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HOW LARGE IS THE CORPORATE TAX BASE EROSION AND PROFIT SHIFTING? A GENERAL EQUILIBRIUM APPROACH

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Abstract

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JEL Classification: C68, E62, H25, H26, H87

Keywords: BEPS, Corporate taxation, Profit shifting, Tax avoidance, CGE model

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How Large is the Corporate Tax Base Erosion and Profit shifting? A General Equilibrium Approach

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Abstract

This paper estimates the size and macroeconomic effects of base erosion and profit shifting (BEPS) using a computable general equilibrium model designed for corporate taxation and multinationals. Our central estimate of the impact of BEPS on corporate tax losses for the EU amounts to €36 billion annually or 7.7% of total corporate tax revenues. The USA and Japan also appear to loose tax revenues respectively of €101 and €24 billion per year or 10.7% of corporate tax revenues in both cases. These estimates are consistent with gaps in bilateral multinationals´ activities reported by creditor and debtor countries using official statistics for the EU. Our results suggest that by increasing the cost of capital, eliminating profit shifting would slightly reduce investment and GDP. It would however raise corporate tax revenues thanks to enhanced domestic production. This in turn could reduce other taxes and increase welfare.

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1. Introduction

The fight against international corporate tax avoidance has been at the agenda of both the OECD and G20 countries for many years. Corporate tax avoidance is broadly defined "as acting within the law, sometimes at the edge of legality, to minimise or eliminate tax that would otherwise be legally owed" (European Commission, 2016a). Profit shifting specifically arises from the exploitation by multinational corporations of a combination of tax provisions, loopholes and/or mismatches between national tax systems. Although already a concern for many years, policy actions have recently stepped up. In 2013, following a call from the G20, the OECD (2013) launched its Base Erosion and Profit Shifting (BEPS) project. Likewise in recent years, the European Union has adopted a series of actions to fight tax avoidance and proposals to increase the transparency of the corporate tax system.[2]

There is a growing desire for policy-makers to try to measure BEPS, as exemplified by recent attempts by the IMF (2014) or "Action 11 - Measuring and Monitoring BEPS" of the BEPS project (OECD, 2015). Accordingly, several papers have tried to estimate the extent of BEPS using various econometric and estimation techniques. However while being informative, these estimates are limited when it comes to understanding the complete set of channels through which BEPS impacts on tax revenues. Clausing (2015) shows that BEPS can be detrimental to tax collection and makes it difficult for governments to accurately predict corporate tax revenues. Corporate tax avoidance also means that the tax burden falls onto other (less mobile) tax bases and this might penalise smaller companies or households (Dyreng et al., 2016) or companies in specific industries (Barrios and d'Andria, 2016) who cannot exploit international tax loopholes as effectively. Importantly, Sorge and Johansson (2016) show that profit shifting distorts competition, leading to higher market concentration and higher mark-ups for companies engaged in tax planning.

Against this background, corporate taxation increases the cost of capital and limits corporate investment. Hence, tax avoidance might also spur investment and produce some

[2] In 2012, the European Commission (2012) adopted an action plan to fight tax fraud and tax evasion and in March 2015 (European Commission 2015a) it presented a package on Tax Transparency. In June 2015, the European Commission (2015b) presented an Action Plan for a Fair and Efficient Corporate Taxation in the EU, in which it announces the re-launch of a proposal for a Common Consolidated Corporate Tax Base (CCCTB), eventually tabled in October 2016. It was followed by the Anti-Tax Avoidance Package (European Commission, 2016b) that consists of a set of proposals for Directive including legally-binding anti-abuse measures, provisions for country-by-country reporting between Member States' tax authorities, a recommendation to introduce a general anti-abuse rule in tax treaties and to revise the definition of permanent establishments, and a communication to invite EU member states to have a more coherent approach vis-à-vis third countries on good tax governance. In September 2017, The European Commission (2017) announced an EU agenda for the taxation of the digital economy. For an account of the fight against harmful tax practices in the EU and the OECD, see Nicodeme (2009).

benefits for the economy as well (see Gravelle, 2013). Mintz and Smart (2004) for example show that international tax planning may positively affect real investment. They find however that high-tax countries may want to eliminate tax planning and cut tax rates to reach a similar level of investment, but at a lower welfare cost. Hong and Smart (2010) use a partial equilibrium model and show that profit shifting to tax havens hurt tax collection in high tax countries while decreasing the sensitivity of real investment location to tax differentials. The latter effect would allow countries to keep or increase their tax rates without large impacts on outwards FDIs. Using a similar model, Slemrod and Wilson (2006) find on the contrary that profit shifting is welfare decreasing. The increased burden of taxes on labour due to profit shifting creates an additional source of deadweight loss. The elimination of tax havens would induce non-tax havens to increase their tax rates, which would otherwise be set at inefficiently low levels, and lead to a welfare improvement.

A comprehensive assessment encompassing the different channels through which BEPS impacts on the economy, taxes and welfare is yet missing. Such an assessment should in particular account for the multiple interactions between corporate tax avoidance, corporate investment and overall economic activity. The use of a computable general equilibrium model (CGE) is warranted in order to model these various channels and interactions and therefore provides a solid basis for comparing possible policy options aimed at curbing BEPS based on welfare analysis. To the best of our knowledge, this paper is the first attempt to estimate the cost of BEPS using such model.

To this aim we use CORTAX, a CGE model designed to assess the macroeconomic impact of tax policies. We calibrate this model for the EU28 Member States, Japan and the USA for the year 2012, which is the most recent year available that covers all dimensions of economic activity modelled in CORTAX. We model profit shifting through transfer pricing of multinationals operating within the EU and consider the presence of a hypothetical tax haven country (applying a 5% corporate tax rate). Unlike previous attempts to measure BEPS, our approach allows deriving the macroeconomic effects of curbing BEPS and the outcome on total tax collection, taking into account the feedback effects on other tax bases and interactions between countries.

Our results show that in our central scenario about €36 billion are lost in corporate tax revenues by EU countries from profit shifting activities. This corresponds to €37.3 billion sent to tax havens and a €1.3 billion net gain from profit shifting across other (non-tax havens) economies. This central estimate hides a large range of estimates reflecting the range of tax

rates elasticities available in the empirical economic literature. For instance, the net losses in tax revenues for the EU may range between €9.7 and €71.6 billion depending on the elasticities of tax shifting used in the calibration of the model. When considering the overall economic effect of BEPS, we find that while profit shifting decreases the cost of capital and hence raises investment and GDP, it has an overall negative and significant effect on welfare, amounting about 0.2% GDP for the EU. For the USA, the total tax revenues lost is estimated at €100.8 billion, including €96.8 billion due to profit shifting to tax havens, while Japan is estimated to lose €24.0 in total, of which €23.3 billion to tax havens. The large loss estimated for the USA can be traced back to its strong multinational links to other countries and one of the highest corporate tax rates. We also find that the welfare losses due to BEPS in Japan and the USA are also larger than the EU, reaching 0.4% of GDP in both cases.

The remaining of this paper is as follows. Section 2 reviews the economic literature on the measurement of profit shifting. Section 3 outlines the main characteristics of our CGE model. Next, Section 4 provides the modelling of BEPS and the calibration for profit shifting and Section 5 shows the results of our simulations. Section 6 displays the macroeconomic effects of restricting the access to tax havens and intra-firm profit shifting. Section 7 offers robustness checks with additional simulations using CORTAX. Finally, conclusions follow.

2. Literature review on the size of profit shifting

Partly because multinational enterprises (MNEs) do not publicise the use of specific tax planning schemes and tools, relatively little is known about the size of corporate tax avoidance. This task is further complicated by the fact that corporate tax avoidance covers a wide variety of possible behaviours such as debt shifting across countries, the manipulation of transfer prices, the location of physical activities of companies or some of their assets (notably intangible assets such as patents), the use of mismatches between tax regimes, the inversion of corporate structures between parents and affiliates, the deferral in repatriation of profit generated in low-tax jurisdictions or the use of treaties networks.[3] These various channels are difficult to measure and can often be used at the same time in complex tax planning structures. Ramboll and Corit (2016) have highlighted the main structures of aggressive tax planning which they consider being the most commonly used by multinational enterprises (MNEs) in the EU. Some of these practices have been designated as 'harmful tax practices' by the OECD and the European Union. Other practices have been targeted for possibly falling within the area of fiscal state aid under EU law (e.g. tax rulings).

[3] See e.g. IMF (2014), p.18.

It is useful to review here the existing literature on the estimates of tax shifting for at least two reasons: first to compare our own results with previous studies, even if those are based on partial equilibrium analysis and make use of different analytical tools; second because we can use these estimates to draw possible ranges of the extent of BEPS depending on plausible values for profit shifting estimates. Dharmapala (2014) and Riedel (2014) have produced reviews of the economic literature related to the measurement of the size of profit shifting. Dharmapala (2014) discusses the different approaches and data used for measuring BEPS across time and concludes that recent estimated values are smaller than the values obtained in studies done in the 1990s. He also highlights the need to deepen the research on the cost of tax planning in order to better understand the different behaviour of firms. The heterogeneity of results is also highlighted by Riedel (2014). The difficulty of measuring profit shifting is also evaluated by Zucman (2013), who looks at tax evasion of individuals and finds that 8% of the global financial wealth of households is held in tax havens (the present paper however focuses instead on corporate tax avoidance).

A first strand of the literature tries to explain the observed taxable profit of multinationals by a proxy measure of the 'true' profit. In this context, the true profit is split into a visible part, generated by the quantity of labour and capital inputs used, and a hidden part 'shifted' to third countries. The latter can be explained by a measure of the tax-related incentive to shift profit and specific company-level characteristics. Hines and Rice (1994) provide a seminal example of this type of analysis using country-level aggregate data of US non-financial companies for 1982 and regressing their reported profit on measures of the costs of capital, labour and on local corporate tax rates. They find that increasing the local corporate tax rate by 1 percentage point reduces reported earnings by between 2.5 and 7%, depending on the model specifications. Using similar data, Grubert and Mutti (1991) estimate the impact of statutory and effective average corporate taxes on measures of profitability of US manufacturing affiliates in 33 jurisdictions in 1982. They find strong negative effects for both measures of taxes, suggesting that higher tax rates lead to lower reported profit. They also find evidence of non-linear effects with a stronger influence at lower tax rates.

With the increased availability of firm-level data, several authors have subsequently used a similar approach to estimate the magnitude of profit shifting. Huizinga and Laeven (2008) use firm-level data for multinationals and their affiliates in 32 European countries in 1999 using the Amadeus database from Bureau van Dijk covering EU countries. They find a semi-elasticity of pre-tax reported profit of 1.31 with respect to corporate tax rates,

corresponding to an elasticity of 0.45. Based on these estimates, they find that changes in tax revenues due to international profit shifting for the EU amounts to about USD 900 million, mostly at the expense of Germany. Using data for German multinationals, Weichenrieder (2009) finds that a 10 percentage-points increase in the parent's country tax rate leads to about half a percentage-point increase in the reported profitability of their German subsidiaries which, given the mean value in his study, correspond to a semi-elasticity of around 0.9. Using German data, Gumpert, Hines and Schnitzer (2016) find that a one-percentage point increase in the foreign tax rate increases the likelihood of owning a tax haven affiliate. Using firm-level data for US MNEs between 2002 and 2012, Dowd, Landefeld and Moore (2017) find an average semi-elasticity of reported profit of 1.4. They also report non-linearities with much stronger effects at lower rates. Heckemeyer and Overesch (2013) carry out a meta-analysis of 25 available studies and report a 'consensus' semi-elasticity of 0.82. The OECD (2015) uses firm-level data using the Orbis database from Bureau van Dijk on unconsolidated accounts of affiliates for 2000-2010 and find a semi-elasticity of reported profit of around 1. Using this point estimate, they estimate the total net revenue losses between 4 and 10% of CIT revenue, which is equivalent to USD 100-240 billion in 2014.[4] The existing literature therefore reports a wide variety of estimates for profit shifting elasticities which might be attributed to differences in data used, case-studies, periods or industries considered. Against this background the results reported in the meta-analysis by Heckemeyer and Overesch (2013) provide in our view a reliable estimate on which to base our central scenario.

In another strand of the literature, the IMF (2014) and Crivelli, De Mooij and Keen (2015) propose to estimate BEPS with strategic rates spillover whose estimates might be closely compared to ours as they look specifically at the extent of BEPS, although their analysis relies on econometric estimations and not on CGE estimates. In this setting, the corporate tax base is regressed on its lagged value, the domestic corporate tax rate, a weighted average of the CIT rates of relevant countries and a set of controls. Using data for 173 countries between 1980 and 2013, Crivelli et al. (2015) find that the domestic corporate tax rate has a negative effect on domestic reported profit with a semi-elasticity of 0.9 while the

[4] It is important to note that the OECD methodology uses estimated semi-elasticities (which are biased toward EU MNEs in Orbis) and multiplies it by a measure of average tax differential and again multiplies it by total CIT revenues, obtaining a measure in USD of lost revenues. The average tax differential, though, is obtained as a weighted average across countries, using tax revenues as weights. This is how an accumulated revenue loss estimate over 2005-2014 of 0.9-2.1 USD trillion and of 100-204 USD for 2014 are obtained. Clearly the combined limitations of Orbis which is heavily EU-centric, the fact that MNEs are unevenly distributed, and the choice to weight the data by tax revenues, make their estimates much more related to EU-USA-Japan than to the rest of the world and thus comparable to our analysis in terms of geographical coverage.

weighted average of the rates in relevant countries exerts a positive effect. Using previous estimates reported by the IMF (2014), Crivelli et al. (2015) also distinguish between short and long-run impact of BEPS. They find that revenue losses due to BEPS are for the OECD of 0.2% GDP (or USD 95 billion) in the short-run and around 1% GDP in the long-run. Applying a similar methodology, Cobham and Jansky (2017) find slightly lower semi-elasticities with global revenue losses of USD 500 billion compared to USD 650 billion in Crivelli et al. (2015).

The IMF (2014) and Dover et al. (2015) also provide estimates based on the so-called CIT efficiency approach. CIT efficiency is defined as the ratio of CIT revenue collected to a measure of what would be collected if the gross operating surplus of corporations – a concept close to EBITDA – would be taxed at the standard CIT rate. The IMF (2014) uses a sample of 51 countries for 1980-2012 and finds that the mean CIT efficiency is 43% when the gross operating surplus (GOS) is used as reference and 86% when the net operating surplus (NOS) is used instead. Dover et al. (2015) find a level of CIT efficiency for the EU for 2009-2013 of about 75% using the NOS reference.[5] Both studies then make the assumption that the average CIT efficiency multiplied by the operating profit and the standard tax rate approximate the revenue that should be collected without profit shifting and that any deviation from that estimated revenue is due to profit shifting.[6] The IMF (2014) reports an unweighted average revenue loss of about 5% of the current CIT revenue. Dover et al. (2015) find that the estimated revenue loss for the EU amounts to €52.3 billion for 2013 and a yearly average of €72.3 billion for the period 2009-2013.[7] Candau and Le Cacheux (2017) have updated this figure for 2015. Using the NOS reference, they find a CIT efficiency of 72%, leading to an estimated CIT loss for the EU28 of about EUR 15 billion per year only.

Yet another strand of the literature proposes to estimate profit shifting using FDI data. This method, developed by the UNCTAD (2015), uses the lower rate of return of FDI stocks from offshores financial centres to estimate profit shifting from direct investment channels. Using this approach profit shifting would amount to USD 200 billion annually for the world economy whereas, refining and updating the computations, Jansky and Palansky (2017) put the figure at between USD 52 and 66 billion using a similar approach covering more years and countries.

[5] Their NOS is adjusted for imputed compensation of self-employed. Importantly, the 75% CIT-efficiency figure is an arithmetic average across the 25 available Member States (EU28 bar Finland, Hungary and Spain).

[6] Which by itself is problematic as companies are in practice neither taxed on their EBITDA nor their EBIT.

[7] The authors also report the figures if CIT-efficiency would be 100% (i.e. Net Operating Surplus would be taxed instead of taxable profit): they are respectively €160.2 billion and EUR €188.1 billion.

Finally, some authors estimate tax avoidance of MNEs by comparing the tax payments of multinationals with those of comparable domestic companies. Egger, Eggert and Winner (2010) find that for 1999-2004 European foreign-owned affiliates pay on average 32% less than domestically-owned companies. Using a similar methodology for German companies in 2007, Finke (2013) finds this difference to be 27%. One issue with this approach however is that the lower taxes paid by multinationals could be due to other reasons than BEPS.

In the following we present our results based on a computable general equilibrium (CGE) which, by contrast with the aforementioned studies, account for the interaction of corporate profit shifting and base erosion with corporate investment and markets while incorporating third country effects.

3. Model description

We evaluate the effects of BEPS in the EU are evaluated using the CORTAX model, a CGE model with a strong focus on corporate taxation elaborated for the 28 member states of the European Union plus the USA, Japan and a tax haven as third countries. This section provides an overview of the model, with the exception of the corporate tax base and profit shifting which are explained in Section 4. A more detailed description of this model can be found in Bettendorf, L. and van der Horst, A. (2006) and Álvarez-Martínez et al. (2016).

