# Tax Loss Carry-Forwards and the Elasticity of Corporate Taxable Income: Evidence from Administrative Tax Records*

Jaroslav Bukovina† Tomáš Lichard‡ Ján Palguta§

Branislav Žúdel†

Revised: June 2022

**Abstract**

We examine how the introduction of tax loss carry-forwards increases the elasticity of corporate taxable income. Using variation from corporate tax reforms and data from administrative tax returns, we estimate corporate ETI from the amount of companies bunching at the minimum corporation tax kinks in Slovakia. We find that bunching sharply increases once companies gain the option to offset tax liability above the kinks by prior tax losses. The implied efficiency cost of raising an additional euro in corporate tax revenue drops 2-36 cents across corporate size categories once corporate ETI is adjusted for tax loss carry-forwards.

**Keywords**: elasticity of taxable income; corporations; tax losses; carry-forwards; bunching; marginal efficiency burden; minimum tax

**JEL**: H21, H25, H26, H30, D25

*We would like to thank anonymous referees, Miguel Almunia, Juan J. Dolado, Štěpán Jurajda, Nikolas Mittag, Ignacio Ortuño, Johannes Schneider, Baptiste Souillard, Samuel Škoda and all conference and seminar participants at CERGE-EI, Charles Uni, CUNEF, EUBA, Masaryk Uni, Prague Uni of Economics and Business, UC3M, 2021 SAEe Symposium, 2021 SEA Conference, 2021 EEA-ESEM Congress, 2021 RES Conference, 2021 ArmEA Conference, 2021 Virtual Conference "Corruption, Tax Evasion and Institutions" at BICEPS Riga, and 2021 Virtual Conference on "The Shadow Economy, Tax Behaviour and Institutions" at Brunel London for insightful suggestions. Palguta acknowledges support from the Autonomous Community of Madrid via grants 2017/T2-SOC-5363 and EPUC3M11 (V PRICIT) and from the project NPO "Systemic Risk Institute" (LX22NPO5101). Lichard acknowledges support from the Grant Agency of the Czech Republic (GAČR 19-15943S). All opinions expressed are those of the authors and have not been endorsed by the Slovak Ministry of Finance. All remaining errors are our own.

†Ministry of Finance of the Slovak Republic. Štefanovičova 5, P. O. BOX 82, 817 82 Bratislava, Slovakia.

‡Prague University of Economics and Business. W. Churchill Sq. 1938/4, 13067 Prague, Czechia.

§University Carlos III of Madrid, Department of Economics. calle Madrid 126, 28903 Getafe, Spain. Correspondence email: jpalguta@eco.uc3m.es

# 1 Introduction

Since the seminal contributions by Feldstein (1995, 1999), the elasticity of corporate taxable income (corporate ETI) has been viewed as the central parameter in the economic analysis of corporate taxation, because in the absence of external effects, this elasticity serves as a *sufficient statistic* for determining the efficiency burden of corporate income tax (Chetty, 2009; Saez, Slemrod and Giertz, 2012). In the modern tax literature, the corporate ETI can be estimated from the mass of firms bunching at kinks in the corporate tax schedule (Saez, 2010). The elasticity, *per se* however, does not differentiate between mechanisms through which the tax results in lower income— whether it is reduced economic activity, outright evasion or shifting profits and deductible costs across tax bases and time.

A defining feature of corporate taxation which strongly determines tax base is that corporations can carry forward past losses for long periods. In 2022 in the U.S., for instance, businesses could *indefinitely* carry forward net operating losses (NOLs) to offset up to 80 percent of taxable income. Many European economies do not set any limits on loss carry-forwards.[1] Thanks to carry-forwards, companies can afford to continue operating even if they are not producing immediate profits. The ability to carry forward losses can, however, increase the taxable income elasticity and result in an overstated efficiency burden if deductible losses are only transferred from one fiscal period to another to offset taxable income towards tax kinks.

In this paper, we use variation from corporate tax reforms and administrative data from all corporate tax returns in 2010-2018 in Slovakia to examine to what extent an introduction of new carry-forwards of corporate tax losses increases the corporate ETI and biases the estimated efficiency burden of corporate taxes. Understanding the impacts of carry-forwards is of first-order importance, as NOLs carried forward in the U.S. in 2013 alone totaled $180 billion (Coles, Patel, Seegert and Smith, 2022).[2] If shift-

[1] Table A.1 reviews loss carry-over provisions across OECD countries (Hanappi, 2018).

[2] We study carry-forwards of *tax losses* above kinks in tax liability distributions, but NOL carry-forwards operate virtually on the exact same principle of offsetting taxable income above zero by prior net operating losses.

ing losses in time does not lead to major efficiency costs, detailed knowledge of the implications of carry-forwards is key for evaluating the effects of tax reforms on business activity, tax revenue and economic welfare (Saez et al., 2012).

Existing studies have either focused solely on estimating the scope of corporate ETI (Gruber and Rauh, 2007; Dwenger and Steiner, 2012; Lediga, Riedel and Strohmaier, 2019) or examined ETI sources other than (tax) loss shifting. Given typically scarce variation in marginal tax rates (MTR) in mostly linear corporate tax schedules and high persistence in the availability of carry-forwards, the literature turned to employing variation from personal tax schedules. Devereux, Liu and Loretz (2014), for instance, examine increased corporate ETI due to shifting profits into the salaries of small business owner-managers. Miller, Pope and Smith (2022) study long- and short-term profit retention within owner-managed firms as a way to avoid personal taxes.[3] Less attention has been paid to examining the contribution of (tax) loss shifting to the corporate ETI, which might be more relevant for larger, more formal and scrutinized companies. Given that these companies tend to concentrate a higher share of economic activity and generate more tax revenue, understanding likely heterogeneity in the sources of corporate ETI is highly relevant both from the fiscal and economic welfare perspectives.

We contribute to the literature in at least four ways. First, we provide evidence that tax loss carry-forwards sharply increase bunching and the implied corporate ETI at kinks in the corporate tax schedule. Second, we demonstrate sizable heterogeneity in the contribution of tax loss carry-forwards to the corporate ETI across corporate size categories. Third, we quantify upward bias in the estimated efficiency burden of raising an additional euro in the corporation tax above tax kinks. Fourth, we show that in the absence of carry-forwards, firms would adjust other margins of their responses to higher MTRs above tax kinks to reduce taxable income towards kinks.

Two features of the Slovak institutional setting enable our empirical analysis. The first is the existence of kinks in the corporate tax schedule in 2014-2017. Kinks emerged

[3]Furthermore, Coles et al. (2022) decompose corporate ETI for small U.S. sub-chapter C companies into real economic responses and overall tax adjustments. In the context of a developing country, Bachas and Soto (2021) separate the elasticity of taxable profit into revenue and cost elasticities.

after a 2014 reform introduced several categories of a *minimum corporation tax*. Large corporations with turnover above €500,000 were newly required to pay at least €2,880 in tax annually, even if the proportional tax rate indicated a lower tax liability. Lower-turnover companies were subject to a minimum tax of €960 if they were VAT registered and a minimum tax of €480 if not.[4] Corporate income thus became subject to zero MTR below the new minimum tax amounts, but remained subject to positive MTR above, similarly to all corporate income prior to the reform. The minimum tax additionally prompted exits by the lowest-profit companies, which effectively had to pay the government to operate.

The second feature introduced by the 2014 reform was that starting in 2015 firms could carry forward *tax losses*, i.e. those tax payments they had to make to match the minimum tax when the proportional MTR indicated lower tax liability. Tax losses could be carried forward for three years, but only to offset tax liability exceeding the minimum tax. The advantage of carry-forwards was that they largely mitigated motivations for misreporting tax losses beneath the minimum tax levels.[5] Importantly for our empirical strategy, carry-forwards remained available even after the minimum tax was abolished after 2017, but still only to offset tax liability above the former kinks.

In our empirical strategy, we use a non-parametric bunching design by Devereux et al. (2014) to estimate corporate ETI at the minimum tax kinks by contrasting the scope of bunching in the post-2015 tax liability distributions against appropriately scaled empirical distributions observed in the pre-reform 2010-2013 period. We then estimate the portion of bunching that would not arise in the counterfactual scenario without the introduction of tax loss carry-forwards using several comparisons. These include: (1) a naive comparison of bunching before and after companies apply carry-forwards, (2) a comparison of bunching before and after the abolition of the minimum tax, when the excess mass at the former kinks consisted solely of companies carrying forward

[4]Corporations had to register for VAT if their turnover in the prior 12 months exceeded €49,790.

[5]This was because (i) companies were subject to the same amount of tax for any level of taxable income reported beneath the minimum tax amounts, and (ii) future offsets of tax losses over-reported today would require reporting higher taxable income above the minimum tax tomorrow anyway.

tax losses, and (3) a comparison of bunching across companies (in)eligible for tax loss carry-forwards. Ultimately, we estimate the cost of raising an additional euro in the corporation tax, i.e. the *marginal excess burden* (MEB), as if in the top tax bracket above the minimum tax amounts, as in Saez et al. (2012), both before and after adjusting corporate ETI for non-distortive tax loss shifting.

Our main bunching estimates unadjusted for carry-forwards imply corporate ETI between 0.12 for companies with turnover above €500,000 (top category with 13.7% of companies) to 0.75 for lower-turnover VAT registered firms (middle category of 47.8% of firms) to 1.44 for VAT non-registered firms (bottom category with 38.5% of companies). The corporate ETI drops at least 50.8%, 23.7% and 21.2%, respectively, in the top, middle and bottom categories once we adjust the estimates for tax loss shifting. As a result, the implied welfare loss should the MTR above the minimum tax levels rise by 1%, drops from 3.8 to 1.8 cents per each additional euro raised in corporation tax for companies in the top category, from 35.6 to 25.0 cents in the middle category, and from 102.5 to 66.7 cents in the bottom category. Additionally, we find that the scope of bunching by firms with no tax losses to be carried forward is much higher compared to bunching before companies apply carry-forwards. This result supports the hypothesis that carry-forwards replace other means of reducing taxable income towards kinks.

Taken together, our results imply highly heterogeneous sensitivity of the corporate tax base with respect to the marginal tax rate, and highlight challenges in the estimation of appropriate sufficient statistics for the welfare analysis in the presence of heterogeneity both in the scope of corporate ETI and the structure of its components, as well as in the presence of substitution between different margins of agents' responses to the tax. Our results add to the literature which has pointed out the relevance of inter-temporal shifting, so far in the context of taxing wage-earners, self-employed individuals and business owner-managers (Slemrod, 1995; Goolsbee, 2000; le Maire and Schjerning, 2013; Kreiner, Leth-Petersen and Skov, 2016; Miller et al., 2022). The heterogeneity in corporate ETI agrees with the results by Pomeranz (2015) and Naritomi (2019) who show that VAT and third-party monitoring improve tax compliance.

We provide additional evidence informative about the sources of tax loss shifting. Our results namely suggest that many companies used to reduce taxable income towards zero before the 2014 reform imposed zero MTR below the minimum tax amounts. Tax loss carry-forwards then became available to corporations which did not exit or move immediately towards the new kinks. We provide support for this explanation by comparing the excess mass of companies emerged at the new kinks against the decline in bunching at zero tax liability. We find that the mass of companies newly missing at zero even exceeds the new excess mass at the minimum tax kinks in all corporate categories, allowing for the option that some companies did not move exactly towards new kinks. Our evidence from difference-in-difference regressions moreover suggests a rather limited *extensive-margin response*: the exit by firms initially below the minimum tax levels prior to the tax reform occurs after the minimum tax reform mostly among companies in the bottom category. Approximately half of such exits are, however, due to the formal closure of inactive companies with zero previous turnover.

Last but not least, we present new insights from a comparison of bunching methods for estimating counterfactual density distributions at tax kinks. We argue that if we neglected that the source of the excess mass at the new kinks originates mostly from around zero and assumed that the mass rather comes proportionally from the whole distribution to the left of the kinks based on cross-sectional methods (which would be the default assumption in the bunching method by Chetty, Friedman, Olsen and Pistaferri, 2011), we would obtain overestimated counterfactuals at kinks and 60-69% lower corporate ETI compared to our preferred estimates based on uniquely available pre-reform data. These results highlight the benefits of searching for appropriate counterfactuals in the empirical bunching analyses, which might be especially desirable in the settings of pronounced income and (tax) loss shifting, tax evasion and avoidance. Our analysis is therefore informative for the tax literature which infers ETI from the scope of bunching (see Kleven, 2016 for a review). Our advice also extends to settings outside of the tax literature in which pre-reform distributions are key to credibly estimated counterfactuals (as in Palguta and Pertold, 2017 and Harasztosi and Lindner, 2019).

The rest of our paper is organized as follows. Section 2 presents the institutional background of corporate taxation in Slovakia. Section 3 describes data from corporate tax returns. Section 4 presents the non-parametric bunching method for estimating corporate ETI. Section 5 presents the main estimates of corporate ETI unadjusted for tax loss shifting. Section 6 quantifies the tax loss shifting component of the corporate ETI. Section 7 studies the sources of tax loss carry-forwards by examining bunching at zero, the extensive-margin response and evidence from cross-sectional bunching approaches. Section 8 examines the implications of neglecting tax loss shifting for the marginal excess burden of the corporation tax. Section 9 summarizes and concludes.

# 2 Corporate income taxation in Slovakia

Slovakia is a high-income, developed market economy located in the Central Europe. After splitting from the former Czechoslovakia in 1993, Slovakia joined the OECD in 2000, the European Union in 2004 and the Eurozone in 2009.

In 2017, governmental tax revenue in Slovakia amounted to 33% of GDP (OECD, 2018). 11% of this revenue was from corporate income tax, 10% from personal income tax, 43% from social security contributions and 33% from taxes on goods and services. Corporation tax is remitted annually by around 190,000 companies.[6]

**Minimum tax reform.** Until 2014, Slovakia applied a flat tax rate on all corporations: 19% in 2004-2012 and 23% in 2013. The effective tax rate was however estimated to be 3.6 - 4.7% in 2005-2013 (Ministry of Finance of the Slovak Republic, 2018). Around 60% of corporations used to pay no income tax. This was partly due to legitimate reasons, such as natural volatility of corporate income and the ability of companies to carry forward losses. The Ministry of Finance of the Slovak Republic (2013) was however also expressing concerns about excessive tax avoidance and evasion.

[6]Sole proprietorships and partnerships are not subject to corporate taxes. Profits of unincorporated firms are attributed to individual partners and taxed according to the personal income tax schedule. From among all legal entities, incorporated companies generate around 96% of tax revenue.

