Update of Pillar Two revenue gain estimates

Methodological note

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Abstract

New Pillar Two revenue gain estimates are presented in the EU Tax Observatory's 2023 *Global Tax Evasion Report*. Their aim is twofold: (i) update previous results with the most recent aggregated country-by-country report (CbCR) statistics released by the OECD for the 2018 income year, and (ii) extend the pre-established methodology to allow for more flexible simulations. This technical note accompanies the new estimates. Section 1 maps the various documents providing information about our methodology and indicates where to find the code. Section 2 discusses data updates and our new preprocessing choices for the 2018 income year. Complementarily, Section 3 explains how we adapt our pre-established methodology to these new data and how we extend it to new scenarios. Section 4 then delineates the alternative estimation methodology we have recently developed for more flexible simulations. Eventually, Section 5 goes through the automated testing procedure we have defined to control the robustness of our computations. Note that this document focuses on the *updates* to our methodology: for most of the data cleaning arbitrages, computations, etc. that have remained unchanged, we explicitly refer to previous documents or simply skip them.

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1 Where to Find Methodological Information and Codes?

1.1 Methodology

Benchmark reference. The benchmark methodological reference is the August 2022 article in *Intertax* (see Baraké et al. (2022)), with the accompanying online appendix (link to PDF).

Recent update. The present document describes the methodological updates introduced in 2023 with respect to the benchmark mentioned above. Note that for most of the data cleaning arbitrages, computations, etc. that have remained unchanged, we explicitly refer to previous documents or simply skip them.

Previous publications. Our Pillar Two revenue gain estimates result from an incremental process started in June 2021. For a chronological view of this work and additional analyses, one can refer to:

- The first EU Tax Observatory report (see Baraké et al. (2021a));
- The first EU Tax Observatory note (see Baraké et al. (2021b));
- The third EU Tax Observatory note (see Baraké et al. (2021c)).

1.2 Code

Python code. The Python code is stored in a GitHub repository (link). For the computations behind our latest revenue gain estimates, one can refer to the `master` branch. A `v1.0` release contains the code behind previous computations, which covers our publications up to Baraké et al. (2022) included. The release is also hosted on GitHub, here, with various options to download the code.

Stata code. Our initial computations, presented in Baraké et al. (2021a), are also available in Stata. The code is stored in a separate GitHub repository (link).

1.3 Simulator

To date, our online simulator (link) corresponds to the computations presented in Baraké et al. (2022).

2 Data and Preprocessing Choices

2.1 Country-by-country report statistics

The benchmark data source is the tabulations of multinational corporations' CbCRs published by the OECD for the financial years of 2016, 2017, and 2018 (see OECD (2023)). This dataset provides aggregate information on the profits that multinational enterprises record and the taxes that they pay in their headquarter country or in foreign jurisdictions. Currently, 45 countries provide such information for their headquartered multinationals.

Samples. The main computations (especially the estimation of effective tax rates, the application of substance-based carve-outs, and the deduction of tax deficits) are based on the subsample of profit-making entities of this dataset, which excludes 5 reporting jurisdictions (Czech Republic, Hungary, Latvia, Panama, and Poland). Compared with Baraké et al. (2022), our new Pillar Two revenue gain estimates involve scenarios in which tax deficits are allocated using the distribution of multinationals' unrelated-party revenues: these allocation keys are drawn from full-sample CbCR statistics, that include loss-making constituent entities (for more details, see Section 3.2.2).

Average effective tax rates. Calculations use the three income years to compute average effective tax rates and profits recorded in 2018 to estimate potential revenue. Apart from the addition of the 2018 income year to the average, effective tax rates are obtained similarly to our previous estimates.

Potential limitations. Baraké et al. (2022) and the accompanying online appendix provide more thorough presentations of the OECD's aggregated CbCR statistics and discuss potential limitations. Among those, two are worth mentioning here too:

- Regarding the potential inclusion of intra-group dividends, we adjust domestic pre-tax profits whenever tax administrations provide the relevant information. On the one hand, the Netherlands and the United Kingdom directly share adjusted variables for the domestic profits of their headquartered multinationals. On the other hand, in a dedicated note that covers all income years, Sweden provides an upper bound for the intra-group dividends included in domestic pre-tax profits "under the assumption that all companies included dividends in their CbCR figures".[1] More details about how we deal with information from the Swedish tax administration can be found in the online appendix complementing Baraké et al. (2022).

- As for 2016 and 2017 income years, we identify possible inconsistencies for a few parent-partner pairs in 2018 data, indicated by excessive profit-to-revenue margins or large fluctuations in profits between years. More specifically, the Belgian CbCR statistics for the income year 2018 again included observations with abnormally high profitability margins and low effective tax rates, giving rise to a very large tax deficit. Like in 2016 data, the Belgium-Netherlands row seemed problematic and like in 2017 data, the Belgium-United Kingdom observation also looked peculiar. Our latest estimates reproduce the adjustment that we have used so far.[2] This methodology relies on the assumption that total revenues are not affected by the specificities making these observations stand out and that the profitability margin observed in a "normal" year also applies to problematic cases.

