Alvarez Martinez, Maria Teresa et al.

**Working Paper**

# A New Calibration for CORTAX: A computable general equilibrium model for simulating corporate tax reforms

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# A New Calibration for CORTAX:
## A computable general equilibrium model for simulating corporate tax reforms

*JRC Working Papers on Taxation and Structural Reforms No 9/2016*

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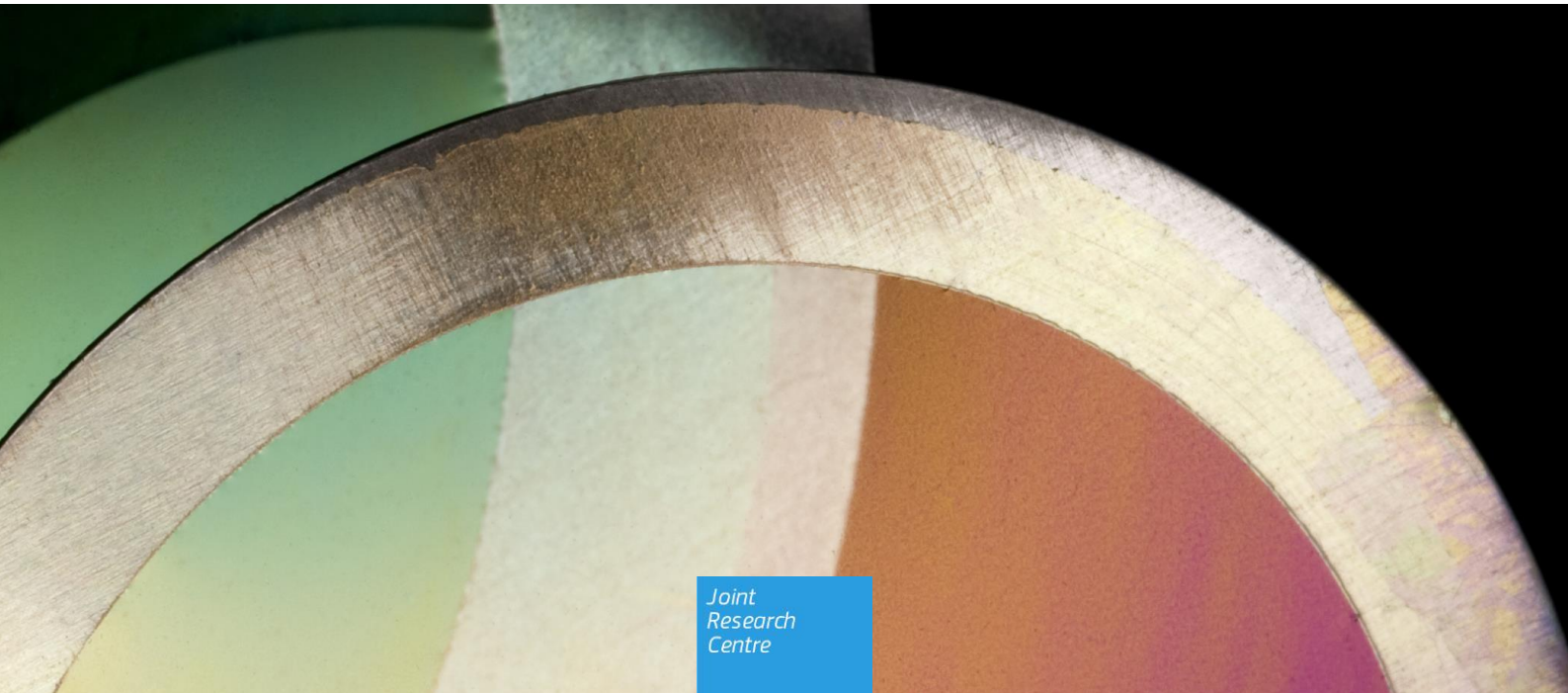

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## Acronyms

| | |
|---|---|
| ACE | Allowance for corporate equity |
| BEPS | Base erosion and profit shifting |
| CBIT | Comprehensive business income tax |
| CCCTB | Common consolidated corporate tax base |
| CES | Constant elasticity of substitution |
| CGE | Computable general equilibrium |
| CIT | Corporate income tax |
| CORTAX | A CORporate TAXation-focused computable general equilibrium model |
| CPB | Centraal Planbureau, Netherlands |
| DB | Declining Balance |
| EMTR | Effective marginal tax rate |
| FDI | Foreign Direct Investment |
| GUO | Global Ultimate Owner |
| KLEMS | Capital, labour, energy, materials, services |
| MNE | Multinational enterprise |
| NPV | Net Present Value |
| SMEs | Small and Medium Sized Enterprises |
| SPE | Special purpose entity |
| SL | Straight Line |

## Abstract

The paper presents a new calibration for CORTAX (short for CORporate TAXation), which is a computable general equilibrium (CGE) model covering all EU member states, the US, Japan and a tax haven. The CORTAX model was originally built by the Centraal Planbureau (CPB) in the Netherlands based on the earlier OECDTAX model of Sorensen (2001). The calibration presented in this paper updates the base year to 2012. As the previous calibration was for 2007, the two calibrations represent pre- and post-crisis data.

CORTAX models many key features of the corporate tax regimes including multinational profit shifting, investment decisions, loss compensation and the debt-equity choice of firms. The model is designed to investigate many aspects of corporate income taxation (CIT), including adjustment or harmonisation of the CIT rate or base and reforms to address the debt bias in CIT. Furthermore, it can examine consolidation of multinational CIT base, which inter alia addresses some of the issues concerning base erosion and profit shifting (BEPS).

Given the choices companies have when confronted with changes in their respective environments, it is important to assess the effects of the reform under a general framework, which takes into account the interactions between different parts of internationally open economies, such as the impact of CIT reforms on firms' investment decisions. Indeed, as a computable general equilibrium model, it simulates all main macroeconomic variables, including GDP, investment and employment.

The paper gives an explanation of the model structure, describes the data used, the calibration method and provides descriptive statistics for the baseline values of the model, comparing those for 2012 with the previous 2007 values.

# 1 Introduction

Corporate tax reforms are motivated by concerns about the fairness and efficiency of the current regimes. Internationally uncoordinated national tax regimes may have loopholes and inconsistencies in the treatment of corporate profits across borders that give rise to strategic tax planning often by large multinationals. There are several well-publicised cases of large multinational firms exploiting differences in country regimes to reduce their tax burden. Economic inefficiency arises as companies may divert productive resources to rent-seeking activities, competition is distorted and excessive compliance costs imposed on both companies and public authorities. In addition, governments are deprived of public revenues and may engage in tax competition. Furthermore, tax planning can be unfair as it effectively shifts the tax burden on other taxpayers, such as consumers or small and medium-size enterprises (SMEs) which operate at local level.

Policy reform proposals have been made to tackle these issues. In addition to the aforementioned fairness and efficiency concerns, policy interest stems from the fact that corporate tax represents a significant revenue source (the third largest category of tax revenue in the EU, after personal income taxes and consumption taxes). The CORTAX model has been used extensively for the evaluation of such reforms. The model was previously used for the Impact Assessment of the 2011 common consolidated corporate tax base (CCCTB) reform proposal (European Commission, 2011), which drew extensively from a report produced for DG TAXUD (Bettendorf et al., 2009b). Among other policies, the report analysed both a common corporate tax base and a common consolidated corporate tax base for the EU.

The CORTAX model has been used to investigate a range of CIT reforms, including additional publications addressing the CCCTB and further innovations of the ideas (Bettendorf et al., 2010a; Bettendorf et al., 2010b). The CORTAX model has also been used to analyse CIT reforms to address the debt bias in corporate taxation (de Mooij and Devereux, 2011) and the impact of corporate taxation on the labour market (Bettendorf et al., 2009a).

These previous studies were based on a calibration for the year 2007. The years since have been especially turbulent, necessitating an update to post-crisis figures. This report provides an update on the calibration of the CORTAX model with 2012 data. As it is meant to update the previous documentation of CORTAX, it also includes a brief description of the model itself and its salient features for cross-border fiscal policy, partly derived from Bettendorf and van der Horst (2006) and Bettendorf et al. (2009b). The paper is structured as follows: first, the structure of the CORTAX model is outlined, followed by an explanation of the data sources and how data are entered into the model. Next the key baseline values are shown. The paper concludes with a brief discussion concerning further development of the model.