**Table 1:** Minimum corporation tax, by corporate size category

| Corporate category | Sales turnover | Registered for VAT | Minimum tax |
|---|---|---|---|
| Top | ≥€500,000 | Yes[a] | €2,880 |
| Middle | <€500,000 | Yes | €960 |
| Bottom | <€500,000 | No | €480 |

*Notes:* [a]Companies in specific sectors, such as financial institutions, insurance companies, post offices and public broadcasting companies, do not need to register for VAT. Exemptions from VAT registration are specified in articles 28–42 of the Slovak Tax Code Act no. 222/2004 on VAT. https://www.zakonypreludi.sk/zz/2004-222#f3048632

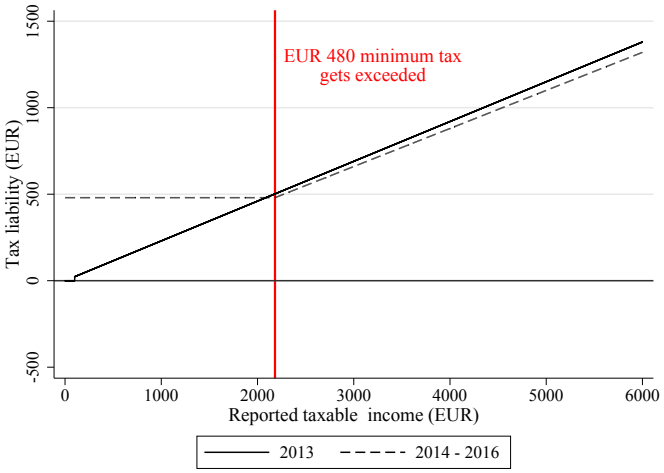
To tackle low effective tax rates, Slovakia introduced in 2014 a *minimum corporation tax* with three levels, as shown in Table 1. The top category of companies with turnover above €500,000 was subject to a €2,880 minimum tax. The middle category of VAT registered companies below the €500,000 turnover limit had to pay at least €960. The lowest category of VAT non-registered companies with annual turnover below €500,000 had to pay at least €480 in tax annually.[7] All income above the minimum tax levels was subject to 22% tax rate in 2014-2016 and 21% rate afterwards.

Figure 1 visualizes the relationship between the reported taxable income and the implied tax liability, both before and after the introduction of the minimum tax. Using an example of companies subject to the €480 minimum tax, the figure shows that the reform increased tax liability for all companies which would have it otherwise below the minimum tax levels. The reform thereby established kinks in the corporate tax schedule with zero MTR below the minimum tax amounts and positive MTR above. On the extensive margin, the reform additionally prompted exit for lowest-profit companies which effectively had to pay the government to operate.

**Tax loss carry-forwards.** In addition to the establishment of the minimum tax, the 2014 reform also introduced the option of *tax loss carry-forwards*, first applicable in 2015. The rule was that after a company calculated its tax liability using the proportional tax

[7]Corporations with more than 20% of handicapped employees needed to pay 50% of the minimum tax. In practice, this reduction was applied to a negligible number of companies. The tax code also did not require minimum tax payments from companies in the first year after incorporation and from corporations filing for bankruptcy and in liquidation. We account for these rules in our analysis.

**Figure 1:** Minimum tax in the bottom corporate category




rate and found it below the minimum tax amount, it was required to make an additional payment to match the minimum tax. Such tax loss could be carried forward for three years, provided that it was used to offset tax liability above the minimum tax levels. Tax loss carry-forwards were not however automatic or mandatory.

The reason for introducing carry-forwards was that tax optimizing firms with volatile income around the minimum tax levels might be motivated without carry-forwards to shift revenues from high-income years into those when they are temporarily below the minimum tax amounts. Costs and investments might be postponed from high-expenditure years into those when tax liability is above the minimum tax levels.

In Table A.2, we provide a stylized example of calculating the maximum amount of tax loss carry-forwards.[8] The example illustrates how tax loss carry-forwards decrease tax liability in some years and increase the mass of companies located at the minimum tax kinks. One way of looking at their use is as non-distortive shifting of corporate taxable income into past fiscal periods, in which a lower MTR is applied on corporate income. In our analysis, we estimate the relevance of such tax loss shifting for the corporate ETI and the marginal excess burden of the corporation tax.

[8]The table gives an example of a VAT registered company with turnover below €500,000, subject to the €960 minimum tax. If such company had a tax liability of €680 in 2014, the company was required to pay up €960 - €680 = €280 to match the minimum tax. Next year, provided that the company had tax liability higher than €960, which is true in our example, the company could apply carry-forwards up to €280 against tax liability exceeding €960. In our stylized example, in the absence of carry-forwards, the company would have to pay €1,100. Therefore, its final tax liability could be reduced to €960.

**Abolition of the minimum tax.** Since 2018, Slovakia again cancelled the minimum corporation tax. The abolition was approved in November 2016, but the minimum tax still applied in 2017. Importantly for our empirical design, the reform maintained tax loss carry-forwards above the former minimum tax levels even after 2018.

In Table A.3, we give another stylized example how to calculate the amount of tax loss carry-forwards after the minimum tax abolition.[9] The example illustrates that even after cancelling the minimum tax, one could expect to find an excess mass of firms located at the abolished kinks. The motivation for bunching at kinks however entirely disappeared for companies without accumulated tax losses. For this reason, we attribute all bunching estimated at the abolished kinks in 2018 to companies shifting tax losses via carry-forwards. The taxable income elasticity implied from such bunching in 2018 will be key for one of our methods for decomposing the corporate ETI.

**Other fiscal reforms.** In addition to the 2014 and 2018 minimum tax reforms, Slovakia implemented several other tax changes in 2010-2018. In 2013, it raised the corporate tax rate from 19% to 23% and reduced it to 22% in 2014. In 2017, the tax rate dropped to 21%. Although the tax rate changes affect the amount of bunching at kinks, we take the current tax rates into account when estimating ETI, as in Saez (2010).

Furthermore, Slovakia imposed stricter rules on regular *net operating loss carry-forwards* in 2014. The maximum time frame from which past losses could be carried forward was reduced from seven to four prior years. Companies were also newly limited to forward annually at most 25% instead of 100% of the accumulated loss. Although these parametric changes might increase the number of companies with positive tax base, they do not create incentives for additional bunching at the minimum tax kinks.[10]

[9] In the table, a low-turnover, VAT non-registered company paid €180 in 2015, €30 in 2016, and €480 in 2017 to match the €480 minimum tax. The sum of these payments (€690) is the tax loss that could be carried over to 2018 to offset tax liability exceeding the former minimum tax. In our example, the company in 2018 had tax liability of €700 prior to carry-forwards. As a result, it could carry over €700 - €480 = €220, making it final tax liability equal to the former kink.

[10] Table A.4 summarizes other fiscal reforms of social security contributions, personal income tax, and other fees and tariffs implemented in 2013 and 2014, along with their fiscal impact estimated by the Ministry of Finance of the Slovak Republic (2014). We are not aware of any further changes in fiscal policy and tax enforcement that could be related to our results.

# 3 Data

We use administrative data from corporate tax returns covering the population of Slovak corporations in 2010-2018.[11] The dataset includes tax variables which correspond to all individual items recorded on tax return forms. These include annual information about corporate turnover, VAT registration, taxable income, tax liability prior to the minimum tax, the amount of tax loss carry-forwards, the applicable minimum tax, and tax actually paid. Over the nine-year observation period, the data covers around 300,000 distinct companies.

Table 2 reports averages of the key variables in our data, separately for 2010-2013 before the minimum tax reform and 2015-2017 when companies were subject to the minimum tax and could already carry forward tax losses. The averages are reported for all companies and separately for the three examined corporate categories.

In both periods, we can note substantial heterogeneity across corporations in terms of tax paid. In 2010-2013, the top category of high-turnover companies paid on average 45 times higher tax than the middle category of VAT registered, low-turnover companies and 100 times higher tax than the bottom category of VAT non-registered companies. After the tax reform, the heterogeneity was partially reduced. The average tax paid in the top category was "only" 37 times higher than in the middle category and 63 times higher than in the bottom category. The table thus indicates that the 2014 reform unequally impacted low-turnover compared to high-turnover companies.

We can note the unequal impact of the reform also by comparing initial tax liabilities (prior to the application of tax loss carry-forwards and the minimum tax) in 2015-2017 against taxes actually paid in this period. The final tax liability is namely 13% and 18% higher in the bottom and middle categories, respectively, compared to the initial tax liability. In contrast, tax bill is only 0.5% higher in the top category.[12]

[11] The dataset is confidential and owned by the Financial Directorate of the Slovak Republic, which provides it to other state organs of the Slovak Republic according to article 11 of the Slovak Tax Code Act no. 563/2009 on tax secrecy. For details, see: https://www.zakonypreludi.sk/zz/2009-563

[12] In accord with these figures, Figure A.1 in the Appendix shows €114 million growth in tax revenue from corporations with tax liability below €4,000 between 2013 and 2014. The growth almost perfectly coincides with the estimated fiscal impact of the minimum tax reform reported in Table A.4.

**Table 2:** Summary statistics

| | 2010 - 2013 | | | | 2015 - 2017 | | | |
|---|---|---|---|---|---|---|---|---|
| | All companies | Bottom category | Middle category | Top category | All companies | Bottom category | Middle category | Top category |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Turnover | 1,192,632 | 18,113 | 102,364 | 7,807,194 | 1,116,979 | 22,534 | 109,067 | 7,880,856 |
| | [33,412,200] | [40,969] | [119,865] | [87,337,095] | [32,844,049] | [42,553] | [119,879] | [89,354,143] |
| Taxable income | 50,755 | 3,071 | 6,931 | 317,784 | 59,431 | 5,490 | 8,910 | 395,681 |
| | [1,833,995] | [169,554] | [418,961] | [4,730,628] | [2,109,150] | [343,670] | [27,952] | [5,714,202] |
| Tax liability prior to tax loss carry-forwards and MT | 9,919 | 618 | 1,372 | 62,002 | 12,640 | 1,191 | 1,925 | 83,987 |
| | [362,805] | [34,096] | [79,644] | [936,789] | [452,277] | [75,316] | [6,062] | [1,225,081] |
| - % of companies with zero tax liability | 59.1 | 66.3 | 60.9 | 35.1 | 39.5 | 44.5 | 40.8 | 19.6 |
| - % of companies with zero tax liability and no reported loss | 19.5 | 30.7 | 13.9 | 11.2 | 12.3 | 18.8 | 8.3 | 6.1 |
| Tax loss carry-forwards | . | . | . | . | 69 | 25 | 72 | 195 |
| | | | | | [351] | [119] | [280] | [765] |
| Tax liability after carry-forwards but before MT | . | . | . | . | 12,571 | 1,166 | 1,853 | 83,792 |
| | | | | | [452,276] | [75,316] | [6,043] | [1,225,086] |
| % subject to €480 MT | 35.5[a] | . | . | . | 40.7 | 100.0 | 0.0 | 0.0 |
| % subject to €960 MT | 50.0[a] | . | . | . | 45.9 | 0.0 | 100.0 | 0.0 |
| % subject to €2880 MT | 14.5[a] | . | . | . | 13.4 | 0.0 | 0.0 | 100.0 |
| Tax actually paid | 9,919 | 618 | 1,372 | 62,002 | 12,925 | 1,343 | 2,275 | 84,445 |
| | [362,805] | [34,096] | [79,644] | [936,789] | [452,267] | [75,314] | [5,932] | [1,225,042] |
| Observations | 669,943 | 237,506 | 335,040 | 97,397 | 618,801 | 251,889 | 283,856 | 83,056 |

*Notes:* The variables are reported in Euro in 2010 prices. Standard deviations are reported in brackets. [a]In 2010-2013, we report the proportion of companies that would be subject to the minimum tax. Averages for 2014 and 2018 are reported separately in Table A.5.

Finally, Table 2 indicates that one of the reasons for the heterogeneous impact of the tax reform might have been that the growth in tax liability was less notably mitigated by tax loss carry-forwards in the bottom and middle categories compared to the top category. Tax loss carry-forwards respectively constitute 16% and 21% of the difference between the initial tax liability and tax paid in the bottom and middle categories. Yet, carry-forwards correspond to 43% of the difference in the top category. This finding hints at a higher relevance of inter-temporal tax loss carry-forwards for large corporations compared to less formal and less scrutinized firms in the bottom categories.

# 4 Empirical methods for estimating the corporate ETI

We estimate corporate ETI from the amount of corporations bunching at kinks in the marginal corporation rate schedule. We build on Saez (2010) who demonstrates that the compensated elasticity of taxable income with respect to the one minus the tax rate is proportional to the amount of bunching at kinks:

$$e \simeq \frac{b\left(t_1,\ t_2\right)}{\mathrm{K} \ln\left(\frac{1-t_1}{1-t_2}\right)} \tag{1}$$

where $K$ is some income level at which the MTR increases by a small amount from $t_1$ to $t_2$ and $b(t_1, t_2)$ corresponds to the fraction of companies which bunch at $K$ relative to the counterfactual density. In most empirical applications, the value of $K$ and the tax rates $t_1$ and $t_2$ are known policy parameters. The key remaining step to identify $e$ is to estimate the excess mass $b(t_1, t_2)$ bunching at $K$.

**Cross-sectional bunching approaches.** For inferring the scope of bunching at kinks, the modern tax literature dominantly employs two cross-sectional approaches by Saez (2010) and Chetty et al. (2011), which we respectively label as the *baseline* and the *adjusted* method.[13] In both methods, one estimates the counterfactual density distribu-

[13] We revise exact regression specifications and bunching formulas in Online Appendix B.

tions of taxable income (or tax liability) by first plotting their empirical distributions in a histogram of firms separated into small bins of a fixed width. In the second step, one fits a flexible high-order polynomial to the histogram excluding data within a narrow window around the kink. The counterfactual is then defined as the predicted values from the polynomial regression, while omitting the contribution of bins around the kink. In the *adjusted* method, one additionally shifts the counterfactual to the one side of the kink upwards until the area under the counterfactual equals the area under the empirical distribution. The assumption, which underlies causal inference in both methods is that the density distributions would be smooth in the absence of kinks.

A complication to identification might arise in the cross-sectional approaches if agents tend to bunch at round numbers in the inspected density distribution (Kleven and Waseem, 2013). In our setting, as we show later, another complication arises if one invokes implausible assumptions about the source of bunching at kinks. In particular, it is plausible that companies in our setting would dominantly bunch at zero tax liability in the counterfactual scenario without the minimum tax. If we assumed that the excess mass of companies at the minimum tax kink originates proportionally from the whole distribution to the left of the kinks, we might overestimate the counterfactual density at the kinks, producing attenuated estimates of the corporate ETI.

**Exploiting pre-reform distributions.** In order to address potential challenges associated with the cross-sectional bunching approaches, we employ also a *non-parametric strategy* by Devereux et al. (2014), in which one relaxes the assumption of a smooth counterfactual and makes no assumptions about the source of bunching. Instead, the strategy exploits timing of the 2014 tax reform and assumes that tax liability distributions after the reform would look the same as before the reform in the counterfactual scenario in which the reform was not implemented.[14]

Under such stationarity assumption, one can estimate a probability density function

[14]We provide support for this assumption in Figure A.2. We show that tax liability distributions had a stable shape in 2010-2013 prior to the introduction of the minimum tax and also across 2013 and 2018, i.e. prior to the introduction of the minimum tax and after its abolition.

