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FISCAL COUNCIL

HOW SENSITIVE IS ESTONIA'S BUDGET DEFICIT TO THE ECONOMIC CYCLE? AN ANALYSIS OF FISCAL ELASTICITIES

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TABLE OF CONTENTS

INTRODUCTION

When an economy is growing, tax revenues tend to increase because incomes, profits and consumption are higher, while certain expenditures, such as unemployment benefits, decrease. Conversely, revenues decline in a downturn, and expenditure on social support rises, leading to automatic fluctuations in the budget. The way that budgetary revenues and expenditures respond to the economic cycle is described by the cyclical sensitivity of the government budget. Measuring this budgetary sensitivity is essential for estimating the structural budget balance, which reflects the underlying fiscal position adjusted for temporary economic effects. An accurate measurement of the structural balance allows the sustainability of fiscal policy to be assessed for whether the budgetary trends are driven by structural factors or temporary economic fluctuations, and whether adjustments are needed to maintain long-term stability.

The budgetary sensitivity for Estonia has previously been estimated initially by Kattai et al. (2003) and then subsequently by the OECD and the European Commission (EC). The estimations of Kattai et al. (2003) found that the Estonian budgetary sensitivity was approximately 0.35 in 1996-2001, while the assessments of the OECD and the EC estimated Estonia's budgetary semi-elasticity at 0.3 in 2005 (European Commission, 2005). This figure was revised upwards to 0.44 in the 2014 assessment (Mourre, Astarita, & Princen, 2014), primarily because the tax elasticities were updated. This revision for Estonia notably increased the elasticities of personal income tax and social security contributions. A further revision in 2018 raised the semi-elasticity to 0.486 (Mourre, Poissonnier, & Lausegger, 2019), but this change was solely due to updates to the shares of revenue and expenditure categories, while the elasticities themselves remained unchanged from the 2014 assessment. It appears that the estimates of budgetary sensitivity have varied a lot, but since this indicator plays an important role in assessment of the structural budget position, and furthermore a considerable amount of time has passed since the last assessment, there is a good reason to update the estimate of Estonian budgetary sensitivity.

The aim of this paper is to provide independent regression-based estimates for the individual budgetary elasticities and the overall sensitivity of the budget in Estonia. It gives up-to-date estimates by using the annual data from 1995 to 2023, and another important contribution it makes is that it uses a policy-adjusted time series of tax revenues, which lets it eliminate the impact of discretionary policy measures. Doing this ensures that the estimated tax elasticities reflect only the automatic, or non-discretionary, response to changes in the tax base. Not all elasticities are empirically derived using Estonian data in the OECD/EC estimations, as EU average values are applied instead, or a unitary elasticity assumption is made. As a result, those estimations do not fully reflect the specific economic conditions in Estonia. This study therefore makes another contribution by assessing all the elasticities that underlie cyclical sensitivity separately, using Estonian data.

A two-step method is used to estimate the relationship between cyclically sensitive budgetary items and the economic cycle. In the first step, the revenues from the four major tax categories of personal income tax, social tax, corporate income tax and indirect taxes, together with unemployment-related expenditures, are regressed against their macroeconomic proxy variables, yielding budgetary-to-base elasticities. In the second step, the base variables are regressed against estimates of the output gap, producing base-to-output gap elasticities. The regression analysis follows the standard approach in the literature and employs an error correction model. Once the individual elasticities have been obtained, the two sets of values are combined to calculate the budgetary-to-output gap elasticities and to derive the overall sensitivity of the budget. The estimations use ESA2010 data from Statistics Estonia on revenues and expenditures, and their bases, and European Commission data on output gaps from AMECO.

The paper is based on the author's assumptions about which variables should be considered as the bases for the different types of tax, and which expenditures should be classified as unemployment-related costs.

The author has however also examined alternative variables and conducted an elasticity analysis based on them as well. These estimates are presented in an Excel-based calculator that is attached to this study, allowing users to define their own assumptions and determine Estonia's budgetary sensitivity accordingly. A data file containing all the input data used in the analysis is also provided alongside the calculator, so anyone who is interested can replicate the analysis in full.