# 2 Structure of CORTAX

The CORTAX model has been designed to simulate the economic impact of national and international tax policy reforms, as well as the international harmonisation of national tax policies. CORTAX allows simulations of the effects of corporate tax changes within a framework that takes into account the transactions between firms (including MNEs), households and governments. In the model, each country is assumed to have the same structure in terms of consumption, savings, production and public finances (though the data and parameters are country-specific, see below). Countries are linked to each other via international trade in goods markets,

investment by MNEs, international capital flows and intermediate inputs within multinationals. Firms are divided into three categories: MNE´s headquarter, their subsidiaries located abroad and domestic firms that only produce in their country of residence. Multinationals and domestic firms differ to the extent that the former optimise profits globally and are engaged in profit shifting activities across borders. Domestic firms pay their corporate taxes in their country of residence according to the revenues generated in this country only. The model solves to the long-run steady state equilibrium (the transition paths between states are not modelled). The effects of reforms can be expressed as changes in GDP, household consumption, business investment and fiscal revenue.

The model is elaborated using data from different data sources. In the present exercise, the model has been constructed with a database for the year 2012. The structural descriptions offered here, as well as aspects of the calibration, borrow heavily from Bettendorf et al. (2009b).

The data sources used are Eurostat, the OECD, UN, ZEW-Mannheim (for tax codes, including asset-specific corporate depreciation allowances) and company-level information on investment by asset type and source of financing from the Bureau van Dijk Orbis database (explained in section 2.3.1). Company behaviour in the model with respect to e.g. profit shifting closely corresponds to insights offered by empirical literature. Likewise, the model incorporates empirical insights on tax compliance costs; following Devereux (2004), which concludes that the likely compliance costs are between 2.7% and 4% of tax revenues, the compliance costs are set at 4% of corporate tax revenues for all firms.

The model captures the economic behaviour of all the agents in the economy: households, firms (domestic, multinationals headquarters and subsidiaries), the government and the foreign sector (see, Bettendorf et al., 2009b, Section 2.1). The following addresses the main elements of each of these in turn.

**Households**. There are two generations of households: old and young. Their lifetime is 40-year periods each and their behaviour remains the same during the whole period. Households maximise their inter-temporal utility function $U(t)$ with $v^y$ being the utility of young generation and $v^0$ the utility of old generation:

$$U(t) = \frac{1}{1-1/\sigma_u}\left[\sum_{\tau=0}^{T-1}\frac{v^y(t+\tau)^{1-1/\sigma_u}}{\rho_u^\tau} + \frac{\rho_0}{\rho_u^\tau}\sum_{\tau=0}^{T-1}\frac{v^0(t+T+\tau)^{1-1/\sigma_u}}{\rho_u^\tau}\right]$$

$$= \frac{1}{1-1/\sigma_u}\left[v^y(t)^{1-1/\sigma_u} + \frac{\rho_0}{\rho_u^\tau}v^0(t+T)^{1-1/\sigma_u}\right]\sum_{\tau=0}^{T-1}\left(\frac{(1+g_a)^{1-1/\sigma_u}}{\rho_u}\right)^\tau \qquad (1)$$

where $\rho_u$ is the rate of time preference, $\sigma_u$ the intertemporal substitution elasticity and $g_a$ is the productivity growth rate.

The intra-temporal utility function when young is composed by consumption ($c^y$) and leisure $(\hat{l})$ included in Equation 2:

$$v^y(\tau) = \begin{cases} \left[c^y(\tau)^{\frac{\sigma_l-1}{\sigma_l}} + \alpha_l\left(A_l(\tau)\hat{l}(\tau)\right)^{\frac{\sigma_l-1}{\sigma_l}}\right]^{\frac{\sigma_l}{\sigma_l-1}} & \sigma_l \neq 1 \\ c^y(\tau)^{\frac{1}{1+\alpha_l}}\left(A_l(\tau)\hat{l}(\tau)\right)^{\frac{\alpha_l}{1+\alpha_l}} & \sigma_l = 1 \end{cases} \qquad (2)$$

where $\alpha_l$ is the weight of leisure in utility and $\sigma_l$ is the intra-temporal substitution elasticity. $A_l$ is an exogenous index that grows at the productivity growth rate. The utility function of the old generation has the same specification with the restriction that $\hat{l} = 1$.

This maximisation is subject to an inter-temporal budget constraint, described by Equation 3, where net savings from young workers (wages, current transfers and negative consumption), in the left side of the equation, are equal to negative value of net savings from old households. Young households receive after-tax income from labour $\bar{w}(t)l$ and other transfers while old households do not work and only receive income from transfers $\left(tr^0(t)\right)$ and the fixed factor $\left(\pi^0(t)\right)$.

$$\bar{w}(t)l + tr^y(t) - (1+\tau_c)c^y(t) = -\left(\frac{1+g_a}{\rho_s}\right)^{\tau}\left[\pi^0(t) + tr^0(t) - (1+\tau_c)c^0(t)\right] \quad (3)$$

The optimal consumption path and labour supply can be obtained from the first order conditions. In accordance with the empirical literature, the model assumes that substitution effects dominate and the uncompensated elasticity of labour supply is positive. Households´ savings are allocated to bonds and stocks, which are imperfect substitutes and have different rates of return. The (gross) returns to assets are determined on world markets and are assumed to be the same irrespective of the residence of their owner. Total bonds and stock holdings are derived from the maximisation of total assets CES combination of bonds $(b)$ and equities $(e)$subject to their total value:

$$A = \left[\alpha^{\frac{-1}{\sigma_s}} b^{\frac{\sigma_s+1}{\sigma_s}} + \alpha^{\frac{-1}{\sigma_s}} e^{\frac{\sigma_s+1}{\sigma_s}}\right]^{\frac{\sigma_s}{\sigma_s+1}} \quad (4)$$

such that $\rho_s A = \rho_b b + \rho_e e$

$A$ is total assets and $\sigma_s$ the substitution elasticity bonds/equities and $\rho_s$ is the total after-tax revenue from assets.

The effects on welfare are calculated using the compensating variation. This is calculated as the difference in transfers received by young households required to compensate the change in utility. It is presented as a percentage of GDP.

**Firms**. In CORTAX there are two types of firms, domestic and multinationals, with the latter disaggregated into headquarters and subsidiaries. Each country has one representative domestic firm, one multinational headquarters and several subsidiaries, which are owned by headquarters in other countries.[1] Firms maximise their value $V_t^n(j)$, subject to the possibilities of the production function and accumulation constraints on physical capital and fiscal depreciation:

$$V_t^n(j) = \sum_{s=t}^{\infty} \Lambda(j) Div_s^n(j) R_s(j) \quad (5)$$

with n=domestic, multinational headquarters or subsidiary and $R_s$ representing the overall effect of discounting:

$$R_s(j) \equiv \frac{1}{\left(1+\bar{r}_e(j)\right)^{s-t+1}}$$

[1] Note that the number of firms is not modelled in CORTAX. This simplification still allows the interpretation of the results of the policy simulations by comparing MNEs with domestic firms´ situation.

$$\bar{r}_e(j) \equiv \frac{r_e(j,j)}{\left(1-\tau_g(j)\right)}$$

$$\Lambda(j) \equiv \frac{\left(1-\tau_d(j)\right)}{\left(1-\tau_g(j)\right)}$$

Where $Div_s^n$ are the dividends, $\bar{r}_e(j)$ represents the discount rate relevant for firms in making decisions and $r_e(j,j)$ is net return on equity in country j for an investor also in country j (the *marginal* investor is assumed to reside in the home country). $\tau_g(j)$ is the tax rate on capital gains and $\tau_d(j)$ is the tax rate on dividends.

**Aggregate production.** The aggregate production is calculated as the sum of production in all industries net of intermediate inputs in foreign subsidiaries:

$$Y(i) = q\left[Y^{dg}(i) + Y^{mg}(i) + \sum_{j\neq i} Y^{fg}(i,j)\right] + (1-q)\left[Y^{db}(i) + Y^{mb}(i) + \sum_{j\neq i} Y^{fb}(i,j)\right] + - \sum_{j\neq i} p_q(j,i)Q(j,i) \quad (6)$$

where $(q)$ is the probability of a good event (shock) and $(1-q)$ the probability of a bad event. $Y^{dg}(i)$ represents domestic production, $Y^{mg}(i)$ the production of parent companies and $\sum_{j\neq i} Y^{fg}(i,j)$ the production of subsidiaries.

In addition to labour and capital, the production function includes a fixed, location-specific production factor (which can be considered as representing land). In the case of multinational subsidiaries, there is an additional input into production, namely an intermediate input, which is purchased from the multinational headquarters. These inputs are combined as follows. Value added ($VA^{nx}$) is a constant elasticity of substitution aggregate of labour ($L^n$) and capital ($K^n$). Production is then a Cobb-Douglas combination of this value added and the fixed factor ($\omega^n N^y$) in the case of domestic firms (d) and multinational headquarters (m). For multinational subsidiaries (f), the intermediate input is also included in the Cobb-Douglas production function. These are shown in equations 7 and 8.