$\widehat{p}_H(j)$ over a finite interval $(Z_{\min}, Z_{\max})$ using a histogram estimator:

$$\widehat{p}_H(j) = \frac{C_{j,t_{pre-reform}}}{\sum_{i=Z_{\min}}^{Z_{\max}} C_{i,t_{pre-reform}}} \tag{2}$$

where $C_{j,t_{pre-reform}}$ is the number of companies in a histogram bin $j$ from the tax liability distribution prior to the minimum tax reform. The counterfactual density is then:

$$\widehat{C}_j = \widehat{p}_H(j) \cdot \sum_{i=Z_{\min}}^{Z_{\max}} C_{i,t_{post-reform}}. \tag{3}$$

The implied excess number of companies bunching within a narrow window $(Z_L, Z_U)$ around the kink is computed as:

$$\widehat{B}(t_1,\ t_2) = \sum_{j=Z_L}^{Z_U} C_j - \widehat{C}_j \tag{4}$$

Finally, the estimated excess mass of companies bunching at the kink relative to the average density of the counterfactual distribution between $Z_L$ and $Z_U$ is:

$$\widehat{b}(t_1, t_2) = \frac{\widehat{B}(t_1, t_2)}{\sum_{j=Z_L}^{Z_U} \widehat{C}_j / N_j} \tag{5}$$

where $N_j$ is the number of bins between $Z_L$ and $Z_U$.

We calculate standard errors using a parametric bootstrap procedure with replacement. This means that we draw values from the estimated vector of errors to generate a new set of bin counts and apply the above bunching method to calculate a new estimate of $\widehat{b}^k$. We define the standard error of $\widehat{b}$ as the standard deviation of the distribution of $\widehat{b}^k$s. Finally, we estimate corporate ETI as a non-linear function of the bunching estimate, kink $K$ and the relative change in the net-of-tax rate $\ln\left(\frac{1-t_1}{1-t_2}\right)$ at $K$ using Eq. (1). We obtain standard errors for the elasticity again by bootstrapping.

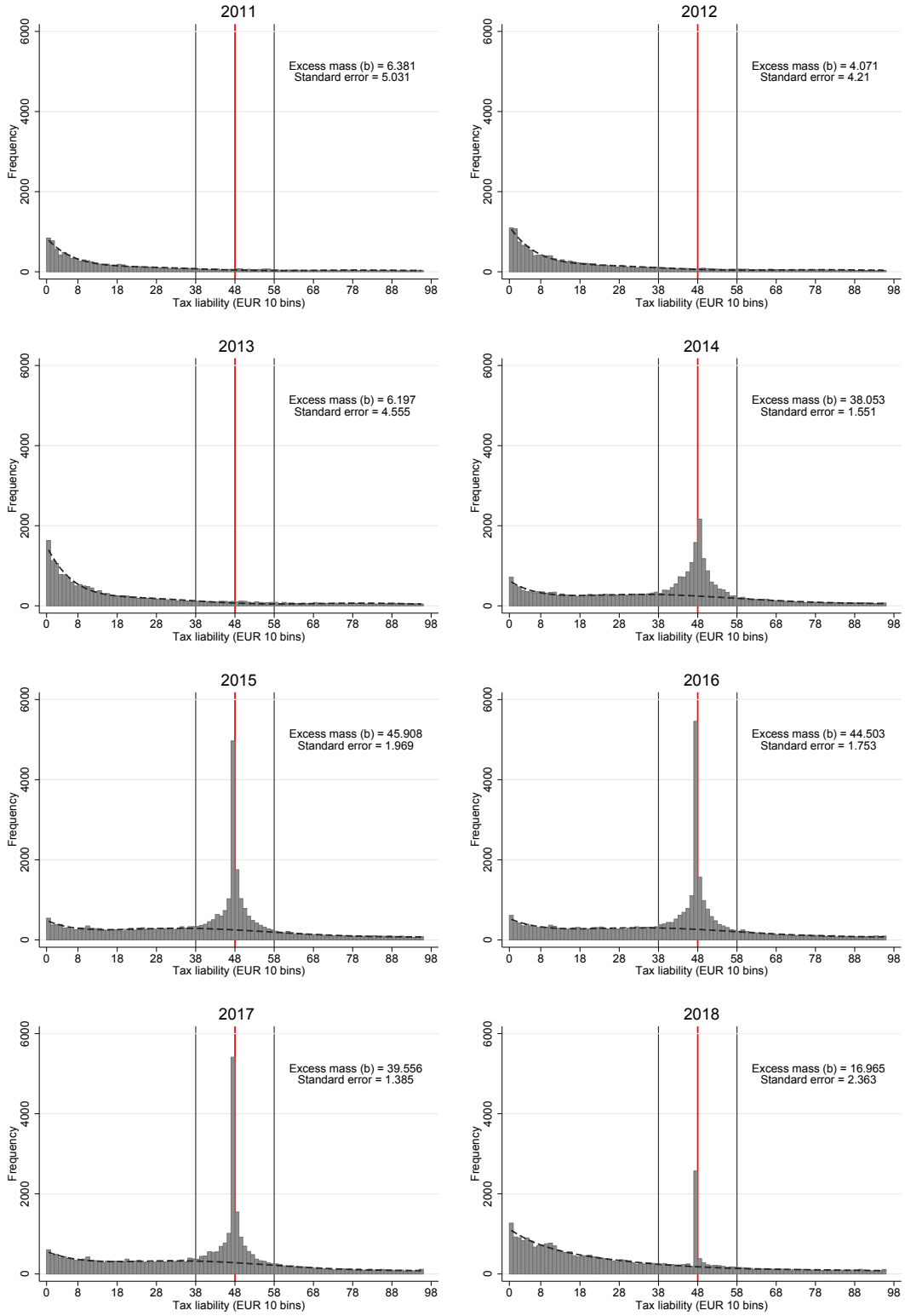
# 5 Main estimates of the corporate ETI

We find pronounced corporate bunching at the minimum tax kinks in otherwise declining distributions of corporate tax liability. Figure 2 displays tax liability distributions annually for the bottom category of low-turnover, VAT non-registered companies after they apply tax loss carry-forwards, but prior to the application of the minimum tax. Bunching clearly appears first in 2014, that is, immediately after companies became subject to the minimum tax. The excess mass is diffused around the kink rather than forming a point mass, as it is presumably difficult to control profits perfectly. Bunching sharply grows in 2015 when some companies could for the first time carry forward tax losses. The excess mass is more strictly concentrated exactly at the point of the kink, as carry-forwards could not be used to reduce tax liability further beneath the minimum tax levels. Bunching remains pronounced up to the end of the observation period, including in 2018 after the minimum tax was abolished, but tax loss carry-forwards remained available above the former minimum tax levels. The excess mass in 2018 yet consists almost entirely of companies located exactly at the point of the kink. Figures 3 and 4 show very similar evidence of bunching at the €960 and €2,880 minimum tax kinks for companies from the middle and top categories.

Next, we estimate the corporate ETI based on the pre-reform counterfactuals. To do so, we employ the 2010-2013 distributions of corporate tax liability and the histogram estimator from Eq. (2). In Table 3, we report corporate ETI for 2015-2016, when firms were subject to the minimum tax and could carry tax losses from 2014-2015 forward. According to our estimates, the corporate ETI is equal to 1.436, 0.745, and 0.118 in the lowest, middle, and top corporate categories, respectively. This means that in response to a hypothetical 10% rise in MTR, companies would respectively decrease taxable income by 14.36%, 7.45% and 1.18%. All estimates are significant at the 1% level.[15]

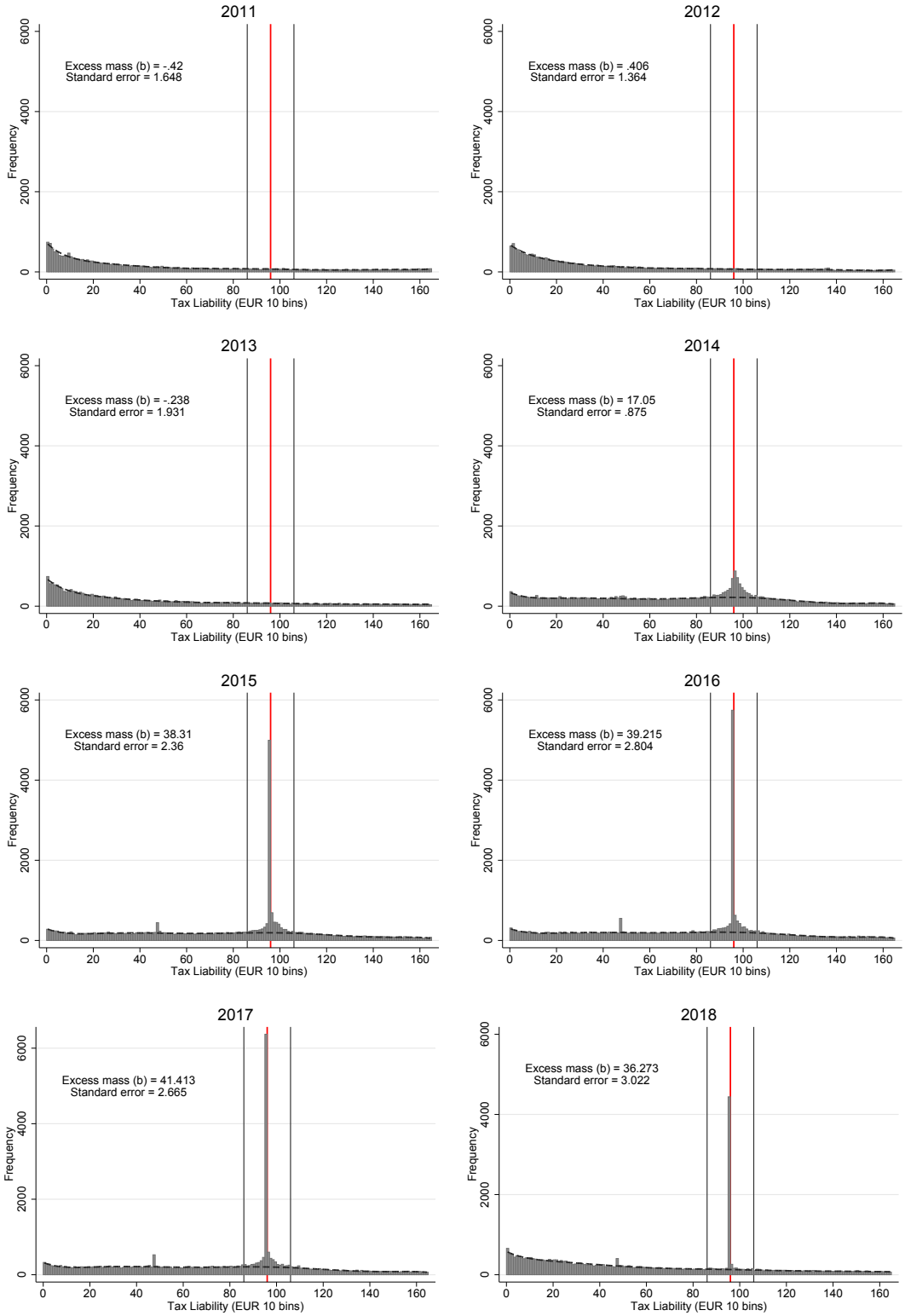
[15] In Table A.6, we examine the impact of omitting year 2013 from the estimation of the counterfactual, as tax liability distribution in this year might have been affected by the change in the main corporate tax rate. We show that the estimated ETI is strongly robust to employing only years 2010-2012.

**Figure 2:** Annual tax liability distributions around the €480 minimum tax kink



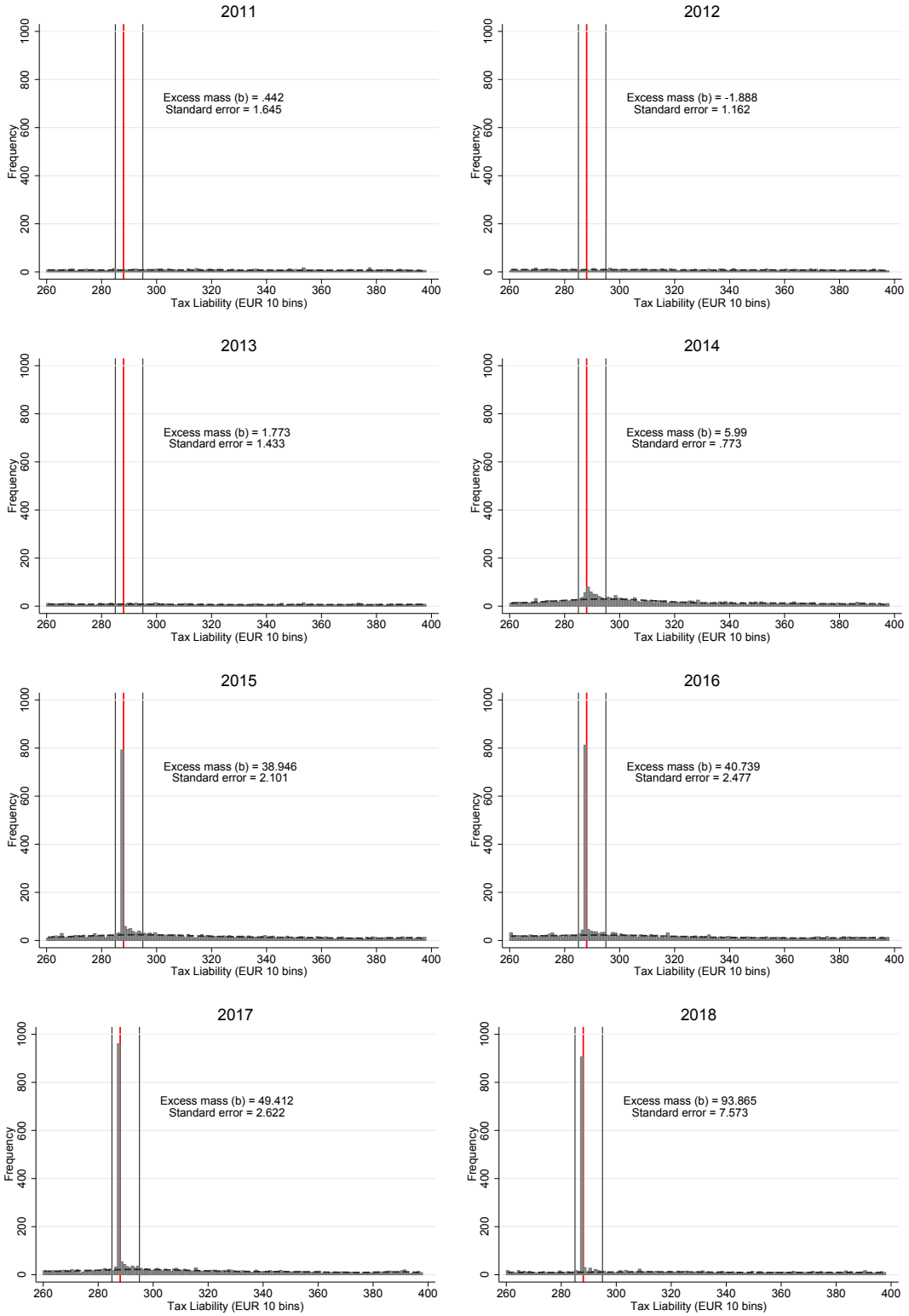

*Notes:* Series shown in bars are annual histograms of corporate tax liability around the €480 minimum tax kink. The liabilities are after tax loss carry-forwards, but prior to the application of the minimum tax. Each bar shows the number of observations in €10 bins. The dashed lines above the histograms are eighth-degree polynomials fitted to the empirical distributions using the *baseline* cross-sectional bunching approach. The excluded intervals around the kinks are demarcated by vertical solid lines.

