which render it virtually impossible to determine the source of profits. Under consolidation, one may approximate the source of profits by using input factors in the formula. Indeed, employment, assets and output approximate the source of where profits are generated and thus come close to achieving taxation on the basis of the source principle.

An alternative is the destination principle, i.e. the destination of sales of final products where consumers reside. In the US, sales have become the most popular formula. Also in the European debate sales are

generally considered as a potential apportionment formula under the CCCTB. In this debate the usual measurement of sales is by destination. That is, if a company in country *X* exports its output to country *Y*, then the sale is in country *Y*. This makes the tax on profit much closer to a destination-based consumption tax. If sales by destination were the only factor in the apportionment formula, then a company's tax liability would not depend on where it undertook any of its activities other than the sale to the final consumer. It follows that the tax system would not distort decisions as to the location of productive activity, headquarters or other aspects of the company's operations. It is for these reasons that there have been independent proposals to base the corporation tax system on a destination basis (Bond and Devereux, 2002, Auerbach et al, 2009).

However, we are not able to analyze the CCCTB under a sales-by-destination formula. This is because we do not have reliable data on the link between production and sales. In order to implement this, we would need information on the geographical scope of sales by subsidiaries of multinational companies. Such data are not currently available.

6. Corporate tax rates

In the European CCCTB proposal, countries are free to choose their own corporate tax rate. This leaves room for tax competition between countries with respect to rates. Indeed, we have seen that apportionment based on employment, assets or payroll induces multinationals to reallocate factors to low-tax jurisdictions. Governments may strategically respond by setting low tax rates in order to attract these multinational factors. An important question for policy is whether tax competition becomes more or less intense under CFA as compared to separate accounting.

6.1. Tax competition under consolidation

The effects of moving to CFA on tax competition are theoretically ambiguous, see e.g. Pethig and Wagener (2003), Sørensen (2004b) and Kind et al. (2005). It depends on the strength of international spillovers of tax policies. Governments under separate accounting have an incentive to underbid each other's tax rates to attract paper profits, while with CFA they keep tax rates low to attract multinational activities (Gordon and Wilson, 1986). Which of these spillovers dominate remains an empirical issue. This section explores whether the incentives for tax competition under CFA are stronger than under separate accounting. To that end, we simulate a unilateral 5%-point reduction in the corporate tax rate in each EU country, both under the current regime of separate accounting (with a CCTB already in place) and under the CFA regime. In both simulations, governments reduce lump-sum transfers to balance their budget. Hence, the corporate tax relief typically improves welfare by alleviating distortions in investment. On average, welfare in a country increases by 0.2% of GDP. The interesting question is whether these welfare improvements differ across the two regimes. If this is the case, it suggests that spillovers differ in size. Indeed, if the same unilateral tax cut raises welfare more under CFA than under separate accounting, spillovers are larger under CFA and the incentives for tax competition are expected to intensify.

The appendix shows the economic impact of a 5%-point unilateral corporate tax rate reduction for individual countries under separate accounting and CFA with a 1/3 formula. Figure 8 summarises the welfare effects under both regimes. In the figure, points are linked to each other via two lines: a dotted line for the CFA regime and a solid line for the separate accounting regime. Countries are ranked according to their initial corporate tax rate.[10]

On average, we find that the welfare effect of a unilateral tax reduction is equivalent across the two regimes. However, the effect differs between low-tax and high-tax countries. Indeed, Figure 8 shows that tax reductions yield larger welfare gains in low-tax countries under the CFA regime. In contrast, tax reductions in high-tax countries yield smaller welfare gains under the CFA regime. The explanation is the following. The costs of transfer price manipulation are convex. It implies that the marginal costs of profit shifting increases if a tax rate falls further relative to other countries. Hence, additional tax rate reductions in low-tax countries yield only small benefits because of the rapidly rising costs of profit shifting. In contrast, the marginal cost of profit shifting for high-tax countries are low. Hence, tax-rate reductions are relatively beneficial. Under the CFA regime, this asymmetry between high-tax countries and low-tax countries disappears because the profit shifting mechanism is absent. Instead, new fiscal spillovers arise that depend less on the initial tax rate. Therefore, low-tax countries find it relatively more and high-tax countries relatively less beneficial to cut their rates under the CFA regime. This finding suggests that under CFA, low-tax countries will find it more beneficial to cut their rates so that they more aggressively compete. High-tax countries find it less beneficial to reduce their rate. The likely result is a further divergence of corporate tax rates across countries. This makes the debate on rate harmonisation more relevant.

[10] These outcomes are qualitatively the same if we take pure employment or asset formulas, although the distributional effects are different. In particular, low-tax countries in Eastern Europe will experience a considerably larger welfare gain from a unilateral tax rate reduction under a pure employment formula.

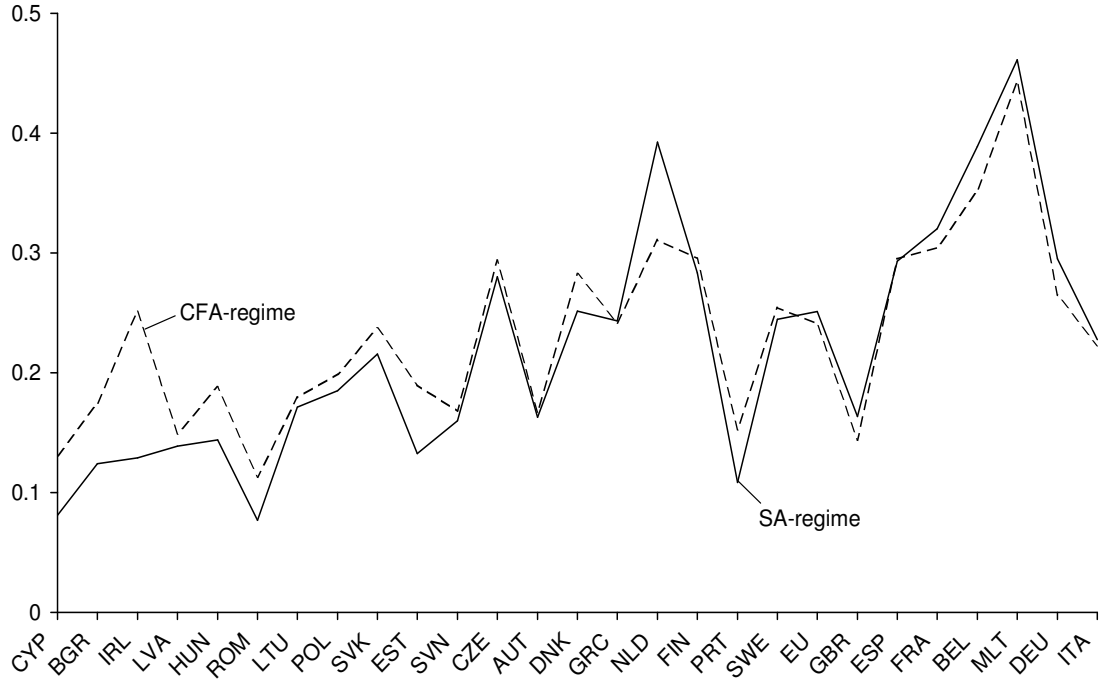

Figure 8 Effect on 5%-point unilateral tax reduction on welfare under separate accounting (SA) and CFA

6.2. Harmonisation of rates

We simulate the welfare effects of rate harmonisation under the CCCTB. Important is the choice of the common tax rate in Europe. We choose a common rate of 32.5%, which implies the same impact on corporate tax revenues as the CCCTB with today's corporate tax rates in Europe. Changes in tax revenues are compensated with a change in either lump-sum transfers or the labour tax rate. Table 6 compares the CCCTB with rate harmonisation at 32.5% with the CCCTB where corporate tax rates remain unchanged.

Table 6: Economic effects for the EU of a CCCTB with country-specific and common corporate tax rate

	No rate harmonisation (see Table 4)		Harmonisation at a common rate of 32.5%	
Budget closing rule	Lump-sum transfers	Labour tax	Lump-sum transfers	Labour tax
CIT revenues	-0.29	-0.30	-0.32	-0.33
Cost of capital	-0.05	-0.05	-0.02	-0.02
Investment	0.38	0.23	0.41	0.25
Wage	0.41	0.42	0.51	0.52
Employment	0.17	0.02	0.19	0.03
GDP	0.18	0.03	0.28	0.13
Welfare	0.08	-0.03	0.14	0.04

Source: Authors' calculations

Table 6 shows that welfare expands by about 0.14% and 0.04% of GDP if government budgets are closed with lump-sum transfers respectively labour taxes. Both are higher than with country-specific changes in the corporate tax rate (as repeated from table 4). It reflects the more efficient allocation of capital in the European Union due to the equalisation of tax rates. The allocation formula exerts no longer an effect on factor allocation when rates are harmonised. Hence, distortions in factor allocation are eliminated. This increases average rates of returns in Europe, which shows up in higher welfare.

7. Sensitivity analysis

The discussion of consolidation and formula apportionment has centred on the average welfare effect (generally negligible) and its distribution across countries (quite uneven). In addition, the distribution is shown to depend on initial tax rates, capital intensity and openness as measured by the size of the multinational sector. This section explores how robust these results are to alternative values of key elasticities and modelling assumptions. Section 7.1 shows that the economic effects of consolidation do not depend much on the substitution between labour and capital or the inclusion of responses to dividend and capital gains taxes. More important are the size of the fixed factor, the responsiveness of paper profits to tax differentials and the inclusion of a discrete location choice of multinationals. The role of losses is discussed in section 7.2.

7.1. Economic effects of consolidation under alternative assumptions

This section presents how sensitive our results are for a number of assumptions in the model. We consider one key reform proposal to illustrate the sensitivity of our results, namely the introduction of CFA with the 1/3 formula, where governments use corporate tax rates to balance their budget (see Table 4). We consider the implications for this simulations under five changes in CORTAX: (i) a smaller elasticity of substitution between labour and capital (from 0.7 to 0.5); (ii) a different assumption regarding the distortionary impact of dividend taxes; (iii) a smaller size of the fixed factor in the calibration (from 2.5% to 1.5%); (iv) a larger response of transfer prices to tax differences (50% larger response); and (v) the inclusion of discrete location choices between countries. Table 7 reports in the first column the EU-average change in welfare under the five alternative assumptions, and compares it with the outcomes from the basic simulation, presented in the first row of the table. Moreover, Table 7 summarizes the sensitivity of individual country effects by means of covariances.[11] In particular, the first row shows the covariance of the welfare effect of the CFA reform with three country characteristics: (i) the initial corporate tax rate; (ii) the capital intensity; and (iii) the degree of openness measured by FDI stocks. We see that the welfare effect is positively correlated with low corporate tax rates, low capital intensity and a small multinational sector (see section 4). Table 7 shows how these country characteristics affect the size of the welfare effect of the CFA reform under alternative assumptions.

[11] A limitation of covariances is that they are sensitive to scaling, which implies that the columns in Table 7 cannot be compared. However, variation in the rows of the table reveals whether the initial tax rate, capital intensity and openess has a weaker or stronger impact on the welfare distribution.

Table 7: Sensitivity of welfare effects of consolidation with formula apportionment (equal shares and corporate tax rate adjustment)

	EU-average	covariance with tax rate	capital intensity	openness
CFA (base case)	0.02	-0.003	-0.193	-0.050
Limited K-L substitution	0.03	-0.003	-0.192	-0.050
No personal taxation	0.02	-0.004	-0.178	-0.046
Smaller fixed factor	-0.02	-0.005	-0.367	-0.105
Intensified paper profit shifting	0.02	-0.002	-0.230	-0.074
Location choice	-0.05	-0.007	-0.414	-0.162

The second row of Table 7 shows the welfare effects of CFA for a lower elasticity of substitution between labour and capital. This elasticity is generally considered to be an important determinant of the economic effects of corporate tax reforms. In particular the response of investments to the user cost depends on this elasticity. Simulations with CORTAX in Bettendorf et al. (2006) show that a limitation of the substitution possibilities reduces the responsiveness of capital and GDP to a change in the tax rate. Table 7 shows that the welfare changes in the CFA-reform are negligible, however. The reason is that the economic and welfare changes are not induced by changes in the user cost of capital, but by changes in profit shifting and the (implicit) taxation of the apportionment factors. These tax planning strategies do not depend much on the elasticity of substitution between labour and capital.