The case of China's 2018 CbCR statistics. Previous points are common to all income years and all our estimates. 2018 data have the particularity of excluding Chinese aggregated CbCR statistics, both in the full-sample dataset and in the sample without loss-making entities. We deal with this absence by using China's 2017 CbCR statistics. To convert the results to 2018 USD, the tax deficit estimates obtained from observations with China as parent are upgraded using 2017-2018 USD nominal worldwide GDP growth.

1. Link: https://www.oecd.org/tax/tax-policy/sweden-cbcr-country-specific-analysis.pdf.

2. For the Belgium-Netherlands row, we replace the 2018 profits before tax by the multiplication of 2018 total revenues and the profitability margin observed in 2017; for the Belgium-UK observation, we replace the 2018 profits before tax by the multiplication of 2018 total revenues and the profitability margin observed in 2016.

2.2 Tørsløv, Wier, and Zucman (2018, 2019)

The OECD's CbCR data were complemented with estimates of profits shifted to tax havens by Tørsløv, Wier, and Zucman (2022) for the 2018 income year. The dataset details the amount of profit that multinationals record in tax havens, broken down by headquarter country. We also consider Tørsløv, Wier, and Zucman (2022)'s estimates of domestic profits and effective tax rates for the 2015 income year. We upgrade profits to 2018 by applying the 2015-2018 USD nominal GDP growth (worldwide by default, specific to the EU for Member-States). In terms of parents covered, these datasets are more comprehensive than the OECD's CbCR statistics. They allow us to expand the original sample of 40 headquarter countries to 84 jurisdictions.

2.3 Other data sources

Five auxiliary data sources are mobilized in this study. First, data on the mean nominal monthly earnings of employees from the International Labor Organization (2021) are used to enrich each observation in aggregated CbCR statistics with a proxy for annual payroll expenses. Compared with our previous estimates, we incorporate the same methodology in the Python code base and extend it to 2018 data. More details can be found in the online appendix accompanying Baraké et al. (2022). Second, the statutory corporate income tax rates used to impute missing effective tax rates in the OECD's 2018 CbCR statistics are taken from KPMG's corporate tax rates table (see KPMG (2021)). Third, the 2022 statutory corporate income tax rates, used to assess the 20% criterion in some applications of the Under-Taxed Payments Rule (UTPR, see below for more details), are drawn from the Tax Foundation (see Tax Foundation (2022)). Fourth, exchange rates are taken from the time series of the European Central Bank (see European Central Bank (2021)). Fifth, nominal growth rates for the EU and worldwide GDP come from the World Economic Outlook Database (see International Monetary Fund (2021)).

3 Main Approach

In this section, we describe the methodology behind most of our latest country-by-country revenue gain estimates based on the 2018 income year. This approach updates the methodology used so far to cover 2018 data and extends it with new simulation scenarios.

3.1 Update of the established methodology

Two scenarios were covered in Baraké et al. (2022): the headquarter or Income Inclusion Rule (IIR) scenario, in which the parent jurisdiction collects the tax deficit of its own multinationals, and the Qualified Domestic Minimum Top-up Tax (QDMTT) scenario, in which tax deficit collection occurs at the source or host country level (i.e., where profits are booked). For these two scenarios, our new computations simply update the established methodology to the 2018 income year. As such, Baraké et al. (2022) and the accompanying online appendix provide a reliable description of the methodology. We quickly highlight three specific points:

- Effective tax rates are now averaged over three income years: 2016, 2017, and 2018. More details on these computations can be found in the online appendix of the paper;
- Data from the ILO on mean nominal monthly earnings are used to deduce payroll expenses from the employee counts in aggregated CbCR statistics. The treatment of these data remains unchanged except that missing earnings are linearly interpolated for the year 2018 (and not 2017) if earnings for adjacent years are provided;[3]
- As before, the substance-based income exclusion is obtained as the sum of tangible assets and payroll components times their respective carve-out rates. The resulting amount is subsequently subtracted from pre-tax profits. On average, in the positive-profit sub-sample of CbCR statistics and with the long-run carve-out rates (5% for payroll expenses and tangible assets), the following is found:
  - 28% of the pre-tax profits reported domestically are carved-out;
  - 22% of the pre-tax profits booked in foreign non-haven jurisdictions are carved-out;
  - 8% of the pre-tax profits booked in foreign tax havens are carve-out.