The production function for domestic firms and multinational headquarters can be defined as:

$$Y^{nx} = A^{nx}(VA^{nx})^{\alpha_v^n} \quad (7)$$

With:

$$A^{nx} = (A_{0x}\omega^n N^y)^{1-\alpha_v^n}$$

$$VA^{nx} = A_{0x}\left[\alpha_{vl}^n (L^n)^{\frac{\alpha_v^n-1}{\alpha_v^n}} + \alpha_{vk}^n (K^n)^{\frac{\alpha_v^n-1}{\alpha_v^n}}\right]^{\frac{\sigma_v^n}{\alpha_v^n-1}}$$

With n=d for domestic and n=m for headquarters.

While for subsidiaries it is:

$$Y^{fx}(j) = A^{fx}(j)A_0^{\alpha_q}Q(j)^{\alpha_q}(VA^{fx})^{\alpha_v^f} \qquad \text{with } 0 < \alpha_q + \alpha_v^f < 1 \quad (8)$$

And with:

$$A^{fx} = (A_{0x}\omega^f N^y)^{1-\alpha_v^f-\alpha_q}$$

$$VA^{fx}(j) = A_{0x}\left[\alpha_{vl}^f (L^f)^{\frac{\alpha_v^f-1}{\alpha_v^f}} + \alpha_{vk}^f (K^f)^{\frac{\alpha_v^f-1}{\alpha_v^f}}\right]^{\frac{\sigma_v^f}{\alpha_v^f-1}}$$

where $Y^{-x}$ is total output, $A^{-x}$ the output contribution of the fixed factor and $Q$ intermediate inputs. $\sigma_{\bar{v}}$ is the substitution elasticity between productive factors.

Firms aim to maximise their value. In the case of multinationals, the objective is to maximise the sum of the value of their headquarters plus all their subsidiaries.

While labour and land are immobile factors, capital and capital revenues are perfectly mobile across countries. The return to capital (after source taxes) is fixed by world capital markets. The supply of the fixed factor is location-specific and inelastic, and revenues generated are accounted for as economic rents. All firms are owned by households. In the case of multinationals, MNE equities are assumed to be perfect substitutes, and so it is not specified which households are the owners. The marginal investor is assumed to be the domestic household, which allows the determination of the discount rate to be used for the valuation of the firm.

**Profit shifting.** Multinationals differ from domestic firms as they use intermediate inputs in the production process. In particular, the intermediate inputs are supplied by the parent company to the foreign subsidiaries. The model allows the parent company to charge a transfer price for intra-firm deliveries of intermediate inputs that deviates from the equivalent price that would be charged if it had been an inter-firm transaction (the 'arms-length' price). Specifically, there is an incentive in place to set an artificial price in order to shift profits from high-to-low tax countries and minimise the overall tax contribution. In order to ensure an interior solution, a convex cost function is specified to describe the organisational costs associated with the manipulation of transfer prices and that make profit shifting increasingly costly at the margin:

$$\frac{\partial c_q}{\partial p_q} = sign(p_q - 1)|p_q - 1|^{\varepsilon_q} \qquad (9)$$

From the first-order condition (equation 10), it follows that multinationals artificially shift profits between each pair of headquarters and subsidiary towards the country with the lower tax rate, since $p_q(j) > 1$ if $\tau_\pi^f(j) > \tau_\pi^m$ and $p_q(j) < 1$ if $\tau_\pi^f(j) < \tau_\pi^m$.

$$\frac{\partial c_q}{\partial p_q}(1 - \tau_\pi^m) = \tau_\pi^f(j) - \tau_\pi^m \qquad (10)$$

**FDI.** Bilateral foreign direct investment (FDI) stocks determine the initial size of subsidiaries. FDI is defined as the equity-financed part of foreign capital and are defined as follows:

$$FDI(i,j) = \left(1 - d_b^f(i,j)\right) K^f(i,j) \qquad (11)$$

with $d_b^f$ being the debt ratio.

Corporate investment is financed by either retained earnings or by issuing bonds. CORTAX does not allow the issuing of new shares. Decisions on the source of finance are based on the difference between the after-tax cost

of debt and equity. The marginal cost of debt finance is specified to increase alongside the debt share, which ensures an interior solution for the debt ratio, and reflects the evidence that, on aggregate, firms choose a combination of debt and equity financing.

Among the alternative corporate tax specifications, the model incorporates the compliance costs incurred by firms for attending their corporate tax obligations. These costs are included as the amount of new workers required to carry out these tasks. Consequently there are two types of labour: workers producing output and workers for the tax administration. The latter are measured as a fixed share of the productive labour force. They increase in proportion to the size of the firm's payroll.

**Cost of capital.** The relationship between corporate taxation and investment in CORTAX is determined by the cost of capital. We take a standard approach (e.g. used in Bettendorf et al., 2009) using the effective marginal tax rate (EMTR) to measure the effect of corporate tax rates and bases on the cost of capital. EMTR is defined as the difference in the cost of capital in the presence and in the absence of tax, expressed as a percentage of the tax-inclusive cost of capital. The EMTR effectively summarises several parameters of the tax system, such as the statutory tax rate, depreciation allowances, treatment of inventories and depreciation of financial costs. It takes a positive value if corporate tax raises the cost of capital and vice versa (see Box 1 below for a simplified example).

**Box 1 – The user cost of capital and the EMTR**

The impact of corporate taxes on the user cost of capital depends on the corporate tax system. This effect is best reflected by considering a simple tax system. Assuming equity-financed investment, the cost of capital ($c$) depends on the corporate tax ($\tau$) in the following way:

$$\mathrm{c} = \frac{1 - \tau A}{1 - \tau} \, (r + \delta)$$

where $A$ denotes the net present value of depreciation allowances in percent of the cost of an investment and $r+\delta$ is the pre-tax cost of capital. This expression shows that the corporate tax rate exerts no effect on the cost of capital if $A = 1$, which is the case under a cash-flow tax. Intuitively, the cash-flow tax turns the corporate tax into a tax on economic rent which is non-distortionary for investment. The smaller the tax allowances become (i.e. the smaller $A$), the more corporate taxes raise the cost of capital.

From the definition of the EMTR, we derive a direct relationship between the EMTR and the statutory corporate tax rate:

$$\mathrm{EMTR} = \frac{c - (r + \delta)}{c} = \frac{1 - A}{1 - \tau A} \, \tau$$

This expression shows the positive relationship between the statutory corporate tax rate and the EMTR. This effect also depends on A. If $A = 1$, the EMTR is zero, irrespective of the rate of corporate tax. It reflects the non-distortionary character of the corporate tax in this case. The lower $A$, the more $\tau$ raises the EMTR, i.e. the more distortionary the corporate tax rate becomes for investment. If $A = 0$, the EMTR equals the statutory corporate tax rate.

*Source*: Bettendorf et al. (2009b:18)

**Losses and loss carry forward**. At the benchmark, all firms are all equal and there are no negative extra profits, but there are random shocks affecting their revenues that can be attributed to, e.g., business cycle evolutions. These shocks may result in losses that can be carried forward in the model. Firms' decisions on inputs are made before knowing whether they will be subject to a random shock and are therefore based only on expected output values and expected marginal productivities. The probabilities of profit and loss are assumed to be independent across years because shocks are not correlated over time. CORTAX allows for losses to be carried forward for one year. While this underestimates the actual opportunities for loss compensation over more than one year, at the same time the assumption of independent shocks tends to overestimate losses that can be offset. Appendix A in Bettendorf et al. (2009) discusses this issue in further detail.

**Tax Haven.** The model allows firms to shift part of their tax base to a tax haven. (This is modelled as a separate channel for profit shifting than transfer pricing between multinational headquarters and subsidiaries outlined above.) The extent to which this occurs is parameterised in line with the literature, in particular the elasticity estimates of a meta-regression study (Heckemeyer & Overesch, 2013). Multinational firms are considerably more able to take advantage of tax haven than domestic firms. Therefore firms in the model know that not all of their CIT tax base will be subject to statutory tax rate, meaning that their effective statutory tax rate is reduced.

**Public Sector.** Government is an intermediate agent in CORTAX. There is a balanced budget where consumption and public debt are a fixed proportion of GDP and lump-sum transfers are also fixed. Tax revenues include indirect taxes on consumption and direct taxes of income from corporate and labour, dividends, capital gains and interest. Government consumption and government debt as a share of GDP are maintained constant after a reform.

**Equilibrium.** In the model, all markets are in equilibrium in the base year. There is only one representative homogeneous good, which is traded in a perfect competitive world market. Therefore countries cannot exert market power and their terms of trade are fixed. The price of this good is the "numeraire" in the model. With respect to asset markets, bonds (and equities) of different origins are perfect substitutes and are freely traded on world markets. The return to these assets is therefore fixed for every country. At the same time, debt and equity are not perfect substitutes. Regarding the foreign sector, the current account equals the change in the net foreign asset position for each country so that the balance of payments is equal to zero.