The third row adopts an alternative assumption regarding the distortionary effect of personal taxes on capital income. In particular, CORTAX adopts the assumption under the old view of dividend taxation that personal capital taxes on capital affect the investment. In the third row of Table 7, we have taken the new view and assume that these taxes are not relevant for investment. We see that the welfare effects are very similar. Hence, the assumption of how personal taxes affect investments does not change the impact of CFA much.

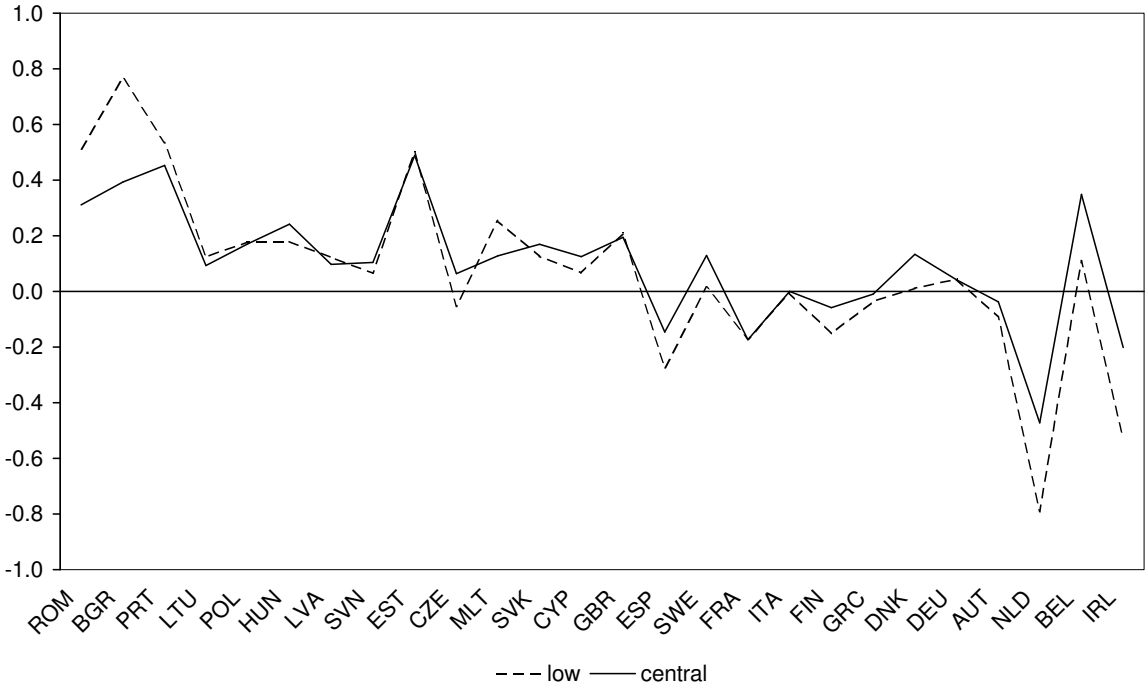

Figure 9 Welfare effects of CFA, with a smaller share of fixed income

The fourth row of Table 7 assumes a smaller fixed factor than in the original CORTAX version. This renders the corporate income tax more distortionary, as a smaller part applies to the non-distortionary economic rent. As a result, we find that CFA yields a welfare loss on average in the EU, rather than a welfare gain. The welfare loss is particularly pronounced in countries featuring high corporate tax rates, high capital intensity and a large multinational sector, which we obtain from the larger covariances. Figure 9 shows the welfare effects for individual countries under the two alternative calibrations. The countries are ranked according to their capital intensity from left to right. We see that labour intensive countries like Romania, Bulgaria and Portugal gain more under a smaller fixed factor. This is because they are able to reduce their tax rates, which yields larger gains if these taxes are more distorionary. Capital intensive countries like the Netherlands, Belgium and Ireland lose more.

The fifth row of Table 7 shows the sensitivity of the results if the response of transfer prices to tax differentials is larger due to smaller cost of profit shifting. On average in the EU, the implications are limited. However, the impact for individual countries changes more substantially. For instance, the welfare effect for low-tax countries becomes smaller. The reason is that transfer pricing only matters under separate accounting. Low-tax countries benefit more from transfer price manipulation if the costs decline. Therefore, they gain less from the shift towards CFA. The variation of effects of the CFA reform therefore becomes smaller. We also see that the effects of CFA are more favourable for labour-intensive countries and for countries with a small multinational sector (as this sector currently gains more from profit shifting).

The last row of Table 7 shows the CFA reform in a version of CORTAX that includes the discriet location choice of multinational enterprises. We see that this is important for the economic effects of the

CFA-reform. In particular, the average EU effect becomes more negative. The reason is that the responsiveness of multinationals to the allocation formula becomes larger if the fixed factor moves across jurisdictions. Indeed, by locating a larger share of the fixed factor in low-tax countries, the multinational reduces its tax liability. CFA thus exacerbates distortions in capital allocation, which causes larger adverse welfare effects in the EU. This negative welfare effect for the EU as a whole comes along with a divergence of effects between countries. Indeed, the covariances in Table 7 increase. The country variation is also shown in Figure 10, which presents the welfare effect of CFA in both versions of CORTAX, i.e. with and without endogenous location choice. Countries in this Figure are ranked according to their corporate tax rate (after the introduction of the CCTB).

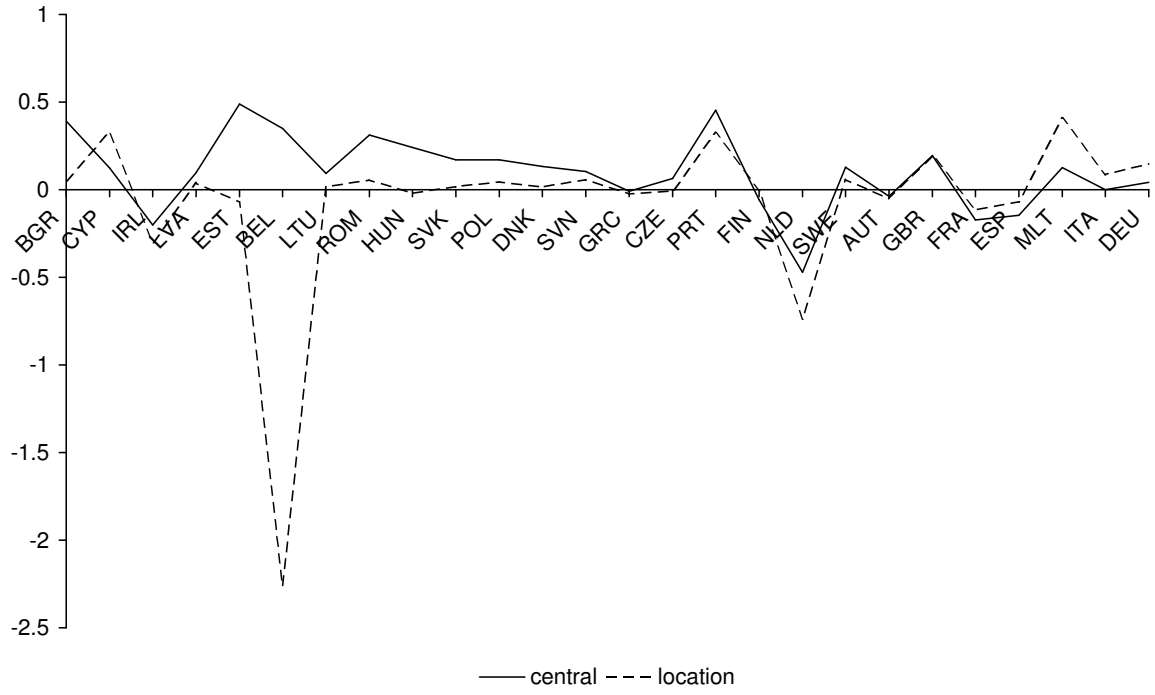

Figure 10 Welfare effects of CFA, with endogenous location choice

Figure 10 shows that high-tax countries benefit more from the CFA-reform if location is endogenous. The intuition is as follows. In the initial situation with separate accounting, differences in statutory tax rates determine location choice. This is unfavourable for high-tax countries. Consolidation implies that the effective tax rate, on which firms base their investment decisions, becomes a weighted average of the statutory rates (see equation 2). The resulting convergence of effective tax rates implies that the disadvantage of high-tax countries is mitigated. This also explains the large difference in effects for Belgium. Belgium is a low-tax country in our baseline with a statutory rate of 14%, because it has abolished its ACE-system under the CCTB (which is our starting point for the CFA reform). With discrete location choice, Belgium has gained substantial inflows of fixed capital due to its low rate. This benefit is offset, however, by consolidation. This explains the welfare loss for Belgium and some other low-tax countries.

7.2. Consolidation and losses

The CORTAX assumptions regarding losses imply that the corporate tax burden is relatively high in the current system of separate accounting with loss carry forward relative to CFA. Indeed, losses can immediately be offset under CFA against profits in another country, which leads to tax relief. It generates a welfare gain if governments compensate this revenue loss with a reduction in lump-sum transfers. The welfare gain is smaller if corporate or labour tax rates are adjusted. The size of these effects depends on the specific CORTAX assumptions regarding loss consolidation. Restrictions to current loss offset might well be less strict, while the possibilities for immediate loss compensation under CFA might be more limited than we have assumed. Accordingly, the impact of loss consolidation would be smaller than assumed in CORTAX.

To shed light on this, we may consider alternative assumptions regarding loss probabilities and the size of losses. Although this keeps the same modelling of the difference between loss carry forward and loss consolidation, it modifies the size of the shock accordingly. CORTAX assumes that losses occur on average once in every five years (i.e. $q=0.8$ in equation 3) and that the size of losses and profits are equal. If losses would occur less frequently, e.g. once in every ten years, or when the size of losses would be halved, this reduces the size of the shock from loss consolidation. Table 8 reveals how this modifies the outcomes for the CFA reform. We see that CFA with lump-sum transfers becomes less beneficial: the welfare gain drops from 0.08% of GDP to 0.02% or 0.04%. However, the welfare effect changes less when corporate or labour taxes are used to balance the budget. Indeed, tax relief by loss consolidation yields only small welfare effects under these alternative balanced-budget rules. Reducing the size of the shock thus only proportionally modifies the size of the effects.

Table 8: Welfare effect of consolidation under alternative assumptions about losses and alternative budget rules

	CFA (base case)	Lower loss probability	Smaller loss to profit ratio
Lump-sum transfers	0.08	0.02	0.04
Corporate tax rate	0.02	0.00	0.01
Labour tax rate	-0.03	-0.01	-0.01

Source: Authors' calculations

CORTAX uses the average probability and size of losses in the European Union. Country-specific information can be deduced from the firm-level data, yielding loss probability and loss-to-profit ratio's per country.[12] Country-specific information about losses is summarized in Figure 11.[13] The horizontal axis shows the fraction of loss-making firms, about 20% on average in the EU. The vertical axis shows the loss-to-profit ratio, defined as the average size of losses per loss-making firm divided by the average size of profits in profit-making firms. This ratio is approximately one, on average in the EU. Figure 11 shows that Denmark, Cyprus and Luxembourg have a high share of loss-making firms (between 35% and 40%), but that the average loss per firm is relatively small (about 50% of the profits in profit-

[12] Note that the calculated values may depend on a very small number of firms, in particular in small countries. Moreover, they may reflect booms or busts in an economy and need not hold outside the sample (2003-2007)..
[13] Appendix table A.1 provide more details on the distribution of losses and the rate of return.

making firms). The UK stands out as a country where a high share (30%) of firms is making losses and where these losses are relatively large. The average return is therefore low, only 1% on average.