  Since Tørsløv, Wier, and Zucman (2022)'s data do not provide information on tangible assets and payroll expenses, we use these averages to extend the impact of substance-based carve-outs beyond CbCR statistics. Profits booked in tax havens are reduced by the third factor above; domestic profits are decreased by the first one.
- For the parent jurisdictions absent from CbCR statistics but covered by Tørsløv, Wier, and Zucman (2022) data (henceforth "TWZ countries"), we lack information about profits booked in foreign non-haven partners. Therefore, we impute TWZ countries' non-haven tax deficit based on their tax haven tax deficit. We follow the same methodology as in our previous estimates, with different approaches for the IIR and QDMTT scenarios. Our previous online appendix provides up-to-date explanations.

Although they are described more extensively in Baraké et al. (2022), it is worth mentioning again the potential sources of bias identified with our methodology. On the one hand, the fact that our estimates build upon aggregated statistics means that we cannot capture firm-level heterogeneity in effective tax rates and introduces a downard bias: in CbCR data, within a given parent-partner pair, entities paying high corporate income taxes may compensate for those in the scope of the minimum tax.[4] On the other hand, four mechanisms may lead to over-estimation: (i) the inclusion of intra-group dividends in CbCR pre-tax profits, (ii) exemptions for newly multinational companies and the *de minimis* exclusion rule (the latter being partially modelled as in our previous estimates), (iii) the fact that no global turnover threshold is applied in Tørsløv, Wier, and Zucman (2022) (whereas we should focus on multinationals above the 750

3. While they were previously operated in Stata, these steps are now part of the Python code base.

4. For example, imagine that half of French multinationals have an effective tax rate of 20% (euro-weighted) in a partner country, and the others have an effective tax rate of 10% in the same country. The average effective tax rate reported in tabulated statistics for French multinationals in this country is 15% and, thus, the estimated top-up tax liability is 0. In reality, the true revenue gain is positive since the multinationals with a less-than-15% effective tax rate report undertaxed profits.

million euro criterion), and (iv) the specific treatment of partially owned entities under the IIR. Baraké et al. (2022) add that the additional corporate income taxes some multinationals should pay under Pillar One are not accounted for while they may increase these firms' effective tax rates: considering the revised Pillar One adoption timeline, this mechanism is unlikely to affect the revenue gains from Pillar Two in the first year(s) of implementation, on which our static estimates focus.

3.2 Extension to new scenarios

3.2.1 New scenario example

Compared with Baraké et al. (2022), which focuses on the polar cases of full IIR and QDMTT implementation, our latest estimates consider additional scenarios. In particular, we simulate partial implementation cases in which a set of implementing jurisdictions impose the minimum tax on their own multinationals and collect part or all of the tax deficits of other headquarter countries' multinationals. For firms whose ultimate parent is located in a non-implementing jurisdiction, their tax deficits are distributed to implementing countries based on a given allocation key.

Example. For instance, one such scenario assumes that EU Member-States are the only countries adopting an IIR on their multinationals, collecting both their domestic and foreign tax deficits. In addition, the (domestic and foreign) tax deficits of non-EU multinationals are entirely allocated among EU Member-States according to the distribution of their extra-group sales. This second mechanism is close in spirit to the UTPR but involves a different allocation key, the Model Rules relying instead on the distribution of employees and tangible assets with equal weights.

Simulation procedure. This relatively simple scenario can be simulated from existing computations:

1. We start from tax deficit estimates in a full IIR / headquarter country scenario that accounts for both foreign and domestic undertaxed profits;[5]
2. Implementing countries (i.e., EU Member-States in the above) are directly attributed 100% of their respective tax deficits;
3. We isolate non-implementing jurisdictions' tax deficits and allocate them to implementing countries based on the distribution of extra-group sales (more details about the apportionment are provided below);
4. EU Member-States final revenue gains are eventually obtained as the sum of their own tax deficit and the amount of foreign tax deficits that they are allocated.

Three remarks. First, as seen in more details below and depending on the scenario one wishes to simulate, the tax deficits of non-implementing jurisdictions can be collected entirely or only partially by implementing countries. For full collection, the allocation key is computed *among implementing countries* while, for partial collection, it is computed *among all countries*. [6] Second, the procedure above directly applies to scenarios in which only one jurisdiction implements Pillar Two. Third, it can also be extended to scenarios where all tax deficits are collected according to a given allocation key, in which case no specific implementing jurisdiction is assumed to collect its own tax deficit entirely.

5. This differs from our benchmark IIR / headquarter country scenario, in which only EU Member-States collect the domestic tax deficits of their multinationals.

6. In the example of EU implementation defined above, assume that France represents 2% of US multinationals' total extra-group sales and 10% of sales to EU Member-States: for the US tax deficit to be collected entirely, France would be attributed 10% of it; otherwise, France would be attributed 2% and collection would be limited to the weight of EU Member-States in US multinationals' extra-group sales.