The rest of the paper is organised as follows. Section 1 gives an overview of the methodology and data used in this estimation, including the specification of the regression equations and the method applied for adjusting the tax revenue series for policy measures. Section 2 presents the results of the regression analysis, pointing out separately the estimates of revenue and expenditure elasticities with respect to their bases, the base elasticities with respect to output gaps, and the derivations of the overall budgetary elasticities. Section 3 discusses the implications of this updated value for budgetary sensitivity in the context of the structural budget balance, and this is followed by the conclusion.

1. METHODS AND DATA

1.1. The methodology for estimating the budgetary sensitivity

The method applied in this study was proposed by Girouard and Andre (2005) and it has been the main approach used by the OECD and the European Commission for estimating the semi-elasticities underlying cyclically-adjusted budget balances. This methodology calculates the budgetary semi-elasticity using a disaggregated approach by estimating separate elasticities for different categories of tax revenues and expenditures, and then aggregating them using GDP shares as weights with the following equation:

$$\alpha = \sum_i \varepsilon_i \frac{T_i}{Y} - \sum_i \gamma_j \frac{G_j}{Y}$$

where α is the budget elasticity to changes in the GDP gap, ε_i is the elasticity of revenue from tax i to the GDP gap, $\frac{T_i}{Y}$ is tax i's share of GDP, γ_j is the elasticity of expenditure j to the GDP gap, and $\frac{G_j}{Y}$ is expenditure j's share of GDP. Four different tax categories are observed for revenues, which are personal income tax, social tax, corporate income tax, and indirect taxes, which mainly covers VAT[1]. The sole item of public spending that is treated as cyclically sensitive is unemployment-related transfers, so the expenditure elasticity is estimated for this item.

The elasticity ε_i shows how public revenues respond to changes in GDP and a two-step method developed by Van den Noord (2000) is applied to estimate this elasticity. The first step is that the revenue-to-base elasticity $\varepsilon_{R/base}$ and base-to-output gap elasticity $\varepsilon_{base/OG}$ are estimated for each tax category. The second step is that both of the estimated elasticities are then multiplied in order to compute the overall elasticity to the output gap $\varepsilon_{R/OG}$:

$$\varepsilon_{R/OG} = \varepsilon_{R/base} \times \varepsilon_{base/OG}$$

A similar calculation is performed on the expenditure side by looking at how expenditures change in response to changes in unemployment, and how unemployment changes in response to changes in the output gap.

[1] As is standard practice, the zero-elasticity assumption is made for non-tax revenues.

1.2. Regression model specification

The elasticities are estimated using regression analysis, which allows the relationship between tax revenues and expenditures and their base variables to be assessed over time. The following analysis uses two regression model specifications to investigate these relationships. The first measures the short-run relationship by estimating a first-difference model in the following form:

$$\Delta \ln T_t = c + \varepsilon_1 \Delta \ln TB_t + u_t$$

where T denotes tax revenue and TB the tax base variable. ε_1 in this equation indicates the short-run relationship between the tax and its base.

To assess both short-term and long-term effects simultaneously, an error correction model (ECM) is estimated, which is a standard approach in the literature, and it has the following specification:

$$\Delta \ln T_t = c + \varepsilon_2 \Delta \ln TB_t + \lambda(\ln T_{t-1} - \beta \ln TB_{t-1}) + v_t$$

where ε_2 indicates the short-run relationship between the tax and its base, like ε_1, but β estimates the long-run relationship between the tax and its base, or the long-run elasticity, and λ is the error correction term (ECT), which indicates how quickly the short-term relationship adjusts to the long-term equilibrium. Both model specifications are estimated using the ordinary least squares (OLS) method, and also the Prais-Winsten method, which allows the autocorrelation in the residuals to be corrected.