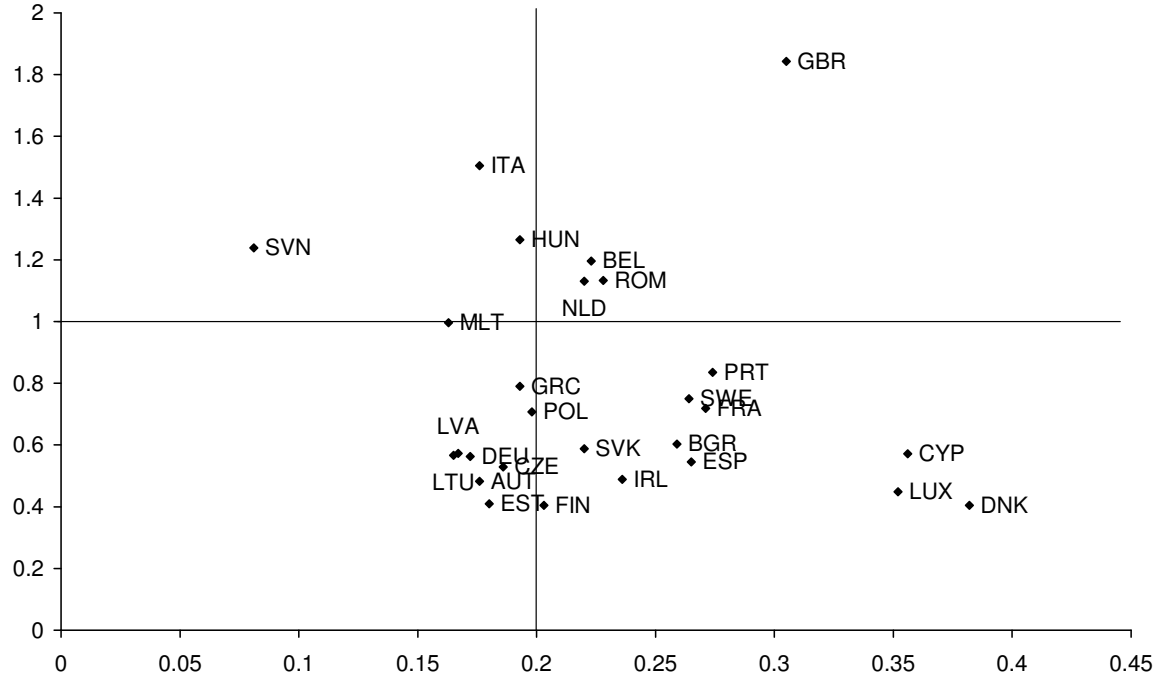

Figure 11 Loss probability (x-axis) and loss-to-profit ratio (y-axis) in the European Union

Figure 12 shows the implications of CFA if we adopt these country-specific loss probabilities and loss/profit ratios in CORTAX. In the Figure, countries are again ranked according to their initial capital-labour ratio (as in Figure 4). We see that labour-intensive countries still gain from CFA. Country-specific losses affect welfare for a few countries, in particular the United Kingdom and the Netherlands. Welfare in the UK declines in Figure 12, because CIT-revenues drop and are compensated with a higher corporate tax rate.

This relatively large drop in CIT-revenues when moving from separate accounting to CFA seems counterintuitive. In particular, larger losses made by UK-firms reduce corporate tax revenues in the UK to their full extent under separate accounting. Under CFA, the same losses will be apportioned to all member states. It would imply that high losses in the UK reduce corporate tax revenue more under separate accounting than under consolidation. However, this intuition overlooks the general equilibrium implications of higher losses which are captured by CORTAX. In particular, higher losses also cause lower expected productivity in a country, which is accompanied by lower wages. In this way, workers share in the incidence of the higher losses. The reduction in wages offsets the negative impact on corporate tax revenues. This offset is larger under separate accounting because part of the losses under CFA are shared with other governments. Effectively, CFA implies that not only larger losses are apportioned to other member states, but higher profits as a result of lower wages too. On balance, the question is who bears the largest share of the higher losses. The answer according to CORTAX is that

the largest share of the revenue loss accrues to the UK-government.[14] Welfare in the UK declines if the UK government raises corporate taxes to compensate for this revenue loss. Indeed, the higher UK-tax rate causes a relocation of employment, capital and output out of the UK. Countries to which British firms relocate, like the Netherlands and Ireland, benefit.

Figure 12 Change in welfare of CFA with corporate tax adjustment, with uniform and country-specific losses

8. Conclusion

This paper explores the economic impact of a common consolidated corporate tax base in the EU using a numerical CGE model for the EU. We find that neither a common base nor consolidation with formula apportionment will yield substantial welfare gains in Europe. Economic benefits may only be achieved to the extent that compliance costs fall, which are not captured by our model.

We find that variation of economic effects across countries is large: some countries gain while others lose. This holds both for the introduction of a common base and for the shift from separate accounting to consolidation with formula apportionment. The dispersion of effects forms a serious complication in achieving political agreement on corporate tax harmonization. However, the distributional impact depends strongly on the choice of the apportionment formula. This leaves some degrees of freedom to finding a feasible outcome. Yet, using input factors in the formula to approximate the source principle of taxation reduces efficiency as remaining tax differences distort factor allocations across countries. Using

[14] In terms of equation (1), $\omega_{UK,UK}$ appears to be relatively large (about 0.44).

sales by destination as the sole formula factor is more efficient, but reduces the degrees of freedom to steer distributional effects across countries.

The simulations reveal that consolidation does not reduce the incentives for tax competition in the EU. In fact, we find that especially low-tax countries will benefit even more from unilateral tax cuts under consolidation as compared to separate accounting. Hence, consolidation may cause a further divergence in tax rates across European countries. It offers another argument for rate harmonisation. Indeed, our simulations suggest that rate harmonisation, in combination with a common consolidated base, will improve welfare in Europe.

REFERENCES

Auerbach, A.J., M.P. Devereux and H. Simpson (2009). "*Taxing Corporate Income*", in Institute for Fiscal Studies, *Reforming the Tax System for the 21st Century: the Mirrlees Review – Dimensions of Tax Design*, Oxford: OUP.

Bettendorf, L., Gorter, J., and van der Horst, A. (2006). "Who benefits from tax competition in the European Union?", CPB Document 125.

Bettendorf, L., van der Horst, A., and de Mooij, R. (2009). "Corporate tax policy and unemployment in Europe: An applied general equilibrium analysis", World Economy, forthcoming.

Bettendorf, L. and van der Horst, A. (2008). Documentation of CORTAX, mimeo.

Bond, S.R. and M.P. Devereux (2002). "Cash flow taxes in an open economy", *CEPR Discussion Paper 3401*.

CCCTB Working Group (2007). "CCCTB: possible elements of a technical outline", CCCTB/WP/057.

Brakman, S., Garretsen H. and Van Marrewijk C. (2001). "*An Introduction to Geographical Economics*", Cambridge University Press.

Devereux, M.P. and Griffith R. (1998). "Taxes and the Location of Production: Evidence from a Panel of U.S. Multinationals", *Journal of Public Economics* 63: 335–67.

Devereux, M. (2004). Debating proposed reforms of the taxation of corporate income in the European Union, *International Tax and Public Finance*. 11: 71–89.

Devereux, M.P. and Lockwood B. (2006). "How are plant location decisions and capital flows in Europe affected by corporate income taxes?", European Tax Policy Forum.

Devereux, M. and Loretz, S. (2008). "The effects of EU formula apportionment on corporate tax revenues", *Fiscal Studies*, 29: 1–33.

Edmiston, K.D., 2002, Strategic apportionment of the state corporate income tax, *National Tax Journal*, 40 (2): 239–261.

European Commission (2001). "Towards an internal market without tax obstacles: A strategy for providing companies with a consolidated corporate tax base for their EU-wide activities". Communication COM(2001)582.

European Commission (2004). "European Tax Survey", Taxation Papers 3.

European Commission (2006). Implementing the Community Lisbon Programme: Progress to Date and Next Steps Towards a Common Consolidated Corporate Tax Base (CCCTB). COM(2006)157final.

Eurostat (2007). Taxation trends in the European Union, Data for the EU Member States and Norway.

Evers, M., R.A. de Mooij, and D.J. van Vuuren, 2008, The wage elasticity of labour supply: a synthesis of empirical estimates, *De Economist* 156, pp. 25-43.

Fuest, C., Hemmegarn, T., and Ramb, F. (2007). "How would the introduction of an EUwide formula apportionment affect the distribution and size of the corporate tax base? An analysis based on German multinationals", *International Tax and Public Finance*, 14:605–626.

Fuest, C. (2008). "The European Commission's proposal for a common consolidated corporate tax base", *Oxford Review of Economic Policy* 24 (4): 720-739.

Goolsbee, A. and Maydew, E. L. (2000). "Coveting thy neighbor's manufacturing: The dilemma of state income apportionment", *Journal of Public Economics*, 75(1):125–143.
Gordon, R. and J. Wilson (1986) "An examination of multijurisdictional corporate income taxation under formula apportionment", *Econometrica*, 54(6): 1357-73.
Gupta, S. and Hofmann, M. A. (2003). "The effect of state income tax apportionment and tax incentives on new capital expenditures", *Journal of American Taxation Association*, 25:1–25.
Hassett, K. and R.G. Hubbard (2002), "Tax policy and business investment", in M. Feldstein and A. Auerbach (eds.), *Handbook of Public Economics* Vol. 3, Elsevier North Holland, pp. 1293-1343.
Hellerstein, W. and C.E. McLure, 2004, The European Commission's report on company income taxation: What the EU can learn from the experience of the US states, *International Tax and Public Finance* Vol. 11, no. 2, pp. 199–220.
Kind, H.J., K.H. Midelfart and G. Schjelderup, (2005). "Corporate tax systems, multinational enterprises, and economic integration," *Journal of International Economics*, Elsevier, vol. 65(2), pages 507-521.
Klassen, K. and Shackelford, D. (1998). "State and provincial corporate tax planning: income shifting and sales apportionment factor management", *Journal of Accounting and Economics*, 25:385–406
Martens-Weiner, J., 2006, *Company Tax Reform in the European Union: Guidance from the United States and Canada on Implementing Formulary Apportionment in the EU*, Springer, New York.
Mintz, J. and Smart, M. (2004). "Income shifting, investment, and tax competition: theory and evidence from provincial taxation in Canada", *Journal of Public Economics*, 88:1149–1168.
Mooij, R. de, and Ederveen S. (2008). "Corporate tax elasticities: a reader's guide to empirical findings", *Oxford Review of Economic Policy* 24 (4): 680-697.
Mooij, R. de, and Devereux M. (2009). "Alternative Systems of Business Tax in Europe: An applied analysis of ACE and CBIT Reforms", Study for DG TAXUD of the European Commission.
Nicodème, G. (2007), 'Corporate tax competition and coordination in the European Union: What do we know? Where do we stand?', in G. Gregoriou and C. Read (eds), International Taxation Handbook, London: Elsevier.
Pethig, R. and A. Wagener (2003), "Profit Tax Competition and Formula Apportionment", *CESifo Working Paper*, 1010, Munich.
Radaelli, C. M. and U.S. Kraemer (2008), "Governance Areas in EU Direct Tax Policy", *Journal of Common Market Studies* 46, 2. pp. 315-336.
Sørensen, P. B. (2001). "OECDTAX: a model of tax policy in the OECD economy", EPRU, University of Copenhagen.
Sørensen, P. B. (2004a). "International tax coordination: regionalism versus globalism",.*Journal of Public Economics*, 88:1187–1214
Sørensen, P. B. (2004b). "Company tax reform in the European Union", *International Tax and Public Finance*, vol. 11, pp. 91–115.
Spengel, C. and A. Oestreicher (2007), "Study on the Impact of Reforms of Corporate Income Taxation Systems at the EU Level on the Size of the Tax Bases of the EU Companies, Using the Model EUROPEAN TAX ANALYZER", Study for the European Commission DG TAXUD.
Van der Horst, A., Bettendorf, L., and Rojas-Romagosa, H. (2007). "Will corporate tax consolidation improve efficiency in the EU?", Tinbergen Institute Discussion Paper 2007-76.
Weichenrieder, A. and Klautke, T. (2008), "Taxes and the efficiency costs of capital distortions", CESIFO Working Paper 2431
Weiner, J. M. (1994). "Company taxation for the European community. how sub-national tax variation affects business investment in the United States and Canada". Harvard University.
Weiner, J.M. (2002). Would introducing formula apportionment in the European Union be a dream come true or the EU's worst nightmare?, *Ifo-Studien*, vol. 48, no. 4, pp. 519–532.