3.2.2 (Sales) apportionments

In the following, we explain how we build each headquarter country's distribution of extra-group sales, used to allocate tax deficits in the example given above. While we use sales as an illustration, the exact same logic applies to employees and tangible assets. Based on the distributions thereby obtained, one can construct any composite allocation key by weighting the three shares as desired.

Mapping sales. To get a mapping of multinational companies' sales, we load full-sample aggregated CbCR statistics for the income year 2018.[7] There are three arguments in favour of this choice. First, while the exclusion of loss-making entities removes a potential bias for the estimation of effective tax rates, there is no particular reason why our allocation key should ignore loss-making constituent entities.[8] Second, due to cost-shifting mechanisms, there may be cases where a constituent entity in a high-tax country combines large unrelated-party revenues and "artificially" negative profits: ignoring those cases could distort the distribution of sales at the expense of high-tax juridisctions. Third, more practically, the full sample aggregates more constituent entities, which relaxes the taxpayer confidentiality constraint and allows a more granular breakdown of partner jurisdictions.

From full-sample CbCR statistics, we compute shares of unrelated-party revenues ("UPR" in the equation below). For given parent and partner jurisdictions i and j, when the allocation key *is not* computed *among implementing countries* (see unilateral or full sales apportionment scenarios in particular), it is given by:

$$\forall j \in P \cap N_i, \text{ UPR share}_{i,j} = \frac{UPR_{i,j}}{\sum_{k \in N_i} UPR_{i,k}} \tag{1}$$

When the allocation key *is* computed *among implementing countries* (see partial cooperation scenario in particular), it is given by:

$$\forall j \in P \cap N_i, \text{ UPR share}_{i,j} = \frac{UPR_{i,j}}{\sum_{k \in P \cap N_i} UPR_{i,k}} \tag{2}$$

Where N_i stands for the set of partner jurisdictions included in country i's aggregated statistics and P for the set of implementing jurisdictions, which collect foreign multinationals' tax deficits. Due to taxpayer confidentiality constraints, N_i may include some continental partners (e.g., "Other Europe") that aggregate several individual countries. We do not know how the sales aggregated into these continental partners are distributed across individual countries. As a simplification, for each parent country, we assume that sales are zero for the partner jurisdictions that are not explicitly listed. For example, if the US does not include Albania in its full-sample CbCR statistics, we assume that the US-Albania share of unrelated-party revenues is 0, while positive sales could be hidden in the "Other Europe" aggregate. This is why the third argument mentioned above is important and to further limit the bias that may arise from this simplification, we focus on parent jurisdictions that report a minimum number of partners. We set the threshold to at least 61 partners (including "Foreign Jurisdictions Total"). For those below this threshold, we consider that computing sales shares directly from the data would introduce too large a bias.

Allocating the tax deficits of parent jurisdictions with a sufficiently granular breakdown. Whenever we must allocate the tax deficit of a parent jurisdiction with sufficiently detailed CbCR statistics to partner countries (if this parent is not implementing the deal in the partial cooperation scenario, or in the unilateral and full apportionment scenarios), we can easily apply the formulas above. For each partner country, we compute either its share of total unrelated-party revenues (*not among implementing countries*, Formula 1) or its share of the unrelated-party revenues to implementing countries (*among*, Formula 2). We can then multiply the parent jurisdiction's tax deficit with each partner's share of unrelated-party revenues and aggregate resulting revenue gains at the partner country level.

7. For China, we use those for the income year 2017.

8. Ideally, since all scenarios are supposed to be implemented at the firm level, we would like to focus on the sales of multinational companies with a positive tax deficit. But, regardless of whether the multinational company has a null or positive total tax deficit, there is no reason to ignore the sales of loss-making constituent entities.

For parent jurisdictions with insufficient data. Things get trickier when the parent jurisdiction does not provide CbCR statistics (TWZ country) or does in an insufficiently granular way. In such cases, we rely on "mean" shares of unrelated-party revenues. On average, which share of the tax deficit of, say, Poland (a TWZ country) could a given partner country collect? The procedure writes as follows:

1. We first estimate the weight of domestic sales in the distribution of the problematic parent jurisdiction's unrelated-party revenues. We compute the mean weight of domestic sales in sufficiently granular CbCR statistics. In 2018 data, this gives roughly 61%. This means that in the hypothetical sales distribution we are trying to build, domestic revenues will be given a weight of 61%. Let us denote this as:

$$\text{Mean share of domestic sales} = 61\%$$

2. We then move to the distribution of foreign sales. We consider each potential partner country and compute its mean share of *foreign* multinational companies' foreign sales based on sufficiently granular unrestricted CbCR statistics:

$$\text{Mean sales share}_j = \frac{\sum_{i \in C \setminus \{j\}} UPR_{i,j}}{\sum_{i \in C \setminus \{j\}} Foreign\ UPR_i} = \frac{\sum_{i \in C \setminus \{j\}} UPR_{i,j}}{\sum_{i \in C \setminus \{j\}} \sum_{k \in N_i \setminus \{i\}} UPR_{i,k}} \tag{3}$$

   Where C designates the set of parent countries with sufficiently granular CbCR statistics. We exclude, if relevant, the partner country j from C because we are interested in the partner country's mean share of *foreign* multinational companies' foreign sales.