These model specifications with the two different estimation methods are used to estimate the tax-to-base elasticities for all the observed tax items, and also to estimate the elasticity of expenditure to its base, and the elasticities of the base to the output gap. In the latter case, the first-difference model is estimated in the form:

$$\Delta \ln\left(\frac{B_t}{Y_t^*}\right) = c + \alpha_1 \Delta \ln\left(\frac{Y_t}{Y_t^*}\right) + u_t$$

and the ECM model in the form:

$$\Delta \ln\left(\frac{B_t}{Y_t^*}\right) = c + \alpha_2 \Delta \ln\left(\frac{Y_t}{Y_t^*}\right) + \lambda\left(\ln\left(\frac{B_{t-1}}{Y_{t-1}^*}\right) - \beta \ln\left(\frac{Y_{t-1}}{Y_{t-1}^*}\right)\right) + v_t$$

In both of these specifications the dependent variable $\left(\frac{B_t}{Y_t^*}\right)$ refers to the proxy base as a share of potential GDP, while the independent variable $\left(\frac{Y_t}{Y_t^*}\right)$ refers to a measure of the economic cycle, in this case nominal GDP as a share of potential GDP.

The regression analysis results in four model estimations and thus four estimates for each elasticity. Several criteria are used for the final selection of the elasticity value. First the R Squared Adjusted and the statistical significance of the ECT are used to decide whether the ECM is a better specification than a first-difference model. Then, in cases where the ECM specification is preferred, the Durbin Watson Statistics are used to confirm the absence of residual autocorrelation and to decide which method, OLS or Prais-Winsten, is better for estimating the ECM.

1.3. Data sources

This study estimates regression-based budgetary elasticities using annual ESA2010 data from 1995 to 2023. The tax items included in the analysis are personal income tax (PIT), social tax (SOT), corporate income tax (CIT), and indirect taxes (INT), which are value-added tax (VAT) and excise duties. The data on the revenues of these taxes are obtained from the Statistics Estonia database “Taxes and social contributions in national accounts by sub-sector”. On the expenditure side, the share of expenditure that is on unemployment is taken from the COFOG classification of expenditures, with the corresponding code 10.5 “Unemployment”.

All the tax bases are approximated using macroeconomic variables following the standard practice in the literature on elasticities, so compensation of employees is used for both PIT and SOT, gross operating surplus is used for CIT, and private consumption for INT. The data on these base variables are obtained from the GDP database of Statistics Estonia. The number of people unemployed is used as the base for unemployment-related expenses and these data are also obtained from Statistics Estonia. All budgetary and base variables enter the analysis at current prices.

The second step of the estimation exercise measures the relationship between the tax base variables and the output gap, and so the estimates depend on the values of output gap as well. The following analysis employs three different estimates of output gap. The first is based on the production function approach, as provided in the European Commission’s AMECO database. Two other estimates are obtained using the Hodrick-Prescott (HP) filter, however, one of them is also sourced from the AMECO database, while the other is calculated by the author using the HP filter with the smoothing parameter set to 30. The three different estimates of the output gap are presented in Figure 1.