# 3 Calibration of CORTAX

## 3.1 Data sources and preparation

For the sake of continuity we generally used the same data sources as in the original calibration undertaken by the CPB, see Bettendorf and van der Horst (2006). The 2012 data was used as the reference year for the calibration, as it represented a good compromise between timeliness and completeness. Following the initial calibration (Bettendorf and van der Horst, 2006) the countries covered include the EU's 28 member states, the United States and Japan. An initial attempt has been made to collect information on an expanded set of countries, including many non-EU OECD members and China, but due to unequal coverage in the original data sources this possibility will have to be more fully explored in subsequent expansions of CORTAX. In a small number of cases alternative data sources or reference year were used or missing values imputed. These differences are all documented below.

*Population and Employment*

Population and employment statistics used in the calibration come from the United Nations. Figures for population aged 20+ have been summed from the five year age groups reported in UNECE (2015) (EU countries and USA) and UNESCAP (2015) (Japan). Figures for the labour force have been calculated from the five year age groups reported under the medium fertility projections of the World Population Prospects (UN 2013).

Additional employment statistics, on annual hours worked, number of employees, number of self-employed and total employment are from Eurostat (database tables lfsi_emp_a, lfsq_eegaed, lfsq_esgaed, lfsq_ewhan2), except for the United States and Japan for which we use forecasts for 2011 (latest available) from the OECD (2009). Data on number of persons engaged, number of employees, total hours worked by persons engaged and total hours worked by employees are from the World Input Output Database (2015) (the successor of KLEMS) as documented in Timmer et al. (2015).

*National accounts*

National accounts data using the expenditure and income approaches are from the OECD (2015) and Eurostat (database tables: gov_a_main, nama_gdp_c, gov_10dd_edpt1 and ert_bil_eur_a for exchange rates). Purchasing power parity (PPPs) exchange rates are from the IMF (2015) and Eurostat (database table prc_ppp_ind). General government consolidated gross debt as a percentage of GDP is from DG ECFIN's Ameco Database (European Commission, 2015).

National accounts data on labour and capital income shares determine the capital and labour parameters for the calibration of the model. The location-specific production factor is set at 2.5% of value added in each country, a value which was necessary for CORTAX to produce a reasonable result in terms of the corporate tax to GDP ratio. A sensitivity analysis with a lower share (1.5%) was not found to produce qualitatively distinct results (reported in Bettendorf et al., 2009b).

*Foreign Direct Investment*

The CORTAX model requires bilateral FDI positions as part of the calibration of the sizes of multinational subsidiaries. For these, we start with the Eurostat bilateral positions. Data on Foreign Direct Investment (FDI)

flows by country of origin and country of receipt are from Eurostat (financial account, direct investment, reporting economy, database table bop_fdi_pos_r2). However, Germany, Luxembourg, Iceland, Switzerland, Cyprus and Japan do not report the country of origin for about half of the 30 countries considered. For the remaining countries information is missing only for about 2-4 countries of origin, typically those from outside the EU. Following the original calibration practice (Bettendorf and van der Horst, 2006):

> (a) Missing values on inwards FDI were filled using the corresponding relationship from the outwards FDI table. In effect, information on FDI that is not reported by the receiving economy is obtained using information reported by the originating economy.
>
> (b) For a small number of country pairs where neither inward nor outward information was available, FDI was approximated using information on the FDI behaviour of similarly-sized and/or neighbouring countries. For instance, inwards FDI to Luxembourg from Germany has been approximated by looking at the corresponding relationship between Luxembourg and Austria: First calculating Austrian FDI into Luxembourg as a share of total Austrian FDI in the EU and then multiplying this share by the total amount of German FDI in the EU.

For some countries, however the FDI data raised concern given the relative importance of special purpose entity (SPE) activity. While SPEs are typically used by companies to isolate the firm from financial risk, they can also be used for debt shifting purposes between related parties (see Dharan, 2002). We check all country aggregates and, in our case, there is concern about the values obtained for Cyprus, Malta, Luxembourg and the Netherlands.[2] In order to correct for this, we use non-SPE data where available. The first choice of source for this data is the OECD Benchmark Definition 4 (BMD4), which provides data on FDI specifically for SPEs and non-SPEs.[3] The most recent data set was released in March 2015, and currently provides data for 2013 only at an aggregate level (bilateral flows are not given). Furthermore data is only available for select countries. Of the four countries, only Luxembourg has non-SPE FDI data listed for OECD BMD4,[4] and the inward and outward positions are adjusted based on these data. The UNCTAD FDI data also removes SPEs. For the remaining three countries, we check against the UNCTAD non-SPE totals.[5] [6] Based on these figures, adjustments are made to the inward position for Cyprus and the outward position for Cyprus, Malta and the Netherlands. Figure 2.1 shows bilateral FDI stocks by country as % of GDP.

[2] Ireland was also considered, but the UNCTAD non-SPE data did not suggest that the Eurostat figures were excessive, and the OECD BMD4 data are not given.

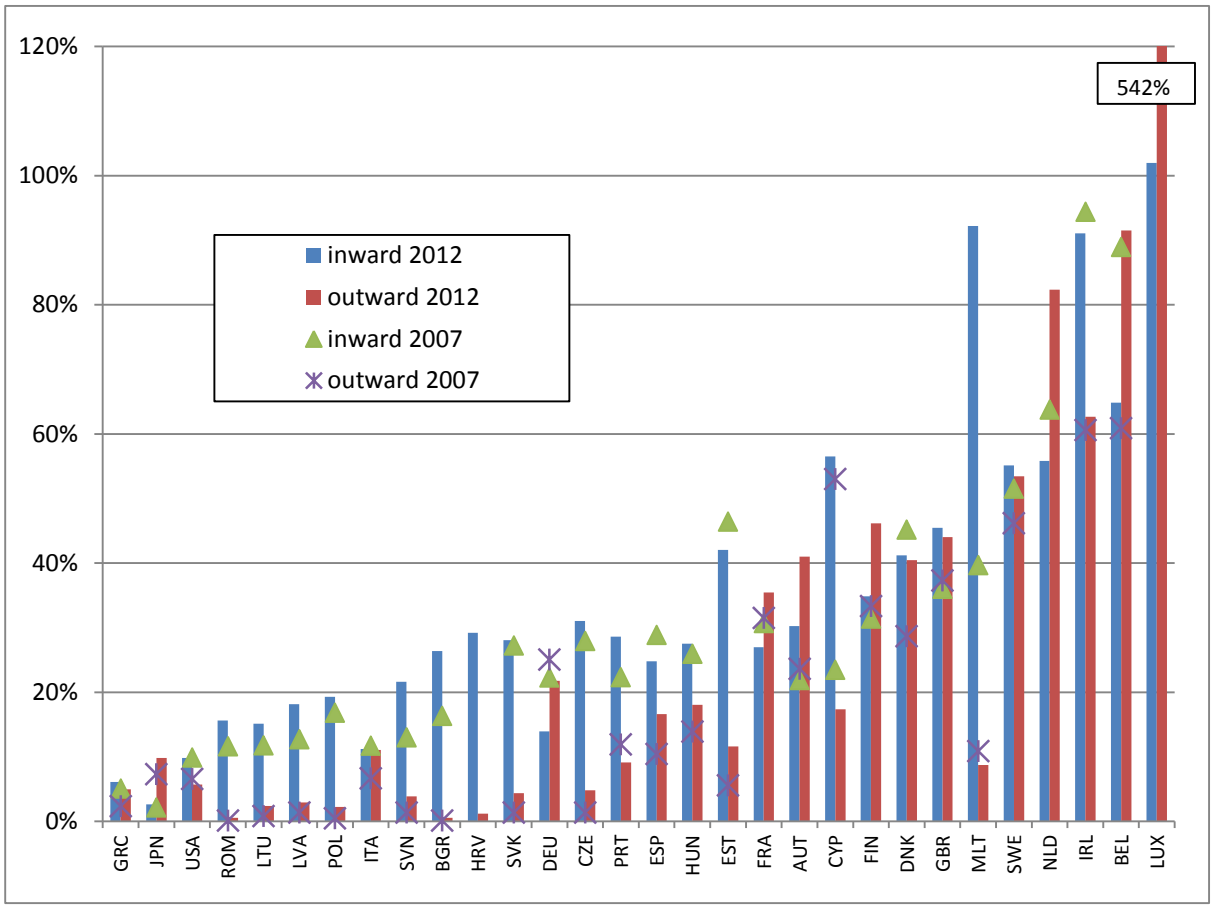
[3] The OECD data claim to set "the world standard for collecting direct investment statistics". Based on the arguments made (see http://www.oecd.org/investment/fdibenchmarkdefinition.htm for details), we consider this our preferred source for non-SPE FDI data aggregates.