APPENDIX A: Country specific tables

The tables in this appendix show the country-specific simulation outcomes. We present the following variables:

- CIT-rate = absolute change in the corporate tax rate imposed on a multinational headquarter
- Rev_CIT = absolute change in the corporate tax revenue as a share of GDP
- CoC = absolute change in the cost of capital, average across all firms
- Wage = relative change in the wage rate
- Capital = relative change in total capital stock
- Employm. = relative change in total employment
- GDP = relative change in gross domestic product
- Welfare = (-1) x compensating variation expressed in \% of base GDP (i.e. positive value reflects a welfare gain)

Table A.1: Distribution of losses and profits

	Average return on assets (2003-2007)				Return on assets		
	10th percentile	median	90th percentile	Loss probability	Loss-making firms	profit-making firms	loss-to-profit ratio
Austria	-2.6%	4.9%	17.8%	17.6%	-7.3%	8.8%	0.48
Belgium	-2.2%	3.6%	16.4%	22.3%	-4.7%	8.0%	1.20
Bulgaria	-4.7%	3.8%	20.4%	25.9%	-6.3%	9.8%	0.60
Cyprus	-10.2%	1.2%	10.7%	35.6%	-8.6%	6.8%	0.57
Czech Rep.	-2.7%	5.0%	20.7%	18.6%	-6.8%	9.9%	0.53
Germany	-2.4%	5.6%	20.8%	17.2%	-7.2%	10.0%	0.56
Denmark	-2.4%	2.1%	15.3%	38.2%	-3.2%	8.7%	0.40
Spain	-1.9%	3.1%	14.4%	26.5%	-3.7%	7.5%	0.55
Estonia	-1.6%	7.2%	24.2%	18.0%	-5.7%	12.2%	0.41
Finland	-2.9%	6.1%	23.4%	20.3%	-6.5%	11.6%	0.40
France	-3.7%	3.7%	17.3%	27.1%	-5.5%	8.9%	0.72
United Kingdom	-7.7%	3.8%	16.9%	30.5%	-8.4%	9.1%	1.84
Greece	-3.2%	4.6%	15.8%	19.3%	-6.5%	8.1%	0.79
Hungary	-3.5%	5.0%	18.4%	19.3%	-7.2%	9.1%	1.27
Ireland	-4.1%	4.5%	16.9%	23.6%	-6.8%	8.7%	0.49
Italy	-1.9%	3.5%	11.7%	17.6%	-6.0%	6.1%	1.50
Lithuania	-2.7%	5.9%	21.2%	16.5%	-6.9%	10.4%	0.57
Luxembourg	-3.1%	2.7%	18.1%	35.2%	-4.0%	9.7%	0.45
Latvia	-3.1%	6.6%	22.4%	16.7%	-8.6%	11.0%	0.57
Malta	-0.7%	2.3%	21.7%	16.3%	-5.6%	11.9%	1.00
Netherlands	-3.4%	5.8%	21.3%	22.0%	-6.4%	10.8%	1.13
Poland	-3.2%	5.9%	22.6%	19.8%	-7.0%	11.0%	0.71
Portugal	-3.1%	2.9%	12.7%	27.4%	-4.3%	6.7%	0.84
Romania	-7.4%	5.5%	24.8%	22.8%	-10.1%	11.9%	1.13
Slovak Rep.	-4.5%	4.0%	18.8%	22.0%	-7.1%	8.9%	0.59
Slovenia	0.2%	4.3%	13.8%	8.1%	-6.0%	6.7%	1.24
Sweden	-4.2%	4.5%	19.0%	26.4%	-6.6%	9.9%	0.75

Source: Authors' calculations on the ORBIS database

Table A.2: Common base with lump-sum financing (compared to Basecase)

	CIT_rate (a)	Rev_CIT (y)	CoC (a)	Wage (r)	Capital (r)	Employm. (r)	GDP (r)	Welfare (y)
AUT	0.00	-0.42	-0.16	0.81	2.13	0.25	0.81	0.27
BEL	0.00	2.48	0.97	-4.35	-11.87	-1.56	-4.56	-1.38
BGR	0.00	-0.07	-0.03	0.16	0.40	0.04	0.15	0.06
CYP	0.00	-0.11	-0.05	0.18	0.60	0.06	0.19	0.06
CZE	0.00	-0.46	-0.16	0.99	2.22	0.24	0.93	0.29
DEU	0.00	-0.15	-0.06	0.27	0.77	0.10	0.29	0.09
DNK	0.00	0.3	0.13	-0.56	-1.55	-0.14	-0.53	-0.21
ESP	0.00	-0.57	-0.23	1.10	2.99	0.36	1.12	0.33
EST	0.00	1.33	0.42	-2.92	-6.08	-0.73	-2.75	-0.83
FIN	0.00	-0.04	-0.02	0.09	0.23	0.02	0.09	0.03
FRA	0.00	0.32	0.15	-0.57	-1.76	-0.18	-0.57	-0.20
GBR	0.00	-0.05	-0.03	0.08	0.33	0.02	0.08	0.03
GRC	0.00	0.07	0.02	-0.09	-0.24	-0.05	-0.12	-0.01
HUN	0.00	-0.37	-0.15	0.68	1.87	0.20	0.67	0.22
IRL	0.00	-0.16	-0.04	0.33	0.74	0.10	0.33	0.09
ITA	0.00	0.11	0.03	-0.15	-0.45	-0.07	-0.18	-0.03
LTU	0.00	0.54	0.21	-1.06	-2.71	-0.33	-1.06	-0.33
LUX	0.00	0.08	0.04	-0.19	-0.42	0.00	-0.13	-0.14
LVA	0.00	0.27	0.10	-0.53	-1.31	-0.17	-0.54	-0.16
MLT	0.00	-0.34	-0.14	0.61	1.95	0.20	0.62	0.19
NLD	0.00	-0.22	-0.07	0.42	1.05	0.13	0.42	0.12
POL	0.00	-0.56	-0.22	1.11	2.85	0.38	1.15	0.36
PRT	0.00	0.08	0.04	-0.12	-0.48	-0.04	-0.12	-0.04
ROM	0.00	0.08	0.04	-0.17	-0.50	-0.05	-0.16	-0.06
SVK	0.00	0.01	0.00	0.02	0.02	-0.01	0.00	0.02
SVN	0.00	-0.24	-0.11	0.44	1.21	0.13	0.44	0.15
SWE	0.00	0.12	0.05	-0.21	-0.64	-0.06	-0.20	-0.07
USA	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00
JPN	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00
EU	0.00	0	-0.01	0.10	0.22	0.03	0.09	0.01

Source: Authors' calculations

Table A.3: CCCTB with lump-sum financing (compared to Common base)

	CIT_rate (a)	Rev_CIT (y)	CoC (a)	Wage (r)	Capital (r)	Employm. (r)	GDP (r)	Welfare (y)
AUT	-0.47	-0.3	-0.03	0.37	0.25	0.18	0.04	0.04
BEL	-4.11	-0.22	-0.13	0.25	0.32	0.09	0.44	0.09
BGR	0.08	0.05	0.00	0.73	0.48	0.13	-0.52	0.34
CYP	6.60	-0.14	0.17	0.54	0.00	0.19	-0.43	0.15
CZE	-0.10	-0.27	-0.04	0.67	0.56	0.24	0.14	0.13
DEU	-3.39	-0.26	-0.11	0.36	0.51	0.15	0.38	0.10
DNK	1.65	-0.25	0.05	0.51	0.45	0.16	-0.04	0.16
ESP	-0.72	-0.43	-0.06	0.55	0.69	0.33	0.46	0.04
EST	-0.62	0.16	0.00	0.37	0.10	-0.09	-0.32	0.30
FIN	1.36	-0.38	0.03	0.54	0.55	0.27	0.18	0.07
FRA	-1.39	-0.41	-0.05	0.36	0.55	0.29	0.41	-0.03
GBR	0.31	-0.11	-0.01	0.29	-0.01	0.01	-0.01	0.17
GRC	-0.64	-0.22	-0.05	0.32	0.34	0.16	0.18	0.04
HUN	0.33	-0.1	-0.01	0.67	0.22	0.15	-0.33	0.26
IRL	11.06	-0.55	0.18	0.99	-0.19	0.55	-0.54	0.02
ITA	-1.77	-0.24	-0.06	0.28	0.35	0.15	0.28	0.04
LTU	0.04	-0.03	0.01	0.25	0.08	0.07	-0.08	0.09
LUX	0.64	-5.47	-0.34	6.52	10.08	4.10	5.05	0.63
LVA	0.20	-0.04	0.00	0.28	0.06	0.08	-0.10	0.09
MLT	-1.90	-0.35	-0.11	0.64	1.28	0.23	0.61	0.19
NLD	3.74	-0.84	0.07	0.66	0.65	0.52	0.18	-0.07
POL	0.08	-0.11	-0.02	0.55	0.43	0.16	-0.04	0.19
PRT	1.47	0.09	0.03	0.35	-0.33	-0.06	-0.25	0.33
ROM	0.06	0.1	0.00	0.43	-0.06	0.01	-0.29	0.26
SVK	0.18	-0.17	-0.02	0.67	1.05	0.23	-0.07	0.17
SVN	0.11	-0.03	0.01	0.22	0.10	0.04	-0.07	0.09
SWE	-0.39	-0.24	-0.02	0.42	0.26	0.11	0.05	0.15
USA	0.00	0.01	0.00	-0.01	-0.01	0.00	0.00	0.00
JPN	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00
EU	-0.82	-0.29	-0.05	0.41	0.38	0.17	0.18	0.08

Source: Authors' calculations

Table A.4: CCTB with corporate tax financing

	CIT_rate (a)	Rev_CIT (y)	CoC (a)	Wage (r)	Capital (r)	Employm. (r)	GDP (r)	Welfare (y)
AUT	2.40	-0.17	-0.11	0.47	1.41	0.12	0.44	0.18
BEL	-20.07	0.66	0.38	-1.23	-5.22	-0.55	0.30	-0.30
DNK	-1.62	0.09	0.08	-0.30	-0.98	-0.06	-0.26	-0.13
FIN	0.20	-0.03	-0.01	0.05	0.15	0.01	0.03	0.02
FRA	-1.70	0.07	0.09	-0.25	-0.98	-0.06	-0.28	-0.11
DEU	0.77	-0.08	-0.03	0.13	0.47	0.06	0.15	0.03
GRC	-0.34	0.01	0.00	-0.01	-0.07	-0.02	-0.03	0.01
IRL	0.69	-0.1	-0.03	0.15	0.50	0.08	0.04	0.01
ITA	-0.65	0.03	0.02	-0.04	-0.21	-0.03	-0.07	0.00
LUX	-0.19	-0.17	0.02	-0.05	-0.15	0.14	-0.22	-0.18
NLD	0.93	-0.19	-0.05	0.22	0.75	0.14	0.14	0.00
PRT	-0.62	0.04	0.03	-0.06	-0.32	-0.02	-0.03	-0.01
ESP	2.49	-0.24	-0.14	0.52	1.77	0.18	0.54	0.16
SWE	-0.68	0.04	0.03	-0.11	-0.40	-0.02	-0.10	-0.05
GBR	0.38	-0.04	-0.02	0.05	0.25	0.02	0.03	0.01
CYP	0.70	-0.03	-0.03	0.10	0.38	0.02	0.11	0.04
CZE	1.84	-0.15	-0.09	0.50	1.28	0.09	0.47	0.17
EST	-8.39	0.29	0.23	-1.51	-3.27	-0.16	-1.04	-0.64
HUN	2.03	-0.12	-0.10	0.38	1.19	0.07	0.34	0.16
LVA	-1.59	0.06	0.06	-0.28	-0.72	-0.05	-0.26	-0.12
LTU	-3.06	0.12	0.12	-0.52	-1.44	-0.10	-0.49	-0.22
MLT	1.40	-0.13	-0.07	0.26	1.26	0.11	0.33	0.06
POL	2.75	-0.18	-0.14	0.59	1.71	0.14	0.59	0.24
SVK	-0.06	0	-0.01	0.03	0.05	-0.01	0.03	0.03
SVN	1.42	-0.08	-0.06	0.24	0.73	0.06	0.23	0.10
BGR	0.41	-0.02	-0.02	0.09	0.25	0.01	0.09	0.05
ROM	-0.60	0.03	0.03	-0.11	-0.34	-0.02	-0.09	-0.05
USA	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00
JPN	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00
EU	-0.05	-0.03	-0.01	0.08	0.20	0.03	0.10	0.01