**Figure 3:** Annual tax liability distributions around the €960 minimum tax kink




*Notes:* Series shown in bars are annual histograms of corporate tax liability around the €960 minimum tax kink. The tax liabilities displayed include tax loss carry-forwards but are prior to the application of the minimum tax. Each bar shows the number of observations in €10 bins. The excluded intervals are demarcated by vertical solid lines.

**Figure 4:** Annual tax liability distributions around the €2,880 minimum tax kink




*Notes:* Series shown in bars are annual histograms of corporate tax liability around the €2,880 minimum tax kink. The tax liabilities displayed include tax loss carry-forwards but are prior to the application of the minimum tax. Each bar shows the number of observations in €10 bins. The excluded intervals are demarcated by vertical solid lines.

**Table 3:** Corporate ETI estimated using pre-reform counterfactuals

| | VAT non-registered, turnover $<$ €500k | VAT registered, turnover $<$ €500k | Turnover $\geq$ €500k |
|---|---|---|---|
| | (1) | (2) | (3) |
| $\widehat{e}$ | 1.436 | 0.745 | 0.118 |
| | [0.123] | [0.058] | [0.002] |
| $\widehat{b}$ | 77.843 | 80.748 | 38.226 |
| | [6.309] | [6.075] | [0.731] |
| $\widehat{B}$ | 26,343 | 18,582 | 1,810 |
| N | 74,195 | 75,367 | 6,435 |

*Notes:* The table reports the corporate ETI $\widehat{e}$ in 2015-2016 estimated using the histogram estimator in Eq. (2). The pre-reform distributions $C_{j,t_{pre-reform}}$ are defined by pooling the number of companies in histogram bins across 2010-2013. The excluded intervals around kinks are +/- €100 for the €480 and €960 kinks and -€30/€70 for the €2,880 kink, as in Figures 2, 3 and 4, respectively. $\widehat{B}$ is the estimated excess number of companies at the kinks. $\widehat{b}$ is the excess mass relative to the average density at the kinks. Bootstrapped standard errors are in brackets.

In sum, our results suggest highly heterogeneous corporate responsiveness to the marginal tax rate. The bunching method yields to the estimates a short-term, intensive-margin interpretation. The much higher elasticity for VAT non-registered companies agrees with the evidence by Pomeranz (2015) and Naritomi (2019) who show that VAT and third-party monitoring improve compliance. The heterogeneity in ETI also theoretically conforms with the ability of small businesses to shift taxable income across corporate and personal tax bases (Devereux et al., 2014; Miller et al., 2022). In the next section, we will examine how the heterogeneity changes with the carry-forwards of corporate tax losses. The adjustments for tax loss shifting will then be decisive for the estimation of the marginal excess burden, which we implement in section 8.

# 6 The impact of tax loss carry-forwards on corporate ETI

As pointed out in the context of personal income taxation, bunching estimates may be elevated if individuals can transfer income towards tax kinks over time (le Maire and Schjerning, 2013; Kreiner et al., 2016; Miller et al., 2022). In the context of corporate income taxation, one of the principal ways how firms can reduce their tax liability by inter-temporal shifting is by offsetting current taxable income (or directly tax liability)

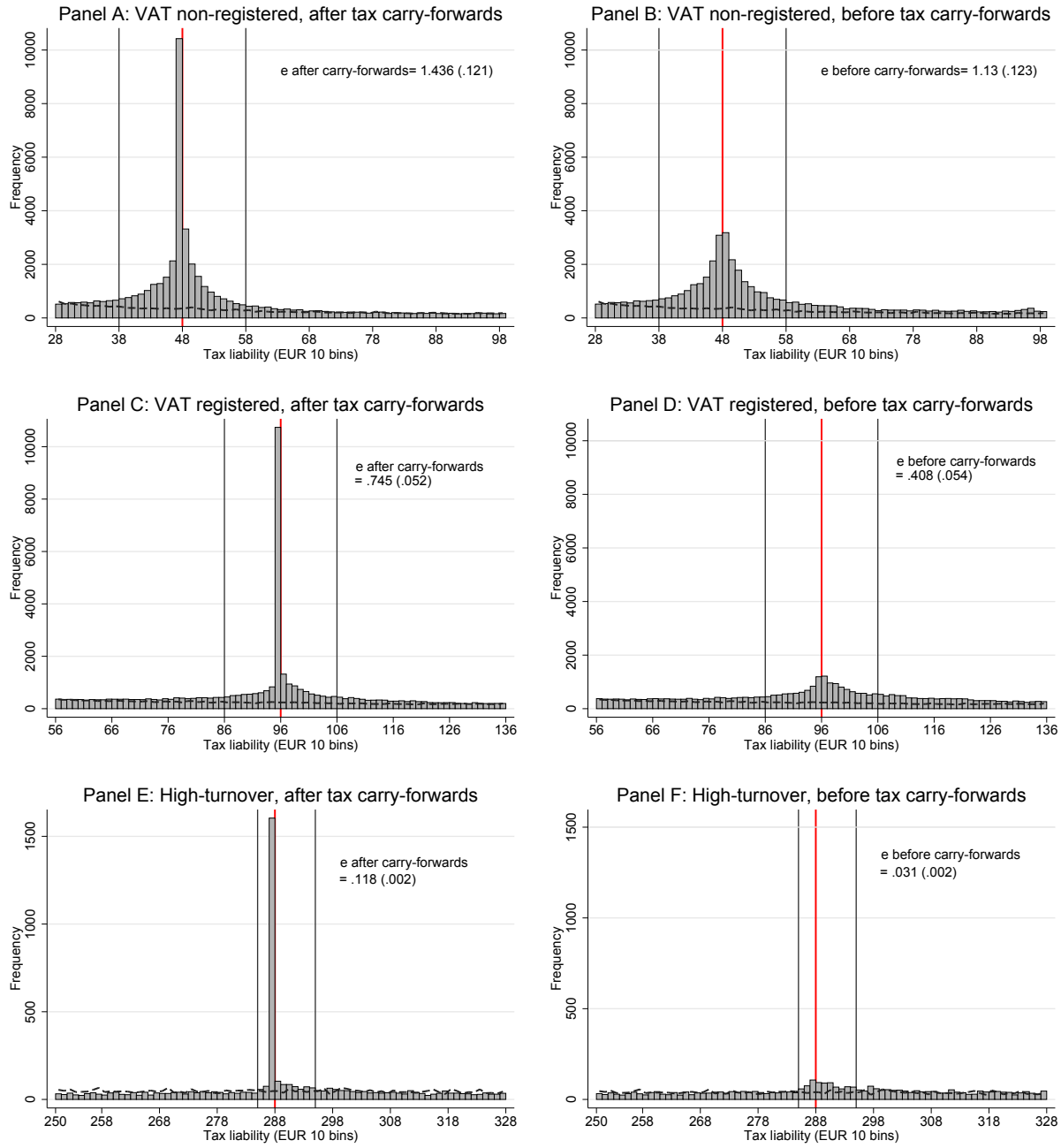
by (tax) losses carried forward from previous fiscal periods.

In this section, we implement three empirical approaches for quantifying the relevance of tax loss carry-forwards for the estimated corporate ETI. We start by a naive comparison of the scope of bunching at the minimum tax kinks before and after companies apply tax loss carry-forwards in their annual tax returns. In the second approach, we compare the scope of bunching across corporations which differed in the eligibility to apply tax loss carry-forwards shortly after their introduction in 2015. In the third approach, we infer the relevance of tax loss shifting from the excess mass of companies at the tax kinks after the minimum tax was abolished in 2018. The reason is that the excess mass at former kinks should consist solely of companies carrying forward tax losses, as the kinks otherwise ceased to exist for companies with no tax losses to be carried forward.

**Within-period comparisons of bunching before and after tax loss carry-forwards.** In Figure 5, we start isolating the tax loss shifting component of the corporate ETI by comparing the scope of bunching in the 2015-2016 tax liability distributions before and after corporations apply tax loss carry-forwards in their annual tax returns. One can clearly note that the density distributions plotted prior to carry-forwards in panels B, D and F are much flatter at the minimum tax kinks in all three corporate categories compared to the corresponding distributions after carry-forwards in panels A, C, and E. The distributions before carry-forwards lack especially the sharp spikes located exactly at the points of the kinks rather than the excess mass around them.

In Table 4, we report the corresponding estimates of the corporate ETI before and after the adjustment for tax loss carry-forwards. For easier comparison, column (1) repeats the earlier estimates of the corporate ETI after tax loss carry-forwards from Table 3. Column (2) reports the new elasticity estimates implied from the density distributions prior to carry-forwards. Column (3) expresses the percentage reduction in the corporate ETI from column (1) due to the naive adjustment for tax loss shifting. The evidence suggests that the corporate ETI is notably lower in all corporate categories if

**Figure 5:** Tax liability distributions before and after tax loss carry-forwards




*Notes:* The histograms show tax liability distributions in the three corporate categories in 2015-2016 before and after tax loss carry-forwards, respectively. The minimum tax kinks are demarcated by red vertical lines. The excluded intervals around the kinks are demarcated by vertical black lines. The dashed lines above the histograms are the re-scaled pre-reform density distributions of corporate tax liability from 2010-2013. $e$ is the estimated corporate ETI for different corporate categories, before and after tax loss carry-forwards, respectively. Bootstrapped standard errors are presented in parentheses.

it is adjusted for tax loss shifting. Corporate ETI is namely 21.3% lower in the lowest category of VAT non-registered companies kink due to an estimated drop in bunching by 5,608 companies at the kink. It is 45.2% lower in the middle category due to 8,398 fewer companies at the kink. It is 73.7% lower in the top corporate category due to 1,337 fewer companies at the kink.

The comparison of bunching before and after tax loss carry-forwards provides the first evidence that tax loss shifting is highly empirically relevant for the estimated corporate ETI. The drawback of the comparison is that companies typically choose tax liabilities before and after carry-forwards simultaneously. Tax liability distributions prior to carry-forwards might not therefore correctly approximate what the density distributions would have looked like if tax loss carry-forwards were not an option. It is plausible that true counterfactual distributions would exhibit more bunching at the kinks in Panels B, D, and F, because companies would adjust other margins of their response to higher MTRs above tax kinks. For instance, companies might have plausibly underreport taxable income more extensively in the scenario without tax loss carry-forwards. We examine the hypotheses of dependencies between different margins of corporate responses to the corporation tax in the next subsection, in which we implement the second empirical approach for quantifying the relevance of tax loss carry-forwards for the magnitude of the corporate ETI.

**Within-period bunching comparisons of companies (in-)eligible for carry-forwards.** Our second approach for quantifying the relevance of tax loss shifting consists in comparing the estimated corporate ETI across groups of corporations which differed in their eligibility to apply tax loss carry-forwards shortly after their first availability in 2015. In particular, 16.3% of companies in the bottom corporate category in 2015 could not carry forward any tax losses, because their tax liability in 2014 was above the minimum tax amounts. In the middle and top categories, the fraction of companies that could not use carry forwards equaled 14.6% and 10.2%, respectively. Given that the introduction of tax loss carry-forwards together with the minimum tax largely miti-

**Table 4:** Tax loss shifting component of the corporate ETI

| | The overall intensive-margin response | Response by corporations prior to tax loss carry-forwards | | Response by corporations ineligible for tax loss carry-forwards | | Response after abolishing the minimum tax, when tax loss carry-forwards remained available above former kinks | | |
|---|---|---|---|---|---|---|---|---|
| | Corporate ETI | Corporate ETI | % reduction compared to (1) | Corporate ETI | % reduction compared to (1) | Corporate ETI implied from tax loss shifting | Corporate ETI adjusted for shifting: (1)-(6) | % reduction compared to (1) |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Bottom corporate category | 1.436 | 1.13 | -21.3% | 1.135 | -21.0% | 0.337 | 1.099 | -23.5% |
| | [0.121] | [0.123] | | [0.135] | | [0.051] | [0.110] | |
| Middle corporate category | 0.745 | 0.408 | -45.2% | 0.568 | -23.7% | 0.347 | 0.398 | -46.6% |
| | [0.052] | [0.054] | | [0.064] | | [0.020] | [0.048] | |
| Top corporate category | 0.118 | 0.031 | -73.7% | 0.058 | -50.8% | 0.117 | 0.001 | -99.2% |
| | [0.002] | [0.002] | | [0.003] | | [0.002] | [0.000] | |

*Notes:* The corporate taxable income elasticity estimates in all columns are obtained using the pre-reform 2010-2013 distributions of corporate tax liability and the histogram estimator from Eq. (2). Bootstrapped standard errors are presented in brackets.

gated reasons for misreporting tax losses beneath the minimum tax levels in 2014, we believe that appropriately scaled tax liability distributions for companies without tax loss carry-forwards in 2015 can serve as a plausible approximation how much the rest of corporations would have been bunching at kinks in the counterfactual scenario in which tax loss carry-forwards were not introduced.

In column (4) in Table 4, we report the estimated corporate ETI for companies which could not use tax carry-forwards in 2015. In column (5), we observe that the corporate ETI is 21.0%, 23.7%, and 50.8% lower in the three corporate categories, respectively, compared to column (1).

In result, even the second approach for quantifying the relevance of tax loss carry-forwards suggests that tax loss shifting is highly empirically relevant and pronounced especially in the top corporate category. Interestingly, we observe that ETI for companies ineligible for tax loss carry-forwards in the middle and top categories (column 4) is much higher compared to ETI implied from bunching before tax loss carry-forwards (column 2). This comparison agrees with our earlier intuition that companies would have been exhibiting more bunching at kinks if they had not had the option of tax loss carry-forwards. The evidence strongly suggests dependencies between individual components of the corporate ETI, although we cannot ascertain which particular margins of the corporate ETI were substituted by tax loss carry-forwards.

**Employing tax liability distributions after the abolition of the minimum tax.** Ultimately, we implement a third method for inferring the relevance of tax loss shifting for the corporate ETI, in which we exploit the abolition of the minimum corporation tax in 2018. The method relies on adjusting corporate ETI downwards for the amount of bunching at kinks observed in 2018, as the excess mass after the abolition of the minimum tax should consist solely of companies carrying forward tax losses.[16]

In column (6) in Table 4, we start implementing the method by reporting the corpo-

[16] In Table A.7, we provide support for this claim based on estimates from annual cross-sectional bunching methods. The estimates indicate that firms bunch at the minimum tax kinks in every year in 2015-2018 with the exception of 2018 prior to tax loss carry-forwards. This lack of significance is reassuring that the observed excess mass after carry-forwards consists solely out of companies carrying forward tax losses.

rate ETI of 0.337, 0.347, and 0.117 in the bottom, middle and top corporate categories, respectively, implied from tax liability distributions after tax loss carry-forwards in 2018. The estimates are all significant at the 1% level. In column (7), we subtract these elasticities from the corporate ETI in column (1). In column (8), we calculate that the corporate ETI in column (1) is reduced 23.5%, 46.6%, and 99.2% in the three categories, respectively, once adjusted for bunching by companies carrying forward tax losses.