The model was originally developed by the Centraal Planbureau (CPB) (Bettendorf and van der Horst, 2006 and Bettendorf et al., 2009) and is based on Sorensen's (2001) OECDTAX model. The fixed parameters and elasticities in the model have been calculated using data for 2012 from various sources such as the ZEW database on corporate taxation, the Orbis corporate companies database (Bureau van Dijk), Eurostat and the EUROMOD microsimulation model. CORTAX simulates the effects of corporate tax changes taking into account the interactions between all agents in the economy but given special attention to firms, which have been disentangled into domestic firms, multinational headquarters and subsidiaries. The model includes households, government and a foreign sector. Countries are linked through international trade in intermediate goods and investment by multinationals. Multinational firms maximise profits globally and for this reason they may engage in international profit shifting activities. Profit shifting between countries other than the tax haven is modelled through transfer pricing. Multinationals can artificially increase or reduce the price of intermediates in order to adjust internal costs and shift benefits to third countries, including tax havens. The model also includes compliance costs to reflect the administrative

cost of profit shifting (i.e. related to the cost of dealing with different legislations, accounting standards, etc.) which is modelled as a non-linear function of the amount of profit shifted abroad.

All firms have the same the production function, which for domestic and multinational headquarters is a Cobb-Douglas combination of fixed factor (A^n) and value added($VA(j)^n$):

$$Y^n(j) = (A^n)^{1-\alpha_v^n} (VA(j)^n)^{\alpha_v^n} \quad (1)$$

with n = domestic (d) or multinational headquarters (m), j = country-specific firm, and α_v^n = share of value-added in production, and A^n is the product of total factor productivity and the exogenous fraction of the fixed factor used in production (scaled by the size of the young generation).

Multinationals´ subsidiaries (f) also use an intermediate input $(Q(j)^{\alpha_q})$ supplied by their headquarters, with $\alpha_q$share of intermediate good in production. The price of this input is adjusted by corporate groups to shift profits across countries. The production function of the subsidiaries is described by Equation 2.

$$Y^f(j) = (A^f)^{1-\alpha_q-\alpha_v^f} Q(j)^{\alpha_q} (VA(j)^f)^{\alpha_v^f} \quad \text{with } 0 < \alpha_q + \alpha_v^f < 1 \quad (2)$$

A^f is analogous to A^n in Equation (1). Firms' value added is described as a CES combination of labour $(L(j))$ and capital $(K(j))$ as in Equation (3):

$$VA(j)^n = A_0 \left[\alpha_{vl}^n (L(j)^n)^{\frac{\alpha_v^n - 1}{\alpha_v^n}} + \alpha_{vk}^n (K(j)^n)^{\frac{\alpha_v^n - 1}{\alpha_v^n}} \right]^{\frac{\sigma_v^n}{\alpha_v^n - 1}} \quad (3)$$

where A_0 is the total factor productivity, α_{vl}^n is a share parameter, σ_v^n is the substitution elasticity between capital and labour.

The aggregate level of production in country *j* is calculated as the sum of production in all industries net of intermediate inputs in foreign subsidiaries:

$$Y(j) = q\left[Y^{dg}(j) + Y^{mg}(j) + \sum_{j\neq i} Y^{fg}(i,j)\right]$$
$$+ (1-q)\left[Y^{db}(j) + Y^{mb}(j) + \sum_{j\neq i} Y^{fb}(i,j)\right] \quad (4)$$
$$+ \quad -\sum_{j\neq i} p_q(i,j)Q(i,j)$$

Where (q) is the probability of a good event (g) and $(1-q)$ the probability of a bad event (b) which are estimated using the Orbis database by country. $Y^{dg}(i)$ represents domestic production, $Y^{mg}(i)$ represents the production of parent companies and $\sum_{j\neq i} Y^{fg}(i,j)$ is the production of subsidiaries.

Firms maximise their value, which equals the sum over the present value of the dividends, V_t^n, subject to the possibilities of the production function and accumulation constraints on physical capital and fiscal depreciation.

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

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

$$R_s \equiv \frac{1}{(1+\bar{r}_e)^{s-t+1}}$$
$$\bar{r}_e \equiv \frac{r_e}{(1-\tau_g)} \quad (6)$$
$$\Lambda \equiv \frac{(1-\tau_d)}{(1-\tau_g)}$$

Where Div_s^n are the dividends, $\bar{r}_e$ represents the discount rate relevant for firms in making decisions and r_e is net return on equity. τ_g is the tax rate on capital gains and τ_d the tax rate on dividends.

$$E\left(Div_t^d\right) = E\left(Y_t^d\right) - w_t L_t^d - \left(d_{b,t}^d \hat{r}_{wb} + c_b^d\right)K_t^d - F_t^d \quad (7)$$

$$-q\tau_t^d \Pi_t^d - I_t^d + d_{b,t+1}^d K_{t+1}^d - d_{b,t}^d K_t^d$$

Where Y denotes total production, *wL* labour demand, $d_b$the share of debt financing, $\hat{r}_{wb}$ the interest rate, $dc_b$the cost of financial distress, *K* the quantity of capital, *I* the amount of investments, *F* returns to fixed factors, *Π* corporate tax base and τ corporate tax rate.

$$\begin{aligned} E(Div_t^m) = E(Y_t^m) - w_t L_t^m + \sum_j \left(p_{q(j)} - 1 - c_{q(j)}\right) Q_j - \left(d_{b,t}^m \hat{r}_{wb} + c_b^m\right) K_t^m \\ - F_t^m - q\tau_t^m \Pi_t^m - I_t^m + d_{b,t+1}^m K_{t+1}^m - d_{b,t}^m K_t^m \end{aligned} \quad (8)$$

$$\begin{aligned} E\left(Div_t^f\right) = E\left(Y_t^f\right) - w_t L_t^f + p_q Q - \left(d_{b,t}^f \hat{r}_{wb} + c_b^f\right) K_t^f - F_t^f - q\tau_t^f \Pi_t^f - I_t^f \\ + d_{b,t+1}^f K_{t+1}^f - d_{b,t}^f K_t^f \end{aligned} \quad (9)$$

Equations for multinational headquarters (m) and subsidiaries (f) include an additional factor, which capture transfer pricing, with $p_q$price of intermediate input, $c_q$cost of transfer pricing and 1 real cost.

In the model, government is an intermediate agent with revenues from taxes on consumption, labour and corporations and expenditures on public consumption and debt. The last two variables are fixed in proportion to GDP and lump sum transfers are also fixed. In the current version of the model, changes in corporate tax revenues are compensated for by adjusting consumption tax revenues in order to keep the public budget constant.

The effects on welfare are calculated using the compensating variation. In the model, intra-temporal households' utility is calculated as a CES combination of consumption and leisure of an old and a young generation. The intertemporal utility (U_t) is a Log-CES function of old (v^o) and young (v^y) intratemporal utility functions.

$$U_t = \frac{1}{1 - 1/\sigma_u} \left[\left(v_t^y\right)^{1-\frac{1}{\sigma_u}} + \frac{\rho_0}{\rho_u^T} \left(v_t^o\right)^{1-\frac{1}{\sigma_u}} \right]_t \sum_{\tau=0}^{T-1} \left(\frac{1+g_a}{\rho_u}\right)^{\tau} \quad (10)$$

Where σ_u measures the degree of substitutability between consumption and leisure across years, ρ is a discount rate and g_a is a growth rate. Households maximize this utility subject to their life-time budget constraint:

$$\overline{w_t}l + tr_t^y - (1+\tau_c)c_t^y = -\left(\frac{1+g_a}{\rho_s}\right)^T [\pi_t^0 + tr_t^o - (1+\tau_c)c_t^o] \quad (11)$$

With $\overline{w_t}$ being the after tax wage rate and tr_t^y being the current transfers received by young households. The terms c_t^y and c_t^o are consumption by the young and old generations and τ_c is the corresponding consumption tax rate. The term π_t^0 is the revenue generated by the fixed factor and received by old households, which are the owners of this factor. Households maximize their utility (9) subject to their budget constraint (10). In the model, the variation of welfare is calculated as the compensating variation, which is the variation in transfers received by young households required to reach the initial level of utility after a shock. The compensating variation is calculated as a percentage of GDP.

$$compensating\ variation = -\frac{tr_f^y(U_t^0) - tr_t^y(U_t^0)}{GDP_0} \quad (12)$$

Where $tr_f^y(U_t^0)$ are the transfers received after the shock that keep the initial utility level of households and $tr_t^y(U_t^0)$ are the transfers before the shock. GDP_0 is the Gross domestic product in the base case scenario.

Finally, the foreign sector is an intermediate sector that accounts for the Balance of Payments adjustment. It captures the capital account, with the registration of net foreign assets, plus the trade balance, net foreign earnings on equities and bonds and FDI.

4. Modelling of BEPS and Calibration

This section discusses the variation of semi-elasticities and parameters used to calculate the magnitude of BEPS in the calibration of the model. CORTAX contains three types of firms: domestic, multinational headquarters and subsidiaries. Each country has one representative domestic firm, one representative multinational headquarters (that owns one foreign subsidiary in each of the foreign countries) and several subsidiaries, each of which is owned by its headquarters based in another foreign country. All firms maximise their value

subject to the production function and accumulation constraints on physical capital and fiscal depreciation described earlier. In addition multinationals can shift their profits across countries (within the EU, from or to the USA and Japan or the tax haven).

4.1 BEPS in CORTAX

Profit shifting between non-tax haven countries is modelled as transfer pricing. In practice, other methods of profit shifting are engaged in, especially debt shifting. As both transfer pricing and debt shifting are driven by differences in the statutory tax rates, they are both accounted for in the model through the transfer pricing coefficient. The profit shifting elasticities used indeed account for all types of profit shifting (other than to tax havens), and are taken from the relevant literature.[8] Importantly however, our model does not directly include the effects of specific and targeted tax regimes – e.g. patent boxes – used in aggressive tax planning structures and profit shifting are solely driven by differences in statutory rates. This is a common assumption, valid for the traditional profit-shifting channels and similar as in IMF (2014) and Crivelli et al. (2015).

Profit shifting between non-tax haven countries is carried out only by multinationals, which by assumption differ from domestic firms in their use of cross-border intermediate goods and services in the production process. These intermediate inputs are supplied by the parent headquarters to its foreign subsidiaries and they can charge a transfer price for intra-firm deliveries that deviates from the equivalent price that would be charged if it had been an inter-firm transaction (the 'arm's-length' price). Specifically, there is an incentive to set an artificially low or high price in order to shift profits from high to low tax countries and to minimise the overall tax burden. 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, which makes profit shifting increasingly costly at the margin.[9] The increase in the cost of transfer pricing, c_q, as a function of changes in the transfer price, $p_{q,(i,j)}$ with ε_q the elasticity of transfer pricing, is given by the following equation:

$$c_{q,(i,j)} = \frac{\left|p_{q,(i,j)} - 1\right|^{1+\varepsilon_q}}{1+\varepsilon_q} \tag{13}$$

[8] Details of the parameterisation are given below.

[9] Although countries with high tax rates may face higher transfer costs than low tax countries, a convex transfer cost function seems to be a good average approximation. On the other hand, there are firms that can shift all their profits to other low tax rates countries, but it does not seem to be the case in average, which reinforces the use of a convex cost function. A convex function is used by Bettendorf et al. (2009), Haufler and Schjelderup (1999) and many others.

This implies that the variation of the cost with respect to the price of intermediates is equal to the following expression:

$$\frac{\partial c_{q(i,j)}}{\partial p_{q(i,j)}} = sign\left(p_{q(i,j)} - 1\right) \times |p_{q(i,j)} - 1|^{\varepsilon_q} \quad (14)$$

By construction, if $p_{q(i,j)}$ equals 1, there is no transfer pricing (i.e. the arm's-length price is adhered to), and so there is no associated cost. The term ε_q is a parameter that determines the gradient of the cost of transfer pricing function. There is an incentive in place to set a price larger than one when the tax rate in the subsidiary country $\left(\tau_{\pi}^{f}\right)$ is lower than the tax rate in the headquarters country (τ_{π}^{m}), which artifically shifts profits to the subsidiary. The opposite is equally incentivised, and therefore:

$$p_{q(i,j)} > 1 \text{ if } \tau_{\pi}^{f} > \tau_{\pi}^{m} \text{ and } p_{q,(i,j)} < 1 \text{ if } \tau_{\pi}^{f} < \tau_{\pi}^{m} \quad (15)$$

In the former case, when the subsidiary has a higher tax rate than the headquarters, the price is adjusted from 1 as follows:

$$p_{q(i,j)} = \left\{1 + \left[\frac{\left(\tau_{\pi(j)}^{f} - \tau_{\pi,(i)}^{m}\right)}{\left(1 - \tau_{\pi,(i)}^{m}\right)}\right]^{1/\varepsilon_q}\right\} \quad (16)$$

In the latter case, the adjustment to the price is in the opposite direction:

$$p_{q(i,j)} = \left\{1 - \left[\frac{\left(\tau_{\pi,(i)}^{m} - \tau_{\pi(j)}^{f}\right)}{\left(1 - \tau_{\pi,(i)}^{m}\right)}\right]^{1/\varepsilon_q}\right\} \quad (17)$$

CORTAX models in detail the corporate tax base depending on the firm type. This is of particular relevance when estimating the size of BEPS and its impact on tax revenues. The tax base $\left(\Pi^{d}\right)$ of corporate taxation for domestic firms (d) is defined by Equation (18):

$$\begin{aligned} \Pi^{d} = Y^{d} - wL^{d} - \left(\beta_b d_b^{d} \hat{r}_{wb} + c_b^{d}\right)K^{d} - \left(\delta + \beta_e\left(1 - d_b^{d}\right)R_e\right)D^{d} \\ -\varphi I^{d} - \frac{(1-q)}{(1+\pi)\left(1+g_y\right)} F_{t-1}^{d} \end{aligned} \quad (18)$$

The corporate tax base is equal to total production (Y^d) minus labour cost (wage (w) times employment(L^d)), minus the deduction for the cost of debt (the sum of the product of the deductible fraction of debt (β_b), the share of debt financing $\left(d_b^d\right)$ and the interest rate ($\hat{r}_{wb}$) and of the cost of financial distress (c_b^d)), times the quantity of capital (K^d)), minus depreciation allowances ($\delta_t D^d$), minus equity allowances (the deductible fraction of equity β_e times the share of equity financing ($1 - d_b^m$) times the opportunity cost of equity R_e times the stock of depreciation allowances D^d), minus the amount of investments that can be expensed immediately (the rate of immediate expensing, φ, times the investment level, I^d), minus the value of losses carried forward (the probability of having made a loss in the previous period $1 - q$ times the loss made in that period F_{t-1} depreciated by inflation π and the growth rate g_y).

For multinationals, the corporate tax base includes the intermediate input $p_q Q$ that allows for transfer pricing and therefore affects the relative size of the tax base of the parent and its subsidiaries. The expression of the tax base for headquarters (m) is defined as follows:

$$\Pi^m = Y^m - wL^m - (\beta_b d_b^m \hat{r}_{wb} + c_b^m)K^m - (\delta + \beta_e(1 - d_b^m)R_e)D^m - \varphi I^m + \sum_j (p_{q(j)} - 1 - c_{q(j)})\, Q_j - \frac{(1-q)}{(1+\pi)(1+g_y)} F_{t-1}^m \quad (19)$$

Where j indicates the subsidiary's location, and c_q is the cost arising from a distorted transfer price($p_q \neq 1$).

For subsidiaries the tax base will correspond to the following expression:

$$\Pi^f = Y^f - wL^f - \left(\beta_b d_b^f \hat{r}_{wb} + c_b^f\right)K^f - \left(\delta + \beta_e\left(1 - d_b^f\right)R_e\right)D^f - \varphi I^f - p_q Q^f - \frac{(1-q)}{(1+\pi)(1+g_y)} F_{t-1}^f \quad (20)$$

These equations enter the firms' maximisation problem via the definition of dividends (defined in Equations 7, 8 and 9), which explicitly captures price transferring. It follows that when computing the size of BEPS and its revenue and macroeconomic impact all behavioural responses, including from an investor perspective, are accounted for.

In order to parameterise the model´s profit functions, we use balance sheets and ownership structure based on micro-data from the Bureau Van Dijk's Orbis database to

produce national-level estimates of debt shares and corporate investment shares (by type of asset) and to compute the cost of capital (financed via equity or debt).