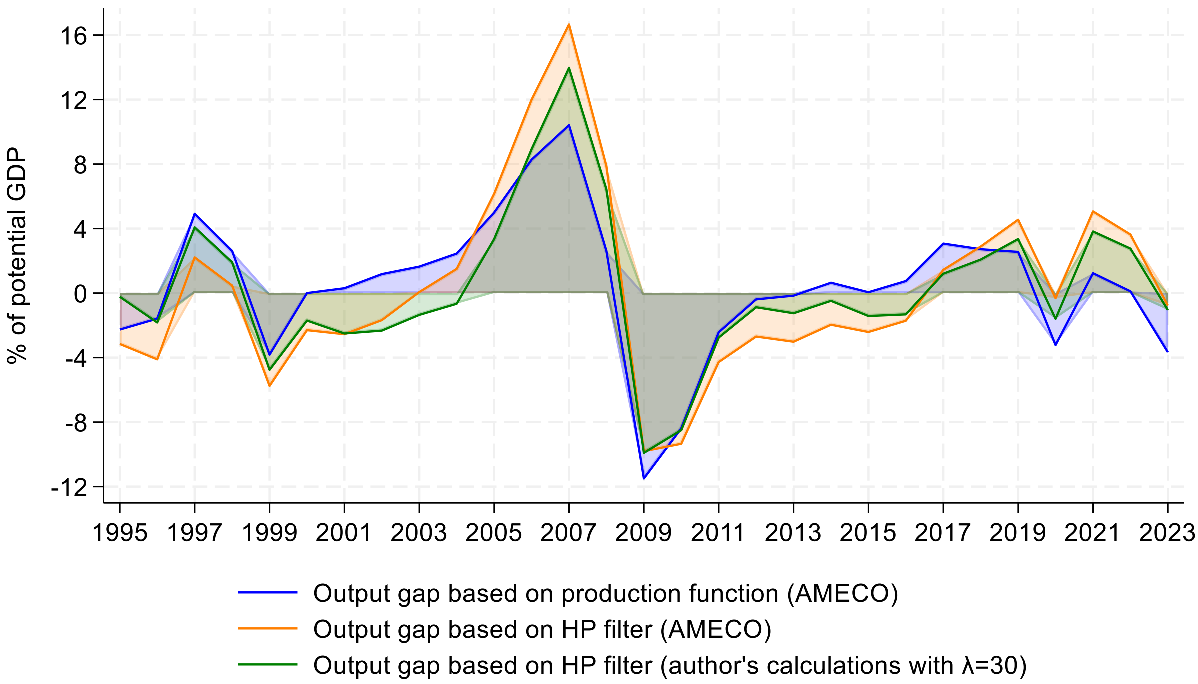

Figure 1. Different estimates of the output gap
Source: AMECO database, author’s own calculations

1.4. Adjusting tax revenues for policy measures

This study attempts to account for the effects of tax policy changes when it estimates Estonian tax elasticities. It does so by first compiling a dataset of discretionary tax measures and their impacts from the ex-ante estimates collected from the forecasts produced by the Ministry of Finance. Appendix 1 gives a detailed list of the policy changes used in the analysis. It then constructs a policy-adjusted revenue variable using the proportional adjustment method, first developed by Prest (1962), as is common in the literature.

The policy-adjusted revenue series represents what revenue would have been in previous years if today's tax system had applied at that time. These calculations are made using the formulas as in Conroy (2019):

$$PAR_t = R_t \times \prod_{k=t+1}^{j} \left(\frac{R_k}{R_k - DM_k} \right) \; for\ all\ t < j$$

where PAR_t represents policy-adjusted revenue in year t. R_t represents the revenue collected in year t. DM_t represents discretionary tax measures that impact the revenues collected in year t, calculated using the initial year and full year impacts of policy changes together with one-off impacts:

$$DM_t = (Policy\ initial_t) + (Policy\ full\ year_{t-1} - Policy\ initial_{t-1}) + One\ off_t$$

This approach involves back-casting the series for all the years before 2023 by adjusting for the discretionary measures introduced in later years. Adding or subtracting these measures means the resulting series accounts for the cumulative impact of all the discretionary policy changes over the period assessed. The result is the series of revenues that would have been collected if the tax system in place in 2023 had been applied throughout the entire period.

Figure 2 presents the estimates of policy-adjusted revenues and the actual revenues collected across all four tax categories. Adjustments have been frequent for PIT over the years, primarily through reductions in the tax rate and increases in the basic tax-free allowance. As a result, the policy-adjusted revenues are lower than the actual revenues in the early years of the sample. If today's PIT rules had been in place during the 1990s and 2000s, the revenues collected would have been significantly lower. The adjustment also takes into account the amendment to the second pillar of the pension system, which had a one-off effect that significantly increased PIT revenues in 2021–2022.