The last method for decomposing the corporate ETI therefore attributes the highest portion of ETI to the response by companies which use tax loss carry-forwards. The extent of tax loss shifting in all methods is however such that it should not be neglected in applied work.

Three notes with respect to the last method are still in place. First, the estimates rely on the assumption that tax liability distributions would have remained stationary between 2013 and 2018 in the absence of the interim tax reforms. We provided support for this assumption in Figure A.2, but the economic growth in 2018 might have enabled higher tax loss shifting than would be observed in other, downturn stages of the economic cycle. Second, bunching in 2018 is attributable only to companies using carry-forwards, but tax base reductions towards former kinks might have been reinforced by other margins of response, for instance, outright evasion, which we cannot isolate in the third approach. Finally, the expectations of cancelling the minimum tax since the end of 2016 could have prompted additional economic activity that might have contributed to higher tax loss shifting in 2018. For these reasons, we remain conservative in our analysis and rely on the quantitatively lowest estimates of tax loss shifting implied from our second method (in columns (4) and (5)). We believe these estimates might most closely reflect the non-distortive tax loss shifting component of the corporate ETI.

# 7 Sources of tax loss carry-forwards

Thus far we have provided evidence of a pronounced corporate response to the variation in marginal tax rates at the minimum corporation tax kinks and showed that the

availability of tax loss carry-forwards sharply increases bunching at kinks and the implied corporate ETI, especially for top-turnover companies.

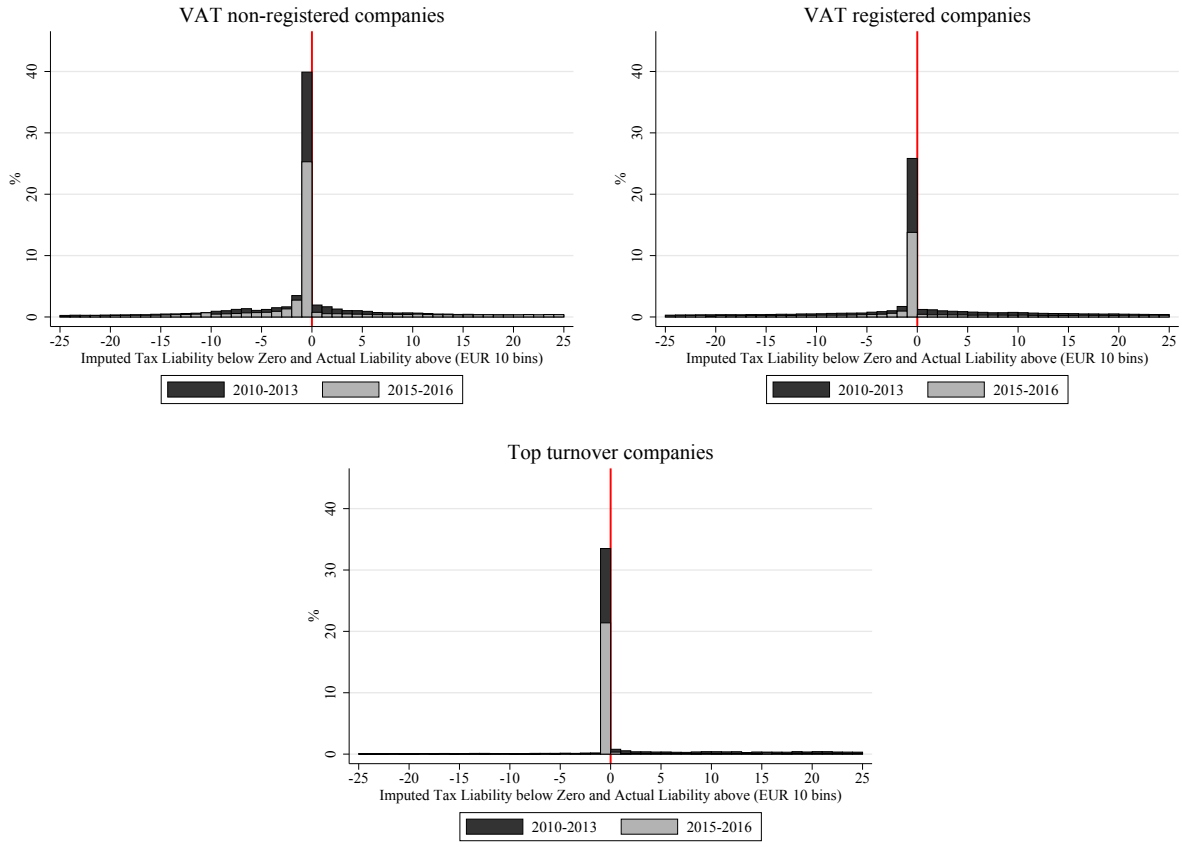
In this section, we study the sources of tax loss shifting. We operate with the hypothesis that many companies used to reduce tax liability towards zero until the 2014 reform imposed zero MTR below the minimum tax amounts. Tax loss carry-forwards then became available to firms which did not exit, but neither moved exactly towards the new kinks. We support this explanation in section 7.1 by comparing the scope of the newly emerged mass of companies at the minimum tax kinks against the decline in bunching at zero after 2014. In section 7.2, we examine the extensive-margin response to the minimum tax reform. In section 7.3, we compare our estimates of the counterfactual densities based on pre-reform data with those from cross-sectional methods and discuss implications for the likely source of the excess mass at the new kinks.

## 7.1 Bunching at zero tax liability

We estimate the mass of companies disappeared at zero tax liability after 2014 using the histogram estimator from Eq.(2) and data on corporate profits and losses after NOL carry-forwards. In particular, we apply corporate tax rates valid in each year both to positive and negative values of profits to obtain density distributions of a "hypothetical" tax liability, even below zero. We then plot the histograms of tax liability around zero before and after the 2014 reform, appropriately scaled, and compare the mass of companies at zero non-parametrically across the two distributions.

In Figure 6, we observe a pronounced drop in the share of companies massing at zero tax liability after the introduction of the minimum tax in all three corporate categories. After re-scaling the 2010-2013 density distributions from before 2014 so that the total number of corporations in the counterfactual distributions equals the number of companies in 2015-2016, we estimate that 29,383 VAT non-registered companies from the bottom corporate category disappeared within a symmetric +/-€30 interval around zero tax liability compared to the same interval in the pre-2014 distributions. This miss-

**Figure 6:** Tax liability distributions around zero




*Notes:* The figure plots density distributions of corporate tax liability around zero before and after the 2014 minimum tax reform. The distribution of tax liabilities below zero is imputed using data on corporate losses. Tax liabilities above zero are the actual tax liabilities. Each bar shows the percentage of observations in €10 bins.

ing mass corresponds to 111.54% of the estimated excess mass of companies bunching at the €480 minimum tax kink in 2015-2016. In the same fashion, we estimate 22,259 VAT registered companies from the middle category missing around zero, which corresponds to 119.78% of the estimated excess mass at the €960 minimum tax kink. Finally, we estimate 2,251 companies from the top category missing at zero, which corresponds to 124.36% of their estimated excess mass at the €2,880 tax kink.

The estimated mass of companies missing at zero combined with the sudden and simultaneous emergence of bunching at the new kinks is strongly suggestive about the source of bunching. The missing mass at zero quantitatively even exceeds bunching at the new kinks, allowing for the options that many companies did not shift exactly

towards the new kinks or exited the market. The greatest excess of companies that could have moved from zero is estimated for companies in the top category. If these companies did not exit, their low tax liability below the minimum tax kinks should have provided them with the highest amount of tax loss carry-forwards for the future. We examine the extensive-margin response to the 2014 reform in the next section.

## 7.2 Extensive-margin response

We examine the extensive-margin response of companies to the 2014 minimum tax reform using an event-study design, as it can provide insights about (i) potential pre-trends, which are key for identification, and (ii) the dynamics of the treatment effect.

**Event-study model.** The main outcome variable in our model is a binary indicator for company $i$ in industry $s$ and corporate category $c$ having been liquidated in fiscal period $t$. We infer corporate liquidation from the failure of companies to file mandatory tax returns to the fiscal authority. The model can be formally expressed as follows:

$$Exit_{it} = \alpha_0 + \sum_{j=-J}^{K} \beta_j Below\ MT^{j}_{it-n} + \gamma \mathbf{X}_{it-n} + \psi_{st} + \varepsilon_{it} \tag{6}$$

The independent variables of interest are a set of $J + K$ event variables $Below\ MT^{j}_{it-n}$ generated as indicators for tax liability being lower $n$ years prior to $j$ than the minimum tax that would apply to firms in corporate category $c$.[17] The model further controls for a rich set of time-varying corporate characteristics $\mathbf{X}_{it-n}$, which include a non-interacted indicator for tax liability being below the minimum tax amount in year $t - n$, binary indicators for employment size categories, ownership type and legal form, as well as fixed effects for the number of years since incorporation. The model accounts for po-

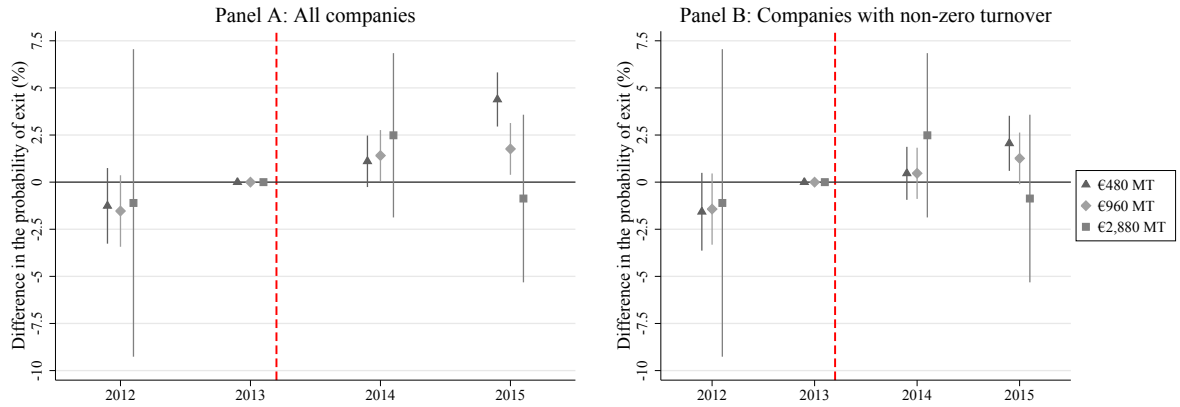
[17] In the reported specifications, we choose $n = 2$, which allows us to observe outcomes in two pre-reform periods in which corporate exit should not have been affected by the 2014 minimum tax reform, while we are able to estimate the post-reform impact of the minimum tax reform in 2014 and 2015, conditional on using only pre-reform years 2010-2013 to define the treatment status. In contrast, if we selected $n = 3$, our models would include one pre-reform period in 2013, although we would be able to estimate the extensive-margin response in three periods up until 2016. We prefer the former choice of $n = 2$, given the likely relevance of he minimum tax in an immediate short run.

tential industry-specific shocks by including "industry $\times$ year" fixed effects ($\psi_{st}$). The stochastic error term is denoted by $\varepsilon_{it}$. We estimate the model separately in every corporate category $c$. In all regressions, we set the regressor for period $j = 0$ equal to zero so that all coefficients are interpreted relative to this period. We cluster standard errors at the company level to allow for any unconditional heteroscedasticity and correlation over time for all observations of the same company.

**Identification.** Our event-study specification is a version of conditional difference-in-differences, which rely on a parallel trends assumption. Put informally, identification requires that in the absence of the 2014 minimum tax reform, the probability of exit would in the immediate short run evolve within industries and corporate categories along parallel paths for companies that previously had their tax liability below and above the minimum tax levels, respectively. The validity of the assumption might be threatened if companies before 2014 selectively targeted their tax liability with respect to the minimum tax levels, which seams highly implausible given no previous knowledge of the minimum tax amounts. Figures 2, 3 and 4 give no indications of any undesirable sorting below the minimum tax values prior to 2014, as evidenced by perfectly smooth tax liability distributions before 2014. Our identification assumption, as we show below, is further supported by finding no evidence of differential pre-trends in corporate exit across companies in the treatment and control groups prior to 2014. To mitigate survivor bias, we restrict the sample to companies established after the beginning of 2010.

**Regression estimates.** Figure 7 visualizes the evidence of a rather limited extensive-margin response of corporations to the introduction of the minimum tax within two years following the 2014 reform. In particular, Panel A plots coefficients $\beta_j$ obtained from Eq.(6) which represent the estimated differences in the annual probability of exit in 2012-2015 across companies with tax liability below and above the values of the minimum tax levels two years prior to the examined fiscal period. Panel B plots $\beta_j$ co-

**Figure 7:** Extensive-margin response to the minimum corporation tax




*Notes:* The figure reports estimated differences in the probability of corporate exit across firms with tax liability below and above the minimum tax amounts two years prior to year $t$, respectively. The estimates are obtained using Eq.(6) separately for each corporate category. Panel A shows coefficient estimates for all companies established after the beginning of 2010. Panel B shows estimates for such companies with non-zero turnover two years prior to $t$. All specifications control for employment size category, ownership type, legal form and age in years since incorporation. The dashed vertical line indicates the 2014 minimum tax reform. The figure displays 95% confidence intervals. Standard errors are clustered at the company level.

efficients for a sub-sample of companies with non-zero turnover two years prior to $t$. All coefficients are multiplied by 100 to show percentage differences in the examined probabilities of corporate exit. In Table 5, we report exact coefficient estimates for all corporate categories and estimation samples.

The presented evidence suggests no statistically significant corporate exit in response to the 2014 reform in the top category of companies with turnover above €500,000. The response is also not significant in the bottom and middle corporate categories in 2014 if one focuses on active companies with non-zero turnover in 2012. The estimates suggest statistically significant response in the bottom and middle corporate categories in 2015: the likelihood of having the company liquidated in 2015 is 2.1 and 1.3 percentage points higher for active companies in the bottom and middle corporate categories, respectively, if their tax liability in 2013 was below the corresponding minimum tax amounts. The coefficients are higher if one considers also formally open companies with no previous turnover in 2013, suggesting that a notable component of the extensive-margin response consisted in the closure of empty companies with no economic activity, as

**Table 5:** Extensive-margin response to the minimum corporation tax

| | All companies | | | Companies with previously non-zero turnover | | |
|---|---|---|---|---|---|---|
| | Bottom category (1) | Middle category (2) | Top category (3) | Bottom category (4) | Middle category (5) | Top category (6) |
| Below MT(t-2) X 2012 | -0.013 | -0.015 | -0.011 | -0.016 | -0.014 | -0.011 |
| | [0.010] | [0.010] | [0.042] | [0.011] | [0.010] | [0.042] |
| Below MT(t-2) X 2014 | 0.011 | 0.014** | 0.025 | 0.005 | 0.005 | 0.025 |
| | [0.007] | [0.007] | [0.022] | [0.007] | [0.007] | [0.022] |
| Below MT(t-2) X 2015 | 0.044*** | 0.018** | -0.009 | 0.021*** | 0.013* | -0.009 |
| | [0.007] | [0.007] | [0.023] | [0.007] | [0.007] | [0.023] |
| Industry × year FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Covariates | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Avg. Outcome | 0.126 | 0.126 | 0.126 | 0.112 | 0.112 | 0.112 |
| N clusters | 34,254 | 28,906 | 5,755 | 25,990 | 27,730 | 5,755 |
| N | 72,942 | 66,524 | 9,477 | 49,737 | 61,684 | 9,477 |
| R2 | 0.046 | 0.033 | 0.146 | 0.030 | 0.027 | 0.146 |

*Notes:* The table reports event-study estimates from Eq.(6) when the examined outcome is a binary indicator for a company having been liquidated in a given fiscal period. All specifications account for "industry × year" fixed effects. They all also include a non-interacted indicator for tax liability being below the minimum tax amount in year $t-2$ and control for employment size categories, ownership type, legal form and age in years since incorporation. Standard errors in parentheses are clustered at the company level. $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

proxied by having no sales turnover.