We calculate the total gains from profit shifting between non-tax haven countries separately from the total losses. The total gains are the sum of all the extra profits from inward profit shifting, which for any given country is a combination of (i) profit shifting from subsidiaries in foreign countries to that country's multinational headquarters, and (ii) profit shifting from multinational headquarters in foreign countries to subsidiaries in that country. Gains from profit shifting are only from foreign countries with higher tax rates (as is clear from the above equations). The calculation is made as follows:

$$TaxProfShHQ_{i,j} = \left(1 - p_{q(i,j)}\right) \times q_{i,j} \times qf_j \times \tau^{m}_{\pi,(i)} \quad (21)$$

$$TaxProfShSubs_{i,j} = \left(1 - p_{q(i,j)}\right) \times q_{i,j} \times qf_j \times \tau^{f}_{\pi,(j)} \quad (22)$$

The value of $p_{q,(i,j)}$ for each pair of headquarters and subsidiary is determined by the equations above with $p_{q,(i,j)}$ being higher the larger the value of τ^{f}_{π} is above τ^{m}_{π} (or lower if vice versa). The quantity of intermediate input used, $q_{i,j}$, depends on the size of the subsidiary[10] and qf_j is the probability that the firm makes a profit (without which no tax would be due in any case). This is then multiplied by the relevant tax rate, which is τ^{m}_{π} for profits moved to/from the headquarters, giving the tax gain/loss to/from the headquarters, $TaxProfShHQ_{i,j}$, and τ^{f}_{π} for profits moved to/from the subsidiaries, giving the tax gain/loss to/from the subsidiary, $TaxProfShSubs_{i,j}$. Therefore for every pair of headquarters and subsidiary, there is a gain/loss to/from the headquarters and an associated gain/loss to/from the subsidiary. Note that for every pair, the loss is always more than the associated gain (which is why the profits are shifted in the first place).

To calculate the total gain for a given country, one adds the positive values of shifting to headquarters to the negatives values of shifting from subsidiaries:

[10] In CORTAX, $q_{j,i}$ is stated in terms of per unit of labour, $ql_{j,i}$, and scaled by worked hours per potential hours, $l_{j,i}$, the number of workers, $N_{('young',i)}$, a conversion factor between the population sizes of host and investor countries, $\omega_{j,i}$, and a scaling factor to convert from hundreds of billions of euros to millions of euros.

$$TaxProfShGain_i = \sum_j \{TaxProfShHQ_{i,j}\} + \sum_j \{TaxProfShSubs_{j,i}\}$$
$$\forall\, TaxProfShHQ_{i,j} > 0 \,\&\, TaxProfShSubs_{i,j} < 0 \tag{23}$$

Conversely, for the total loss of a given country, one adds the negative values of shifting from headquarters to the positive values of shifting to subsidiaries:

$$TaxProfShLoss_i = \sum_j \{TaxProfShHQ_{i,j}\} + \sum_j \{TaxProfShSubs_{j,i}\}$$
$$\forall\, TaxProfShHQ_{i,j} < 0 \,\&\, TaxProfShSubs_{i,j} > 0 \tag{24}$$

Firms have the additional option to shift a portion of their profits to a notional tax haven jurisdiction with a low tax rate, i.e., the so-called tax haven. In the model, the loss in tax revenues for domestic government due to tax haven is determined according to the following expression:

$$\tau_\pi^m \theta^* \widehat{\Pi} = \tau_\pi^m A(\tau_\pi^m - \tau_\pi^h)^{\gamma_{sh}} \widehat{\Pi} \tag{25}$$

Where θ is the fraction of the tax base (Π) that is shifted to the tax haven where profit is taxed at tax rate τ_π^h, (compared to the non-tax haven tax rate τ_π^m) and A is a fraction representative of the notion that only a share of profits are amenable to profit shifting. The terms γ_{sh} is a profit-shifting elasticity parameter that measures the responsiveness of profit shifting to the tax differential between a given country *m* and the tax haven.

Our measure of tax revenues shifted to the tax haven from country *m* can then be expressed as:

$$LostTaxRevTaxHaven_m = \pi_{sh,d0} \times (\tau_m - \tau_{TH})^{\gamma_{sh}} \{Dom_{CITrevenue}\} + \pi_{sh,0} \times (\tau_m - \tau_{TH})^{\gamma_{sh}} \{MNE\_CITrevenue\} \tag{26}$$

where $\pi_{sh,d0}$ and $\pi_{sh,0}$ are profit-shifting parameters for domestic and multinational firms respectively and they represent the shares of revenue liable for profit shifting; τ_m is the tax rate in country m and τ_{TH} is the tax rate in the tax haven.

4.2 Calibration of profit shifting parameters.

For the calibration procedure we must choose a low corporate tax rate for the stylized tax haven country τ_{TH}. We assume a tax rate of 5%. To assess the extent of profit shifting, we need to parameterise $\pi_{sh,d0}$, $\pi_{sh,0}$and γ_{sh}. As mentioned above, Heckemeyer and Overesch (2013) provide a meta-analysis of tax sensitivity of affiliate's profits with respect to corporate tax rates and find a 'consensus' estimate for the predicted semi-elasticity of pre-tax profits to tax differentials of 0.821. Their study also allows distinguishing between financial and non-financial channels, with respective estimated semi-elasticities[11] of 0.227 and 0.594. In an international setting, we can assume that multinational enterprises have access to both types of profit shifting (non-financial and financial), whereas domestic firms have access to financial profit shifting only. This is because transfer pricing needs – by definition – at least two correlated parties in two different tax jurisdictions which may trade in goods or services and thus it can only be exploited by enterprises that have branches or affiliates in multiple countries. On the contrary, both multinational and domestic companies are in principle able to take advantage of tax deductibility of interest paid. In order to shift profits to a tax haven through interest payments, a firm needs to establish an entity in this low-tax jurisdiction, which has the sole purpose to supply lending facilities to it. We call it the Offshore Financial Centre company (OFC company). The difference between domestic and multinational firms is then qualified as a multinational trades an intermediate input factor across multiple affiliates, while a domestic firm is defined as a firm that has one production site only. Both multinational and domestic firms may have affiliated OFC companies located in the tax haven. However, we assume that only multinationals can exploit such OFC companies to engage in transfer pricing.[12] For these reasons, we assume that in the central case the semi-elasticity for domestic firms is 0.227 and that for multinationals is 0.821.

[11] The methodology proposed to separate semi-elasticities for transfer pricing and financial shifting exploits the use of EBIT and pre-tax profit as alternative dependent variables. Because EBIT is calculated as the difference between revenues and operating costs, thus before subtracting net financial costs, the semi-elasticity of EBIT only captures profit shifting that is not related to financial activities. The semi-elasticity of pre-tax profit, instead, includes both transfer pricing and financial shifting activities. As the two semi-elasticities are defined with respect to different bases, they are not directly comparable. Heckemeyer and Overesch (2013) proposed to transform the semi-elasticity of EBIT into an equivalent semi-elasticity also based on pre-tax profits. This is accomplished by multiplying the semi-elasticity of EBIT by the ratio of EBIT over pre-tax profits. Heckemeyer and Overesch (2013) used S&P500 data to compute this ratio and found that on average EBIT is 25% larger than pre-tax profit. Thus, the difference between the semi-elasticity of EBIT (multiplied by 1.25) and the semi-elasticity of pre-tax profit obtains an estimate for the semi-elasticity of financial shifting alone.

[12] The extent to which firms can undertake this form of profit shifting is constrained in many countries by thin capitalisation and earnings stripping rules, which apply to domestic and foreign EU firms alike (see Blouin et al. 2014).

We use these elasticities in our model, distinguishing between profit shifting to non-tax haven and to tax haven countries. The procedure followed aims at equating semi-elasticities taken from the literature by changing the parameters that define the effective taxable base. The semi-elasticity by country varies slightly due to the differences in statutory CIT rates, τ_m. This feature allows the response to vary appropriately depending on the benefit received. Instead of matching the semi-elasticity for every country, we choose values for the share of corporate revenues liability parameters for domestic and multinational firms $\pi_{sh,d0}$, $\pi_{sh,0}$, the elasticity of transfer pricing ε_q and the profit shifting elasticity γ_{sh}, , in order to match the cross-country weighted average of semi-elasticities and to meet our values of choice, see Equations (9) to (13). However many combinations of these parameters can produce the desired weighed average semi-elasticity. We address this by choosing γ_{sh} equal to 1 in order to have a quadratic cost function for profit shifting to the tax haven. For multinational firms, where profit shifting between non-tax haven countries is possible, the parameter ε_q needs to be derived as well. For the Central case, again we assume a quadratic cost function for this kind of profit shifting which implies an ε_q equal to 1. This value implies an average semi-elasticity of profit-shifting with respect to the tax rate of -0.363. As noted above, our estimate for the total semi-elasticity of profit shifting for multinationals -0.821, implying that the remaining -0.458 is due to profit shifting to tax havens. Given the quadratic cost function, the value for $\pi_{sh,0}$ can be calculated and is equal to 0.413. The same calculation can be done for domestic firms resulting in a $\pi_{sh,d0}$ of 0.215 to obtain a semi-elasticity of -0.227. The scenarios and parameters used for profit shifting are summarised in Table 1 below.

Table (1). Scenarios and parameters in CORTAX simulations

	Profit shifting between non-tax haven countries		**Profit shifting to tax havens**						**Total profit shifting**
	MNEs (only)		**Domestic firms**			**MNEs**			**MNEs (only)**
Scenarios (references for semi-elasticities)	**(1)** ε_q (see eq. 13)	**(2) semi-elast. to CIT rate**	**(3)** γ_{sh} (see eq.26)	**(4)** π_{shd0} (see eq.26)	**(5) semi-elast. to CIT rate**	**(6)** γ_{sh} (see eq.26)	**(7)** π_{sh0} (see eq. 26)	**(8) semi-elast. to CIT rate**	**(9) semi-elast. to CIT rate (2)+(8)**
1. Central scenario (Heckemeyer, Overesch, 2013)	1.000	-0.363	1.000	0.215	-0.227	1.000	0.413	-0.458	-0.821
2. Lower Bound (Barrios, d'Andria, 2016)	0.664	-0.156	1.000	0.000	0.000	1.000	0.188	-0.197	-0.353
3. Upper Bound (Dischinger et al., 2014) (Loretz, Mokkas, 2015)	1.610	-0.750	1.000	0.474	-0.535	1.000	0.771	-0.946	-1.696

As a sensitivity analysis, we also employ a set of upper- and lower-bound semi-elasticities using studies based on panel data regression models (see Table (1), rows 2 and 3). The most conservative estimates come from a recent study by Barrios and d'Andria (2016) where both EBIT and pre-tax profit were employed as dependent variables. They find the financial channel to be statistically insignificant, and therefore we set profit shifting by domestic firms to zero (as they only employ the financial channel). The semi-elasticity of pre-tax profit through the non-financial channel is then found to be 0.353, which is 43 percent lower than the estimate by Heckemeyer and Overesch (2013). In order to apportion this between non-tax haven and tax haven profit shifting, we reduce both semi-elasticities by the same percentage resulting in respective semi-elasticities of -0.156 and -0.197. The appropriate values for ε_q and π_{sh0} are recalculated to produce these semi-elasticities, giving 0.664 and 0.188.

As upper-bound estimate for the pre-tax profit we employ a semi-elasticity of 1.696 taken from Dischinger et al. (2014) who calculated it for a sub-sample of subsidiaries located in high-tax jurisdictions. This value is 2.07 times the Heckemeyer and Overesch (2013) estimate and the semi-elasticities for multinationals are adjusted proportionally to -0.750 and -0.946. The values for ε_q and π_{sh0} that produce these average elasticities are 1.610 and 0.771. Finally, to get an upper-bound estimate of the semi-elasticity of financial profit shifting, we refer to Loretz and Mokkas (2015) whose results imply (after applying the method from

Heckemeyer and Overesch 2013, discussed before, to transform the semi-elasticity of EBIT into one based on pre-tax profits) a value of 0.535. This is used for domestic firms (who only use financial profit shifting), and implies a value for π_{shd0} of 0.474.

Note finally that the tax elasticities in the model are common to all countries – taken as EU28 average – although we must acknowledge that in reality these may vary across countries. It is also important to note that the tax base is defined in terms of standard deductions and allowances. At country level, however, a variety of specific exceptions to the general rules apply. This may cause an overestimation of revenues in certain countries where particular deductions are not accounted for (such as patent boxes or IP boxes for revenues from intellectual property, which are available in several Member States). There may be particular differences for countries that make broad use of types of "special regimes" negotiated with individual firms or groups of firms. The rest of the model parameters are calibrated using 2012 data, detailed results of the model calibration are described in Joint Research Centre (2016).

It is important to note that our model assumes – as previous literature on profit shifting – that profit shifting is driven solely by the differences in statutory tax rates (through transfer pricing). Whereas there are strong empirical evidence of a negative and statistically significant relationship between the difference in statutory corporate tax rates and reported profit, other specific more complex channels of profit shifting may exist such as the exploitation of mismatches (e.g. different tax treatment of the same financial instrument, double deduction schemes, etc.) and specific tax regimes such as patent boxes which are not captured by the model. As a consequence in our model, countries with low statutory corporate tax rates are found to be beneficiaries of profit shifting at the expense of countries with high statutory corporate tax rates, although in practice countries with high statutory tax rates may also benefit from profit shifting through the use of specific regimes. For example, the United States – with a high statutory tax rate – may lose corporate tax revenues because US multinationals shift profit to tax havens and to European countries with lower statutory rates, but European countries may actually not capture the respective tax revenues at standard tax rates from these shifted profits if US multinationals use specific tax regimes. We hence need to be more cautious with regards to our results for profit shifting within the EU and between the EU and the two other developed economies in the model – the USA and Japan.

5. Central Estimates of BEPS.

In this section, we present the central scenario estimates and their comparison with alternative statistics since there are no other studies elaborated using a CGE model.

5.1 Main results

The results of the CORTAX model for tax revenues losses to profit shifting are given in Table (2). The respective columns show the corporate tax revenues that are (1) gained and (2) lost, (3) the net gain or loss from inter-country profit shifting, (4) the corporate tax revenue loss from profit shifting to the tax haven, (5) the total corporate tax revenue gain or loss from both types of profit shifting, (6) the gain or loss as a percentage of the baseline total CIT revenue[13] in the CORTAX model calibration and lastly (7) the gain or loss as a percentage of GDP.

Focusing on the profit shifting between non-tax haven countries in columns (1) to (3), in total there must be a net loss of corporate tax revenue since the reason for engaging in profit shifting is simply to move profits from higher tax to lower tax jurisdictions without further considerations regarding economic efficiency. For the 30 countries modelled, we estimate a net loss of €3.46 billion in profit shifting between non tax havens, which is composed of gains of €7.37 billion and losses of €10.82 billion.

Individual countries may record either net gains or net losses, with low (high) CIT rate countries usually experiencing net tax gains (losses). The magnitude of these absolute gains or losses is driven by the difference in the respective CIT rates and the size of the multinational links with other countries. In other words, they are driven by the size of the country's subsidiaries in foreign countries, and the size of foreign subsidiaries based in that country. For instance, Ireland, with a CIT rate of 12.5%, loses nearly no tax revenues and gains €283 million. The largest gains in absolute monetary value are in the UK, with a CIT of 24%, which despite losing some €103 million to countries with even lower CIT rates, receives large gains from countries with higher rates (especially from the USA and France).

It is no surprise that, with a statutory rate at 37.9%[14] and strong multinational links, the USA shows the largest absolute net losses (€4.0 billion). The second largest net loss is for France (€2.8 billion), which has strong multinational links to the other modelled countries and the highest CIT rate in the EU. Those countries with CIT rates close to the weighted average

[13] Note that this level of CIT revenue *includes* the gain or loss from profit shifting, which is part of the Central case calibration.

[14] This figure is composed of the federal rate of 35%, plus an estimate for state taxes (see Álvarez-Martínez et al., 2016, for details).

show a balance between gains and losses, Germany for example, with a CIT rate of 31%, shows gains of €712 million and losses of €869 million. It is interesting to note that (despite losses from profit-shifting within the EU member states) the profit shifting from the US and Japan to the EU is large enough to cause a net loss of €1.3 billion.

Profit shifting to tax havens (Table (2), column (4)) causes only losses in revenue which are significantly larger than the profit shifting taking place between non-tax havens countries. As explained above, the losses are driven by the combination of the size of the CIT revenues and the prevailing CIT rate. Our results suggest that the largest absolute loss will be recorded by the US at €96.8 billion, with Japan the second largest at €23.3 billion. The EU-annual average loss is €37.3 billion, putting the join aggregate loss for US, Japan and the EU at €160 billion, a figure very close to the €186 billion calculated by Tørsløv et al. (2017) for the world's tax revenues losses due to profit shifting to tax havens every year. The largest losses in the EU are experimented by Germany (€8.5 billion) which, despite having a lower CIT rate than France, has also a larger CIT base.

The total net gain or loss from both types of profit shifting is shown in Column (5). To highlight the relative importance of these figures, Column (6) in Table 2 gives this figure as a share of total CIT revenues. The total net loss across all 30 countries is €160.8 billion or 9.85% of CIT revenue. The EU shows a net loss for the €36.0 billion or 7.73% of CIT revenues, showing that the losses to the tax haven swamp the gains for inter-country profit shifting. Four countries show overall tax revenues gains, with Ireland being the largest beneficiary of profit shifting (€204 million or 6.7% of CIT revenues). The largest absolute losses are again the US and Japan. The largest loss as a share of CIT revenue is 15.95% for Malta (driven by its high 35% statutory corporate tax rate), followed by France (14.94%) and Belgium (14.89%).