[4] We use the directional principle data, which is adjusted to 2012 using the growth/reduction in assets over this period. The figures are total inward and outward positions with the rest of the world. Therefore, these are adjusted for the share of positions for the EU and USA and Japan out of the rest of the world, based on UNCTAD shares estimates http://unctad.org/Sections/dite_fdistat/docs/webdiaeia2014d3_LUX.pdf.

[5] The inward and outward FDI stocks are available here: http://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx.

[6] As for Luxembourg, the data are adjusted by the share of the inward and outward positions for the EU and USA and Japan out of the world totals.

**Figure 3.1 Inward and outward FDI in % of GDP in EU countries, 2012**




*Source*: Eurostat, adjusted for CYP, MLT, LUX and NLD according to non-SPE figures by the OECD and UNCTAD.

Note: Countries ranked by the sum of inward FDI plus outward FDI.

*Tax information*

CIT receipts as a percentage of GDP are from European Commission (2014, Table 18). Additional tax revenue statistics, expressed in national currency and as a percentage of GDP, are from the OECD (Dataset: Revenue Statistics - Comparative tables). Implicit tax rates on consumption are from Eurostat (2014:255). Statutory Corporate Income Tax (CIT) rates are from ZEW (2014:2) Tax rates on dividends, interest and capital gains upon disposal of shares are from ZEW (2014: A14-A20). Implicit tax rate on labour income have been estimated using the EUROMOD[7] tax-benefit microsimulation model.

*Firm-level data from the Orbis database*

The CORTAX model requires information on companies' debt shares and asset structure in order to calculate relevant corporate tax parameters such as the cost of capital (financed via equity or debt). Information on balance sheets and ownership structure from the Orbis database provided by Bureau Van Dijk was used for this

[7] EUROMOD is based on EU-SILC data, and so gives a broad coverage of individuals for all EU countries in a consistent fashion. Further information on EUROMOD is available here: https://www.euromod.ac.uk/.

purpose. Although Orbis is a firm-level database, for the purposes of the calibration it is only used to produce national-level estimates of debt shares and of corporate investment shares (by type of asset).

In keeping with an earlier calibration of CORTAX (Bettendorf et al, 2009b) the sample was narrowed down to firms reporting total assets larger than two million US dollars and to firms who had complete information on investment on tangibles and intangibles. Kalemli-Ozcan et al. (2015) outline a number of steps required to make Orbis data nationally representative primarily by excluding observations that are the source of systematic error, probably due to miscoding by the data provider. They show that once these observations have been dropped then the resulting output figures closely match Eurostat's Structural Business Statistics (note that they also complement some of the missing observations from Amadeus, which we are unable to do). Our analysis, as was also the case in the earlier calibration (Bettendorf et al, 2009b), is broadly consistent with the relevant recommendations by Kalemli-Ozcan et al. (2015), most notably with the exclusion of observations with implausible information such as negative values for total assets, for tangibles and for intangibles. This leaves 1,005,188 companies based in the EU28, the United States and Japan. Many of these companies are subsidiaries belonging to multinational groups. Unconsolidated accounts are used as these best describe the actual investment behaviour of multinational enterprise subsidiaries across EU member states.

For these companies we obtained data on their asset structure, including inventories (Orbis variable name "Stock"), fixed tangible assets, fixed intangible assets, total assets. While in principle Orbis contains information on corporate investments in buildings and machinery (Orbis variables "Plant and Machinery", "Transport Equipment"), in practice this information was missing for many companies. As information on the shares of investment directed into these two assets is necessary for the estimation of tax parameters, we estimate them using information on the Orbis-derived total quantity of investment on tangibles, multiplied by the sector-shares on buildings and machinery provided by Eurostat (Eurostat variable codes sbs_na_con_r2, sbs_na_dt_r2, sbs_na_ind_r2, sbs_is_inv_r2). For those countries and sectors for which this information was not available in Eurostat (principally France, Latvia and Malta) in common with established practice (Egger et al., 2008; Devereux and Loretz, 2008; Bettendorf et al. 2009b) we estimate them by multiplying Orbis-derived total quantity of investment on tangibles by the sector-shares on buildings and machinery provided by McKenzie et al. (1998). Table 2.1 reports the resultant investments shares used in the calibration.

Orbis was also used to approximate corporate debt shares, calculated as the ratio of the sum of current and non-current liabilities over total assets.

**Table 3.1. Summary Statistics of Investment Shares, 2012**

| | Buildings | Machinery | Intangibles | Stocks | Land | No. of companies |
|---|---|---|---|---|---|---|
| Austria | 31.6% | 27.0% | 5.1% | 25.3% | 11.0% | 25,316 |
| Belgium | 28.2% | 32.8% | 5.2% | 23.1% | 10.6% | 41,077 |
| Bulgaria | 30.7% | 24.3% | 2.8% | 30.6% | 11.6% | 8,735 |
| Cyprus | 22.5% | 26.9% | 3.7% | 40.1% | 6.8% | 134 |
| Czech Republic | 28.2% | 32.9% | 2.6% | 25.7% | 10.7% | 15,120 |
| Germany | 23.8% | 30.3% | 4.0% | 32.1% | 9.9% | 124,911 |
| Denmark | 15.6% | 31.5% | 5.4% | 40.8% | 6.6% | 9,619 |
| Spain | 27.0% | 23.7% | 5.2% | 32.3% | 11.7% | 98,010 |
| Estonia | 27.7% | 28.4% | 5.1% | 30.6% | 8.2% | 2,222 |
| Finland | 27.1% | 24.5% | 9.3% | 29.8% | 9.2% | 11,314 |
| France | 18.8% | 24.8% | 19.5% | 30.6% | 6.4% | 84,491 |
| UK | 34.3% | 21.0% | 7.2% | 23.3% | 14.2% | 100,189 |
| Greece | 26.6% | 28.9% | 5.5% | 29.5% | 9.6% | 10,524 |
| Croatia | 34.7% | 23.2% | 3.5% | 28.4% | 10.2% | 5,303 |
| Hungary | 26.1% | 31.5% | 4.4% | 28.3% | 9.6% | 9,305 |
| Ireland | 35.7% | 20.9% | 6.0% | 23.7% | 13.7% | 9,393 |
| Italy | 19.8% | 25.3% | 9.9% | 37.2% | 7.8% | 167,922 |
| Lithuania | 28.1% | 25.9% | 3.2% | 35.4% | 7.4% | 1,522 |
| Luxembourg | 33.1% | 20.7% | 14.5% | 20.3% | 11.5% | 3,027 |
| Latvia | 30.7% | 27.8% | 2.6% | 27.4% | 11.5% | 3,154 |
| Malta | 29.6% | 25.9% | 7.6% | 26.2% | 10.6% | 749 |
| Netherlands | 24.1% | 43.5% | 7.4% | 16.1% | 8.8% | 59,580 |
| Poland | 28.9% | 28.3% | 3.8% | 31.0% | 8.0% | 21,741 |
| Portugal | 21.2% | 27.7% | 4.3% | 37.9% | 8.9% | 19,508 |
| Romania | 28.6% | 30.4% | 2.1% | 26.8% | 12.0% | 13,616 |
| Slovak Republic | 35.2% | 25.7% | 2.6% | 23.4% | 13.0% | 8,178 |
| Slovenia | 25.8% | 36.6% | 4.1% | 26.4% | 7.1% | 2,774 |
| Sweden | 27.3% | 24.8% | 8.3% | 30.1% | 9.6% | 10,989 |
| Japan | 22.1% | 38.5% | 3.2% | 27.4% | 8.8% | 105,429 |
| USA | 29.0% | 14.5% | 2.4% | 41.9% | 12.1% | 31,336 |
| EU (wei. ave./total) | **25.5%** | **27.1%** | **7.7%** | **29.9%** | **9.8%** | **868,423** |
| All (wei. ave./total) | 27.4% | 27.6% | 5.7% | 29.4% | 9.9% | 1,005,188 |

*Source*: Own calculations based on Orbis, Eurostat and McKenzie et al. 1998.