   NB: Intuitively, one might expect the Mean sales share$_j$ to sum to 1 over the whole set of potential partner countries, but this is not exactly the case. Indeed, for each j, the mean share is computed while excluding j from parent jurisdictions considered ($C \setminus \{j\}$), so the denominator differs across partner countries and the sum does not yield exactly 1.

3. In this final step, there are two cases.

   (a) If the allocation does not occur *among countries implementing*, meaning that the portion of foreign tax deficits a country can claim is determined by its share of total sales. Then, we apply the following for each problematic parent jurisdiction o whose tax deficit we wish to allocate:

      i. Mean share of domestic sales = 61% of the to-be-allocated tax deficit of multinationals headquartered in o is attributed to o (regardless of whether it is effectively collected in the end);

      ii. All potential *foreign* partner countries get a share of the to-be-allocated tax deficit. However, to avoid double-counting, we must re-scale the Mean sales share$_j$ so that they sum only to the portion attributed to foreign jurisdictions (i.e., $1 -$ Mean share of domestic sales = 39%). Foreign partner countries' share of the to-be-allocated tax deficit is thus given by:

$$\forall j \neq o,\ \text{Mean sales share}'_j = \text{Mean sales share}_j * \frac{1 - \text{Mean share of domestic sales}}{\sum_{j \neq o} \text{Mean sales share}_j}$$

   (b) If the allocation does occur *among countries implementing* in the partial cooperation scenario, the allocation is easier. Indeed, the allocation based on sales is only relevant for non-implementing countries, so the partners among which the tax deficit is split are all foreign: we do not need to consider the Mean share of domestic sales anymore. We are only interested in the Mean sales share$_j$ of countries implementing the deal. We still need to re-scale them though, such that they sum to 1 and the entire tax deficit is allocated across implementing countries. Here, we get:

$$\forall j \in P,\ \text{Mean sales share}'_j = \text{Mean sales share}_j * \frac{1}{\sum_{j \in P} \text{Mean sales share}_j}$$

4 Alternative Approach

Our revision of Pillar Two revenue gain estimates was designed not only to update previous results with 2018 data, but also to broaden the range of scenarios that can be simulated. As described above, simple cases of tax deficit apportionment based on sales, employees, assets, or a mix of those can be constructed as extensions of the full IIR implementation scenario. However, some other cases make it increasingly difficult to adapt the existing computations: what if some implementing countries but not all collect their own domestic tax deficit, while having foreign and domestic tax deficits collected by different sets of UTPR-adopting jurisdictions? What about scenarios mixing IIR and QDMTT implementations?

The latest estimates of Pillar Two revenue gains are therefore accompanied with a new, more flexible methodology for computing and attributing tax deficits. This approach allows to declare lists of countries implementing the IIR while including or not their domestic tax deficit, countries adopting a QDMTT which applies or not to the profits of their own multinational companies, and countries adopting a UTPR that targets or not foreign multinationals' domestic tax deficit. Tax deficits are estimated at the parent-partner level and they are attributed to the relevant country depending on declared lists, while reflecting the priority order between instruments (first QDMTTs, then IIRs, and eventually UTPRs). This approach is also quite flexible regarding whether to condition the application of the UTPR on statutory tax rates, the composition of the UTPR allocation key between sales, assets, or employees, etc.

As described in more details below and in the following section, this new approach relates closely to the methodology used so far. It is designed so that both methods yield consistent results for all common scenarios (the set of cases covered by the pre-existing approach being included in the new one's).

4.1 Bilateral disaggregation of our data

We build a full bilateral disaggregation of tax deficit estimates at the parent-partner level.[9]

Directly available information. We start by stacking three types of bilateral observations, directly available in our data: (i) all observations from the profit-making sub-sample of the OECD's aggregated CbCR statistics, (ii) all observations from Tørsløv, Wier, and Zucman (2022)'s data on tax haven profits, and (iii) all observations from Tørsløv, Wier, and Zucman (2022)'s data on domestic profits excluding parent countries reporting CbCR statistics. For each observation, we gather two variables: post-carve-out pre-tax profits[10] and the effective tax rate[11]. We apply the usual formula with the minimum tax rate retained (e.g., 15% in the central case) and deduce a tax deficit for each observation. For some parent countries, present in CbCR statistics and in Tørsløv, Wier, and Zucman (2022)'s data on tax haven profits, the "same" information is available twice: in such cases, consistently with the pre-existing method, we retain the data source that yields the largest tax haven tax deficit. Profits are turned to zero for all tax haven observations from the non-retained source.[12]

9. The parent country designates the ultimate parent entity's location and the partner corresponds to the jurisdiction where profits are booked.