Table A.5: CCCTB with corporate tax financing (compared to Common base)

	CIT_rate (a)	Rev_CIT (y)	CoC (a)	Wage (r)	Capital (r)	Employm. (r)	GDP (r)	Welfare (y)
AUT	0.24	-0.07	-0.02	0.02	-0.40	0.05	-0.22	-0.04
BEL	14.41	-0.52	0.41	1.09	-0.09	0.38	-1.21	0.35
BGR	0.04	0.06	0.00	0.84	0.57	0.15	-0.58	0.39
CYP	7.27	-0.03	0.18	0.42	-0.31	0.14	-0.55	0.13
CZE	0.85	-0.14	0.00	0.43	0.13	0.17	-0.04	0.07
DEU	-2.48	-0.10	-0.10	0.14	0.03	0.06	0.18	0.04
DNK	2.79	-0.14	0.09	0.43	0.21	0.13	-0.19	0.14
ESP	0.08	-0.12	-0.03	0.01	-0.27	0.15	0.08	-0.15
EST	-0.94	-0.08	-0.01	1.22	0.81	0.16	-0.45	0.49
FIN	2.09	-0.11	0.06	0.13	-0.18	0.15	-0.10	-0.06
FRA	-0.68	-0.08	-0.03	-0.11	-0.52	0.13	0.01	-0.17
GBR	1.48	-0.06	0.00	0.26	-0.13	-0.01	-0.06	0.19
GRC	0.17	-0.07	-0.01	0.11	-0.09	0.09	-0.04	-0.01
HUN	1.04	-0.03	0.01	0.58	0.02	0.12	-0.37	0.24
IRL	10.50	-0.02	0.18	0.05	-1.55	0.22	-1.16	-0.20
ITA	-0.57	-0.12	-0.03	0.12	-0.05	0.09	0.11	0.00
LTU	0.17	-0.01	0.00	0.26	0.03	0.07	-0.15	0.09
LUX	2.27	-4.52	-0.23	3.96	7.50	3.90	3.94	-0.98
LVA	0.43	0.00	0.00	0.27	-0.02	0.07	-0.17	0.10
MLT	-1.50	-0.31	-0.08	0.56	1.23	0.23	0.57	0.12
NLD	4.31	-0.07	0.09	-0.67	-1.49	0.10	-0.81	-0.47
POL	0.69	-0.04	-0.01	0.45	0.22	0.12	-0.09	0.17
PRT	1.96	-0.04	0.04	0.66	-0.12	-0.01	-0.19	0.45
ROM	-0.33	0.07	-0.01	0.56	0.01	0.04	-0.30	0.31
SVK	0.65	-0.12	0.01	0.65	0.99	0.22	-0.17	0.17
SVN	0.10	-0.03	0.01	0.24	0.12	0.04	-0.05	0.10
SWE	0.73	-0.13	0.01	0.30	-0.09	0.06	-0.10	0.13
USA	0.00	0.02	0.00	-0.01	-0.02	0.00	0.01	0.00
JPN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EU	0.35	-0.11	-0.02	0.20	-0.13	0.09	-0.06	0.02

Source: Authors' calculations

Table A.6: CCTB with labour tax financing

	CIT_rate (a)	Rev_CIT (y)	CoC (a)	Wage (r)	Capital (r)	Employm. (r)	GDP (r)	Welfare (y)
AUT	0.00	-0.43	-0.16	0.82	1.97	0.09	0.65	0.19
BEL	0.00	2.52	0.97	-4.39	-10.89	-0.44	-3.51	-0.82
DNK	0.00	0.3	0.13	-0.56	-1.48	-0.06	-0.45	-0.16
FIN	0.00	-0.04	-0.02	0.09	0.23	0.02	0.08	0.03
FRA	0.00	0.33	0.15	-0.57	-1.65	-0.06	-0.46	-0.13
DEU	0.00	-0.16	-0.06	0.28	0.69	0.02	0.21	0.05
GRC	0.00	0.07	0.02	-0.10	-0.17	0.01	-0.05	0.02
IRL	0.00	-0.16	-0.04	0.33	0.65	0.01	0.24	0.05
ITA	0.00	0.11	0.03	-0.15	-0.37	0.01	-0.10	0.01
LUX	0.00	0.08	0.04	-0.19	-0.37	0.06	-0.08	-0.12
NLD	0.00	-0.22	-0.07	0.42	0.93	0.02	0.31	0.07
PRT	0.00	0.08	0.04	-0.13	-0.45	0.00	-0.09	-0.02
ESP	0.00	-0.59	-0.23	1.11	2.68	0.05	0.82	0.19
SWE	0.00	0.12	0.05	-0.21	-0.62	-0.03	-0.18	-0.06
GBR	0.00	-0.05	-0.03	0.08	0.30	0.00	0.06	0.02
CYP	0.00	-0.11	-0.05	0.18	0.54	0.00	0.13	0.03
CZE	0.00	-0.46	-0.16	1.00	2.07	0.09	0.78	0.21
EST	0.00	1.35	0.42	-2.95	-5.53	-0.14	-2.18	-0.56
HUN	0.00	-0.37	-0.15	0.68	1.74	0.06	0.54	0.15
LVA	0.00	0.27	0.10	-0.53	-1.18	-0.04	-0.41	-0.10
LTU	0.00	0.55	0.21	-1.07	-2.46	-0.07	-0.81	-0.21
MLT	0.00	-0.35	-0.14	0.62	1.77	0.02	0.45	0.10
POL	0.00	-0.57	-0.22	1.12	2.56	0.09	0.87	0.23
SVK	0.00	0.01	0.00	0.02	0.04	0.01	0.02	0.03
SVN	0.00	-0.24	-0.11	0.44	1.12	0.04	0.35	0.10
BGR	0.00	-0.07	-0.03	0.16	0.37	0.02	0.13	0.05
ROM	0.00	0.08	0.04	-0.17	-0.46	-0.01	-0.13	-0.05
USA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JPN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EU	0.00	0.00	-0.01	0.10	0.19	0.00	0.07	0.01

Table A.7: CCCTB with labour tax financing (compared to Common base)

	CIT_rate (a)	Rev_CIT (y)	CoC (a)	Wage (r)	Capital (r)	Employm. (r)	GDP (r)	Welfare (y)
AUT	-0.48	-0.30	-0.03	0.38	0.01	-0.06	-0.19	-0.08
BEL	-4.10	-0.23	-0.13	0.26	0.07	-0.19	0.18	-0.07
BGR	0.08	0.06	0.00	0.71	1.12	0.77	0.09	0.65
CYP	6.60	-0.14	0.17	0.54	0.05	0.24	-0.38	0.17
CZE	-0.10	-0.28	-0.04	0.66	0.55	0.22	0.13	0.12
DEU	-3.40	-0.26	-0.11	0.37	0.29	-0.08	0.16	-0.01
DNK	1.64	-0.24	0.05	0.51	0.48	0.18	-0.03	0.17
ESP	-0.72	-0.44	-0.06	0.57	0.37	0.01	0.15	-0.11
EST	-0.62	0.17	0.00	0.36	0.44	0.29	0.03	0.46
FIN	1.36	-0.38	0.03	0.54	0.32	0.04	-0.03	-0.06
FRA	-1.39	-0.44	-0.05	0.37	0.09	-0.19	-0.05	-0.30
GBR	0.32	-0.11	-0.01	0.29	-0.02	0.00	-0.03	0.16
GRC	-0.64	-0.22	-0.05	0.33	0.16	-0.01	0.00	-0.04
HUN	0.33	-0.10	-0.01	0.66	0.66	0.60	0.10	0.51
IRL	11.08	-0.56	0.19	1.01	-0.44	0.29	-0.78	-0.10
ITA	-1.77	-0.25	-0.06	0.29	0.12	-0.09	0.05	-0.07
LTU	0.04	-0.03	0.01	0.24	0.17	0.16	0.01	0.13
LUX	0.64	-5.70	-0.34	6.84	2.42	-3.39	-2.23	-2.66
LVA	0.20	-0.03	0.00	0.27	0.19	0.21	0.02	0.15
MLT	-1.90	-0.35	-0.11	0.64	1.12	0.06	0.45	0.11
NLD	3.75	-0.87	0.07	0.70	-0.25	-0.40	-0.71	-0.52
POL	0.08	-0.1	-0.02	0.54	0.67	0.40	0.20	0.30
PRT	1.46	0.09	0.03	0.36	-0.13	0.13	-0.05	0.43
ROM	0.06	0.11	0.00	0.42	0.22	0.30	0.00	0.40
SVK	0.18	-0.16	-0.02	0.66	1.19	0.37	0.06	0.23
SVN	0.11	-0.03	0.01	0.21	0.23	0.17	0.06	0.17
SWE	-0.40	-0.24	-0.02	0.42	0.21	0.06	0.01	0.13
USA	0.00	0.01	0.00	-0.01	-0.01	0.01	0.01	0.00
JPN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EU	-0.82	-0.30	-0.05	0.42	0.23	0.02	0.03	-0.03

Source: Authors' calculations

Table A.8: Direct effect on CIT revenues of CCCTB with alternative apportionment formulas (compared to Common base)

	employment	payroll	capital	production	equal shares
AUT	-0.33	-0.23	-0.16	-0.22	-0.24
BEL	-0.15	0.35	0.70	0.36	0.30
BGR	0.13	-0.06	-0.05	-0.06	0.01
CYP	-0.12	-0.06	-0.15	-0.09	-0.12
CZE	-0.02	-0.34	-0.20	-0.26	-0.16
DEU	-0.21	-0.17	-0.06	-0.16	-0.14
DNK	-0.13	-0.10	-0.07	-0.09	-0.10
ESP	-0.27	-0.44	-0.31	-0.37	-0.32
EST	0.59	-0.05	0.27	0.01	0.29
FIN	-0.28	-0.31	-0.22	-0.27	-0.25
FRA	-0.31	-0.18	-0.33	-0.21	-0.28
GBR	0.06	0.16	-0.22	0.03	-0.04
GRC	-0.16	-0.16	-0.11	-0.14	-0.13
HUN	0.04	-0.16	-0.16	-0.15	-0.09
IRL	-0.74	-0.69	-0.29	-0.56	-0.53
ITA	-0.09	-0.13	-0.09	-0.13	-0.11
LTU	0.06	-0.07	-0.05	-0.06	-0.02
LUX	-5.67	-4.60	-4.06	-3.38	-4.37
LVA	0.02	-0.07	-0.05	-0.06	-0.03
MLT	0.09	-0.19	-0.19	-0.17	-0.09
NLD	-0.98	-0.89	-0.51	-0.77	-0.75
POL	0.03	-0.17	-0.13	-0.14	-0.08
PRT	0.52	0.17	-0.14	0.07	0.15
ROM	0.21	-0.03	-0.05	-0.03	0.04
SVK	0.02	-0.19	-0.06	-0.14	-0.06
SVN	0.08	-0.03	-0.05	-0.02	0.00
SWE	-0.13	-0.05	-0.12	-0.09	-0.11

Source: Authors' calculations

Table A.9: CCCTB with employment formula and corporate tax financing (compared to Common base)