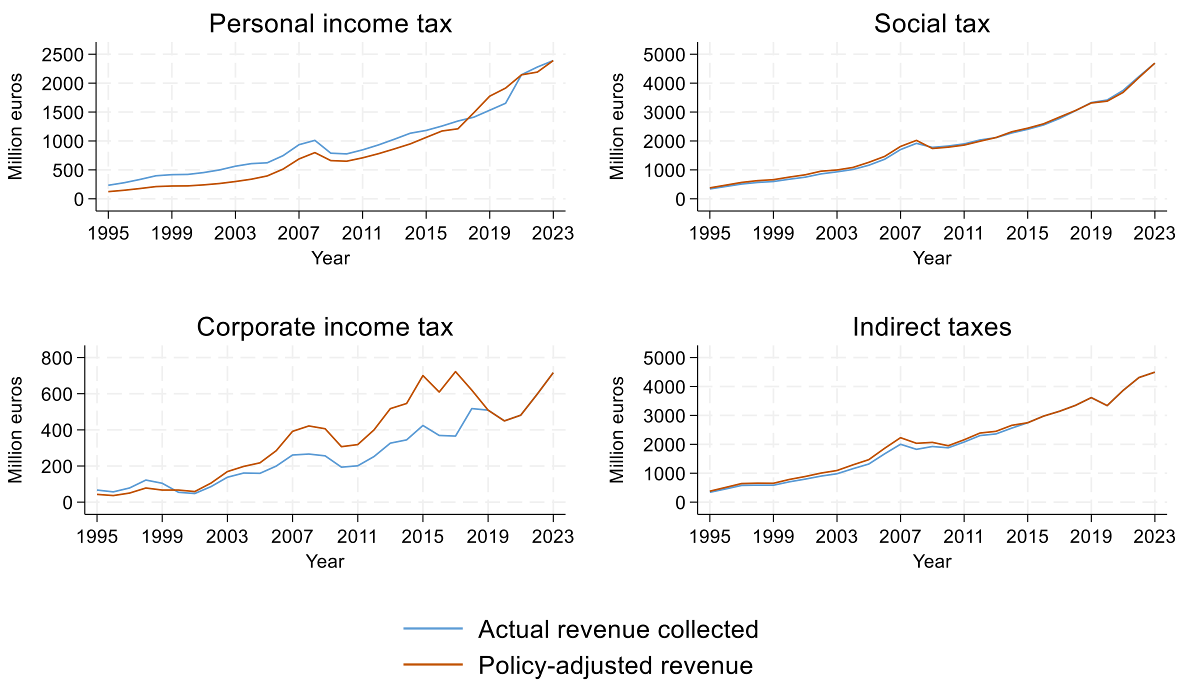

Figure 2. Actual and policy-adjusted tax revenues
Source: Statistics Estonia, Ministry of Finance, author's own calculations

Revenue collection for CIT was affected by a set of policy changes that were introduced in 2018. These included a reduced CIT rate of 14% for regularly distributed profits, the introduction of an advance payment for income tax from banks, and restrictions on transferring tax-free profits as loans. These measures had the overall effect of increasing CIT revenues. Had these changes been in place earlier, tax revenues in previous years would have been higher, as is reflected by the policy-adjusted line being above the actual revenues collected. Looking backward however, the gap between policy-adjusted revenues and actual revenues collected gradually decreases, largely because of the gradual reduction in the CIT rate between 2005 and 2015.

Changes for SOT have occurred in both directions during the period observed, with some increasing revenues, such as the rise in the compulsory minimum payment, and others reducing them, such as the cut in the unemployment insurance contribution rate. These effects have largely cancelled each other out, leaving the policy-adjusted line close to the actual tax revenues collected.

For indirect taxes, the VAT rate was raised in 2009, and then the Estonian Tax and Customs Board implemented measures in 2015 to improve the efficiency of VAT collection. These changes pushed the policy-adjusted line slightly upward, but the difference from the actual revenues collected remains quite small. As mentioned earlier, indirect taxes are not only VAT, but also excise duties, but since various excise rates are changed almost every year and often in different directions over time, there are no reliable estimates of their effects, and so the impact of those changes has not been accounted for in this study. The policy-adjusted tax revenues constructed above are used in the following regression analysis to estimate tax elasticities.

2. RESULTS

2.1. Revenue elasticities with respect to tax bases

As outlined before, the revenue side of budget elasticity is constructed using separate estimates for the four tax categories of personal income tax, social tax, corporate income tax and indirect taxes. The tax base for estimating the elasticity of personal income tax and social tax is defined as the compensation of employees. The operating surplus of the previous period is used as the proxy for the tax base of corporate income tax, and private consumption is applied as the proxy for the tax base for indirect taxes. The time series used to estimate the revenue elasticities of different tax categories to their bases are presented in Figure 3, which shows that the tax revenues and their bases move quite closely together over time, suggesting elasticities around 1. However, only PIT revenues tend to respond more than proportionally to changes in the base, implying an elasticity greater than 1.