10. Those are obtained in the same way as in our standard methodology, that is in three steps. In aggregated CbCR statistics, we subtract from pre-tax profits a share of tangible asset value and a share of the employee count times annual earnings estimated from ILO data (the shares corresponding to selected carve-out rates). We compute the mean impact of the substance-based income exclusion for domestic observations and in tax havens. We apply these mean reductions to profits observed in Tørsløv, Wier, and Zucman (2022)'s data on domestic and tax haven activities respectively.

11. For the observations drawn from CbCR statistics, the effective tax rate is averaged over the three income years (2016, 2017, and 2018). The observations that come from Tørsløv, Wier, and Zucman (2022)'s data on tax haven profits are all associated with an assumed effective tax rate of 10%. Eventually, Tørsløv, Wier, and Zucman (2022)'s data on domestic profits directly provide effective tax rates.

12. To be fully precise, the set of countries concerned with this "replacement" of some CbCR observations with data from Tørsløv, Wier, and Zucman (2022) is determined in the absence of carve-outs. If the substance-based income exclusion applies, we assess this set without carve-outs holding everything else constant (e.g., the minimum rate, the treatment of problematic CbCR observations, etc.) and operate the replacement based on the list of parent countries thereby obtained. This specific procedure is also inherited from our initial methodology. The purpose is to ensure that carve-outs have a smooth impact on tax deficit estimates: if we allowed the replacement set to vary with carve-outs, some countries' tax haven tax deficit could be drawn from different data sources depending on the chosen carve-out rates, and total tax deficits could thus evolve in a discontinuous manner with carve-out rates.

Splitting the "Rest of non-EU tax havens". In Tørsløv, Wier, and Zucman (2022)'s data, non-EU tax havens except for Switzerland are aggregated into a single partner, the "Rest of non-EU tax havens". How are they treated with our usual method? In the full IIR case, the tax deficits computed for these observations are simply attributed to parent countries; in the full QDMTT case, we distribute the total tax deficit amount concerned across non-EU tax havens (outside of Switzerland) in proportion to their tax deficits from CbCR observations. Our new method must be consistent with both cases while disaggregating these observations bilaterally. Based on CbCR statistics, we compute the share of foreign tax deficits associated with a relevant (non-Switzerland) non-EU tax haven as partner that are collected via a QDMTT.[13] Based on this share, we split the "Rest of non-EU tax havens" tax deficits in Tørsløv, Wier, and Zucman (2022)'s data into two parts: a portion not collected via a QDMTT remains associated with a "REST" partner; the complement, assumed to be collected via a QDMTT, is distributed across new observations formed with the relevant non-EU tax havens that implement a QDMTT as partners, in proportion to the tax deficits with which they are associated in CbCR statistics.

Imputing missing non-haven tax deficits. Another issue resides in the foreign non-haven tax deficit of TWZ countries. With our initial methodology in the full IIR case, for each such parent, we impute the non-haven tax deficit based on the tax haven tax deficit. The methodology behind this imputation is described in the online appendix of Baraké et al. (2022). For the full QDMTT case, we assess the total tax deficit amount imputed in the full IIR case (holding all parameters constant) and distribute it across non-haven jurisdictions in proportion to the tax deficits with which they are associated as foreign partners in CbCR statistics. With our new method, (i) we compute the tax haven tax deficit associated with each TWZ country, (ii) we derive each TWZ country's non-haven tax deficit with the same imputation as in our pre-existing methodology, (iii) we form new observations with the non-haven partners observed in CbCR statistics, and (iv) we distribute the imputed non-haven tax deficits across these new observations, in proportion to the tax deficits with which they are associated in CbCR statistics.

Resulting bilateral dataset. We then stack all bilateral observations, be they observed initially, disaggregated from a "Rest of non-EU tax havens" partner, or imputed in the previous step.

4.2 Application of the various Pillar Two instruments

Based on this bilateral mapping of tax deficits, we can apply the different Pillar Two instruments in the relevant priority order and deduce country-by-country revenue gains. This step requires lists of countries implementing the IIR while including or not their domestic tax deficit, countries adopting a QDMTT which applies or not to the profits of their own multinational companies, and countries adopting a UTPR that targets or not foreign multinationals' domestic tax deficit. One can also choose to condition the application of the UTPR onto a statutory tax rate threshold, set any weights for sales, assets, and employees in the UTPR allocation key, and vary additional parameters.