We point out that our estimates are likely close to the upper bound of the true extensive-margin response, as many small- and medium-sized enterprises in the small and open Slovak economy might have moved their residence to the neighbouring countries or changed their organization form from incorporated to unincorporated businesses, without affecting the real output. On the other hand, the drawback of our estimates is that they cannot capture the number of companies that did not get newly incorporated due to the imposition of the minimum tax.

### 7.3 Pre-reform vs. cross-sectional counterfactuals

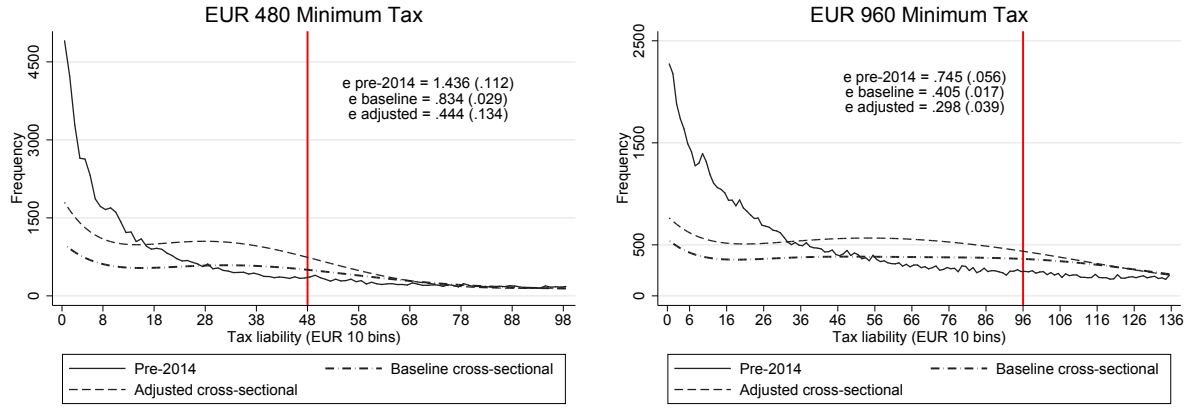
Next, we proceed to the comparison of the bunching methods for estimating the counterfactual density distributions of corporate tax liability at the minimum tax kinks, as it may be informative about the sources of the excess mass at the kinks.

In Figure 8, the dashed-and-dotted lines in Panels A and B represent the counterfactuals predicted using the *baseline* cross-sectional bunching approach around the €480 and €960 kinks, respectively. The dashed lines correspond to the counterfactuals obtained using the *adjusted* cross-sectional method, which shifts the left part of tax liability distributions from the *baseline* method upwards so that it satisfies the integration constraint. To allow direct comparison with our main estimates based on the pre-reform 2010-2013 tax liability distributions, the solid lines in the figure correspond to the counterfactuals predicted using the non-parametric histogram estimator. For every approach, we report the estimated corporate ETI and bootstrapped standard errors.[18]

The figure strongly suggests that the main difference between the bunching approaches consists in the assumed source of bunching at the tax kinks. While the *baseline* method does not address the source of bunching, the *adjusted* method assumes that the excess mass originates proportionally from the whole distribution to the left of the

[18]We do not compare the bunching methods for companies in the top category, as the cross-sectional methods cannot consider those parts of the tax liability distributions which are below the €2,500 tax liability threshold. Above this limit, companies need to pay quarterly tax advances to the tax office.

**Figure 8:** Cross-sectional vs. pre-reform counterfactuals




*Notes:* The figure compares the estimates of the corporate ETI in 2015-2016 obtained using alternative methods for quantifying bunching at the minimum tax kinks. "*e pre-2014*" refers to the corporate ETI obtained using the non-parametric estimator in Eq. (2) which builds upon the pre-reform 2010-2013 tax liability distributions. "*e baseline*" refers to the corporate ETI based on the cross-sectional model in Eq. (B.1) which ignores the integration constraint. "*e adjusted*" refers to the corporate ETI obtained using the cross-sectional bunching method in Eq. (B.4) which preserves the total number of corporations under the counterfactual equal to the number in the empirical distribution. Bootstrapped standard errors are presented in parenthesis.

kinks. More plausibly, the *non-parametric* histogram estimator suggests that the dominant source of bunching is around zero tax liability and much less from the area near the kinks. At the €480 kink, this difference leads to 3.2 times higher corporate ETI if it is based on pre-reform rather than *adjusted* cross-sectional distributions. At the €960 kink, the corporate ETI is 2.5 times higher if it is based on pre-reform distributions. Put alternatively, corporate ETI based on the *adjusted* method is 69% and 60% lower for firms in the bottom and middle categories, respectively, compared to the ETI based on pre-reform distributions. The differences are significant at least at the 5% level.[19] In Tables A.8 and A.9, we show that the cross-sectional estimates of ETI are not sensitive to the parametric choice of the polynomial order and bin size.

Overall, our evidence highlights that bunching methods based on pre-reform distributions can be very useful for obtaining credible estimates of counterfactual densities, especially when agents possess flexibility in shifting themselves along the inspected

[19]We note that the 95% confidence intervals from the *adjusted* cross-sectional method and the histogram estimator do not overlap. Checking the overlap corresponds to a conservative test of the difference in the elasticity in case of a positive covariance between the two estimates.

distributions. The inspection of the source of bunching might be thus desirable especially in the settings of pronounced income shifting, tax avoidance and evasion.

In our setting, the comparison of the counterfactuals strongly supports the hypothesis that the excess mass of companies at the minimum tax kinks originates from around zero. Companies that did not shift after 2014 exactly towards new kinks should have thus available tax losses to carry forward against future tax liabilities above kinks.

# 8 Marginal excess burden of the corporation tax

We now study the implications of neglecting tax loss carry-forwards in the estimation of the marginal excess burden (MEB) of the corporation tax. Following the framework by Saez et al. (2012), which we revise in Appendix C, we estimate the MEB above the minimum tax kinks, as if in the top bracket of corporate taxation.

If we did not contemplate the impact of tax loss carry-forwards on the corporate ETI, we could express the welfare loss per one monetary unit of extra tax raised as:

$$-dB/dR = \frac{ea\tau}{1-\tau-ea\tau} \tag{7}$$

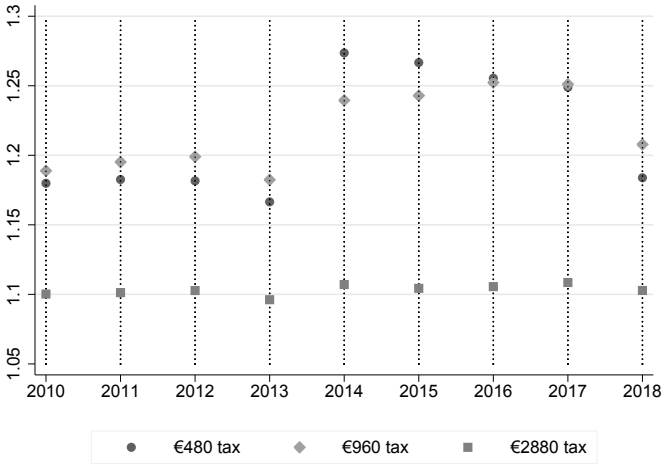
where $\tau$ is a constant MTR above the level of corporate taxable income $\bar{z}$ that corresponds to the minimum tax amount, $e$ is the corporate ETI with respect to the net-of-tax rate $(1-\tau)$ estimated earlier, and $a$ is a parameter ratio calculated as the average taxable income $z^m$ above $\bar{z}$, divided by the difference between $z^m$ and $\bar{z}$: $\frac{z^m}{z^m-\bar{z}}$.

In the extended framework which allows for tax loss shifting across fiscal periods, the formula for the marginal welfare loss becomes:

$$-dB/dR = \frac{ea(\tau-st)}{1-\tau-ea(\tau-st)}. \tag{8}$$

where $s<1$ is a fraction of income that disappears from tax base in one period and is shifted to another period, in which it is taxed, on average, at tax rate $t$.

**Figure 9:** Parameter ratio $a$




*Notes:* The figure reports values of the parameter ratio $a$ at the levels of income corresponding to the minimum tax amounts.

In Figure 9, we first estimate the parameter ratio $a$ at $\bar{z}$ annually in 2010-2018 for all companies with tax liability between the minimum tax and €200,000. We observe that $a$ is stable in time at the €2,880 kink and equal to around 1.1. For the €480 and €960 kinks, the values of $a$ increase slightly from around 1.18 in 2010-2013 to around 1.25 in 2014-2017. For calculating MEB, we choose $a$ from 2015 when companies were subject to the minimum corporation tax, could already apply tax loss carry-forwards and had to pay the MTR of 22% on all taxable income above $\bar{z}$.

In the next step, we estimate the marginal welfare loss and show that the adjustment for tax loss carry-forwards substantially reduces the estimated dead-weight cost. This, in fact, is true for all examined categories of firms. In particular, in the bottom category we estimate MEB equal to 102.5% of the mechanical increase in tax revenue should we raise the MTR above tax kinks by 1% and ignore that firms shift tax losses over time. This calculation is based on the corporate ETI of 1.436 from Table 3 and suggests that the welfare loss even exceeds tax revenue gained from increasing MTR. The welfare loss ratio, however, drops to 66.7% when we use the corporate ETI of 1.135, most conservatively adjusted in Table 4 for tax loss shifting. The drop in MEB is substantial and suggests that tax loss shifting should not be neglected in applied work.

We arrive at the same conclusion when inspecting the MEB in the middle corporate category. Using the corporate ETI of 0.745 unadjusted for tax loss carry-forwards, we estimate the fraction of the welfare loss relative to the mechanical increase in tax revenue equal to around 35.6% should the tax rate rise by 1%. Our estimates of the MEB however drop to around 25.0% when we consider the corporate ETI of 0.568, which is corrected for tax loss carry-forwards using their most conservative estimate.

Finally, we estimate MEB around 3.8% for companies in the top category when we do not account for tax loss carry-forwards. The MEB is around 1.8% after adjusting the corporate ETI using the most conservative tax loss shifting estimate.

# 9 Conclusion

Carry-forwards of corporate losses are the defining feature of corporate income taxation. In 2013 alone, net operating losses carried forward in the U.S. totaled $180 billion (Coles et al., 2022). In this study, we used state-of-the-art bunching techniques, administrative data from all corporate tax returns in 2010-2018 in Slovakia and variation from corporate tax reforms to estimate to what extent the introduction of new carry-forwards of corporate tax losses increases the elasticity of corporate taxable income and biases the estimated efficiency burden of raising an additional euro in the corporation tax.

Using the non-parametric bunching technique by Devereux et al. (2014), we estimated the corporate ETI from the mass of companies bunching at the kinks introduced by the 2014 minimum corporation tax reform. We employed uniquely observable tax liability distributions from before the reform to predict counterfactual density distributions at the new kinks. We showed that corporate income is highly heterogeneously sensitive to the variation in marginal tax rate across corporate size categories: we found corporate ETI between 0.12 for companies with turnover above €500,000 to 0.75 for lower-turnover VAT registered firms and 1.44 for VAT non-registered firms. Smooth pre-reform distributions and a sudden disappearance of a large mass of companies at zero right after 2014 suggest that many firms used to reduce taxable income towards

zero before the 2014 reform.

Our main finding is that corporate bunching at the kinks sharply increases once firms gain the option to offset tax liability above the kinks by prior tax losses. The contribution of tax loss shifting was heterogeneous across corporate size categories, and most pronounced for top-turnover firms. Consequently, our estimates of the marginal efficiency burden, should the corporate tax rate above the kinks rise by 1%, fell by 2-36 cents for each euro raised once we corrected corporate ETI for tax loss carry-forwards. We consider our results important as they highlight non-trivial challenges in the estimation of appropriate statistics sufficient for economic welfare evaluation of the corporation tax.

How relevant are our results for other countries? We highlight three dimensions of the external validity of our results. First, we analyzed *tax loss* carry-forwards above the minimum tax kinks, but regular *net operating loss* carry-forwards operate virtually on the exact same principle of offsetting taxable income above zero by prior losses. Loss carry-forwards are available to corporations all around the world, as shown in Table A.1. Second, the corporate ETI in our setting was estimated for companies bunching at the minimum tax kinks, but might not exactly relate to very large, multi-national firms which might have access to more sophisticated tax avoidance technologies. Third, companies in our sample could carry forward tax losses at most three years and from 2014 at the earliest. The regulation of net operating loss carry-forwards is much less strict in other countries. For instance, corporations in the U.S. in 2022 could carry forward NOLs indefinitely to offset up to 80% of taxable income. Many European countries do not specify any time limit on loss carry-forwards. The relevance of loss carry-forwards might therefore be much higher in other countries compared to our setting.

A natural follow-up question, which we leave for future research, relates to the overall welfare evaluation of the minimum tax legislation. The International Monetary Fund (2021) shows that minimum corporation taxes are an increasingly popular fiscal tool available in various forms (asset-, turnover-, or modified income-based) in more than 50 countries around the world. According to the Ministry of Finance of the Slovak

Republic (2014), the minimum corporation tax in our setting managed to raise non-trivial additional revenue of around €110 million just in 2014. At the same time, our difference-in-difference estimates indicated a rather limited extensive-margin response immediately after the minimum tax reform. The exit was largely driven by the closure of formally open, but otherwise inactive companies. To calculate the total implications of the minimum tax, one would need to obtain further information about business incorporation decisions, growth and investments, as well as information about capital and personal gains to be able to evaluate dynamic aspects of the minimum corporation tax regulation. Despite the lack of clear evidence of immediate negative impacts of the minimum tax, we leave the question unanswered in this paper.