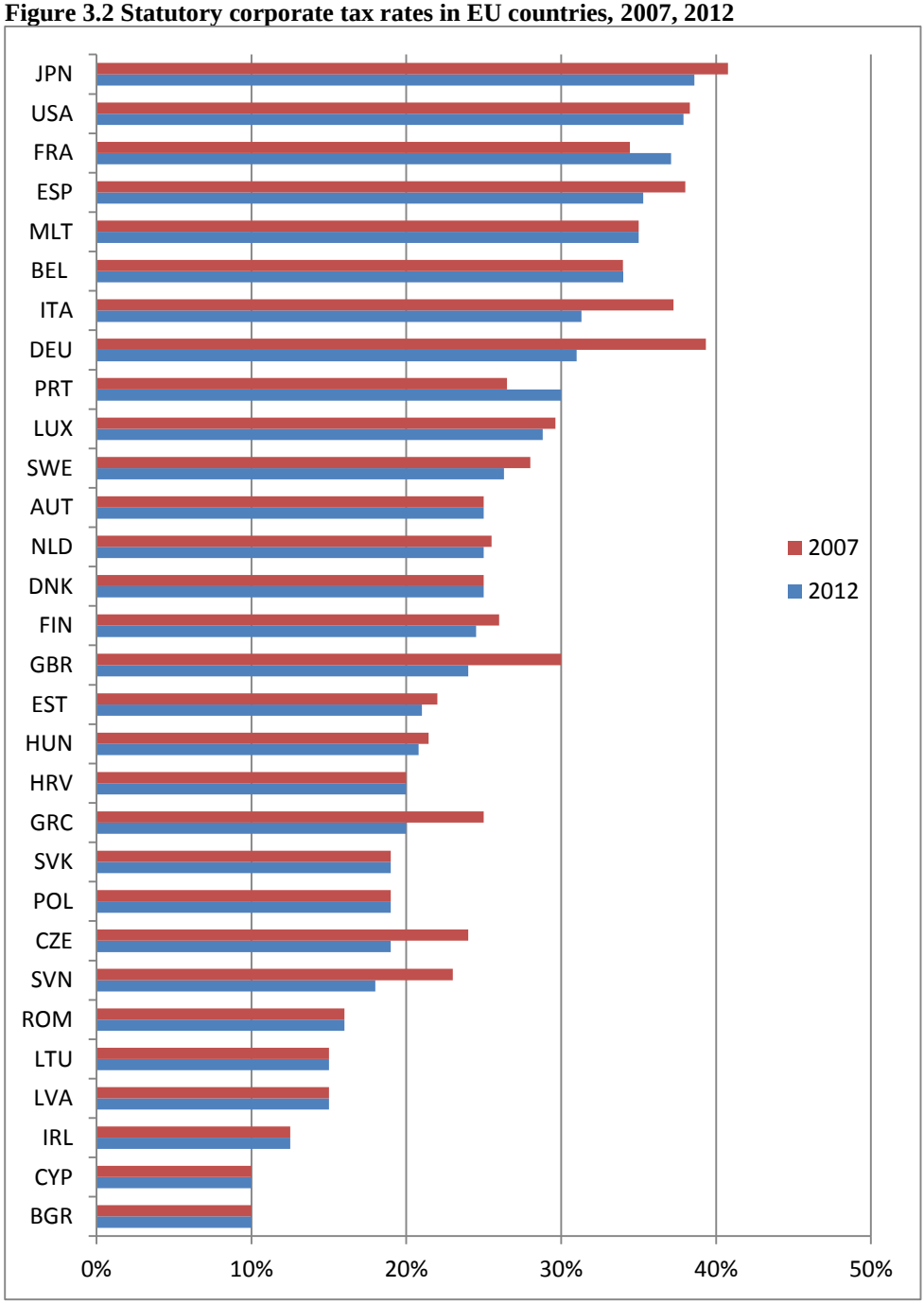
## 3.2 European Tax Systems and Model Baseline

In a model designed to appraise the impact of tax reforms, the initial structure of the tax systems concerned is extremely important. In the present calibration CORTAX is using tax data for 2012, implying that subsequent simulations of EU reforms produce outcomes relative to tax systems as they were in 2012. The baseline also describes economic changes induced by these reforms, as simulated by the model.

*Corporate tax rates*

Figure 2.2 presents prevalent statutory corporate income tax rates across the EU. These averaged at 23 percent in 2012, but with considerable variation across the EU, from a high 37 percent in France to a low 10 percent in Cyprus and Bulgaria. With respect to 2007, most countries either decreased, or maintained their tax rates, with the notable exceptions of France and Portugal.

**Figure 3.2 Statutory corporate tax rates in EU countries, 2007, 2012**




*Source*: ZEW (2014), "Effective Tax Levels Using Devereux/Griffith Methodology", p. 2

*Fiscal depreciation*

Differences in depreciation rules and inventory valuation mean that tax bases vary considerably across the EU. We have used information on tax laws of EU countries reported in ZEW (2012) to calculate relevant parameters such as the cost of capital. Table 2.2 summarises this information, presenting both rates and the rules for the calculation of annual allowances (declining balance [DB] or straight line [SL]). In 2012 most countries allowed SL depreciation for investments in buildings and intangibles (corresponding to prevalent rules for the depreciation of a patent), whereas for machinery the rules are more varied. Estonia has no depreciation scheme applicable, due to its unique corporate taxation rules.

**Table 3.2 Depreciation schemes and inventory valuation in corporate tax systems in the EU, 2012**

| | **Buildings** (number of years in brackets) | **Machinery** (number of years in brackets) | **Intangibles** (number of years in brackets) | **Inventory valuation** |
|---|---|---|---|---|
| Austria | SL 3% (33.33) | SL 14.29% (7) | SL 10% (10) | LIFO |
| Belgium | DB 10% (7) SL 5% (9.6) | DB 28.57%(2) SL 14.29% (3) | SL 20% (5) | LIFO |
| Bulgaria | SL 4% (25) | SL 30% (3.33) | SL 15% (6.67) | average |
| Croatia | SL 10% (10) | SL 50% (2) | SL 50% (2) | average |
| Cyprus | SL 4% (25) | SL 20% (5) | SL 20% (5) | FIFO |
| Czech Republic | DB 30 years | DB 6 years | SL 16.66% (6) | average |
| Denmark | SL 4% (25) | DB 25% (n.a.) | SL 100% (1) | FIFO |
| Estonia | n.a. | n.a. | n.a. | LIFO |
| Finland | DB 7% (n.a.) | DB 25% (n.a.) | SL 10% (10) | FIFO |
| France | SL 5% (20) | DB 32.14% (4) SL 7.07% (3) | SL 20% (5) | average |
| Germany | SL 3% (33.33) | SL 14.29% (7) | SL 20% (5) | LIFO |
| Greece | SL 8% (12.5) | DB 42.86% (4) SL 10.7% (1) | SL 10% (10) | LIFO |
| Hungary | SL 2% (50) | SL 50% (2) | SL 50% (2) | average |
| Ireland | SL 4% (25) | SL 12.5% (8) | SL 10% (10) | average |
| Italy | SL 2% (1) SL 4% (24.5) | SL 12.5% (7.5) SL 6.25% (1) | SL 33.33% (3) | LIFO |
| Latvia | DB 10% (n.a.) | DB 40% (n.a.) | SL 20% (5) | average |
| Lithuania | DB 25% (n.a.) | DB 40% (n.a.) | DB 66.66% (n.a.) | LIFO |
| Luxembourg | SL 4% (25) | DB 30% (4) SL 8% (3) | SL 20% (5) | LIFO |
| Malta | SL 12% (1) SL 2% (44) | SL 20% (5) | SL 10% (10) | FIFO |
| Netherlands | SL 2.5% (40) | SL 14.29% (7) | SL 20% (5) | LIFO |
| Poland | SL 2.5% (40) | SL 10% (10) | SL 20% (5) | LIFO |
| Portugal | SL 5% (20) | DB 35.71% (n.a.) | SL 10% (10) | average |
| Romania | SL 2.5% (40) | SL 50% (1) SL 8.33% (6) | SL 50% (1) SL 5.55% (9) | LIFO |
| Slovak Republic | DB 20 years | DB 6 years | SL 20% (5) | average |
| Slovenia | SL 3% (33.33) | SL 20% (5) | SL 10% (10) | average |
| Spain | SL 3% (33.33) | DB 28.57% (4) SL 8.68% (3) | DB 25% (6) SL 4.45% (4) | average |
| Sweden | SL 4% (25) | DB 30% (n.a.) | DB 30% (n.a.) | FIFO |
| UK | n.a. | DB 18% (n.a.) | SL 10% (10) | FIFO |

*Source*: ZEW (2014), pp. A15-A21.

Using information reported in Table 2.2 we calculate for each asset the net present value of the depreciation allowances as a share of the purchase price of the investment. Higher percentages denote more generous fiscal depreciation rules for that particular type of asset. Using shares of investment by different classes of assets from Orbis (as reported in Table 2.1) we then calculate a weighted average of these values for each of the one million firms considered. Finally, we calculate country-level medians to use in CORTAX. The choice of medians over means is in keeping with the previous calibration and has the attractive feature of minimising the influence of outliers. Table 2.3 presents country-level medians of firm-specific allowances, for the first year and net present value. Net present values vary considerably, from a low 12% in the United Kingdom to just over 60% in the

Netherlands, though most countries are in the 40-50% range. Compared to 2007 net present values increased on average for the first year, and especially, for the remaining years of tax depreciation.