Table (2). Gains and losses in corporate tax revenues due to profit shifting (€ Millions)

	(1) Tax revenues via inter-country profit shifting GAINS	(2) Tax revenues via inter-country profit shifting LOSSES	(3) Tax revenues via inter-country profit shifting NET (1)+(2)	(4) Total tax revenues lost via profit-shifting to tax havens	(5) Total tax revenues gained/lost via profit-shifting (3)+(4)	(6) Total revenues lost as % of total CIT revenue	(7) Total revenues lost as % of GDP
Austria	180.4	-72.8	107.5	-619.9	-512.3	-5.33%	-0.18%
Belgium	309.9	-574.5	-264.7	-715.6	-980.2	-14.89%	-0.27%
Denmark	133.0	-19.3	113.8	-337.2	-223.5	-4.53%	-0.12%
Finland	81.5	-22.0	59.5	-253.7	-194.2	-4.93%	-0.12%
France	66.9	-2,867.3	-2,800.4	-7,505.3	-10,305.7	-14.94%	-0.54%
Germany	712.1	-868.8	-156.7	-8,509.0	-8,665.7	-8.27%	-0.32%
Greece	22.6	-5.8	16.7	-178.7	-162.0	-3.96%	-0.07%
Croatia	17.2	-0.5	16.6	-14.7	1.9	0.65%	0.00%
Ireland	283.2	-0.1	283.1	-78.7	204.4	6.70%	0.13%
Italy	255.2	-318.4	-63.2	-2,945.5	-3,008.7	-8.40%	-0.18%
Luxembourg	211.4	-111.6	99.8	-164.0	-64.1	-3.67%	-0.18%
Netherlands	1,049.3	-131.0	918.4	-1,036.7	-118.3	-0.82%	-0.02%
Portugal	55.5	-35.0	20.6	-442.7	-422.1	-7.80%	-0.20%
Spain	77.2	-761.9	-684.7	-6,478.4	-7,163.0	-10.81%	-0.61%
Sweden	226.7	-116.2	110.4	-570.3	-459.8	-6.22%	-0.15%
UK	3,108.3	-102.5	3,005.8	-5,593.7	-2,587.9	-3.08%	-0.15%
Cyprus	11.8	0.0	11.8	-3.8	8.0	3.41%	0.04%
Czech Rep.	88.0	-1.8	86.2	-252.1	-165.9	-2.86%	-0.07%
Estonia	7.1	-2.1	5.0	-16.3	-11.3	-3.41%	-0.04%
Hungary	96.5	-3.6	92.9	-255.6	-162.7	-3.13%	-0.09%
Latvia	6.0	-0.1	5.9	-9.5	-3.6	-1.13%	-0.01%
Lithuania	7.3	-0.1	7.3	-17.3	-10.0	-1.68%	-0.02%
Malta	0.1	-18.0	-17.9	-52.9	-70.8	-15.95%	-0.73%
Poland	198.7	-1.7	197.0	-986.7	-789.7	-3.37%	-0.12%
Slovakia	29.6	-0.6	29.0	-67.1	-38.1	-2.46%	-0.03%
Slovenia	15.0	-0.1	15.0	-28.7	-13.7	-1.95%	-0.03%
Bulgaria	18.4	0.0	18.4	-15.7	2.7	0.26%	0.00%
Romania	51.1	-0.4	50.7	-165.1	-114.4	-2.26%	-0.04%
USA	46.5	-4,063.4	-4,016.9	-96,789.9	-100,806.9	-10.69%	-0.79%
Japan	0.0	-722.7	-722.7	-23,261.5	-23,984.2	-10.74%	-0.67%
Total	7,366.6	-10,822.4	-3,455.7	-157,366.3	-160,822.0	-9.85%	-0.54%
EU	7,320.2	-6,036.3	1,283.9	-37,314.8	-36,030.9	-7.73%	-0.27%

5.2 Comparing our estimates of BEPS with alternative sources.

To the best of our knowledge there are no other estimates of BEPS using a general equilibrium model such as ours. As a way of checking whether our estimates provide sensible measures of BEPS we can compare our results with alternative statistics, although we must acknowledge that such comparison is only tentative and meant to compare orders of magnitude. To this end we rely on the foreign affiliates statistics (FATS) published by Eurostat.[15] The FATS data set provides aggregate bilateral country-to-country information for companies that are controlled by foreign entities and is used here to investigate the differences in estimates of foreign affiliates´ activities depending on the country reporting such statistics. Our approach is analogue to the one used by Lane and Milesi-Ferretti (2007) on the existence of a global gap in foreign investment portfolio when comparing statistics reported by debtor and creditor countries. Here we use turnover figures for "outward" FATS, meaning that the values are for companies that are resident in a non-EU country and are owned by an ultimate controlling entity resident in an EU country. In this way, we can obtain total turnover estimated to be produced/declared, for example, in the Cayman Islands by affiliates to multinational groups having their ultimate controlling entity in, say, France.

As a first step to proxy the profits of EU multinationals that are located in tax havens we need to define which countries are deemed "tax havens".[16] We use two definitions in this paper. The first one defines a jurisdiction as tax haven if it was included in the common EU list of third country jurisdictions for tax purposes adopted in December 2017 and whose so-called black list contains 17 jurisdictions.[17] This list can be used as a reference for a lower bound of BEPS estimates. The second definition uses Eurostat (2012, page 83)'s list of "off-shore" centres which includes a broader set of 40 countries and which can be used as a reference for a higher bound for estimating BEPS.[18] We add-up the total turnover that all multinational EU companies (having the ultimate controlling institutional unit in a European Member country) possess in 2012 in their controlled affiliates located in such tax haven

[15] A detailed description of the database is found in Eurostat (2012).

[16] We do not take into account the bilateral agreements between governments and firms (rulings) that some European countries may have in order reduce the CIT rates paid by multinationals since this information is unknown.

[17] See Council of the European Union (2017). The list includes American Samoa, Bahrain, Barbados, Grenada, Guam, Korea (Republic of), Macao SAR, Marshall Islands, Mongolia, Namibia, Palau, Panama, Saint Lucia, Samoa, Trinidad and Tobago, Tunisia, and United Arab Emirates.

[18] The list contains Andorra, Antigua and Barbuda, Anguilla, Aruba, Barbados, Bahrain, Bermuda, Bahamas, Belize, Cook Islands, Curaçao, Dominica, Grenada, Guernsey, Gibraltar, Hong Kong, Isle of Man, Jersey, St Kitts and Nevis, Cayman Islands, Lebanon, Saint-Lucia, Liechtenstein, Liberia, Marshall Islands, Montserrat, Mauritius, Nauru, Panama, Philippines, Seychelles, Singapore, Sint Maarten, Turks and Caicos Islands, St Vincent and the Grenadines, US Virgin Islands, Vanuatu, and Samoa.

countries, grouped by EU Member State. As operating costs and FDI in these countries are likely to be just a small share of total turnover from foreign affiliates, we assume turnover figures to be a reasonable proxy for profits that multinational companies hold in these jurisdictions. We then multiply these figures by the respective parent country's statutory tax rate in order to obtain a proxy measure of revenues lost to those countries.

The value for the EU of this figure for the EU list of 17 jurisdictions is € 24.1 billion, while the value obtained using the Eurostat's 40 offshore centers list is €61.9 billion. The magnitude of these figures can be compared to the corresponding central CORTAX estimate of €37.3 billion (see Table (2)). The figures obtained with the two lists therefore provide reasonable lower and upper bounds that fit with our CORTAX estimates. Furthermore the estimates of revenue losses per Member State produced using FATS data correlate well with the CORTAX estimates: comparing the central CORTAX country-level estimates with the 17-country list gives a correlation coefficient of 0.91. The estimates obtained with the 40-country list give a correlation coefficient of 0.82. Therefore the BEPS estimates from CORTAX produce figures that are comparable both in terms of magnitude and country ranking with those produced using FATS data.

Different results from the different methodologies are to be expected. Among other reasons, there is the use of third parties (i.e. conduit intermediaries, fiduciary deposits, sham corporations: see Zucman, 2013), which may prevent the identification of the firms' owner who also would escape official statistics. Nevertheless, we conclude that at EU level, the CORTAX estimates for revenue losses lie well within the range of estimates that can be obtained by identifying gaps in bilateral multinationals´ activities present in official statistics.

6. Macroeconomic effects of BEPS

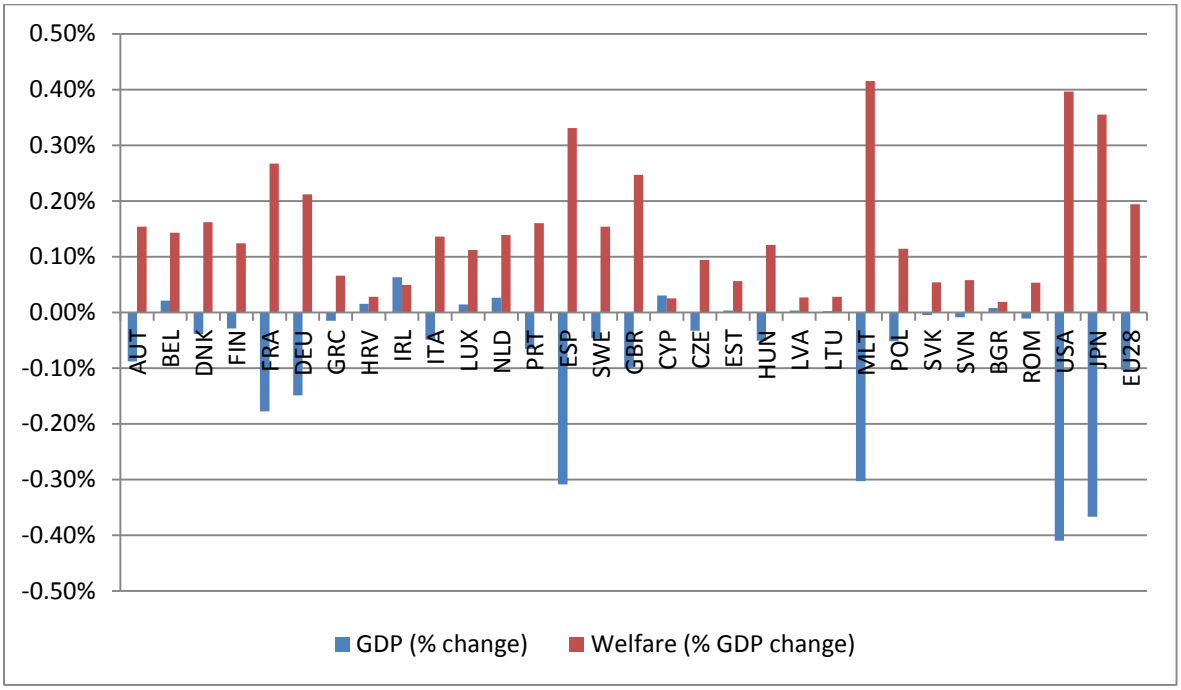
We now turn to the analysis of the macroeconomic effects of BEPS. This is a key advantage of our CGE methodology as the impacts of BEPS are not limited to corporate tax revenues losses but have second-round effects via the investment or the many channels that operate through the economy. In addition, the use of a general equilibrium model allows us assessing the impact of removing profit shifting accounting for these different channels, some of which may impact positively or negatively on corporate investment. We estimate successively the macroeconomic effects of (i) eliminating profit shifting to tax havens, (ii) eliminating profit shifting between non-tax haven countries, and (iii) eliminating both categories of profit shifting simultaneously. We provide an extensive explanation of the

channels of transmission for the effects in the case of eliminating profit shifting to tax havens. The same channels operate in the other two simulations, and therefore a brief treatment is sufficient. Our results are presented graphically below and Appendix 2 (Tables A.2.1 to A.2.3) provides our summary results tables showing the figures for the change in capital stock, employment, wages, GDP, CIT revenue and welfare.

6.1 Eliminating the access to tax havens

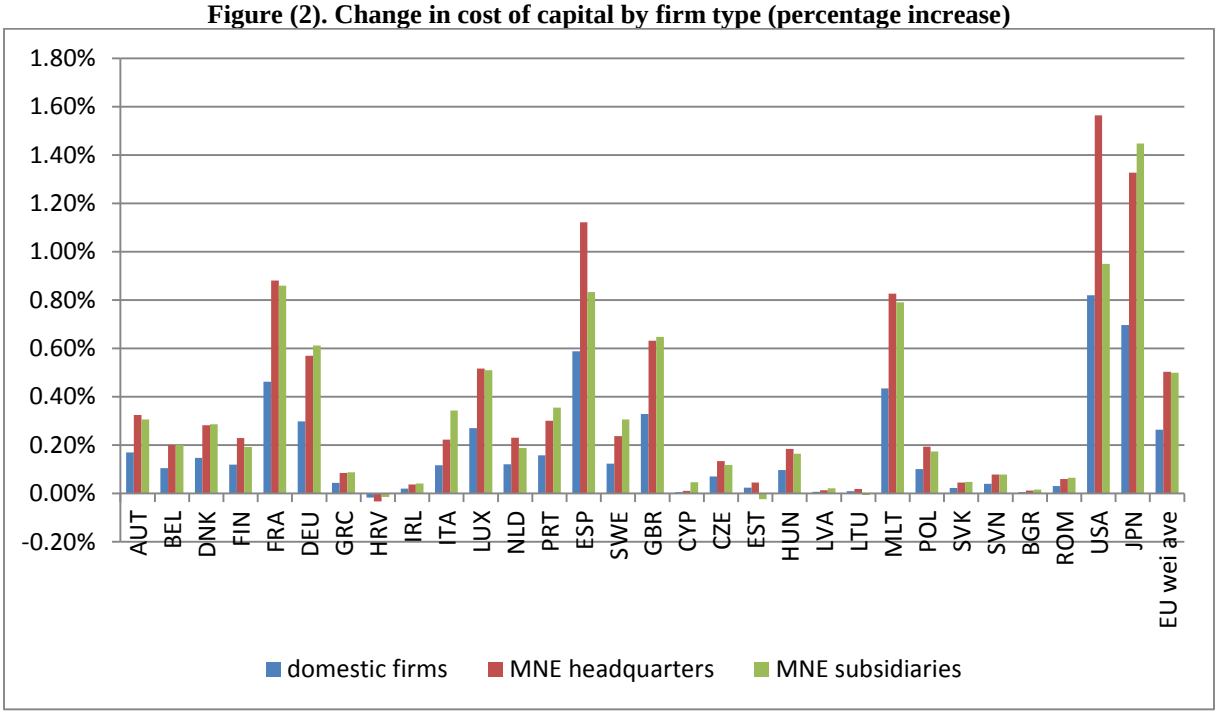
In our first simulation, we fully remove the access to tax havens. The results for GDP and welfare are presented in Figure (1).

Figure (1). GDP and welfare change from removing tax havens (% GDP change)



In general, we observe a fall in GDP and a rise in welfare. For the EU28, GDP is found to fall by 0.10% and welfare to rise by 0.19%. The loss of access to the tax haven raises the cost of capital, mainly for multinationals. This discourages investment and mechanically causes a reduction in GDP.

Figure (2). Change in cost of capital by firm type (percentage increase)



As shown in Figure (2), the rise in the cost of capital is typically lower for domestic firms than for multinationals (both headquarters and subsidiaries). For example, the EU weighted average rise in the cost of capital is 0.26% for domestic firms compared with 0.50% for both multinational headquarters and subsidiaries. This is in line with expectations as the semi-elasticity of CIT revenue to the CIT rate is lower for domestic firm (-0.227) than for multinationals (-0.458). The loss for multinationals due to the suppression of the tax haven channel is approximately double the loss for domestic firms. This drives the consequent shift in production, which generally falls for multinationals and rises for domestic firms as shown in Figure (3).