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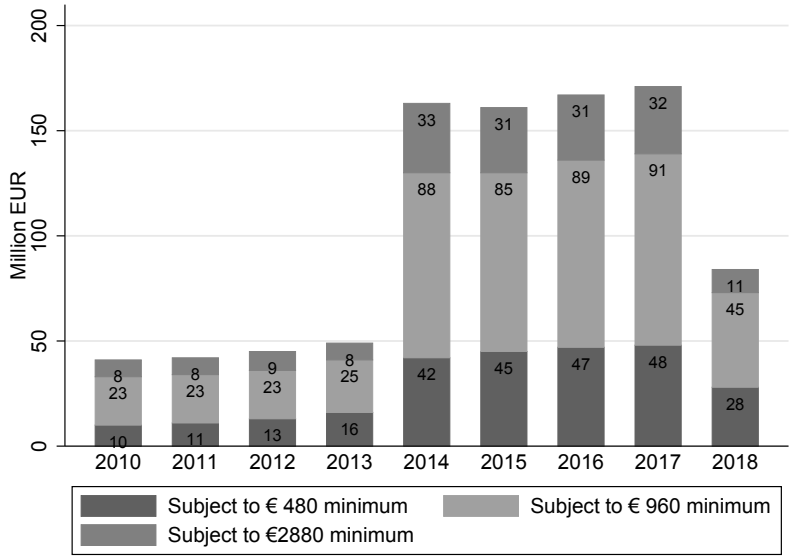
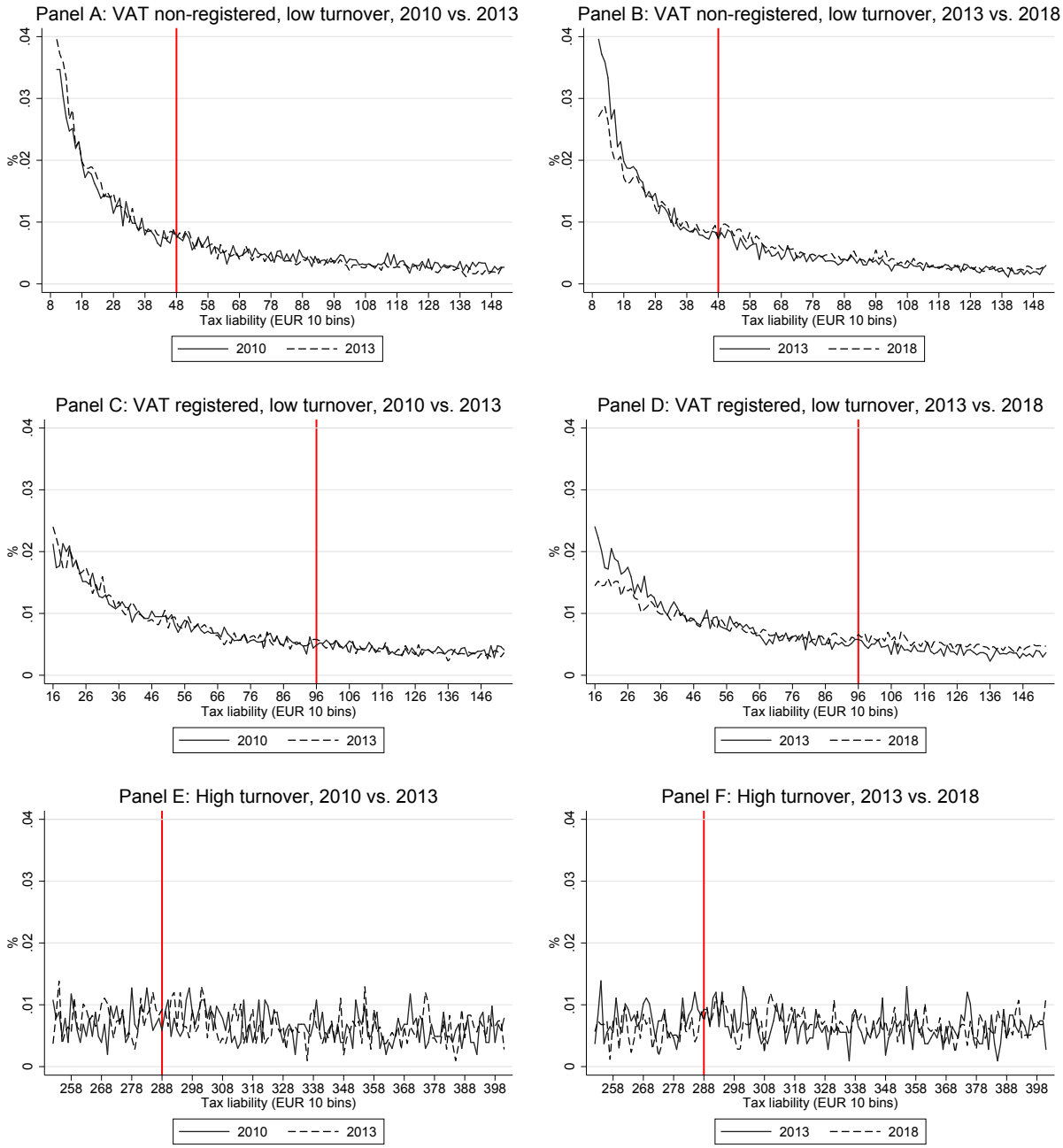
# A Online appendix: Additional figures and tables

**Figure A.1:** Tax revenue from small corporations in 2010-2018




*Notes:* The figure plots government fiscal revenue in 2010-2018 (in 2010 prices) from small corporations with tax liability below €4,000. These companies are expected to be those primarily affected by the 2014 minimum tax reform. The sharp jump in revenue after 2014 almost exactly coincides with the fiscal impact of the minimum tax reform estimated by the Ministry of Finance of the Slovak Republic (2014).

**Figure A.2:** Stationarity of the tax liability density distributions




*Notes:* The figure visually compares empirical histograms of the corporate tax liability over time. Panels A and B compare the density distributions for low-turnover, VAT non-registered companies from the bottom corporate category across 2010 vs. 2013, and 2013 vs. 2018, respectively. Panels C and D make the same comparisons for VAT registered companies from the middle corporate category. Panels D and E make these comparisons for high-turnover companies from the top corporate category. The density distributions are adjusted so as to contain equal numbers of observations across years compared. The red vertical lines are the values of the minimum tax. The histograms are drawn using bins of €10 width.

**Table A.1:** Loss carry-over provisions: Country comparison (Hanappi, 2018)

| Country | Carry-forward | Carry-back | Limit to deductibility of losses |
|---|---|---|---|
| Australia | Unlimited | 0 | |
| Austria | Unlimited | 0 | Reduction of max. 75% of taxable income per year |
| Belgium | Unlimited | 0 | |
| Canada | 20 | 3 | |
| Chile | Unlimited | Unlimited | |
| Costa Rica | 3 | 0 | (1) |
| Czech Republic | 5 | 0 | |
| Denmark | Unlimited | 0 | |
| Finland | 10 | 0 | |
| France | Unlimited | 1 | Deductions above €1 million are restricted to 50% of taxable income per year |
| Germany | Unlimited | 1 | Deductions above €1 million are restricted to 60% of taxable income per year |
| Greece | 5 | 0 | |
| Hungary | 5 | 0 | Reduction of max. 50% of taxable income per year (2) |
| Iceland | 10 | 0 | |
| Ireland | Unlimited | 1 | |
| Israel | Unlimited | 0 | |
| Italy | Unlimited | 0 | Max. 80% of taxable income (100% for losses referring to the first 3 years) (3) |
| Japan | 10 | 0 | (4) |
| Luxembourg | Unlimited | 0 | |
| Mexico | 10 | 0 | |
| Netherlands | 9 | 1 | |
| Norway | Unlimited | 0 | |
| Poland | 5 | 0 | Max. 50% of accumulated losses per year |
| Portugal | 12 | 0 | Reduction of max. 70% of taxable income per year |
| Singapore | Unlimited | 1 | |
| Slovak Republic | 4 | 0 | Max. 25% of accumulated losses per year |
| Slovenia | Unlimited | 0 | Reduction of max. 50% of taxable income per year |
| South Africa | Unlimited | 0 | |
| Spain | Unlimited | 0 | Max. 60% (2016) and 70% (2017+) of the taxable base before the capitalization reserve per year (5) |
| Sweden | Unlimited | 0 | (6) |
| Switzerland | 7 | 0 | |
| Turkey | 5 | 0 | |
| UK | Unlimited | 1 | |
| USA | 20 | 2 | |

*Notes:* (1) In Costa Rica, carry-forwards are limited to 3 years for industrial and 5 years for agricultural companies. (2) In Hungary, taxpayers operating in the agricultural sector may deduct the amount of the deferred loss from the pre-tax profit of the preceding two tax years; however, the deduction cannot exceed 30% of the taxable income of the respective tax year. (3) In Italy, net operating losses can be carried forward for an unlimited number of years up to 80% of the corporate taxable income in the tax period of utilization of the losses (100% if losses are referred to the first three years of business and relate to a new production activity). (4) In Japan, loss related deductions of large companies are restricted to 65% of taxable income in 2016, this limit is further reduced to 50% starting from fiscal year 2017. (5) In Spain, deductibility of losses is limited to a maximum of 60% (2016) and 70% (2017+) of the taxable base before the capitalization reserve provided for in Article 25 of the Corporate Income Tax Law and before offsetting any negative tax bases. Recently, in the case of large companies, Royal Decree Law 3/2016, of 2nd December, as regards taxable periods beginning from 1st January 2016, reduced the upper limits to offset negative tax bases as follows: (i) The limit shall be 50% where in the 12 previous months, at the beginning of the taxable year, the net turnover is at least €20 million, but less than €60 million; (ii) the limit shall be 25% where in the 12 previous months, at the beginning of the taxable year, the net turnover is at least €60 million. (6) In Sweden, the tax allocation reserve allows firms to put up to 25 per cent of pre-tax income into an untaxed reserve for up to six years. The funds from the tax allocation reserve can be used to quit against losses that occur in a later year. The tax allocation reserve thus allows some carry-back of losses.

**Table A.2:** Tax loss carry-forwards (example 1)

| Year | VAT | Turnover | MT | Tax liability before MT and CF | Pay-up$_t$ | Pay-up$_{t-1}$ | Non-negative (5) - (4) | CF$_t$ | Tax paid |
|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| 2014 | Yes | <500k | 960 | 680 | 280 | - | 0 | 0 | 960 |
| 2015 | Yes | <500k | 960 | 1,100 | 0 | 280 | 140 | 140 | 960 |

*Notes:* MT – minimum tax, CF – tax loss carry-forwards.

**Table A.3:** Tax loss carry-forwards (example 2)

| Year | VAT | Turnover | MT | Tax liability before MT and CF | Pay-up P$_t$ | P$_{t-1}$ | P$_{t-2}$ | P$_{t-3}$ | Non-negative (5) - (4) | CF$_t$ | Tax paid |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| 2014 | No | <500k | 480 | 250 | 230 | - | - | - | 0 | 0 | 480 |
| 2015 | No | <500k | 480 | 300 | 180 | 230 | - | - | 0 | 0 | 480 |
| 2016 | No | <500k | 480 | 450 | 30 | 180 | 230 | - | 0 | 0 | 480 |
| 2017 | No | <500k | 480 | -500 | 480 | 30 | 180 | 230 | 0 | 0 | 480 |
| 2018 | No | <500k | 480* | 700 | 0 | 480 | 30 | 180 | 220 | 220 | 480 |

*Notes:* MT – minimum tax. CF – tax loss carry-forwards. *In 2018, MT is the minimum tax that would have been applied in the given category if minimum tax had not been abolished.

**Table A.4:** The estimated impact of fiscal policies adopted in 2013 and 2014

| | 2013 | 2014 |
|---|---|---|
| **Social security contributions (SSC)** | | |
| - increase and the unification of maximum bases for SSC assessment | +160 | |
| - increase in SSC for self-employed | +27 | |
| - changes in the fully-funded pillar of the public pension system | +695 | |
| - allowance for long-term unemployed | | -5 |
| **Personal income tax (including self-employed)** | | |
| - introduction of the second (25%) tax rate | +53 | |
| - limitation of the allowance for self-employed | +18 | |
| **Corporate income tax** | | |
| - change in the tax rate from 19% to 23% | +230 | |
| - change in the tax rate from 23% to 22% | | -57 |
| - introduction of the minimum tax | | +112 |
| - changes in the rules for loss carry-forwards | | +37 |
| **Other fees and tariffs** | | |
| - extension of a special levy in the banking sector | +92 | |
| - levy on enterprises in regulated industries | +79 | |
| - re-introduction of television/radio licence fee | +74 | |
| - increase in vehicle registration fee | +27 | |
| - extension of the levy on enterprises in regulated industries | | +80 |
| - changes in the levy on motor vehicles | | -8 |

*Notes:* The estimated fiscal impacts are expressed in € millions. Source: Stability Programme of the Slovak Republic for 2014 - 2017 (Ministry of Finance of the Slovak Republic, 2014)

**Table A.5:** Summary statistics, 2014 and 2018

| | 2014 | | | | 2018 | | | |
|---|---|---|---|---|---|---|---|---|
| | All companies | Bottom category | Middle category | Top category | All companies | Bottom category | Middle category | Top category |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Turnover | 1,064,023 | 19,160 | 103,526 | 7,896,409 | 1,009,273 | 22,941 | 105,335 | 7,172,534 |
| | [31,329,502] | [39,087] | [119,028] | [87,385,871] | [32,715,763] | [43,336] | [145,867] | [89,609,867] |
| Taxable income | 50,962 | 4,137 | 7,049 | 360,334 | 50,301 | 5,184 | 9,158 | 331,502 |
| | [2,022,424] | [251,021] | [29,258] | [5,633,083] | [1,553,218] | [217,503] | [27,920] | [4,238,104] |
| Tax liability prior to tax loss carry-forwards and MT | 10,961 | 916 | 1,548 | 77,299 | 10,400 | 1,088 | 1,920 | 68,397 |
| | [437,999] | [57,153] | [6,428] | [1,219,599] | [323,902] | [45,675] | [5,859] | [883,796] |
| - % of companies with zero tax liability | 45.4 | 49.9 | 47.1 | 25.0 | 42.1 | 48.7 | 43.1 | 18.4 |
| - % of companies with zero tax liability and no reported loss | 15.0 | 23.3 | 9.7 | 7.6 | 12.7 | 20.2 | 8.6 | 4.4 |
| Tax loss carry-forwards | . | . | . | . | 89 | 25 | 87 | 294 |
| | | | | | [482] | [136] | [358] | [1,090] |
| Tax liability after tax loss carry-forwards but before MT | 10,961 | 916 | 1,548 | 77,299 | 10,311 | 1,063 | 1,834 | 68,105 |
| | [437,999] | [57,153] | [6,428] | [1,219,599] | [323,899] | [45,675] | [5,828] | [883,804] |
| % subject to €480 MT | 40.6 | 100.0 | 0.0 | 0.0 | 40.0[a] | . | . | . |
| % subject to €960 MT | 46.7 | 0.0 | 100.0 | 0.0 | 46.7[a] | . | . | . |
| % subject to €2880 MT | 12.8 | 0.0 | 0.0 | 100.0 | 13.3[a] | . | . | . |
| Tax actually paid | 11,364 | 1,111 | 2,029 | 78,078 | 10,311 | 1,063 | 1,834 | 68,105 |
| | [437,990] | [57,151] | [6,330] | [1,219,551] | [323,899] | [45,675] | [5,828] | [883,804] |
| Observations | 197,564 | 80,143 | 92,203 | 25,218 | 222,447 | 89,004 | 103,953 | 29,490 |

*Notes:* The variables are reported in euro in 2010 prices. Standard deviations are reported in brackets. [a]In 2018, we report the proportion of companies that would be subject to the minimum tax.