	CIT_rate (a)	Rev_CIT (y)	CoC (a)	Wage (r)	Capital (r)	Employm. (r)	GDP (r)	Welfare (y)
AUT	-1.57	-0.12	-0.06	-0.17	-0.37	0.09	-0.20	-0.19
BEL	14.44	-0.51	0.41	0.25	-2.66	0.43	-1.92	-0.18
DNK	2.36	-0.17	0.07	0.32	-0.28	0.15	-0.30	0.05
FIN	1.00	-0.17	0.01	0.05	-0.11	0.17	-0.06	-0.13
FRA	-1.12	-0.14	-0.04	-0.16	-0.09	0.19	0.15	-0.25
DEU	-4.03	-0.19	-0.14	0.03	0.67	0.14	0.43	-0.10
GRC	-0.67	-0.12	-0.04	0.05	0.01	0.11	0.02	-0.07
IRL	11.69	-0.06	0.20	-0.93	-3.12	0.29	-1.86	-0.83
ITA	-2.11	-0.19	-0.07	0.11	0.40	0.12	0.27	-0.04
LUX	-0.16	-6.85	-0.38	5.12	11.19	5.27	6.08	-1.54
NLD	3.14	-0.22	0.06	-1.17	-1.35	0.23	-0.75	-0.88
PRT	-0.92	0.11	-0.02	1.31	-0.93	-0.15	-0.49	1.08
ESP	-1.06	-0.20	-0.07	0.07	0.57	0.20	0.36	-0.15
SWE	-0.27	-0.19	-0.01	0.23	-0.11	0.08	-0.08	0.07
GBR	0.75	-0.09	-0.01	0.37	0.00	-0.02	0.00	0.28
CYP	6.63	-0.03	0.17	0.43	-1.42	0.12	-0.85	0.16
CZE	-0.15	-0.13	-0.04	0.71	0.23	0.12	-0.05	0.26
EST	-1.95	0.13	-0.03	2.45	-1.36	0.03	-1.91	1.28
HUN	-0.10	0.07	-0.02	1.03	-0.80	0.03	-0.78	0.60
LVA	0.02	0.09	-0.01	0.56	-0.63	0.03	-0.55	0.29
LTU	-0.33	0.09	-0.01	0.57	-0.42	0.03	-0.50	0.32
MLT	-4.23	-0.41	-0.22	0.77	2.46	0.22	0.93	0.28
POL	-0.21	0.04	-0.03	0.76	0.02	0.03	-0.28	0.42
SVK	0.13	-0.09	-0.01	0.90	0.39	0.19	-0.52	0.33
SVN	-0.64	-0.03	-0.02	0.36	0.13	0.02	-0.07	0.21
BGR	-0.76	0.83	-0.03	3.16	-3.44	-0.28	-4.58	2.23
ROM	-1.80	0.72	-0.04	1.80	-2.36	-0.36	-2.16	1.45
USA	0.00	0.01	0.00	-0.01	-0.01	0.00	0.00	0.00
JPN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EU	-0.74	-0.15	-0.05	0.30	-0.11	0.09	-0.15	0.00

Source: Authors' calculations

Table A.10: CCCTB with payroll formula and corporate tax financing (compared to Common base)

	CIT_rate (a)	Rev_CIT (y)	CoC (a)	Wage (r)	Capital (r)	Employm. (r)	GDP (r)	Welfare (y)
AUT	1.54	0.06	0.00	-0.14	-0.78	-0.01	-0.38	-0.08
BEL	15.16	-0.26	0.43	0.97	-3.54	0.16	-2.47	0.43
DNK	3.31	-0.09	0.10	0.41	-0.51	0.11	-0.41	0.15
FIN	2.83	-0.14	0.08	0.11	-0.41	0.19	-0.14	-0.12
FRA	-0.06	0.08	0.00	-0.16	-0.48	0.01	-0.07	-0.11
DEU	-1.79	-0.05	-0.08	0.03	0.30	0.05	0.25	-0.02
GRC	0.33	-0.07	-0.01	0.06	-0.17	0.08	-0.06	-0.04
IRL	12.05	0.04	0.21	-0.78	-3.57	0.23	-2.02	-0.69
ITA	-0.30	-0.15	-0.03	0.15	0.17	0.11	0.19	0.00
LUX	2.70	-4.83	-0.21	4.05	9.99	4.23	4.93	-1.25
NLD	4.96	0.01	0.11	-1.20	-1.71	0.15	-0.92	-0.83
PRT	-0.57	-0.25	-0.01	1.10	-0.62	0.07	-0.22	0.64
ESP	-0.69	-0.34	-0.06	0.12	0.56	0.32	0.44	-0.24
SWE	1.38	-0.03	0.03	0.31	-0.49	-0.01	-0.25	0.20
GBR	1.16	0.08	0.00	0.45	-0.32	-0.13	-0.15	0.47
CYP	6.80	0.07	0.17	0.58	-1.74	0.07	-0.97	0.32
CZE	-0.03	-0.50	-0.04	0.57	0.38	0.41	0.23	-0.09
EST	-2.10	-0.48	-0.04	0.75	-0.15	0.34	-0.37	0.05
HUN	-0.01	-0.27	-0.02	0.62	-0.42	0.26	-0.36	0.14
LVA	0.04	-0.10	-0.01	0.21	-0.18	0.11	-0.14	0.03
LTU	-0.32	-0.13	-0.01	0.23	-0.07	0.12	-0.09	0.03
MLT	-1.95	-0.57	-0.11	0.91	2.33	0.39	0.96	0.18
POL	-0.20	-0.30	-0.03	0.50	0.25	0.29	0.08	0.07
SVK	0.13	-0.33	-0.01	0.52	0.30	0.35	-0.12	-0.01
SVN	-0.56	-0.14	-0.01	0.34	0.18	0.11	0.01	0.10
BGR	-0.80	-0.20	-0.03	0.46	0.02	0.21	-0.22	0.10
ROM	-1.78	-0.22	-0.04	0.50	0.02	0.19	-0.08	0.14
USA	0.00	0.02	0.00	-0.01	-0.02	0.00	0.01	0.00
JPN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EU	0.31	-0.10	-0.02	0.19	-0.15	0.11	-0.04	0.02

Source: Authors' calculations

Table A.11: CCCTB with capital formula and corporate tax financing (compared to Common base)

	CIT_rate (a)	Rev_CIT (y)	CoC (a)	Wage (r)	Capital (r)	Employm. (r)	GDP (r)	Welfare (y)
AUT	0.76	-0.05	-0.01	0.16	-0.18	0.03	-0.16	0.06
BEL	12.98	-0.48	0.36	1.80	5.02	0.25	0.06	0.86
DNK	2.48	-0.12	0.07	0.47	1.05	0.11	0.01	0.18
FIN	1.94	-0.10	0.05	0.21	0.03	0.13	-0.05	0.00
FRA	-1.17	-0.10	-0.05	-0.19	-1.08	0.17	-0.11	-0.25
DEU	-2.37	-0.10	-0.10	0.27	-0.35	0.04	0.06	0.14
GRC	0.41	-0.06	-0.01	0.17	-0.01	0.08	-0.02	0.03
IRL	8.75	0.14	0.14	1.28	2.15	0.06	0.20	0.70
ITA	-0.44	-0.12	-0.03	0.14	-0.30	0.09	0.03	0.01
LUX	1.23	-4.10	-0.29	3.70	4.65	3.41	2.74	-0.67
NLD	3.83	-0.01	0.08	-0.13	-0.80	-0.05	-0.63	-0.03
PRT	4.15	-0.09	0.09	0.14	-0.02	0.08	-0.14	-0.01
ESP	0.23	-0.12	-0.02	0.03	-0.91	0.16	-0.10	-0.14
SWE	0.73	-0.13	0.01	0.28	0.12	0.06	-0.05	0.12
GBR	1.93	-0.09	0.01	0.00	-0.63	0.05	-0.19	-0.06
CYP	7.55	-0.03	0.19	0.26	1.13	0.14	-0.21	0.03
CZE	1.16	-0.13	0.01	0.34	0.33	0.18	0.03	0.01
EST	-0.91	-0.07	-0.01	1.12	3.12	0.15	0.41	0.44
HUN	1.70	-0.04	0.03	0.31	0.80	0.14	-0.11	0.06
LVA	0.57	0.00	0.01	0.18	0.44	0.06	0.01	0.05
LTU	0.40	-0.02	0.01	0.13	0.34	0.06	-0.02	0.03
MLT	-0.55	-0.34	-0.03	0.43	-0.05	0.30	0.27	-0.04
POL	1.13	-0.06	0.01	0.28	0.47	0.14	0.03	0.06
SVK	0.66	-0.09	0.01	0.63	2.07	0.21	0.18	0.17
SVN	0.60	-0.04	0.02	0.14	0.16	0.06	-0.02	0.02
BGR	0.48	-0.02	0.01	0.30	1.28	0.11	0.03	0.08
ROM	0.63	-0.02	0.01	0.16	0.44	0.07	-0.03	0.04
USA	0.00	0.02	0.00	-0.01	-0.02	0.00	0.01	0.00
JPN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EU	0.50	-0.11	-0.01	0.17	-0.13	0.09	-0.05	0.01

Source: Authors' calculations

Table A.12: CCCTB with production formula and corporate tax financing (compared to Common base)

	CIT_rate (a)	Rev_CIT (y)	CoC (a)	Wage (r)	Capital (r)	Employm. (r)	GDP (r)	Welfare (y)
AUT	1.12	-0.06	-0.01	0.07	-0.45	0.05	-0.23	-0.01
BEL	14.94	-0.51	0.43	1.24	-1.25	0.37	-1.57	0.44
DNK	3.03	-0.13	0.09	0.46	0.00	0.13	-0.25	0.15
FIN	2.71	-0.10	0.08	0.12	-0.31	0.16	-0.13	-0.08
FRA	-0.91	-0.07	-0.04	0.02	-0.27	0.10	0.05	-0.06
DEU	-2.20	-0.09	-0.09	0.12	0.13	0.06	0.20	0.03
GRC	0.41	-0.07	-0.01	0.10	-0.15	0.08	-0.06	-0.01
IRL	10.72	-0.02	0.18	-0.08	-2.28	0.24	-1.42	-0.29
ITA	-0.15	-0.11	-0.02	0.09	-0.07	0.09	0.10	-0.02
LUX	2.95	-2.88	-0.19	3.22	6.65	2.65	2.75	-0.25
NLD	4.60	-0.06	0.10	-0.70	-1.48	0.12	-0.80	-0.51
PRT	2.74	-0.05	0.06	0.53	-0.50	0.01	-0.26	0.33
ESP	0.22	-0.12	-0.02	-0.08	-0.26	0.17	0.09	-0.22
SWE	1.24	-0.11	0.03	0.35	-0.20	0.05	-0.12	0.17
GBR	1.27	-0.03	0.00	0.38	-0.10	-0.05	-0.04	0.31
CYP	7.39	-0.02	0.19	0.55	-0.72	0.14	-0.65	0.22
CZE	1.58	-0.17	0.02	0.19	-0.21	0.23	-0.12	-0.11
EST	0.29	-0.13	0.01	0.37	-0.11	0.15	-0.49	0.04
HUN	1.61	-0.06	0.02	0.36	-0.34	0.14	-0.41	0.09
LVA	0.68	-0.01	0.01	0.12	-0.19	0.06	-0.18	0.02
LTU	0.45	-0.02	0.01	0.11	-0.18	0.06	-0.16	0.01
MLT	-0.48	-0.31	-0.03	0.47	1.28	0.27	0.57	0.02
POL	1.19	-0.08	0.01	0.27	-0.05	0.15	-0.12	0.04
SVK	1.16	-0.13	0.02	0.37	0.41	0.23	-0.23	0.01
SVN	0.38	-0.04	0.01	0.19	0.01	0.05	-0.07	0.06
BGR	0.51	-0.03	0.01	0.26	0.05	0.11	-0.29	0.06
ROM	0.40	-0.02	0.00	0.23	-0.12	0.07	-0.19	0.08
USA	0.00	0.01	0.00	-0.01	-0.02	0.00	0.01	0.00
JPN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EU	0.60	-0.10	-0.01	0.16	-0.19	0.09	-0.06	0.02

Source: Authors' calculations

Table A.13: CCCTB with a common corporate tax rate at 32.5% (compared to Common Base); government budget closed with lump-sum transfers