Figure (3). Production change by firm type (% of total production)

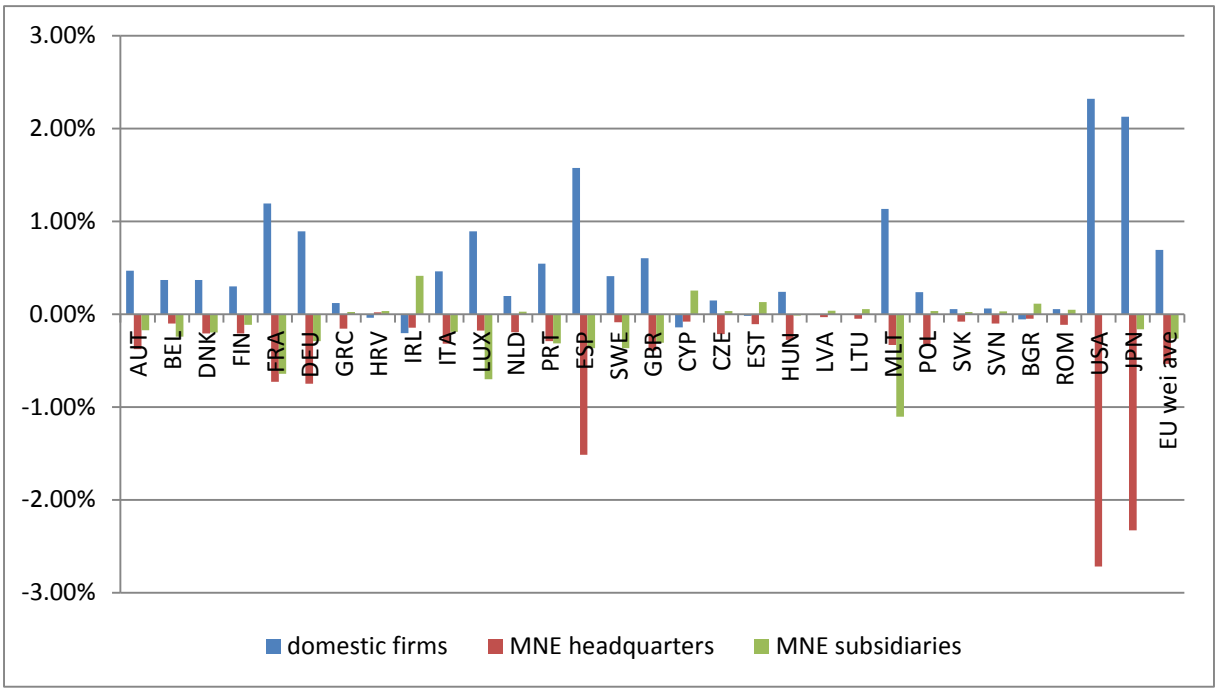


Figure (3) shows that the decrease of EU production by 0.1% is composed of a rise in domestic production of 0.69% of total production, and decreases in MNE headquarters and subsidiaries production of 0.54% and 0.26% respectively. It is also instructive to note that the production structure becomes less capital intensive, as shown by Figure (4). Across all firm types there is a reduction in capital use relative to labour. One sees that there is little change in the use of labour in production, whereas the reduction in capital in 0.36% across the EU and more in the USA and Japan (1.14% and 0.99%).

Figure (4). Change of use of capital and labour in production (%)

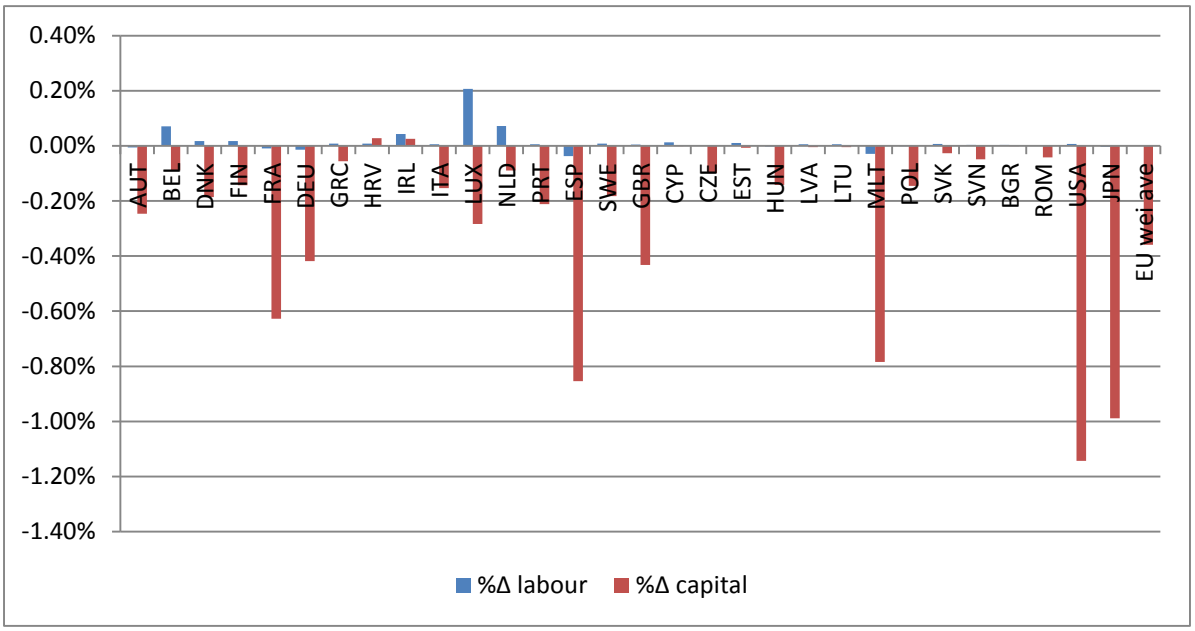
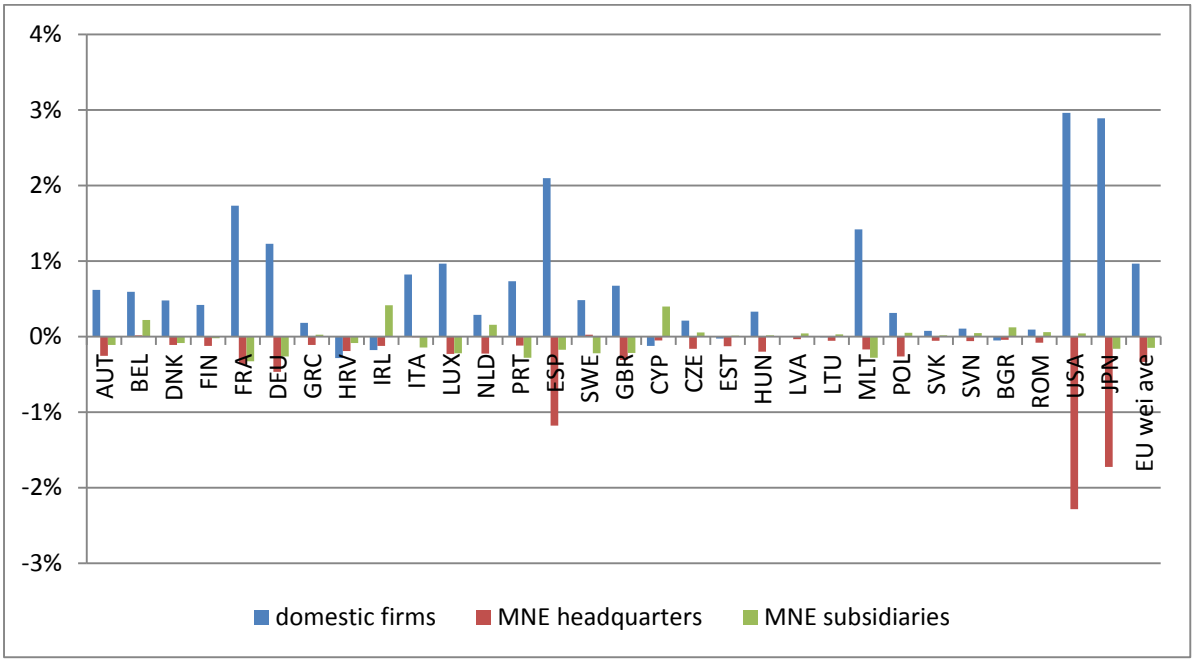


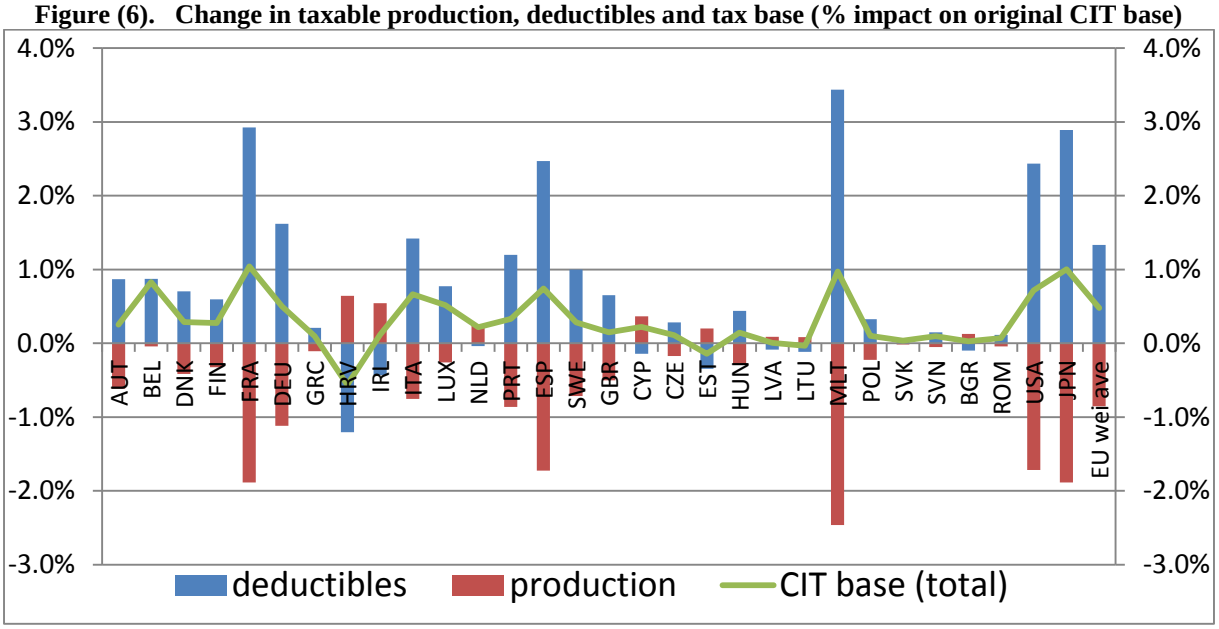
Figure (5). CIT tax base change by firm type (% of total CIT base)



As shown in Figure (5), we observe a similar pattern for the CIT base than for production. However, whilst total production falls, total CIT revenues rise in most countries. This is because the rise in the tax base of domestic firms exceeds the reduction in the tax base of multinationals. The reduction in capital usage reduces production, which alone reduces the CIT base. However, it reduces the deductibles within the tax base even more, leading to

increased CIT bases[19]. For example, the EU28 average reduction in production reduces the CIT base by 0.85% but the cut in deductibles increases the CIT base by 1.33%, resulting in a net increase of 0.48%. The importance of these two aspects on the CIT base is shown in Figure (6) below.

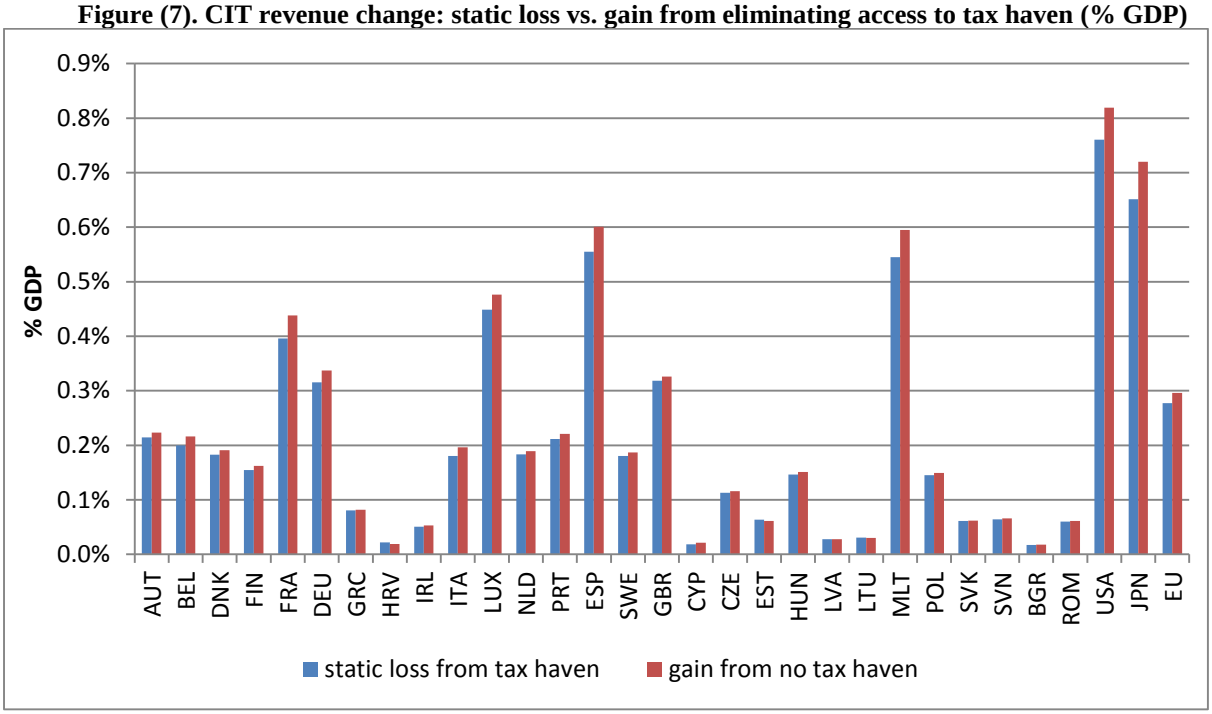
Figure (6). Change in taxable production, deductibles and tax base (% impact on original CIT base)



The result of evaluating the restriction on access to tax havens with a CGE model not only leads to a static direct gain in CIT revenues, it also accounts for second-round effects that lead to a bigger expansion of the tax base. Figure (7) shows both the simulated gain in CIT revenue from eliminating access to the tax haven and the static loss. It shows that the static loss for the EU is 0.277%, whereas the simulation results, which account for the general equilibrium effects, show that the gain from no access to tax havens in 0.296%.[20] It is generally the case for individual countries that the static loss would not only be recovered but would be exceeded when considering the general equilibrium effects. This is due to the aforementioned changes in the production structure caused by changing firms' incentives.

[19] Primarily, it reduces immediate expensing and (non-immediate) depreciation allowances.
[20] These figures are provided in Appendix 2 Table A.2.1 as a percentage of GDP, and in Table (2) in Euros.

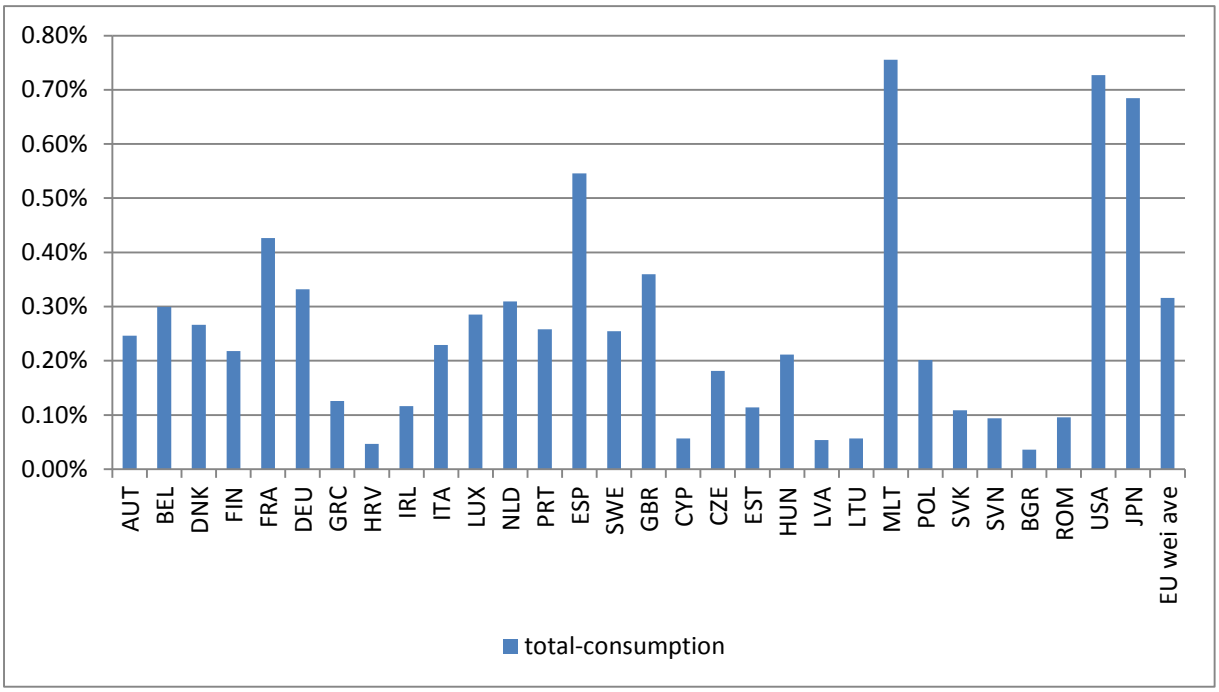
Figure (7). CIT revenue change: static loss vs. gain from eliminating access to tax haven (% GDP)



Comparing Figures 6 and 7, one point of clarification is that Figure 6 shows the tax base change prior to firms accessing the tax haven. Once the tax haven is accounted for, the percentage changes in the CIT base (Figure 6) differ slightly from the percentage changes in CIT revenue (Figure 7).