The regression-based elasticities of tax revenues to their bases in different subsets of the time series are presented in Table 1. The subsets are chosen to illustrate different phases in the economic cycle. The first subset covers the full observation period from 1995 to 2023 and serves as the baseline for the analysis. The second subset also begins in 1995, but ends just before the recent crisis triggered by the Covid-19 pandemic in 2020. The third subset for 2010-2019 focuses on the period between the two crises, capturing a relatively stable economic phase. The second and third subsets are included primarily for comparison, and the full-period estimates are considered the main reference point throughout the study.

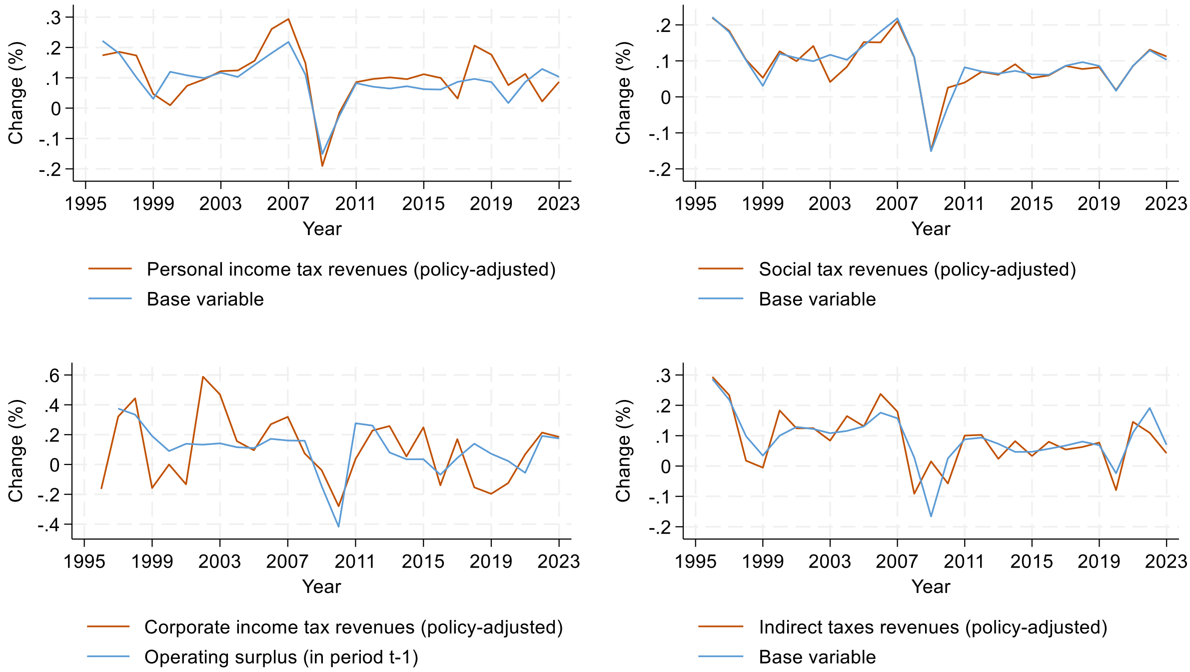

Figure 3. Changes in the revenues of different tax categories and their tax bases
Source: Statistics Estonia, author's own calculations

It appears from Table 1 that, as predicted by the graphs in Figure 3, the elasticities fluctuate around 1. Only the elasticity of PIT revenues to the compensation of employees exceeds 1, with estimates ranging from 1.12-1.32 depending on the subset of the time series observed. The elasticity of SOT revenues to its base is slightly below one across all the periods estimated, and is lowest in 2010-2019. The same applies for CIT, though it reaches slightly above one in 1995-2019. The elasticity for INT revenues also exceeds 1 when estimated for 1995-2019, but when the observable period is extended to 2023, it falls slightly below 1.