	CIT_rate (a)	Rev_CIT (y)	CoC (a)	Wage (r)	Capital (r)	Employm. (r)	GDP (r)	Welfare (y)
AUT	0.00	-0.37	-0.03	0.38	0.48	0.21	0.31	0.09
BEL	0.00	-0.4	0.02	0.44	0.58	0.19	0.35	0.19
BGR	0.00	-0.29	-0.01	0.82	0.65	0.17	0.30	0.24
CYP	0.00	-0.48	-0.02	0.98	0.73	0.33	0.46	0.13
CZE	0.00	-0.45	0.00	0.51	0.48	0.33	0.42	0.02
DEU	0.00	-0.31	-0.03	0.35	0.47	0.21	0.30	0.12
DNK	0.00	-0.31	-0.04	0.41	0.47	0.25	0.26	0.05
ESP	0.00	-1.06	-0.07	1.36	1.40	0.87	1.28	-0.01
EST	0.00	-0.21	-0.01	0.16	0.32	0.14	0.19	0.06
FIN	0.00	-4.72	-0.29	9.48	5.55	3.57	4.88	0.47
FRA	0.00	-0.76	-0.04	0.88	0.87	0.24	0.42	0.29
GBR	0.00	0.14	0.00	-0.16	0.35	-0.12	-0.02	0.39
GRC	0.00	-0.45	-0.03	0.70	0.67	0.36	0.48	0.07
HUN	0.00	-0.28	-0.02	0.40	0.60	0.09	0.24	0.27
IRL	0.00	-0.08	-0.02	-0.03	0.39	-0.02	0.07	0.28
ITA	0.00	-0.32	-0.02	0.55	0.59	0.17	0.27	0.21
LTU	0.00	-0.41	-0.04	0.98	0.87	0.32	0.48	0.15
LUX	0.00	0.25	0.02	0.00	0.29	-0.21	-0.14	0.36
LVA	0.00	-0.24	-0.04	0.64	0.70	0.17	0.30	0.25
MLT	0.00	-0.1	0.00	0.16	0.32	0.09	0.12	0.11
NLD	0.00	-0.07	0.01	0.13	0.29	0.07	0.08	0.12
POL	0.00	-0.47	0.00	1.87	0.94	0.37	0.50	0.24
PRT	0.00	-0.23	-0.05	0.66	0.65	0.21	0.30	0.23
ROM	0.00	-0.26	-0.03	1.16	0.76	0.27	0.37	0.20
SVK	0.00	-0.04	0.01	0.14	0.25	0.04	0.07	0.12
SVN	0.00	-0.01	-0.02	0.46	0.51	0.02	0.06	0.31
SWE	0.00	0.06	-0.01	0.03	0.29	-0.05	-0.01	0.23
USA	0.00	0.01	0.00	-0.01	0.00	0.00	0.00	-0.01
JPN	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00
EU	0.00	-0.32	-0.02	0.41	0.51	0.19	0.28	0.14

Source: Authors' calculations

Table A.14: CCCTB with a common corporate tax rate at 32.5% (compared to Common Base); government budget closed with labour tax rates

	CIT_rate (a)	Rev_CIT (y)	CoC (a)	Wage (r)	Capital (r)	Employm. (r)	GDP (r)	Welfare (y)
AUT	0.00	-0.38	-0.03	0.07	0.49	-0.12	-0.01	-0.08
BEL	0.00	-0.41	0.02	0.15	0.59	-0.14	0.04	0.02
BGR	0.00	-0.29	-0.01	0.85	0.65	0.19	0.32	0.25
CYP	0.00	-0.5	-0.02	0.71	0.74	0.05	0.19	-0.04
CZE	0.00	-0.46	0.00	0.12	0.50	-0.06	0.04	-0.20
DEU	0.00	-0.32	-0.03	0.15	0.48	0.02	0.11	0.02
DNK	0.00	-0.32	-0.04	0.18	0.48	0.00	0.03	-0.05
ESP	0.00	-1.13	-0.07	0.52	1.43	-0.06	0.42	-0.43
EST	0.00	-0.22	-0.01	0.04	0.33	0.02	0.07	0.00
FIN	0.00	-5.04	-0.29	0.96	5.95	-4.89	-3.28	-2.84
FRA	0.00	-0.79	-0.04	0.14	0.90	-0.53	-0.32	-0.08
GBR	0.00	0.15	0.00	0.07	0.34	0.11	0.21	0.52
GRC	0.00	-0.46	-0.03	0.40	0.67	0.06	0.20	-0.06
HUN	0.00	-0.28	-0.02	0.43	0.59	0.13	0.27	0.29
IRL	0.00	-0.08	-0.02	0.00	0.38	0.01	0.10	0.30
ITA	0.00	-0.34	-0.02	0.40	0.59	0.01	0.12	0.14
LTU	0.00	-0.43	-0.04	0.86	0.88	0.20	0.37	0.09
LUX	0.00	0.27	0.02	0.38	0.27	0.23	0.26	0.56
LVA	0.00	-0.23	-0.04	0.78	0.69	0.32	0.44	0.34
MLT	0.00	-0.11	0.00	0.18	0.31	0.11	0.13	0.12
NLD	0.00	-0.07	0.01	0.17	0.29	0.11	0.11	0.13
POL	0.00	-0.48	0.00	1.70	0.95	0.20	0.34	0.14
PRT	0.00	-0.23	-0.05	0.70	0.65	0.24	0.33	0.23
ROM	0.00	-0.27	-0.03	1.14	0.76	0.23	0.34	0.19
SVK	0.00	-0.04	0.01	0.28	0.25	0.16	0.19	0.19
SVN	0.00	-0.01	-0.02	0.73	0.50	0.30	0.33	0.45
SWE	0.00	0.07	-0.01	0.20	0.28	0.12	0.16	0.31
USA	0.00	0.01	0.00	0.00	0.00	0.01	0.00	-0.01
JPN	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00
EU	0.00	-0.33	-0.02	0.25	0.52	0.03	0.13	0.04

Source: Authors' calculations

Appendix B Modelling firm behaviour in CORTAX

This appendix discusses in more detail how firm behaviour is modelled. CORTAX starts from a standard dynamic optimization problem of the firm, which maximizes its value subject to accumulation constraints and a production function. In optimizing its value, firms choose their optimal levels of employment and investment, as well as the optimal financial structure between debt and equity. We also discuss the two extensions of the basic framework: the introduction of losses and the modelling of location choices.

Model of the firm

Denote the value of the firm in year t by V_t and its dividend payments by Div_t. We ignore new equity issues and abstract from residence taxes on capital levied at the household level. An investor is indifferent between investing in the firm and investing elsewhere at a rate of return r as long as:

$$rV_t = Div_t + V_{t+1} - V_t \tag{B.1}$$

The right-hand side of (B.1) reflects the sum of dividends and capital gains on the investment in the firm. The left-hand side shows the return on the asset V_t if it were invested elsewhere. The rate r denotes the discount rate used by the firm. Solving (B.1) for V_t yields an expression for the value of the firm as the discounted stream of future dividends:

$$V_t = \sum_{s=t}^{\infty} Div_s \left[\frac{1}{1+r}\right]^{s-t+1} \tag{B.2}$$

Dividends follow from the cash-flow restriction of the firm:

$$Div_t = Y_t - wL_t - [r_b + c_b]d_{bt}K_t - \tau\Pi_t - I_t + d_{bt+1}K_{t+1} - d_{bt}K_t \tag{B.3}$$

where Y_t denotes output (price is normalised to 1) and wL_t stands for labour costs. The third term on the right-hand side of (B.3) captures the cost of debt. It equals the debt ratio (d_b) times the capital stock (K_t) times the real interest on firm debt r_b. In addition to this, the variable c_b denotes a financial distress or agency cost associated with high debt finance. It depends on the leverage of the firm, i.e. $c_b = c_b(d_{bt})$. The fourth and fifth terms on the right-hand side of (B.3) reflect corporate tax payments ($\tau\Pi_t$) and investment (I_t). Finally, cash-flow is affected by a change in debt of the firm, captured by the last two terms on the right-hand side of (B.3).

The corporate tax base, Π_t, is defined as:

$$\Pi_t = Y_t - wL_t - d_{bt} R_b K_t - \delta_f D_t - \phi I_t \quad \text{(B.4)}$$

It consist of total revenue from sales minus labour costs, deductible financial costs and deductible depreciation allowances. The third term on the right-hand side of (B.4) reflects the deductible financial costs from investment. As shown by (B.4), it is the nominal interest payments on actual debt ($d_{bt}R_bK_t$) which are deductible from the corporate tax base, where $R_b = (1+r_b)(1+\pi)-1 \approx r_b + \pi$ is the nominal interest rate and π is the rate of inflation. Most corporate tax systems do not allow a deduction of the cost of equity, except for Belgium that introduced such a system in 2006. The last two terms on the right-hand side of (B.4) reflect fiscal depreciation. The fourth term is the annual rate of fiscal depreciation, equal to δ_f, times the stock of fiscal depreciable assets, denoted by D_t. The last term denotes the share of the investment that can be depreciated immediately after its purchase, measured by ϕ. Note that $\phi = 1$ would imply immediate expensing of investment. If $\phi = \delta_f$, annual fiscal depreciation at rate δ_f would start in the period of purchase, rather than one year after the purchase.

Regarding economic and fiscal depreciation, we assume a declining balance at a rates of, respectively, δ and δ_f. The accumulation of capital in, respectively, the firms financial accounts and its tax accounts is thus reflected by:

$$K_{t+1} = I_t + (1-\delta)K_t \quad \text{(B.5)}$$

$$(1+\pi)D_{t+1} = (1-\phi)I_t + (1-\delta_f)D_t \quad \text{(B.6)}$$

where (B.6) takes into account that fiscal depreciation only applies to the share that is not immediately expensed, i.e. $(1-\phi)$ and that the price of fiscal assets is not indexed for inflation.

Firm behaviour is now derived from maximizing its value (B.2), subject to the accumulation equations (B.5) and (B.6):

$$L = \sum_{s=t}^{\infty} \left[Div_s - \lambda_{s+1}[(1+\pi)D_{s+1} - (1-\phi)I_s - (1-\delta_f)D_s] - \mu_{s+1}[K_{s+1} - I_s - (1-\delta)K_s] \right] \left[\frac{1}{1+r} \right]^{s-t+1} \quad \text{(B.7)}$$

where λ_t is the Langrange multiplier for D_t and μ_t the Langrange multiplier for K_t (Tobins q) and discounting occurs at the real rate r. We will now subsequently discuss the optimal choice regarding the financial structure and investment by the firm.

Financial behaviour

We first optimize (B.7) with respect to the debt share. This yields the following first-order condition:

$$c_b + \frac{\partial c_b}{\partial d_{bt}} d_{bt} = r - r_b + \tau R_b \tag{B.8}$$

The left-hand side of (B.8) denotes the marginal cost of a higher debt share. High debt may be costly due to financial distress associated with a larger risk of bankruptcy or higher agency costs. In the optimum, the marginal cost of higher debt equal the marginal benefit reflected by the right-hand side of (B.8). This marginal benefit of debt finance is equal to the difference in the real required market cost of debt versus equity plus a tax term that reflects the favourable treatment of debt over equity. Hence, due to this discrimination of the corporate tax system in favour of debt, the corporate tax rate raises the relative benefits of debt finance.

The benefits from debt finance on the right-hand side of (B.8) are independent of the debt share. To avoid a corner solution in which firms find it optimal to finance the entire capital stock with either debt or equity, we specify a convex cost function of holding debt. In particular, we use the following function for the cost of holding debt:

$$c_b = \frac{\chi}{d_b^{(1+\varepsilon_b)}(1-d_b)^{(1-\varepsilon_b)}} - \frac{c_{b0}}{d_b} \tag{B.9}$$

so that

$$c_b + \frac{\partial c_b}{\partial d_b} d_b = \left[\frac{d_b - \varepsilon_b}{1-d_b}\right](c_b + \frac{c_{b0}}{d_b}) \tag{B.10}$$

As long as the debt share exceeds ε_b, expression (B.10) suggests that the marginal cost of holding debt is positive. The marginal costs tend to rise in the debt share and fall in the parameters χ and ε_b. Hence, the higher the initial leverage of the firm, the more costly it is to further raise the share of debt finance. The parameters χ and ε_b are set at levels so as to replicate the elasticity of the debt share found in empirical studies.