The model closure is chosen such that government revenues remain constant, and therefore the increase in the CIT revenues allows for a reduction in consumption taxes, which in turn raises consumption (net of taxes), as shown in Figure (8) below.

Figure (8). Change in total consumption by young and old generations (%)

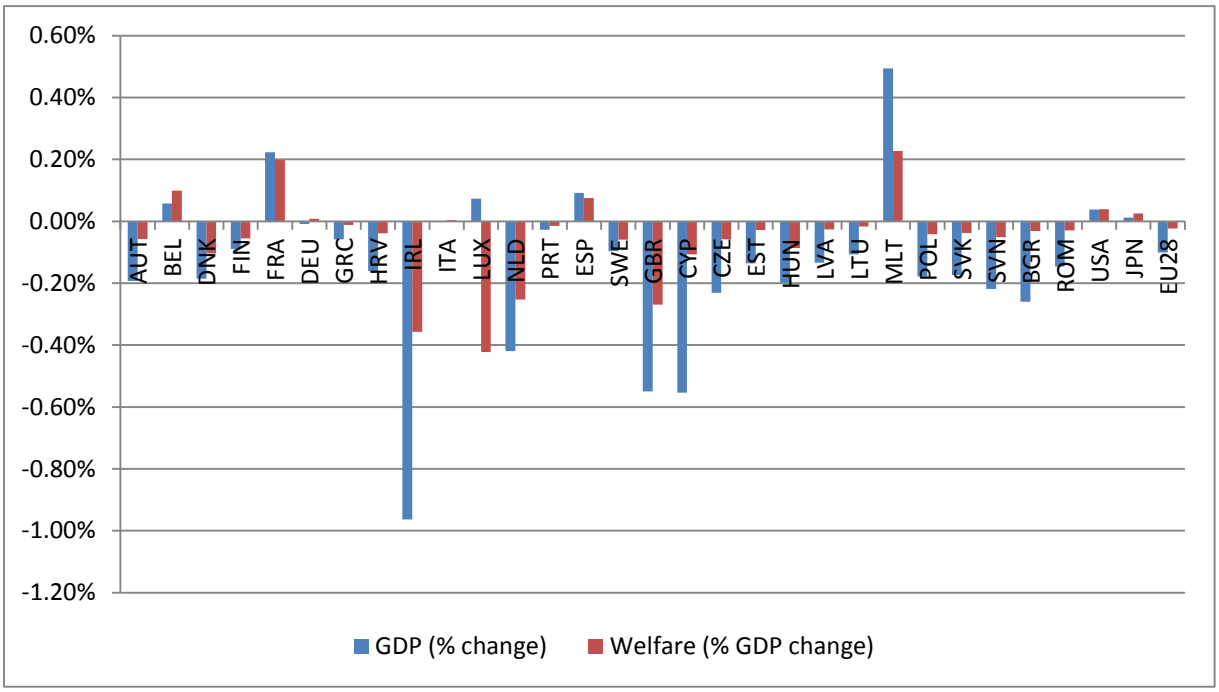


The rise in consumption ranges from 0.04% to 0.76%, with an EU weighted average at 0.32%. This rise in consumption is the main driver of the rise in welfare.

6.2 Eliminating profit shifting between non-tax havens countries.

For most countries, the effects of removing the possibility of profit shifting between non-tax haven countries are smaller than for removing the access to tax havens. The effects for GDP and welfare operate in the same direction for all countries (except Luxembourg). The results are shown in Figure (9).

Figure (9). GDP and welfare change from removing profit shifting between non-tax havens (% GDP)



The welfare effects generally move in the same direction as GDP. In the majority of cases the welfare impact is lower than the GDP impact. For the EU, welfare falls by 0.02% compared with a fall of 0.10% for GDP.

The restriction on profit shifting among non-tax haven countries reduces production by multinational subsidiaries in all countries. The production shifts towards domestic firms and multinational headquarters. In some cases, such as Ireland that has high share of total production undertaken by subsidiaries, the reduction in the production of subsidiaries is the dominant effect, resulting in an overall GDP fall. On the other hand, France for example, where subsidiaries constitute a smaller share of total production, the net effect is a rise in GDP. The change in production by firm type is shown in Figure (10).

Figure (10). Production change by firm type (% total production)

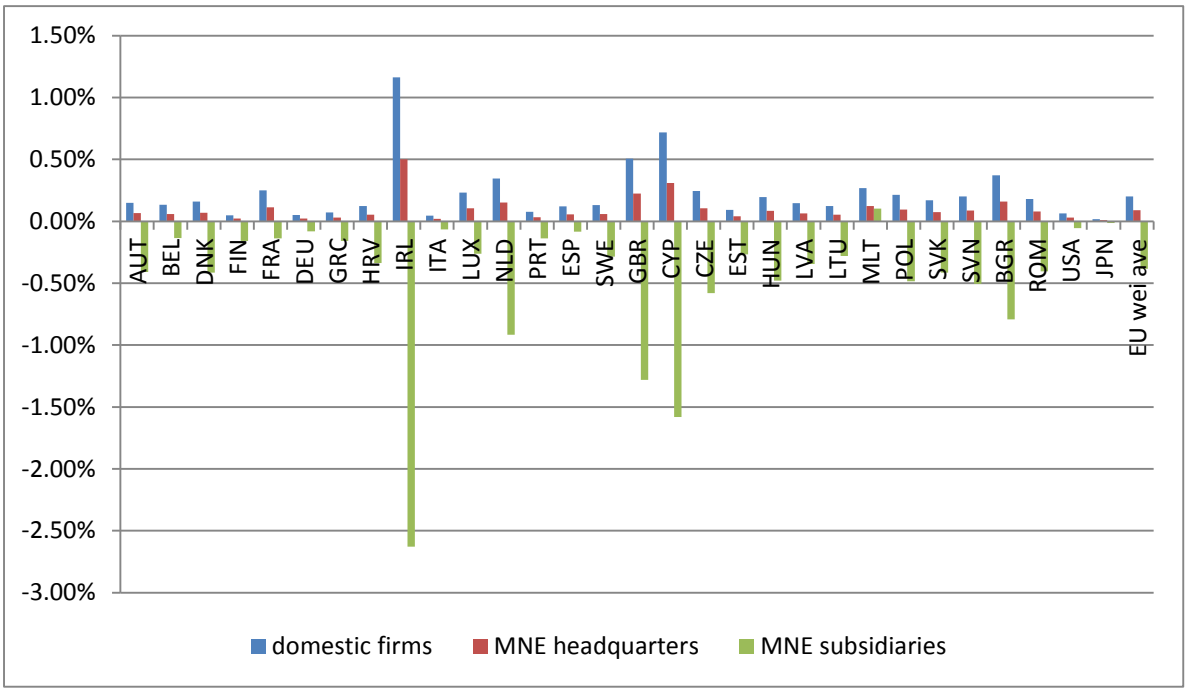
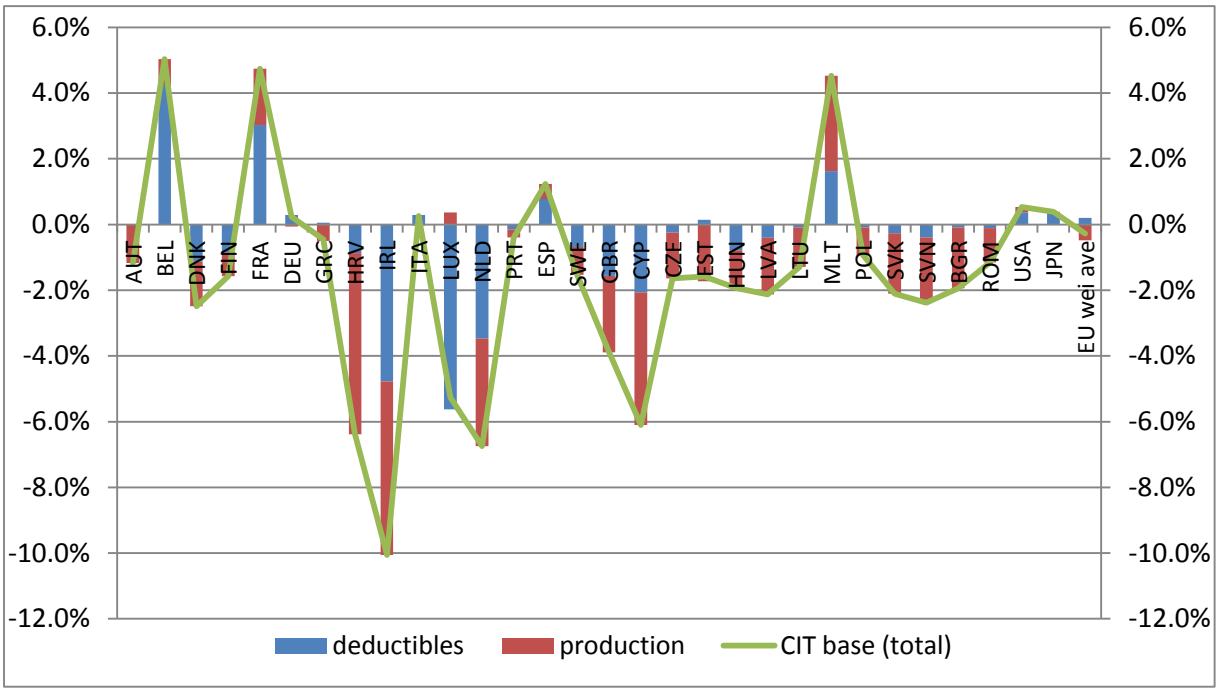


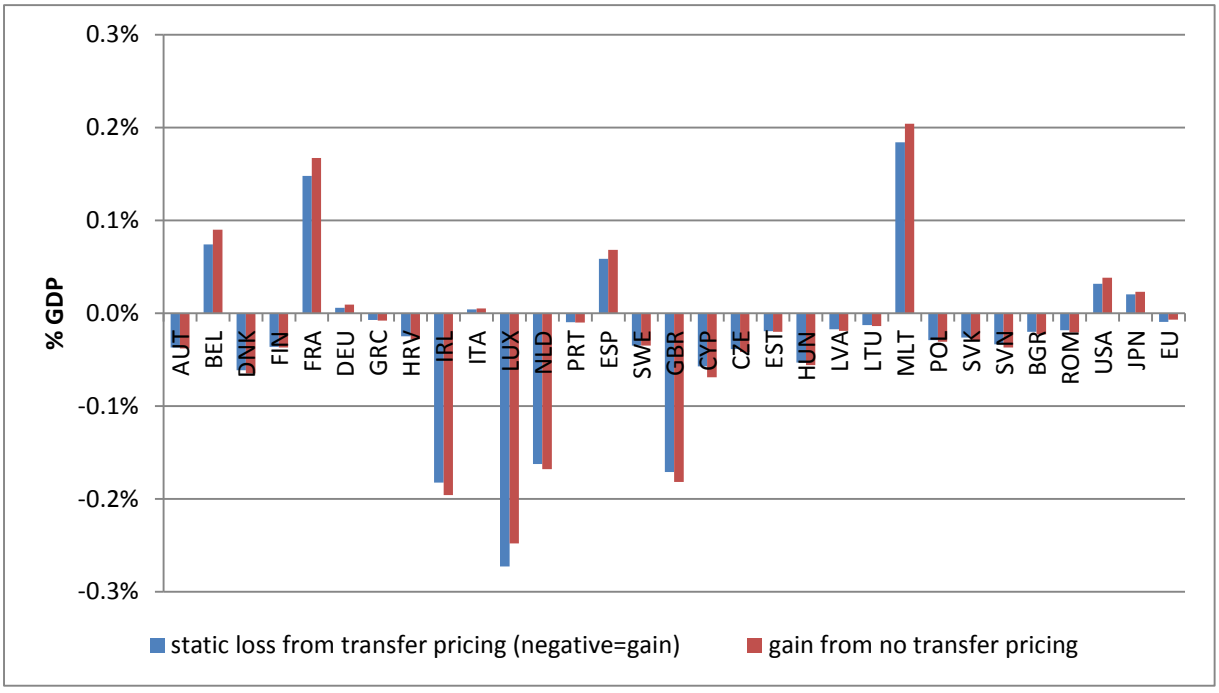
Figure (11) shows the change in the CIT base. The total change is here again the combined effect of changes in the value of deductibles and changes in production (net of intermediate inputs). In contrast to the elimination of access to tax haven simulation (see Figure 6), the impacts of both changes in production and deductibles typically operate in the same direction. To understand why this is the case, consider a multinational subsidiary receiving inward profit shifting, which is modelled as paying less than the arms-length price for intermediate inputs. In the simulation, with this type of profit shifting eliminated, the multinational subsidiary (i) pays the full arms-length price for intermediate inputs, and (ii) reduces production because the cost of capital has risen. Both effects operate in the same direction to reduce the tax base of the multinational subsidiary. (The opposite story applies to firms experiencing outward profit shifting.) At the EU level, there is a small reduction of CIT revenue of 0.28% as aggregate production falls by more than deductibles.

Figure (11). Change in taxable production, deductibles and tax base (% original CIT base)



The outcomes for CIT revenue, shown in Figure (12), are mostly of a smaller magnitude than for profit shifting to tax havens, though large effects are seen for some individual countries. The magnitude of the effects from eliminating profit shifting between non-tax haven countries is similar to the static loss calculated previously (euro values given in Table 2, column 3). Whether the simulated loss is larger or lower than the static loss depends on the country characteristics.

Figure (12). CIT revenue change from removing profit shifting between non-tax havens (% GDP)

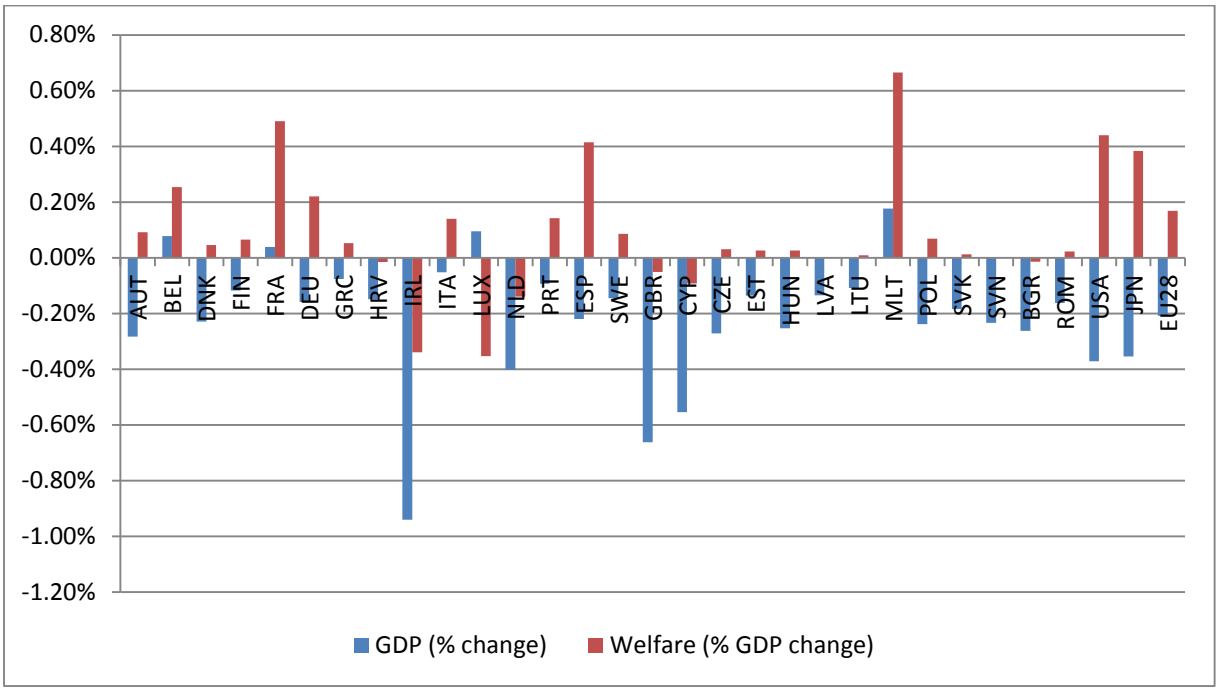


At the EU level, there is a small overall loss in CIT revenue of 0.01% of GDP in the simulation. There are two reasons why the EU does not see an overall gain in CIT revenue. First, as noted in Figure (9), there is a fall in GDP and, second, the EU loses the net inward profit shifting from the USA and Japan. Note that if we run the same simulation but only eliminate profit shifting between EU countries, we obtain a CIT revenue gain for the EU.