**Table 3.3 Summary information about NPV of fiscal depreciation schemes in percent of purchase price**

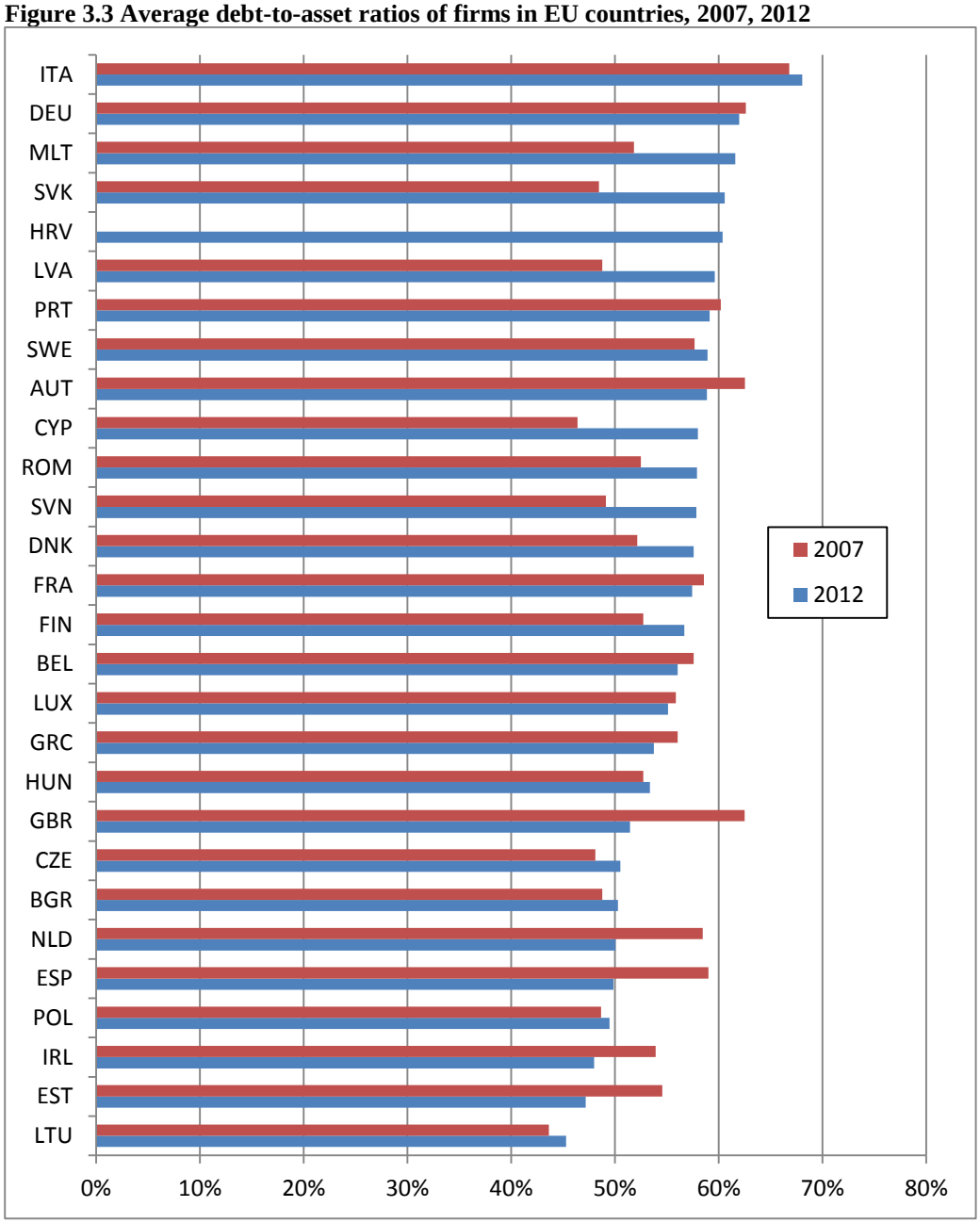
| | First year tax depreciation 2012 | Net present value of allowances 2012 | First year tax depreciation 2007 | Net present value of allowances 2007 |
|---|---|---|---|---|
| Austria | 3.92% | 43.10% | 5.31% | 36.83% |
| Belgium | 5.17% | 57.01% | 13.50% | 44.37% |
| Bulgaria | 6.89% | 49.01% | 6.14% | 39.93% |
| Croatia | 13.89% | 62.52% | | |
| Cyprus | 7.01% | 44.04% | 4.33% | 41.78% |
| Czech Republic | 4.98% | 49.68% | 4.32% | 39.26% |
| Denmark | 6.55% | 45.11% | 1.35% | 45.72% |
| Estonia | 0.00% | 0.00% | 0.00% | 0.00% |
| Finland | 7.88% | 49.41% | 8.80% | 40.46% |
| France | 5.05% | 53.00% | 9.64% | 40.07% |
| Germany | 3.95% | 43.10% | 8.80% | 35.67% |
| Greece | 6.32% | 57.04% | 6.01% | 41.09% |
| Hungary | 16.43% | 39.93% | 5.19% | 35.32% |
| Ireland | 4.24% | 47.84% | 4.32% | 35.79% |
| Italy | 2.02% | 46.73% | 5.98% | 38.04% |
| Latvia | 11.91% | 55.40% | 15.73% | 46.17% |
| Lithuania | 20.57% | 59.70% | 19.43% | 49.53% |
| Luxembourg | 3.57% | 48.47% | 9.45% | 39.35% |
| Malta | 10.07% | 41.76% | 6.87% | 28.79% |
| Netherlands | 8.51% | 60.74% | 8.01% | 35.70% |
| Poland | 3.84% | 38.99% | 4.52% | 37.41% |
| Portugal | 8.32% | 49.83% | 10.48% | 39.63% |
| Romania | 16.50% | 41.43% | 20.18% | 43.65% |
| Slovak Republic | 5.46% | 54.81% | 6.81% | 44.30% |
| Slovenia | 8.85% | 52.05% | 8.65% | 46.01% |
| Spain | 3.07% | 43.45% | 6.24% | 32.95% |
| Sweden | 6.88% | 48.61% | 9.57% | 39.68% |
| United Kingdom | 2.71% | 12.42% | 8.41% | 39.28% |
| EU (wei. ave.) | 4.92% | 43.03% | 7.61% | 37.87% |
| Standard deviation | 4.79% | 13.10% | 4.62% | 8.90% |

*Source*: National-level median values using ZEW depreciation schemes and weighted by Orbis investment shares.
Note: To better represent contemporary conditions, we assumed inflation=1.875%, risk-free real interest rate=1.5% and return on equity=3% (i.e. 25% lower than the values assumed by CPB).

*Effective marginal tax rates*

CORTAX calculates the EMTR for both equity- and debt-financed investment. The mode of financing is very important. Unlike equity finance, nominal interest is deductible for the corporate tax base allowing for more generous EMTR for debt-financed investment. To get a handle on how investment was actually financed by firms in 2012 we use Orbis to calculate average debt-share of investment across countries (Figure 2.3). These range from a high of almost 0.7 in Italy to a low of 0.4 in Lithuania. Compared to 2007, firms in most EU countries experienced a rise in their debt-to-asset ratio, likely a reflection of the protracted impact of the crisis.