Indicator variables. We enrich the bilateral tax deficit mapping with dummy variables that indicate whether collection occurs via a "foreign QDMTT" (a QDMTT applying to profits booked by multinationals in foreign countries), a "domestic QDMTT" (a QDMTT applying to profits booked by multinationals domestically), a foreign IIR, a domestic IIR, foreign UTPRs, or domestic UTPRs. If a statutory tax rate threshold applies to the UTPR, we take it into account in the UTPR dummies. To do so, we add parent countries' 2022 statutory tax rates and compare them with the safe harbour threshold.

UTPR. Then, we isolate the subsets of observations whose tax deficits are collected through foreign and domestic UTPRs respectively. We must allocate these tax deficits among the jurisdictions that implement a UTPR and we distinguish two cases depending on the parent country considered. On the one hand, if CbCR statistics directly provide a sufficiently granular breakdown of the allocation key, we use this mapping to split tax deficits. On the other hand, when the parent country is absent from CbCR statistics or is

13. This step thus requires the lists of countries adopting a QDMTT, that covers or not domestic under-taxed profits. The other lists, which determine the implementation of the IIR and the QDMTT, can be declared at a later stage.

associated with an insufficiently detailed breakdown, we rely on the average allocation keys described in Section 3.2.2. Note that we follow this procedure separately for foreign and domestic observations as the set of collecting jurisdictions may differ in both cases: countries may account or not for foreign multinationals' domestic tax deficits when adopting a UTPR. Besides, if UTPR implementing jurisdictions are supposed to share the full not-yet-collected tax deficits (like in the ongoing implementation of Pillar Two), we re-scale the allocation key so that it sums to one for each tax deficit being distributed; without this re-scaling, UTPR implementing jurisdictions only collect foreign multinationals' tax deficits in proportion to their weight in the global distribution of the allocation key. We end up with a *(parent, partner, collecting country)* trilateral dataset where the main variables are the *(parent, partner)* amount of tax deficit and the share attributable to the collecting country through the UTPR.

QDMTT and IIR. Next, we consider the remaining observations and apply QDMTTs or IIRs. Depending on pre-defined dummies, the collecting country is either the partner jurisdiction (if it adopts a QDMTT) or the parent country (if its IIR is relevant). We add an attributable share of one to reproduce the trilateral structure obtained above.

Final revenue gains. Once the two datasets are concatenated, we compute each jurisdiction's revenue gains by multiplying tax deficits with the attributable share and aggregating along collecting countries.

5 Sanity Checks and Testing

Interestingly, we now have two independent methods to simulate many of our scenarios of interest. This has at least three main advantages: (i) establishing the new approach allowed to challenge the existing calculations, (ii) we can ensure that the two methods yield the same results in cases (e.g., scenarios, income years, minimum rates, etc.) for which they were not benchmarked amid the construction process, and (iii) their comparison may allow to quickly detect issues in future developments.[14] Overall, having these two methods side-by-side makes our computations more robust.

To take full advantage of it, we implement tests that automatically compare the results of the two methods.[15] They cover the following scenarios:

- The full IIR / headquarter country scenario, with or without non-EU domestic tax deficits. We compare the results obtained with the two methods for all *(income year, carve-outs, minimum rate)* combinations where the income year is 2017 or 2018, carve-outs are based on long-term or first-year rates or are simply ignored, and two minimum rates are drawn from a uniform distribution respectively between 10% and 20% and between 20% and 30%;

- The full QDMTT scenario, for the same *(year, carve-outs, minimum rate)* combinations as above;

- Various partial cooperation scenarios: (i) EU Member-States implementing an IIR and a UTPR that cover the domestic tax deficits of EU and foreign multinationals; (ii) EU Member-States and a set of non-EU countries implementing an IIR and a UTPR that cover the domestic tax deficits of EU and foreign multinationals; (iii) a scenario similar to (i) in which non-EU multinationals' tax deficits are only collected in proportion to the weight of EU countries in their total sales; (iv) a scenario similar to (ii) in which the tax deficits of multinationals headquartered in a non-implementing jurisdiction are only collected in proportion to the weight of implementing countries in their total sales; (v) a scenario similar to (i) in which EU countries only collect the foreign and domestic tax deficits of multinationals headquartered in a non-EU country with a statutory tax rate below 20%. In the latter, we only compare the revenue gains from EU multinationals. All these cases are tested with all *(income year, carve-outs, allocation key weights)* combinations where the income year and carve-outs are the same as above and allocation key weights either focus on extra-group sales or are drawn randomly. The minimum rate is drawn from a uniform distribution between 0.15 and 0.3;