6.3 Eliminating profit shifting between non-tax haven countries and to tax havens

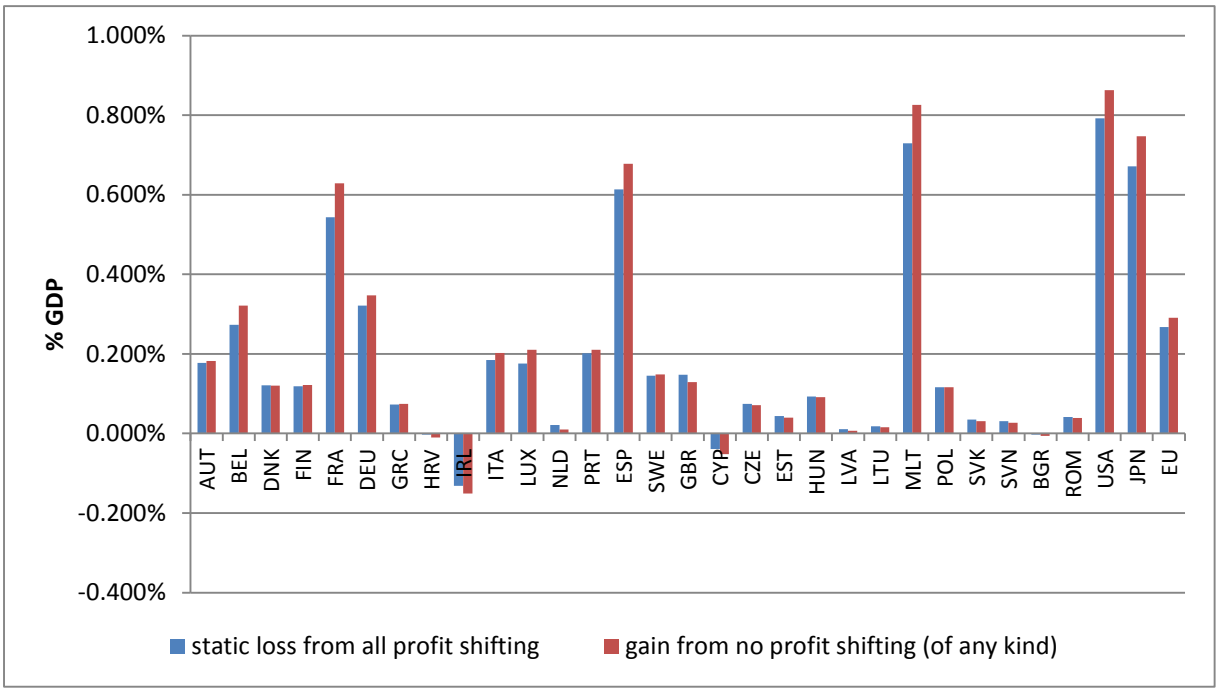
Finally, we eliminate both profit-shifting to tax havens and between non-tax havens countries. The GDP and welfare effects are shown in Figure (13).

Figure (13). GDP and welfare change from removing all profit shifting (% GDP)



The results of the combining both shocks resemble the sum of the two separate shocks, implying that the interaction effects are modest (i.e. compare Figure (13) with Figures (1) and (9)), implying that eliminating profit shifting to the tax haven is indeed the dominant effect. At the EU level, the GDP loss is 0.21% and the welfare gain is 0.17%. The USA and Japan show a fall of 0.37% and 0.36% in GDP, and a rise of 0.44% and 0.38% of GDP in welfare.

Figure (14). CIT revenue change from removing all profit shifting by firm type (% total CIT base)



Turning to Figure (14), most countries show an increase in CIT revenues, which is largely due to eliminating access to tax havens (compare with Figure 8). This is however not the case for Ireland and Cyprus (and to a small extent Croatia and Bulgaria), where the effects of removing profit shifting between non-tax havens countries are more relevant than the closure of access to tax havens. These counteracting effects are driving the negative results in small economies where the initial CIT rate is low relative to other countries. Figure (14) also compares the gain from eliminating profit shifting in the simulation with the static loss (shown previously in Table 2). In most countries, the gain in revenue exceeds the static loss, which is primarily driven by the changes in production that eliminating access to the tax haven, as explained in Section 6.1.

7. Sensitivity analysis

In this section, we present the results using the upper and lower bounds for profit shifting semi-elasticities. As discussed in Section 2, there is a wide range of estimates for the semi-elasticities, and in Section 4.2 we have chosen three estimates which represent our central, upper and lower bounds scenarios, respectively at -0.821, -0.353 and -1.696.

As the semi-elasticities are equally modified for all countries, the relative magnitudes remain similar in all three scenarios. Overall our results vary significantly depending on the assumption made regarding the tax shifting elasticities. This is rather unsurprisingly given the

role played by the role played by the differences in the statutory tax rates in explaining profit shifting. Columns (4), (5) and (9) of Table (3) compare the relative gains/losses due to BEPS (in % of CIT revenues) for the three alternative assumptions regarding profit shifting. For the US, the tax revenues losses due to BEPS vary greatly depending on the assumption retained for the elasticity of profit shifting: from 2.35% (lower bound), 10.69% (Central scenario) to 24.47%. The variations for the EU (1.98%, 7.73% and 16.71%) and Japan (2.27%, 10.74%, 24.75%) are equally large. These differences in results are simply reflective of the central role played by the elasticity of profit shifting in our model and the very wide variety of results obtained by empirical studies. However, as argued earlier we think that the central estimate based on the meta-analysis by Heckemeyer and Overesch (2013) provides the most reliable estimate of profit shifting such that our Central scenario should also represent the most reliable one to estimate the cost of BEPS.

Table (3) also provides the detailed impact of BEPS in absolute (i.e. monetary) terms for the lower and upper bounds and considering separately the gains and losses of profit shifting from tax havens and non-tax havens countries.[21] The US shows the largest net loss for non-tax haven profit shifting for the lower bound scenario (€1.69 billion) and the upper bound (€8.09 billion), and the UK displays the largest absolute net gain (€1.245 billion and €6.161 billion). The losses of the USA to the tax haven now range between €22.27 billion and €196.697 billion. The largest loss to the tax haven among the EU member states is for Germany, with a lower bound loss of €2.073 billion and an upper bound loss of €17.189 billion.

Comparing the figures for total revenue gains or losses (columns (3) and (8)) with the central CIT revenue (columns (4), (5) and (9)) brings out the relative magnitude of profit shifting. The total global loss from profit shifting ranges from 2.15% of CIT revenue in our lower bound scenario to 21.75% in our upper bound scenario. For the EU, the corresponding range is from 1.98% to 16.71%. Individually, the largest percentage loss in CIT revenues is for Malta, ranging from 5.45% to 37.4%, closely followed by France (4.3% to 34.5%). Conversely, Ireland's gain ranges from 3.6% to 11.4%. For non-EU countries variations are similarly large depending on the assumption concerning semi-elasticities: from -2.3% to 24.7% for Japan and from 2.3% to 24.5% for the US.

[21] Complete tables are provided in Appendix 1, Tables A.1.1 and A.1.2.

Earlier studies for the USA reported in Gravelle (2015) found significantly lower estimates for the cost of profit shifting in the US although these estimates are based on earlier years from the early 1990s and 2000s. More recent estimates lie within the range of our own findings, however. In a more recent study Clausing (2011) project revenue losses from deferral estimate that profit shifting caused a tax revenue loss of $90 billion in 2008 in the USA. More recent estimates reported by the Joint Committee on Taxation estimate revenues losses at $83 billion annually for 2014. Our estimates seem therefore in line with recent evidence for the USA. For Japan there are currently no comparable estimates to the best our knowledge.

Table (3). Sensitivity analysis: total lost tax revenues due to profit shifting- upper bound (€ Millions)

	LOWER BOUND				Central Scenario	UPPER BOUND			
	(1) Tax revenues via inter-country profit shifting to non tax-havens	(2) Total tax revenues lost via profit-shifting to tax havens	(3) Total tax revenues lost via profit-shifting (1)+(2)	(4) Total revenues lost as % of total CIT revenue	(5) Total revenues lost as % of total CIT revenue	(6) Tax revenues via inter-country profit shifting to non tax-havens	(7) Total tax revenues lost via profit-shifting to tax havens	(8) Total tax revenues lost via profit-shifting (6)+(7)	(9) Total revenues lost as % of total CIT revenue
Austria	39	-168	-129	-1.29%	-5.33%	238	-1.264	-1.025	-11.26%
Belgium	-131	-258	-390	-5.37%	-14.89%	-348	-1.356	-1.703	-29.61%
Denmark	42	-102	-60	-1.17%	-4.53%	261	-692	-431	-9.08%
Finland	16	-72	-56	-1.38%	-4.93%	185	-526	-341	-8.96%
France	-1.081	-2.243	-3.325	-4.33%	-14.94%	-6.056	-13,.48	-20.004	-34.46%
Germany	-72	-2.073	-2.145	-1.92%	-8.27%	-274	-17.189	-17.463	-18.27%
Greece	8	-39	-31	-0.74%	-3.96%	32	-367	-335	-8.56%
Croatia	6	-4	2	0.57%	0.65%	39	-32	7	2.29%
Ireland	131	-24	107	3.63%	6.70%	541	-171	370	11.40%
Italy	-37	-719	-755	-1.97%	-8.40%	-104	-5.928	-6.032	-18.52%
Luxemb.	27	-59	-32	-1.80%	-3.67%	264	-347	-83	-4.79%
Netherl.	354	-331	23	0.16%	-0.82%	1.926	-2.197	-270	-1.89%
Portugal	5	-120	-115	-2.02%	-7.80%	60	-895	-835	-16.72%
Spain	-268	-1.683	-1.952	-2.72%	-10.81%	-1.428	-12.869	-14.297	-24.32%
Sweden	55	-193	-137	-1.78%	-6.22%	109	-1.111	-1.002	-14.69%
UK	1.245	-1.749	-504	-0.59%	-3.08%	6.161	-11.547	-5.386	-6.59%
Cyprus	5	-1	4	1.89%	3.41%	23	-8	15	6.12%
Czech Rep.	36	-64	-29	-0.49%	-2.86%	178	-519	-341	-6.04%
Estonia	2	-4	-2	-0.74%	-3.41%	13	-34	-21	-6.41%
Hungary	37	-65	-28	-0.52%	-3.13%	194	-528	-334	-6.65%
Latvia	2	-2	0	0.04%	-1.13%	12	-20	-8	-2.41%
Lithuania	3	-4	-1	-0.15%	-1.68%	15	-36	-21	-3.53%
Malta	-6	-21	-27	-5.45%	-15.95%	-43	-95	-138	-37.36%
Poland	84	-234	-150	-0.62%	-3.37%	395	-2.027	-1.631	-7.21%
Slovakia	11	-17	-6	-0.35%	-2.46%	62	-139	-77	-5.09%
Slovenia	6	-7	-2	-0.26%	-1.95%	34	-60	-26	-3.77%
Bulgaria	9	-4	5	0.46%	0.26%	35	-32	2	0.21%
Romania	22	-38	-16	-0.31%	-2.26%	100	-340	-240	-4.85%
USA	-1.690	-22.270	-23.960	-2.35%	-10.69%	-8.090	-196.697	-204.787	-24.47%
Japan	-297	-5.209	-5.505	-2.27%	-10.74%	-1.611	-47.172	-48.782	-24.75%
Total	-1.436	-37.778	-39.214	-2.15%	-9.85%	-7.077	-318.143	-325.220	-21.75%
EU	550	-10.300	-9.749	-1.98%	-7.73%	2.624	-74.275	-71.650	-16.71%

Finally, we turn to the macroeconomic effects of the alternative scenarios and the central case. Table (4) shows the differential effect of these scenarios on CIT and Welfare, compared to a base case scenario with no profit shifting to tax havens or other EU countries. Like before for Table (3), the large variation in estimated welfare and CIT revenue impact can be directly attributed to the different elasticities of profit shifting used. Importantly though the estimates reported in Table (4) all refer to percent of GDP values. Given that the value of GDP is simulated by the model, the estimate of BEPS expressed in percentage of GDP also account for its macroeconomic impact. This is particularly important for small countries with low CIT rates where the GDP level depends significantly on the level of FDI. With a higher elasticity, the increase of profit shifting reduces CIT revenues in all countries which need to be compensated with an increase of VAT revenues to keep government income and public budget constant. The decrease in CIT revenue as a share of GDP in the EU is small in the lower bound scenarios but has significant effects in the central case and the upper bound scenarios. Profit shifting leads to a negative impact on welfare, which falls in the EU by between 0.04% and 0.33% of GDP compared to the Central scenario. These welfare losses are by comparison potentially more important for the USA (from 0.12% to 0.89%) and Japan (from 0.09% to 0.79%).

When comparing the different scenarios we also find a very large variation of the impact of BEPS on CIT revenues and welfare which are between 7 and 8 larger for the upper bound scenario and 3 to 4 times larger for the central scenario compared to the lower bound scenario. These variations are also reflective of the wide variety of profit shifting estimates.

Table (4). Sensitivity analysis: macroeconomic effects compared to the Central scenario

%GDP	Lower bound Tax havens & Non-tax haven countries		Central Scenario		Upper bound Tax havens & Non-tax haven countries	
	CIT	Welfare	CIT	Welfare	CIT	Welfare
Austria	-0.04	-0.02	-0.18	-0.09	-0.36	-0.18
Belgium	-0.13	-0.10	-0.32	-0.25	-0.55	-0.41
Denmark	-0.03	0.00	-0.12	-0.05	-0.23	-0.08
Finland	-0.04	-0.02	-0.12	-0.06	-0.21	-0.08
France	-0.20	-0.17	-0.63	-0.49	-1.21	-0.94
Germany	-0.09	-0.05	-0.35	-0.22	-0.69	-0.44
Greece	-0.01	-0.01	-0.07	-0.05	-0.15	-0.11
Croatia	0.01	0.01	0.01	0.02	0.03	0.04
Ireland	0.08	0.17	0.15	0.34	0.28	0.65
Italy	-0.05	-0.03	-0.20	-0.14	-0.40	-0.28
Luxembourg	-0.11	0.17	-0.21	0.35	-0.25	0.88
Netherlands	0.01	0.07	-0.01	0.14	-0.02	0.27
Portugal	-0.06	-0.04	-0.21	-0.14	-0.41	-0.27
Spain	-0.19	-0.13	-0.67	-0.41	-1.34	-0.82
Sweden	-0.04	-0.02	-0.15	-0.09	-0.33	-0.22
U. Kingdom	-0.02	0.05	-0.13	0.05	-0.27	0.09
Cyprus	0.03	0.05	0.05	0.09	0.10	0.18
Czech Rep.	-0.01	0.00	-0.07	-0.03	-0.15	-0.06
Estonia	-0.01	0.00	-0.04	-0.03	-0.07	-0.04
Hungary	-0.01	0.01	-0.09	-0.03	-0.19	-0.05
Latvia	0.00	0.01	-0.01	0.00	-0.01	0.00
Lithuania	0.00	0.00	-0.02	-0.01	-0.03	-0.02
Malta	-0.31	-0.26	-0.82	-0.66	-1.60	-1.31
Poland	-0.02	-0.01	-0.12	-0.07	-0.24	-0.14
Slovakia	0.00	0.00	-0.03	-0.01	-0.06	-0.02
Slovenia	0.00	0.00	-0.03	0.00	-0.05	0.00
Bulgaria	0.01	0.01	0.01	0.01	0.01	0.02
Romania	0.00	0.00	-0.04	-0.02	-0.08	-0.05
USA	-0.21	-0.12	-0.86	-0.44	-1.72	-0.89
Japan	-0.17	-0.09	-0.74	-0.38	-1.50	-0.79
EU28	-0.08	-0.04	-0.29	-0.17	-0.57	-0.33

8. Conclusions

Several recent papers have used econometric and quantification techniques to estimate the size of base erosion and profit shifting for different geographical entities. The evidence so far rests on partial equilibrium analysis thus omitting the many interactions and incidence corporate taxation might have on investment, employment and other economic channels. In addition, these studies cannot provide welfare implications of BEPS or cannot predict the implications of a potential reduction in BEPS that could be achieved through increased cooperation across tax administrations and greater transparency in corporate tax systems. A more comprehensive assessment of the extent of BEPS and its impact on tax revenues is therefore warranted. This paper contributes to this goal and proposes a novel approach using a computable general equilibrium model that allows modelling the general equilibrium impacts of tax avoidance and its welfare implications.

We model multinationals´ profit shifting explicitly and capture the direct and indirect effects of BEPS, including its impact of other taxes collected, as well as its macroeconomic impacts. By contrast with the existing literature our CGE approach allows us to provide more detailed results by country and distinguishing between profit shifting occurring between tax haven and non-tax haven countries. Our detailed country approach also allows showing that countries may gain or lose from profit shifting, although generally speaking countries with large FDI stocks and high corporate income tax rates suffer most from BEPS. As contradictory as it may seems BEPS might bring positive effects for corporate investment as well which are also captured in our model. Despite this our results suggest that BEPS brings a net corporate tax revenue losses suggesting that reducing it would bring efficiency and welfare gains as a whole.