Investment behaviour

To find optimal investment, we specify the production function $Y_t = CES\,(K_t, L_t)$ as a constant elasticity of substitution function with capital and labour as inputs. Production features decreasing returns to scale with respect to these to inputs. Thus, a fixed factor is at the background, which earns an economic rent in production. In optimizing its value, the firm determines the optimal demand for labour and investment. Labour demand is determined by setting the value of the marginal product of labour equal to the before-tax wage rate. Below, we concentrate on the demand for investment. Denote the marginal product of capital as Y_K. The first-order conditions for investment I_t, and the stock variables D_t and K_t read as follows:

$$(1-\phi\tau) = (1-\phi)\lambda + \mu \tag{B.11}$$

$$\lambda = \tau \frac{\delta_f}{R+\delta_f} \tag{B.12}$$

$$Y_K(1-\tau) = \mu(r+\delta) - d_b(r - r_b - c_b) - d_b \tau R_b \tag{B.13}$$

where we used the property that λ and μ are constant on a steady state balanced growth path. The first-order conditions in (B.11) – (B.13) together determine the optimal investment by firms. In particular, by substituting (B.11) and (B.12) into (B.13), we get the following expression for the optimal capital stock:[1]

$$Y_K = \frac{1}{1-\tau}\left[r^* + \delta - \tau\left[\frac{\phi R + \delta_f}{R+\delta_f}\right](r+\delta)\right] \tag{B.14}$$

$$r^* = d_b\left[r_b + c_b - \tau d_b R_b\right] + (1-d_b)r \tag{B.15}$$

Expression (B.14) denotes the cost of capital, i.e. the marginal productivity of capital that is required to make up for the cost of finance and depreciation. In the absence of a corporate income tax, the cost of capital is equal to the financial cost of investment (i.e. the weighted average of debt and equity) and economic depreciation. To understand the impact of corporate taxation, we first consider the case of equity-financed investment (i.e. if the marginal debt share is zero, $d_b = 0$). In that case, (B.14) and (B.15) modify to:

$$Y_K = r + \delta + \frac{\tau}{1-\tau}\left[1 - \frac{\phi R + \delta_f}{R+\delta_f}\right](r+\delta) \tag{B.16}$$

We see that the cost of capital is equal to that in the absence of tax ($r + \delta$), plus a tax term between square brackets. The tax term is zero if $\phi = 1$. In that case, there is immediate expensing of investment, which transforms the corporate income tax into an R-based cash-flow tax. This system is neutral to the cost of capital and, therefore, for investment. Also if the normal return on equity-financed investment would be deductible from the corporate tax, the corporate tax would be neutral to the cost of capital and investment. This neutrality property of the ACE requires that the imputed return on equity equals the nominal discount rate used by the firm.

[1] We assume no adjustment costs in capital formation so the capital stock will immediately move to its new optimum.

If $\phi < 1$, the term between square brackets on the right-hand side of (B.16) is always positive. Hence, corporate taxes raise the cost of capital financed by equity. A higher cost of capital requires that the marginal product of capital increases. In light of decreasing returns to scale with respect to capital in production, a smaller capital stock is required to achieve this. Consequently, a higher cost of capital induced by a higher corporate tax rate will reduce investment.

If part of investment is financed by debt ($d_b > 0$), (B.15) is modified as the financial cost of investment is now a weighted average of the cost of debt and the cost of equity. We see that the cost of debt is reduced by the deductibility of nominal interest costs. The interest deductibility thus reduces the cost of capital, perhaps even below the level obtained in the absence of tax.

Profit shifting behaviour

In producing output, subsidiaries use intermediate inputs that are supplied by their parent company. The arms-length price for this intermediate input is equal to the market price of the numeraire good, but the parent company can manipulate this transfer price for intra-company deliveries. In particular, the benefit from marginally changing the transfer price is measured by the difference in the statutory corporate tax rate that applies to the subsidiary (τ^f) and the rate that applies to the parent (τ^m). This benefit needs to be weighed against the cost of transfer pricing. We adopt the following cost function for manipulating transfer pricing (i.e. the price that the headquarter charges for goods supplied to its subsidiary):

$$c_q = \frac{\left| p_q - 1 \right|^{1+\varepsilon_q}}{1+\varepsilon_q} \tag{B.17}$$

Hence, deviating the transfer price (p_q) from its arms-length price (equal to one) creates a cost for the multinational, which is convex if $\varepsilon_q > 0$. In the optimum, the marginal cost from transfer price manipulation is set equal to marginal benefit, which is determined by the corporate tax differential between the foreign subsidiary and the multinational headquarter, i.e.:

$$\frac{\partial c_q}{\partial p_q} = sign(p_q - 1)\left| p_q - 1 \right|^{\varepsilon_q} = \tau^f - \tau^m \tag{B.18}$$

Expression (B.18) shows that the headquarter company has an incentive to set an artificially low (high) transfer price for supplies to subsidiaries in countries that feature a lower (higher) statutory corporate tax rate. In this way, it shifts profits from high to low-tax countries, thereby reducing its overall tax payment. The marginal cost of this manipulation depends on the initial deviation of the transfer price from its arms-length price. The speed at which transfer prices

increase is determined by the parameter ε_q. In the model, we set its value so as to replicate empirical evidence on profit shifting.

Incentive effects of loss consolidation versus loss carry forward

Assume a firm that produces output by combining labour and capital. Ex-ante, firms are equal. Ex-post, they may suffer from a random shock in the value of sales. In the good outcome, the revenue from sales equals Y_t^g. In the bad outcome, there is a lower value Y_t^b, such that profits are negative. Ex-post, a share of q firms obtain a good outcome and a share $1-q$ obtains a bad outcome. Assuming risk neutrality, firms consider the expected value of output when determining their demand for inputs.

Under loss consolidation, we assume that all losses can be immediately offset against profits elsewhere in the multinational group. The expected aggregate corporate tax base is:

$$E\left(\Pi^C{}_t\right) = qY_t{}^g + (1-q)Y_t{}^b - wL_t - d_{bt}R_bK_t - \delta_f D_t - \phi I_t \tag{B.19}$$

The expected after-tax stream of dividends is:

$$Div_t = qY_t{}^g + (1-q)Y_t{}^b - wL_t - [r_b + c_b]d_{bt}K_t - \tau\Pi_t - I_t + d_{bt+1}K_{t+1} - d_{bt}K_t \tag{B.20}$$

As before, firms maximize the value of the firm, which is the net present value of the stream of dividends, subject to the accumulation of capital. It yields the following first-order conditions for capital, cf. equation (B.14) and (B.15):

$$qY_K{}^g + (1-q)Y_K{}^b = \frac{1}{1-\tau}\left[r^* + \delta - \tau\left[\frac{\phi R + \delta_f}{R + \delta_f}\right](r+\delta)\right] \tag{B.21}$$

and labour:

$$qY_L{}^g + (1-q)Y_L{}^b = w \tag{B.22}$$

which are the familiar conditions based on the expected marginal productivity of respectively capital and labour. Both expressions suggest that firms set the expected marginal productivity of capital and labour equal to their respective prices. According to (B.21), the corporate tax raises the cost of capital as long as investment is not fully deductible, i.e. $\phi<1$.

Under loss carry forward, firms cannot immediately offset losses. Instead, we assume they carry forward their loss one year and then offset it against a possible profit. The loss Π^{-} in the previous year is given by:

$$\Pi^{-}_{t-1} = {Y_{t-1}}^{b} - wL_{t-1} - d_{bt-1}R_b K_{t-1} - \delta_f D_{t-1} - \phi I_{t-1} < 0 \tag{B.23}$$

The nominal value of this lagged loss (with probability *1-q*) can be offset against current profits if current profits are positive (with probability *q*), such that the expected tax base $E(\Pi^{L})$ is:

$$E\left(\Pi^{L}\right)_t = q\left[{Y_t}^{q} - wL_t - d_{bt}R_b K_t - \delta_f D_t - \phi I_t + \frac{1-q}{1+r^n}\Pi^{-}_{t-1}\right] \tag{B.24}$$

where r^n is the nominal rate of return. Compared to loss carry forward, the tax base is unambiguously smaller under consolidation:

$$E\left(\Pi^{C}\right) - E\left(\Pi^{L}\right) = (1-\theta)\Pi^{-}_{t-1} < 0, \qquad \theta = q\left(1+\frac{1-q}{1+r^n}\right) \tag{B.25}$$

where $\theta \leq 1$ is the fraction of expenditures which can be deducted from total revenues. Given the expected tax base in (B.24), dividends can be written as:

$$Div_t = qY_t^{g} + (1-q)Y_t^{b} - wL_t - [r_b + c_b]d_{bt}K_t - \tau E\left(\Pi^{L}_{t}\right) - I_t + d_{bt+1}K_{t+1} - d_{bt}K_t \tag{B.26}$$

Note that the limited deductibility of losses implies that the first-order condition for labour is adjusted to:

$$(1-\tau)q{Y_L}^{g} + \left(1-\frac{q\tau}{1+r^n}\right)(1-q){Y_L}^{b} = (1-\theta\tau)w \tag{B.27}$$

which can be written as:

$$q{Y_L}^{g} + (1-q){Y_L}^{b} = w + \frac{\tau}{1-\tau}(1-q)\left(1-\frac{q}{1+r^n}\right)\left(w - {Y_L}^{b}\right) \tag{B.28}$$

which shows that limited loss offset induces an increase in labour costs, given that $w \geq {Y_L}^{b}$.
The first-order conditions for investment I_t, and the stock variables D_t and K_t now read as:

$$(1-\theta\phi\tau) = (1-\phi)\lambda + \mu \tag{B.29}$$

$$\lambda = \tau \frac{\delta_f}{R + \delta_f} \tag{B.30}$$

$$(1-\tau) q Y_K{}^g + \left(1 - \frac{q\tau}{1+r^n}\right)(1-q) Y_K{}^b = \mu(r+\delta) - d_b r(1-\theta\tau) \tag{B.31}$$

where we abstract in (B.31) from financial distress costs and inflation. Equations (B.29)-(B.31) can be combined to:

$$\begin{aligned} q Y_K{}^g + (1-q) Y_K{}^b = r + \delta + \frac{\tau}{1-\tau}\left[1 - \frac{\phi r + \delta_f}{r + \delta_f}\right](r+\delta) \\ + \frac{\tau}{1-\tau}(1-q)\left(1 - \frac{q}{1+r^n}\right)\left(d_b r_b + \phi(r+\delta) - Y_K{}^b\right) \end{aligned} \tag{B.32}$$

which shows that limited loss offset raises the cost of capital if marginal productivity of capital in the bad outcome is less than the deductibility of debt and immediate expenses.

Discrete location choice

Another extension of CORTAX refers to location choice. The literature on foreign direct investment emphasises that investment is not only responsive to the cost of capital, but that also inframarginal investment and location choices are important. One reason may be that firms earn firm-specific economic rents that are mobile across borders. Such rents can be due to patents, brand names, specific managerial talents or market power. Firms then locate their affiliates in countries where the average effective tax rates are relatively low.

In CORTAX, we do not explicitly model the origins of firm-specific economic rents. Instead, we endogenise the value of economic rents earned by a multinational in CORTAX in each location by making it dependent of the corporate tax rate. In particular, suppose that the multinational owns a firm-specific fixed factor *H*, which it can allocate between two countries, H_i and H_j. If the firm maximizes the sum of profits in the two locations ($\Pi_i + \Pi_j$), the first order condition with respect to the allocation of the fixed factor in country *i* reads as

$$\frac{\partial \Pi}{\partial H_i} = (1-\tau_i) F_{Hi} - (1-\tau_j) F_{Hj} = 0 \tag{B.33}$$

In the production function of CORTAX, firms combine labour and capital using a CES production function and then combine this with the fixed factor using a cobb-douglas structure. This yields a simple expression for the marginal value of allocating the fixed factor in each of

the two locations. Using this production structure, we can write the optimal share of the fixed factor in the two locations as:

$$\frac{H_j}{H_i} = \frac{X_j}{X_i}\left[\frac{1-\tau_j}{1-\tau_i}\right]^{\frac{1}{1-\alpha}} \tag{B.34}$$

where X denotes the composite input of labour and capital. Hence, the share of the fixed factor allocated in country *j* relative to country *i* falls in the tax rate in country *j* relative to country *i*. In CORTAX, we model the share of the fixed factor of a multinational in a specific country as a function of the statutory tax rate in that country, relative to the weighted EU average. The responsiveness of the fixed factor to this tax differential is set so as the replicate empirical estimates on the impact of corporate taxes on FDI.