- A unilateral implementation scenario in which one country adopts an IIR that applies the foreign and domestic tax deficits of its own multinationals and collects a portion of the foreign and domestic tax deficits of non-implementing jurisdictions' multinationals. This portion is determined by the implementing country's weight in foreign multinationals' total activities (sales, assets, and/or employees). The initial method allows to simulate such a scenario for all parent countries in our data altogether. We test these results in two ways. First, we control that the tax deficits collected from countries' own multinationals are identical to the ones obtained in the full IIR scenario with domestic tax deficit collection. Second, we select three countries randomly. For each of those, we use the new approach to simulate the revenue gains from unilateral implementation (including the collection of a part of foreign multinationals' tax deficits) and compare the results obtained with both methods. We follow this procedure for the same *(income year, carve-outs, allocation key weights)* combinations as above. The minimum rate is again drawn from a uniform distribution between 0.15 and 0.3;

- A full apportionment scenario in which all foreign and domestic tax deficits are distributed to all countries according to an allocation key. In Pillar Two terms, this could be seen as all jurisdictions implementing a UTPR covering the profits booked abroad or domestically by multinationals, without

14. The methods are independent in the sense that none of them relies on intermediary outputs from the other. Some data preparation elements are however common to both methods: in particular, the OECD's and Tørsløv, Wier, and Zucman (2022)'s data are preprocessed with the same code and, when necessary, allocation keys are obtained via the same procedure. In addition, the new approach was specifically designed to ensure consistency with the pre-established methodology on some key results. These links between the two methods may limit but do not fundamentally question the advantages discussed here.

15. These tests build on the Python testing framework `pytest`. They can be run manually from a simple command; they are also run automatically whenever a change in the local code is pushed to the GitHub-hosted remote repository. In the latter case, as runtime is limited to six hours per job, we reduce the set of income years covered from 2016-2018 to 2018 only.

any IIR or QDMTT. Revenue gains can be simulated with the two methods and we simply compare country-by-country estimates. We follow this procedure for the same *(income year, carve-outs, allocation key weights)* combinations as above. The minimum rate is again drawn from a uniform distribution between 0.15 and 0.3.

6 References

Baraké, Mona, Theresa Neef, Paul-Emmanuel Chouc, and Gabriel Zucman. 2021a. *Collecting the Tax Deficit of Multinational Companies: Simulations for the European Union.* Research Report. EU Tax Observatory, June. https://halshs.archives-ouvertes.fr/halshs-03323095.

———. 2021b. *Minimizing the Minimum Tax? The Critical Effect of Substance Carve-Outs.* Research Note. EU Tax Observatory, July. https://shs.hal.science/halshs-03323087.

———. 2021c. *Revenue Effects of the Global Minimum Tax: Country-by-Country Estimates.* Research Note. EU Tax Observatory, October. https://shs.hal.science/halshs-04103899.

Baraké, Mona, Paul-Emmanuel Chouc, Theresa Neef, and Gabriel Zucman. 2022. "Revenue Effects of the Global Minimum Tax Under Pillar Two." *Intertax* 50 (10): 689–710. https://kluwerlawonline.com/journalarticle/Intertax/50.4/TAXI2022074.

European Central Bank. 2021. *Euro Foreign Exchange Reference Rates.* ECB / Eurosystem policy and exchange rates. https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html.

International Labor Organization. 2021. *Mean Nominal Monthly Earnings of Employees by Sex and Economic Activity (Local Currency).* ILO Statistics. https://www.ilo.org/shinyapps/bulkexplorer14/?lang=en&id=EAR_XEES_SEX_ECO_NB_M.

International Monetary Fund. 2021. *World Economic Outlook (WEO) database.* https://www.imf.org/en/Publications/WEO/weo-database/2021/April.

KPMG. 2021. *Corporate Tax Rates Table.* https://kpmg.com/be/en/home/services/tax/tax-technology/tax-rates-online/corporate-tax-rates-table.html.

OECD. 2023. *Table I – Aggregate Totals by Jurisdiction.* Available income years: 2016, 2017, and 2018. Data: https://stats.oecd.org/Index.aspx?DataSetCode=CBCR_TABLEI. Data limitations disclaimer: https://www.oecd.org/tax/tax-policy/anonymised-and-aggregated-cbcr-statistics-disclaimer.pdf.

Tax Foundation. 2022. *Corporate Tax Rates around the World.* https://taxfoundation.org/data/all/global/corporate-tax-rates-by-country-2022.

Tørsløv, Thomas, Ludvig Wier, and Gabriel Zucman. 2022. "The Missing Profits of Nations." *The Review of Economic Studies* 90, no. 3 (July): 1499–1534. ISSN: 0034-6527. https://doi.org/10.1093/restud/rdac049. eprint: https://academic.oup.com/restud/article-pdf/90/3/1499/50212159/rdac049.pdf. https://doi.org/10.1093/restud/rdac049.