Our central results suggest that BEPS in the EU28 entail €36 billion corporate tax revenues losses annually. The losses to tax havens amount to €37.3 billion. For the US, the total tax revenues lost is estimated at €100.8 billion, including €96.8 billion due to profit shifting to tax havens, while Japan is estimated to lose €24.0 and €23.3 billion in tax revenues respectively. For the EU these estimates are within the range of gaps estimated using bilateral statistics on multinationals´ foreign affiliates activities. Our results are also in line with recent studies for the USA while for Japan no comparable estimates are currently available to the best of our knowledge.

In terms of macroeconomic impact, profit shifting to tax havens allows reducing the cost of capital, mainly of multinationals, which in turn has a positive effect on investment and

GDP. However, the effects are small and the rise in consumption taxes needed to compensate for corporate tax revenue losses lead to a net loss in welfare, estimated at about 0.2% of GDP for the EU28 and 0.4% for the USA and Japan. The magnitudes of the effects of removing profit shifting between non-tax haven countries are generally smaller than those for the elimination of tax havens. For most countries, the impact of eliminating access to tax havens dominates.

Finally, when considering the total tax revenue losses from profit shifting our estimates at about 8-10% of the corporate tax revenues are in the high-range of those found by the OECD (2015) and larger than those found in a recent study by Crivelli et al. (2015). Importantly, however, those studies are based on firm-level data and as stated before provide only partial equilibrium estimates.

We must acknowledge that our modelling approach only partially capture the extent of BEPS since we do not model potential mismatches between corporate tax rules, loopholes or specific tax regimes (e.g. patent boxes) which might bring "unfair" tax advantages to countries with high statutory tax rates and bring additional tax revenues and welfare losses. As a result the main cause of profit-shifting in our analysis lies on the differences in statutory corporate tax rates and the "standard" modes of profit shifting including transfer pricing and debt shifting. Yet we believe our approach is general enough given that it captures the main channels of BEPS and provides reliable estimates of its economic impact. Such an approach could also serve as basis to account for other more indirect *modus operandi* of profit shifting in order to provide a more comprehensive assessment of the economic and welfare implications of BEPS.

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Appendix (1): Full tables for sensitivity analysis: upper and lower bounds

This section presents the full tables for the upper and lower bound estimates for the semi-elasticity of profit shifting. The summary figures are reported in Table (3) above.

Table A.1.1. Sensitivity analysis: total lost tax revenues due to profit shifting: lower bound (€ Millions)

	(1) Tax revenues via inter-country profit shifting GAINS	(2) Tax revenues via inter-country profit shifting LOSSES	(3) Tax rev via inter-country profit shifting NET (1)+(2)	(4) Total tax revenues lost via profit-shifting to tax havens	(5) Total tax revenues lost via profit-shifting (3)+(4)	(6) Total revenues lost as % of total CIT revenue
Austria	61.0	-22.0	39.0	-167.5	-128.5	-1.29%
Belgium	68.3	-199.5	-131.2	-258.3	-389.5	-5.37%
Denmark	47.5	-5.5	42.0	-101.7	-59.6	-1.17%
Finland	23.8	-7.9	16.0	-72.1	-56.1	-1.38%
France	8.0	-1,089.2	-1,081.1	-2,243.4	-3,324.5	-4.33%
Germany	214.6	-286.6	-72.0	-2,072.9	-2,144.9	-1.92%
Greece	9.5	-1.9	7.6	-38.7	-31.1	-0.74%
Croatia	5.9	-0.1	5.8	-4.2	1.6	0.57%
Ireland	130.8	-0.0	130.8	-24.2	106.6	3.63%
Italy	72.0	-108.5	-36.6	-718.6	-755.2	-1.97%
Luxembourg	64.0	-36.9	27.2	-59.3	-32.1	-1.80%
Netherlands	394.0	-39.6	354.4	-331.4	23.1	0.16%
Portugal	15.7	-10.7	4.9	-120.4	-115.5	-2.02%
Spain	13.9	-282.2	-268.3	-1,683.4	-1,951.7	-2.72%
Sweden	81.8	-26.3	55.5	-192.8	-137.3	-1.78%
UK	1,281.0	-36.0	1,245.0	-1,748.9	-504.0	-0.59%
Cyprus	5.4	-0.7	5.4	-1.1	4.3	1.89%
Czech Rep.	36.1	-1.0	35.5	-64.4	-28.9	-0.49%
Estonia	2.2	-0.0	1.5	-4.0	-2.5	-0.74%
Hungary	38.3	-0.0	37.3	-64.9	-27.6	-0.52%
Latvia	2.4	-6.1	2.4	-2.3	0.1	0.04%
Lithuania	2.9	-0.4	2.9	-3.8	-0.9	-0.15%
Malta	0.0	-0.2	-6.1	-20.6	-26.8	-5.45%
Poland	84.9	-0.0	84.4	-234.2	-149.8	-0.62%
Slovakia	11.6	-0.1	11.4	-17.0	-5.6	-0.35%
Slovenia	5.6	-296.8	5.6	-7.5	-1.9	-0.26%
Bulgaria	8.6	0.0	8.6	-3.8	4.9	0.46%
Romania	22.4	0.0	22.3	-38.4	-16.1	-0.31%
USA	4.9	0.0	-1,690.0	-22,269.5	-23,959.6	-2.35%
Japan	0.0	0.0	-296.8	-5,208.7	-5,505.5	-2.27%
Total	2,717.3	-2,458.2	0.0	-37,778.0	-37,778.0	-2.15%
EU	2,712.4	-2,458.2	550.5	-10,299.8	-9,749.3	-1.98%

Source: Own elaboration using CORTAX

Table A.1.2. Sensitivity analysis: total lost tax revenues due to profit shifting: upper bound (€ Millions)

	(1) Tax revenues via inter-country profit shifting GAINS	(2) Tax revenues via inter-country profit shifting LOSSES	(3) Tax rev via inter-country profit shifting NET (1)+(2)	(4) Total tax revenues lost via profit-shifting to tax havens	(5) Total tax revenues lost via profit-shifting (3)+(4)	(6) Total revenues lost as % of total CIT revenue
Austria	427.9	-189.5	238.4	-1,263.5	-1,025.1	-11.26%
Belgium	977.5	-1,325.0	-347.6	-1,355.8	-1,703.4	-29.61%
Denmark	320.3	-58.9	261.5	-692.0	-430.6	-9.08%
Finland	235.8	-51.0	184.8	-525.8	-341.0	-8.96%
France	337.1	-6,393.3	-6,056.3	-13,947.5	-20,003.8	-34.46%
Germany	1,817.5	-2,091.7	-274.2	-17,189.2	-17,463.4	-18.27%
Greece	46.1	-14.2	31.9	-367.2	-335.3	-8.56%
Croatia	41.3	-2.0	39.4	-32.4	7.0	2.29%
Ireland	541.0	-0.3	540.7	-170.9	369.8	11.40%
Italy	675.8	-779.5	-103.8	-5,927.8	-6,031.5	-18.52%
Luxembourg	541.1	-277.1	264.0	-347.1	-83.2	-4.79%
Netherlands	2,303.8	-377.3	1,926.4	-2,196.8	-270.4	-1.89%
Portugal	150.7	-91.0	59.7	-894.7	-835.1	-16.72%
Spain	287.5	-1,715.6	-1,428.1	-12,868.8	-14,296.8	-24.32%
Sweden	512.1	-403.4	108.7	-1,110.6	-1,001.9	-14.69%
UK	6,394.9	-234.1	6,160.8	-11,546.8	-5,386.0	-6.59%
Cyprus	22.9	-4.8	22.9	-8.0	14.9	6.12%
Czech Rep.	182.8	-5.2	178.0	-518.7	-340.7	-6.04%
Estonia	18.6	-10.9	13.4	-34.0	-20.7	-6.41%
Hungary	204.8	-0.4	194.0	-528.3	-334.4	-6.65%
Latvia	12.6	-0.2	12.2	-19.8	-7.6	-2.41%
Lithuania	15.5	-43.6	15.2	-35.9	-20.6	-3.53%
Malta	0.5	-4.7	-43.1	-95.0	-138.1	-37.36%
Poland	399.8	-1.6	395.1	-2,026.5	-1,631.4	-7.21%
Slovakia	63.8	-0.2	62.2	-139.2	-77.1	-5.09%
Slovenia	33.7	-1.1	33.5	-59.7	-26.2	-3.77%
Bulgaria	34.8	-8,343.9	34.8	-32.5	2.3	0.21%
Romania	101.2	-1,610.6	100.1	-340.2	-240.1	-4.85%
USA	253.4	0.0	-8,090.5	-196,696.6	-204,787.1	-24.47%
Japan	0.0	0.0	-1,610.6	-47,171.9	-48,782.4	-24.75%
Total	16,954.6	-24,031.2	0.0	-318,143.4	-318,143.4	-21.75%
EU	16,701.2	-24,031.2	2,624.5	-74,274.9	-71,650.5	-16.71%

Source: Own elaboration using CORTAX

Appendix (2): Summary tables for simulations

Table A.2.1. No access to tax havens

	Capital %-change	Wage %-change	Empl %-change	GDP %-change	Rev_CIT % GDP	Welfare % GDP
Austria	-0.247	-0.132	-0.006	-0.088	0.223	0.154
Belgium	-0.088	-0.1	0.07	0.021	0.216	0.143
Denmark	-0.186	-0.093	0.017	-0.039	0.191	0.162
Finland	-0.144	-0.079	0.017	-0.029	0.162	0.124
France	-0.627	-0.289	-0.009	-0.178	0.438	0.267
Germany	-0.419	-0.224	-0.014	-0.149	0.337	0.212
Greece	-0.056	-0.04	0.008	-0.015	0.082	0.066
Croatia	0.028	0.008	0.008	0.015	0.019	0.028
Ireland	0.026	0.006	0.042	0.063	0.053	0.049
Italy	-0.154	-0.105	0.006	-0.049	0.196	0.136
Luxembourg	-0.283	-0.323	0.206	0.014	0.476	0.112
Netherlands	-0.089	-0.082	0.072	0.026	0.189	0.139
Portugal	-0.212	-0.119	0.006	-0.066	0.221	0.160
Spain	-0.854	-0.467	-0.037	-0.309	0.601	0.331
Sweden	-0.182	-0.087	0.008	-0.046	0.187	0.154
U. Kingdom	-0.433	-0.166	0.005	-0.101	0.326	0.247
Cyprus	-0.001	0.007	0.012	0.030	0.021	0.025
Czech Rep.	-0.099	-0.059	0.001	-0.033	0.116	0.094
Estonia	-0.007	-0.017	0.010	0.003	0.061	0.056
Hungary	-0.141	-0.082	-0.002	-0.051	0.151	0.121
Latvia	-0.005	-0.006	0.005	0.003	0.028	0.027
Lithuania	-0.005	-0.008	0.005	0.002	0.030	0.028
Malta	-0.785	-0.457	-0.029	-0.303	0.595	0.415
Poland	-0.146	-0.086	-0.002	-0.052	0.149	0.114
Slovakia	-0.027	-0.021	0.007	-0.005	0.062	0.054
Slovenia	-0.049	-0.023	0.003	-0.009	0.066	0.058
Bulgaria	-0.001	-0.001	0.004	0.008	0.018	0.019
Romania	-0.042	-0.026	0.003	-0.011	0.061	0.053
USA	-1.144	-0.716	0.006	-0.410	0.819	0.396
Japan	-0.989	-0.619	-0.003	-0.367	0.720	0.355
EU28	-0.339	-0.175	0.000	-0.103	0.296	0.194

Source: Own elaboration using CORTAX

Table A.2.2. No profit shifting between non-tax haven countries

	Capital %-change	Wage %-change	Empl %-change	GDP %-change	Rev_CIT % GDP	Welfare % GDP
Austria	-0.005	-0.010	-0.001	-0.193	-0.038	-0.057
Belgium	-0.001	-0.013	0.005	0.057	0.090	0.099
Denmark	-0.007	-0.011	-0.003	-0.186	-0.065	-0.104
Finland	0.000	-0.003	0.003	-0.089	-0.037	-0.055
France	-0.011	-0.017	0.000	0.223	0.167	0.198
Germany	0.002	-0.003	0.002	-0.009	0.009	0.008
Greece	-0.006	-0.004	-0.004	-0.058	-0.008	-0.012
Croatia	-0.007	-0.008	-0.004	-0.161	-0.028	-0.039
Ireland	-0.062	-0.110	0.005	-0.964	-0.196	-0.357
Italy	0.001	-0.003	0.000	-0.003	0.005	0.004
Luxembourg	0.028	-0.033	0.049	0.073	-0.248	-0.422
Netherlands	-0.023	-0.032	0.002	-0.419	-0.168	-0.253
Portugal	-0.003	-0.005	-0.002	-0.027	-0.010	-0.015
Spain	-0.012	-0.008	-0.001	0.092	0.068	0.075
Sweden	0.002	-0.011	0.000	-0.097	-0.035	-0.059
U. Kingdom	-0.015	-0.038	-0.007	-0.550	-0.182	-0.269
Cyprus	-0.013	-0.052	-0.027	-0.554	-0.069	-0.107
Czech Rep.	-0.023	-0.017	-0.010	-0.231	-0.042	-0.058
Estonia	-0.011	-0.007	-0.002	-0.136	-0.020	-0.028
Hungary	-0.014	-0.013	-0.002	-0.198	-0.056	-0.086
Latvia	-0.012	-0.009	-0.007	-0.134	-0.019	-0.026
Lithuania	-0.017	-0.008	-0.006	-0.107	-0.014	-0.017
Malta	-0.027	-0.039	-0.006	0.494	0.204	0.227
Poland	-0.026	-0.014	-0.011	-0.178	-0.031	-0.042
Slovakia	-0.018	-0.011	-0.009	-0.174	-0.029	-0.038
Slovenia	-0.016	-0.012	-0.009	-0.219	-0.037	-0.051
Bulgaria	-0.040	-0.025	-0.018	-0.260	-0.023	-0.031
Romania	-0.017	-0.012	-0.01	-0.146	-0.021	-0.029
USA	-0.011	-0.004	0.000	0.038	0.038	0.039
Japan	0.001	-0.001	0.001	0.012	0.023	0.025
EU28	-0.010	-0.014	-0.003	-0.101	-0.007	-0.023

Source: Own elaboration using CORTAX

Table A.2.3. No profit shifting between non-tax havens countries and to tax havens

	Capital %-change	Wage %-change	Empl %-change	GDP %-change	Rev_CIT % GDP	Welfare % GDP
Austria	-0.254	-0.145	-0.009	-0.283	0.182	0.091
Belgium	-0.089	-0.117	0.077	0.078	0.321	0.254
Denmark	-0.196	-0.109	0.012	-0.229	0.120	0.046
Finland	-0.144	-0.084	0.020	-0.118	0.122	0.065
France	-0.640	-0.312	-0.009	0.039	0.629	0.490
Germany	-0.417	-0.228	-0.012	-0.159	0.347	0.220
Greece	-0.064	-0.046	0.003	-0.076	0.074	0.052
Croatia	0.020	-0.002	0.002	-0.149	-0.010	-0.015
Ireland	-0.057	-0.131	0.042	-0.941	-0.151	-0.339
Italy	-0.153	-0.108	0.006	-0.052	0.202	0.140
Luxembourg	-0.247	-0.364	0.270	0.095	0.210	-0.353
Netherlands	-0.122	-0.125	0.072	-0.402	0.010	-0.140
Portugal	-0.215	-0.125	0.003	-0.094	0.210	0.142
Spain	-0.870	-0.477	-0.038	-0.220	0.678	0.414
Sweden	-0.179	-0.102	0.008	-0.145	0.148	0.086
U. Kingdom	-0.452	-0.218	-0.006	-0.662	0.129	-0.051
Cyprus	-0.018	-0.058	-0.023	-0.554	-0.052	-0.092
Czech Rep.	-0.129	-0.081	-0.011	-0.272	0.071	0.031
Estonia	-0.021	-0.026	0.007	-0.136	0.040	0.026
Hungary	-0.160	-0.099	-0.005	-0.253	0.091	0.026
Latvia	-0.019	-0.017	-0.004	-0.135	0.007	-0.002
Lithuania	-0.026	-0.017	-0.002	-0.108	0.016	0.009
Malta	-0.818	-0.507	-0.037	0.176	0.826	0.665
Poland	-0.179	-0.104	-0.016	-0.238	0.116	0.068
Slovakia	-0.05	-0.036	-0.005	-0.184	0.031	0.012
Slovenia	-0.069	-0.039	-0.008	-0.234	0.027	0.002
Bulgaria	-0.048	-0.030	-0.018	-0.263	-0.006	-0.014
Romania	-0.063	-0.040	-0.010	-0.163	0.039	0.022
USA	-1.158	-0.721	0.007	-0.372	0.863	0.440
Japan	-0.987	-0.621	-0.001	-0.355	0.747	0.383
EU28	-0.352	-0.194	-0.004	-0.209	0.291	0.169

Source: Own elaboration using CORTAX