**Table A.6:** Specification checks – Choice of fiscal periods for building the counterfactual

| | Bottom category | Middle category | Top category |
|---|---|---|---|
| Fiscal periods used to build counterfactual: 2010-2013 | | | |
| $\widehat{e}$ | 1.436 | 0.745 | 0.118 |
| | [0.123] | [0.058] | [0.002] |
| $\widehat{B}$ | 26,343 | 18,582 | 1,810 |
| N | 74,195 | 75,367 | 6,435 |
| Fiscal periods used to build counterfactual: 2010-2012 | | | |
| $\widehat{e}$ | 1.448 | 0.742 | 0.125 |
| | [0.106] | [0.053] | [0.003] |
| $\widehat{B}$ | 26,389 | 18,565 | 1,834 |
| N | 74,195 | 75,367 | 6,435 |

*Notes:* The table reports the corporate ETI $\widehat{e}$ in 2015-2016 estimated using the histogram estimator in Eq. (2). The pre-reform distributions $C_{j,t_{pre-reform}}$ are defined by pooling the number of companies in histogram bins across 2010-2013 or 2010-2012. The excluded intervals around the minimum tax kinks are always as in Table 3. $\widehat{B}$ is the estimated excess number of companies at the kinks. Bootstrapped standard errors are presented in brackets.

**Table A.7:** Annual bunching estimates before and after tax loss carry-forwards, obtained using cross-sectional polynomial regressions

| | Bottom category | | Middle category | | Top category | |
|---|---|---|---|---|---|---|
| Year | Excess mass | SE | Excess mass | SE | Excess mass | SE |
| Tax liability distribution: after tax loss carry-forwards | | | | | | |
| 2015 | 45.908 | [1.969] | 38.31 | [2.36] | 38.946 | [2.101] |
| 2016 | 44.503 | [1.753] | 39.215 | [2.804] | 40.739 | [2.477] |
| 2017 | 39.556 | [1.385] | 41.413 | [2.665] | 49.412 | [2.622] |
| 2018 | 16.965 | [2.363] | 36.273 | [3.022] | 93.865 | [7.573] |
| Tax liability distribution: before tax loss carry-forwards | | | | | | |
| 2015 | 27.739 | [1.579] | 12.425 | [0.748] | 6.027 | [0.795] |
| 2016 | 25.199 | [1.277] | 11.016 | [0.647] | 6.333 | [0.983] |
| 2017 | 20.685 | [1.114] | 10.472 | [0.594] | 4.638 | [0.844] |
| 2018 | 1.944 | [1.464] | 1.099 | [0.736] | 1.532 | [1.508] |

*Notes:* The table estimates the excess mass of companies at the minimum tax kinks relative to the average density at the kink. The estimates were obtained using the cross-sectional bunching methodology summarized by Eq. (B.1). The excluded areas around the kinks correspond to +/- €100 for the €480 and €960 kinks and -€30/€70 for the €2,880 kink. The order of the fitted polynomial is always eight. Bootstrapped standard errors are presented in brackets.

**Table A.8:** Specification checks – Choice of the polynomial order

| | Bottom category | Middle category | Top category |
|---|---|---|---|
| | Order of the polynomial: 9th | | |
| $\widehat{e}$ | 0.843 | 0.374 | 0.117 |
| | [0.03] | [0.018] | [0.005] |
| $\widehat{B}^0$ | 23,069 | 15,421 | 1,797 |
| | Order of the polynomial: 8th | | |
| $\widehat{e}$ | 0.834 | 0.405 | 0.122 |
| | [0.029] | [0.018] | [0.005] |
| $\widehat{B}^0$ | 22,991 | 15,827 | 1,814 |
| | Order of the polynomial: 7th | | |
| $\widehat{\widehat{e}}$ | 0.845 | 0.42 | 0.125 |
| | [0.024] | [0.018] | [0.005] |
| $\widehat{B}^0$ | 23,088 | 16,023 | 1,823 |
| N | 71,261 | 75,265 | 6,387 |

*Notes:* $\widehat{e}$ denotes the corporate ETI estimated using Eq. (B.1) and $\widehat{B}^0$ denotes the excess number of companies at the value of the minimum tax. Bootstrapped standard errors are presented in brackets. The bin size always corresponds to €10. The excluded area around the value of the minimum tax is kept constant across specifications with different polynomial orders.

**Table A.9:** Specification checks – Choice of the bin size

| | Bottom category | Middle category | Top category |
|---|---|---|---|
| | Size of histogram bin: €10 | | |
| $\widehat{e}$ | 0.834 | 0.405 | 0.122 |
| | [0.029] | [0.018] | [0.005] |
| $\widehat{B}^0$ | 22,991 | 15,827 | 1,814 |
| | Size of histogram bin: €20 | | |
| $\widehat{e}$ | 0.838 | 0.411 | 0.117 |
| | [0.035] | [0.019] | [0.004] |
| $\widehat{B}^0$ | 23,121 | 15,951 | 1,782 |
| | Size of histogram bin: €30 | | |
| $\widehat{e}$ | 0.802 | 0.397 | 0.118 |
| | [0.037] | [0.02] | [0.007] |
| $\widehat{B}^0$ | 22,808 | 15,705 | 1,775 |
| N | 71,261 | 75,265 | 6,387 |

*Notes:* $\widehat{e}$ denotes the corporate ETI estimated using Eq. (B.1) and $\widehat{B}^0$ denotes the excess number of companies at the value of the minimum tax. Bootstrapped standard errors are presented in brackets. The order of the polynomial is always eight. The excluded area around the value of the minimum tax is kept constant across specifications with different bin sizes.

# B Online appendix: Polynomial bunching methods

In this appendix, we review cross-sectional bunching methods by Saez (2010) and Chetty et al. (2011), which we apply in our study to estimate the amount of excess bunching of corporations at the minimum corporation tax kinks.

**Baseline bunching methodology.** In the baseline approach by Saez (2010), one can estimate bunching of companies at tax kinks using a counterfactual distribution, i.e., how tax liability distribution would look had there been no minimum tax and no kinks in the tax schedule. The counterfactual is estimated from the empirical density of tax liability observed outside of the range affected by bunching.

The econometric procedure takes two steps. In the first step, we plot the empirical distribution of corporate tax liability in a histogram with the minimum tax amount re-centered to zero. This means that all companies are separated into small histogram bins of a fixed width according to their tax liability.[20] In the second step, we fit a flexible high-order polynomial to the histogram excluding data within a narrow window $(Z_L, Z_U)$ around the kink. This regression can be formally expressed as follows:

$$C_j = \sum_{i=0}^{q} \beta_i \cdot Z_j^i + \sum_{i=Z_L}^{Z_U} \gamma_i \cdot \mathbf{1}[Z_j = i] + \epsilon_j \tag{B.1}$$

where $C_j$ is the number of companies present in histogram bin $j$, $Z_j$ is the re-centered corporate tax liability in histogram bin $j$, and $q$ is the order of the polynomial.

The estimate of the counterfactual distribution is defined as predicted values from Eq. (B.1), while omitting the contribution of the dummy variables around the kink:

$$\widehat{C}_j^0 = \sum_{i=0}^{q} \beta_i \cdot Z_j^i \tag{B.2}$$

The implied excess number of companies bunching at the tax kink is:

$$\widehat{B}^0\,(t_1,\, t_2) = \sum_{j=Z_L}^{Z_U} C_j - \widehat{C}_j^0 \tag{B.3}$$

**Adjusted counterfactuals.** One concern with the calculation of the excess mass in the baseline method, as pointed out by Chetty et al. (2011), is that the method potentially overestimates $\widehat{B}$. This is because the introduction of the minimum tax might have induced companies to report higher taxable income (move towards the value of the kink). The observed number of companies in bins to the left of the new kink can thus be lower than if there had not been a kink. In this case, the estimated counterfactual would be based on an underestimate of the number of companies that would have been observed had there not been the minimum tax obligation.

In order to address this bias, we follow Chetty et al. (2011) and iteratively shift the counterfactual distribution to the left of the kink upwards until the area under the estimated counterfactual equals the area under the empirical distribution:

[20] We choose a value of the histogram bin width equal to €10. We demonstrate the robustness of our results with respect to different parametric choices of the bin width in Table A.9.

$$C_j \cdot \left(1 + \mathbf{1}\left[j < Z_L\right] \frac{\widehat{B}^0\left(t_1, t_2\right)}{\sum_{j=1}^{Z_L} C_j}\right) = \sum_{i=0}^{q} \beta_i \cdot Z_j^i + \sum_{i=Z_L}^{Z_U} \gamma_i \cdot \mathbf{1}\left[Z_j = i\right] + \epsilon_j \tag{B.4}$$

The estimated counterfactual then corresponds to fitted values $\widehat{C}_j = \sum_{i=0}^{q} \beta_i \cdot Z_j^i$ from Eq. (B.4) which omit the contribution of the histogram bins in the excluded range around the kink. The counterfactual allows us to define the excess mass of companies bunching at the kink: $\widehat{B}\left(t_1, t_2\right) = \sum_{j=Z_L}^{Z_U} (C_j - \widehat{C}_j)$.

We can express the estimated excess mass of companies bunching at the kink relative to the average density of the counterfactual distribution between $Z_L$ and $Z_U$ as:

$$\widehat{b}\left(t_1, t_2\right) = \frac{\widehat{B}\left(t_1, t_2\right)}{\sum_{j=Z_L}^{Z_U} \widehat{C}_j / N_j} \tag{B.5}$$

where $N_j$ is the number of bins in the excluded range.

We calculate the standard error for $\widehat{b}$ using a parametric bootstrap procedure. More specifically, we draw values from the estimated vector of errors $\xi_j$ in (B.4) with replacement to generate a new set of bin counts and apply the above bunching methodology to calculate a new estimate of $\widehat{b}^k$. We define the standard error of $\widehat{b}$ as the standard deviation of the distribution of $\widehat{b}^k$s.

We estimate corporate ETI as a non-linear function of $\widehat{b}$, the tax kink $K$ and the relative change in the net-of-tax rate $\ln\left(\frac{1-t_1}{1-t_2}\right)$ at the kink as in Eq. (1). We obtain the standard errors for this elasticity again using the bootstrap procedure.

# C Online Appendix: Marginal excess burden framework

In this appendix, we review the conceptual framework by Saez et al. (2012) which allows estimation of the marginal excess burden (MEB) as if in the top tax bracket above the minimum tax kinks. We present the framework first without contemplating the possibility of tax loss shifting and then when we allow for shifting.

**Benchmark framework without tax loss shifting.** To calculate the MEB of the corporation tax, we consider a situation with a constant MTR $\tau$ above a given level of reported income $\bar{z}$. In our setting, this tax rate corresponds to the rate on companies which earn income implying tax liability above the minimum tax amounts. We further assume that corporate income depends on net-of-tax rate $(1-\tau)$. We assume that there are $N$ corporations with taxable income above $\bar{z}$ when the MTR is $\tau$. We denote by $z^m(1-\tau)$ the average income reported by those N corporations, as a function of the net-of-tax rate. The aggregate elasticity of the taxable income implying tax liability above the minimum tax amount is thus defined as $e = \left[\frac{\partial z^m}{\partial(1-\tau)}\right]\left[\frac{1-\tau}{z^m}\right]$.

We now suppose the government increases $\tau$ by a small amount $d\tau$ while keeping the minimum tax amount fixed. We can contemplate two effects on government revenue. First, there is a "mechanical" increase in revenue due to the fact that corporations face a higher tax rate on incomes above $\bar{z}$. We define this mechanical effect as:

$$dM \equiv N\left(z^m - \bar{z}\right) d\tau > 0. \tag{C.1}$$

The mechanical effect can be viewed as the projected increase in tax revenue in the absence of behavioral responses to the tax change.

Second, the increase in the tax rate produces a behavioral response that reduces the average reported income for N corporations by $dz^m = -ez^m d\tau/(1-\tau)$. A change in the reported income of $dz^m$ changes the tax revenue by $\tau dz^m$. The aggregate change in tax revenue due to the behavioral response is therefore equal to:

$$dB \equiv -Nez^m \frac{\tau}{1-\tau} d\tau < 0. \tag{C.2}$$

Summing up the mechanical and behavioral effects, we can express the total change in tax revenue due to the tax change as:

$$dR = dM + dB = N\left(z^m - \bar{z}\right)\left[1 - e\frac{z^m}{z^m - \bar{z}}\frac{\tau}{1-\tau}\right] d\tau. \tag{C.3}$$

We denote the ratio $\frac{z^m}{z^m - \bar{z}}$ as a. If the top tail of the corporate taxable income distribution is Pareto distributed, then parameter $a$ does not vary with $\bar{z}$ and is exactly equal to the Pareto parameter. Using the definition of $a$, we can rewrite the effect of the small tax reform on tax revenue as:

$$dR = dM\left[1 - \frac{\tau}{1-\tau} ea\right]. \tag{C.4}$$

Formula (C.4) shows that the fraction of the tax revenue lost due to the behavioral response, which is the second term in the square bracket, is a simple function increasing

in the tax rate $\tau$, the corporate ETI $e$, and the parameter $a$.

According to the envelope theorem, the utility loss measured in monetary terms due to the small tax change $d\tau$ is exactly equal to the mechanical effect $dM$. Applying formula (C.4) and because $dR = dM + dB$, we can express the MEB per one monetary unit of extra tax raised as:

$$-dB/dR = \frac{ea\tau}{1-\tau-ea\tau} \tag{C.5}$$

This means that for each extra euro raised, the government imposes an extra cost equal to $-dB/dR > 0$ on taxpayers. We will compare the MEB implied by (C.5) to the MEB implied by the calculation when we allow for shifting of corporate tax losses into other fiscal periods.

**Framework with tax loss shifting.** To see the implications of tax loss shifting, we assume that a fraction $s < 1$ of the corporate income that corresponds to the tax liability offset by the carried-forward tax loss disappears from the corporate tax base following the tax rate increase $d\tau$ and is shifted to the tax base in another fiscal period, in which it is taxed, on average, at tax rate $t$. A behavioral response now generates a tax revenue change equal to $(\tau - \mathrm{st})\, dz$. As a result, the change in tax revenue due to the behavioral response becomes:

$$dB = -Nez^m \frac{\tau}{1-\tau} d\tau + Nez^m \frac{st}{1-\tau} d\tau \tag{C.6}$$

Thus, formula (C.4) for the effect of a small tax reform on total tax revenue becomes:

$$dR = dM + dB = dM \left[1 - \frac{\tau - st}{1-\tau} ea\right]. \tag{C.7}$$

Finally, the MEB expressed in terms of extra tax collected in the presence of tax loss shifting can be written as:

$$-dB/dR = \frac{ea(\tau - st)}{1 - \tau - ea(\tau - st)}. \tag{C.8}$$