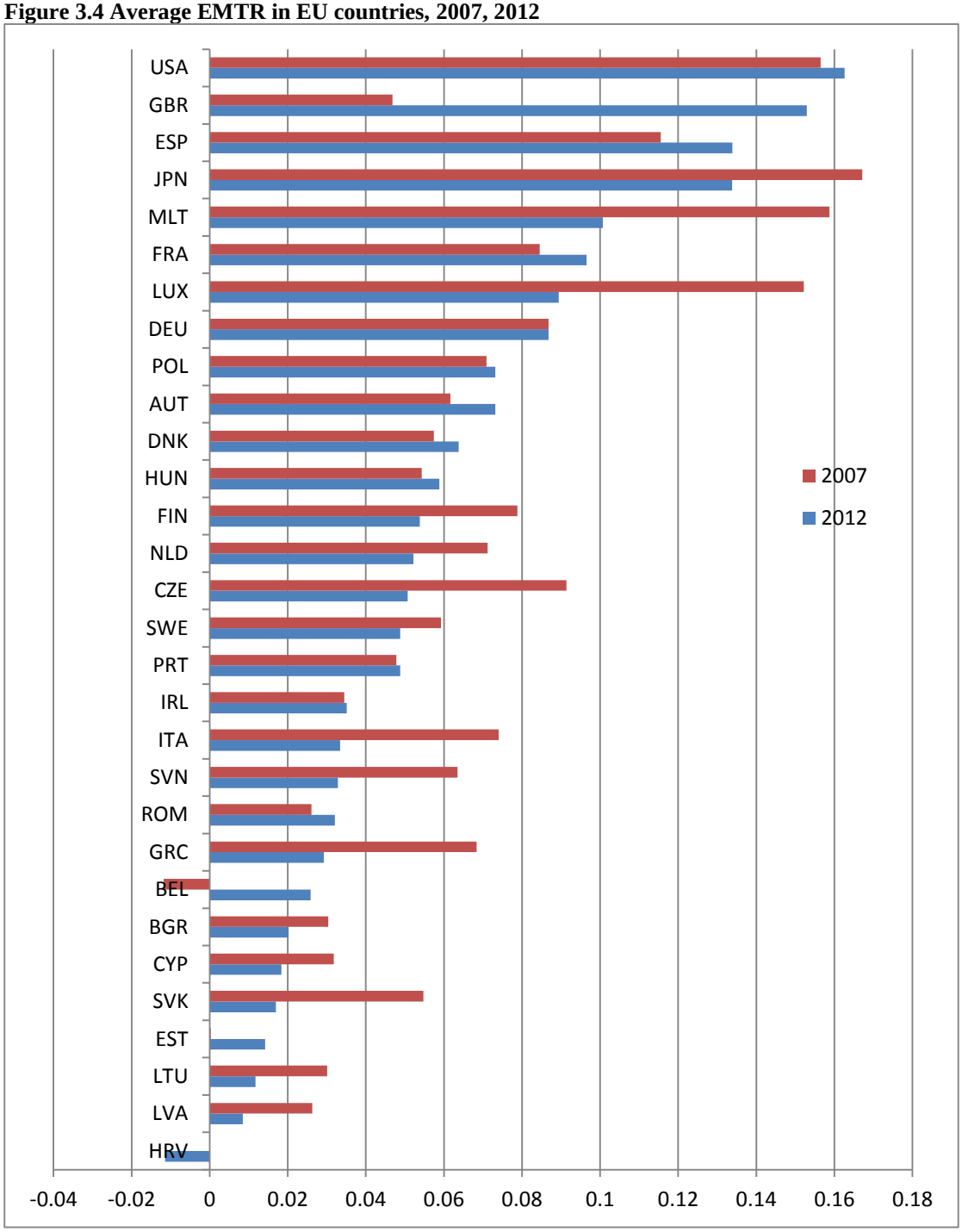
**Figure 3.3 Average debt-to-asset ratios of firms in EU countries, 2007, 2012**




*Source*: National-level averages from Orbis
Note: Croatia did not feature in the 2007 calibration of the model.

Using information on the debt-share of each country, CORTAX calculates a weighted average of EMTRs for debt and equity finance (Figure 2.4). This can be interpreted as a summary indicator of how distortionary the corporate tax system is for marginal investment decisions. On one end, the United Kingdom and Spain have the highest average EMTR whereas on the other end, Croatia has a negative EMTR.

**Figure 3.4 Average EMTR in EU countries, 2007, 2012**



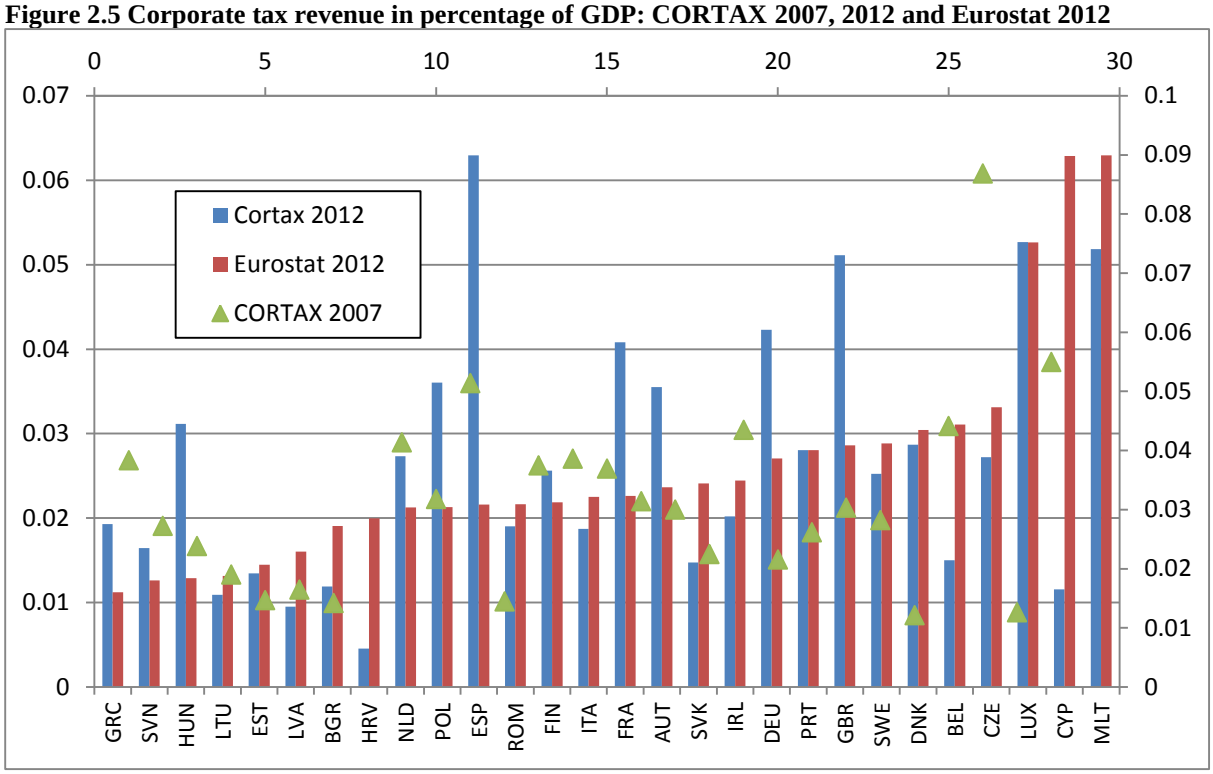

*Source*: CORTAX
Note: Croatia did not feature in the 2007 calibration of the model.

*Corporate tax revenue*

The CORTAX baseline simulates corporate tax revenues in each country. To determine the corporate tax base we use national accounts data on gross value added minus total labour income, thereby correcting for the income from the self-employed. The share of economic rents is set at 2.5% of value added. To calculate deductible costs we use fiscal depreciation rates from Table 2.3, a nominal interest rate of 3.4% and debt shares from Figure 2.3. In addition, we account for the possibility of firms to carry loss forward as well as for capital allowances.

Figure 2.5 shows the calibrated values in CORTAX for the corporate tax-to-GDP ratio versus those reported by Eurostat for 2012. Comparing CORTAX estimates with EUROSTAT data, we find that in terms of simple averages of the corporate tax-to-GDP ratio, the two are close (2.69% in CORTAX compared to 2.61% in Eurostat). Taking the GDP-weighted averages, the CORTAX figure is 3.69%, which is higher than the Eurostat figure of 2.46%.

**Figure 2.5 Corporate tax revenue in percentage of GDP: CORTAX 2007, 2012 and Eurostat 2012**




Source: Eurostat and CORTAX
Note: Croatia did not feature in the 2007 calibration of the model.

There are several factors that may cause the differences between the CORTAX and Eurostat estimates.[8] The CORTAX baseline includes profit shifting between countries parameterised according to available estimates, but naturally precise data does not exist. Furthermore, these figures are produced using the standard version of

[8] Some sensitivity analysis was carried out to investigate if one could more closely match the CORTAX and Eurostat revenue totals by adjusting the probability of a good event, in case the differences were due to this factor. The results were varied with the differences becoming somewhat smaller for some countries and somewhat larger for others. It was decided there was not sufficient evidence that this improved the calibration.

CORTAX *without* the tax haven, and some of the overestimation in CORTAX is likely due to the use of tax havens. Another relevant factor in determining the fit between Eurostat and CORTAX values is the use in CORTAX of a simplified definition of the tax base in terms of deductions and allowances. At country level a variety of exceptions to the general rules apply, which may cause an overestimation of revenues in certain countries where particular deductions are not accounted for (such as the various incentives for innovative investment in Hungary or the Innovation Box in the Netherlands). Lastly, in additional to profit shifting by some firms, there is always a degree of other forms of tax evasion and tax avoidance that is not fully accounted for.

# 4 Conclusion and further steps in the development of CORTAX

This short paper has documented the basic model structure, data used, updated calibration method and provided descriptive statistics for the baseline values of the model. It provides the most up to date snapshot of CORTAX's, against which a wide variety of policy simulations can be evaluated. However development of the model continues. In particular, work is underway to produce a version of CORTAX that includes knowledge production. This would endogenise investment decisions for innovation and the resulting production of intangible assets. This development would allow a more thorough analysis of tax incentives for research and development. As this would be linked to an improved representation of intangible assets, consequences for the ease of profit shifting could also be taken into account. Further developments will be considered as relevant policy questions arise.

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## JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

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