Table 1. Elasticities of the tax revenues to their bases

	Error correction model estimates			**Latest OECD/EC estimates**
	1995-2023	**1995-2019**	**2010-2019**	
Personal income tax	1.12	1.14	1.32	1.46
Social tax	0.93	0.92	0.88	1.36
Corporate income tax	0.94	1.03	0.78	1.81
Indirect taxes	0.97	1.04	1.00	1.00

Notes:
**In the case of the error correction model estimations, three-year average estimates are presented.*
***The latest OECD/EC estimates are the individual elasticities calculated in 2014, which were also used in the subsequent 2018 revision. However, the 2018 update involved only an adjustment of weights, without any changes to the elasticities themselves.*
****For short-term and long-term estimations together with error correction terms, see Appendix 2.*
Source: Author's own estimations, Price et al., (2014), Mourre et al., (2014).

The elasticities in Table 1 were estimated using the data on policy-adjusted revenue. To assess how the discretionary tax measures affected these elasticities, a similar regression analysis was conducted on the actual tax revenues (detailed results are provided in Appendix 3). Comparing the net and gross elasticities[2] reveals that, after adjusting for policy measures, the estimate of elasticity increased significantly for PIT and slightly for SOT and INT, while it remained almost unchanged for CIT. This suggests that discretionary tax measures have generally made tax revenues less sensitive to changes in their base variables, as net elasticities are higher than gross elasticities.

The EC/OECD tax elasticity estimates presented in the last column of Table 1 were calculated in 2014, but they were also used in 2019, when the latest update to the budgetary cyclicality assessments was made, with only the GDP shares being adjusted. These estimates can therefore be considered the currently valid official values that serve as a reference for institutions like the European Commission and the Estonian Ministry of Finance in their analysis of fiscal policy. Comparing the estimated elasticities with the OECD/EC 2014 estimations shows that there are notable differences across the various tax categories. For both PIT and SOT revenues, the regression-based elasticities are lower in all three periods than the OECD/EC estimate from 2014, suggesting that the relationship between income levels and PIT and SOT revenues is less responsive over time than has previously been considered. This difference may stem not only from the differences in the samples, but also from differences in the methodologies, as the OECD/EC does not use regression analysis but rather derives its elasticities from average and marginal tax rates across income distributions.

The estimated CIT elasticity is also significantly lower than the OECD/EC estimate, but it must be noted that the OECD/EC estimate for the CIT revenues to its base elasticity is taken as the EU average, which means that is does not necessarily reflect the Estonian situation. The specific characteristics of the Estonian corporate income tax system mean it cannot be assumed that the European average applies for Estonia. Finally, the regression-based elasticity for INT revenues is slightly higher in 1995-2019, but it is still relatively close to the unitary elasticity assumption used by the OECD/EC. When comparing the results of this study with the OECD/EC estimates, it is important to note that while this study uses policy-adjusted time series, the EC estimates are based on actual tax revenues and therefore reflect gross elasticities. Overall, it can be assumed that since the tax-to-base elasticity for all tax categories is lower than the official OECD/EC estimate, the overall budgetary sensitivity may turn out to be also lower than the current official estimate.

2.2. Expenditure elasticities with respect to expenditure bases

On the expenditure side, only unemployment-related expenses[3] are considered to be cyclically sensitive. They are however a very small share of total government expenditure at only 1–2%. In the following analysis for Estonia, the number of people unemployed is used as the proxy for the base of unemployment-related expenditures. The time series used to estimate the elasticity of expenditure to its base are presented in Figure 4. The figure shows that unemployment-related expenses and unemployment tend to move in the same direction over time, indicating a positive correlation. However, this relationship appears to have weakened over the period observed. Up until the financial crisis, changes in unemployment-related expenses were more pronounced than changes in unemployment. The relationship appears to be weaker, in contrast, during the more stable period following the crisis, suggesting that elasticity may have decreased.

[2] As gross elasticity is defined to measure the percentage change in tax revenue caused by a one percentage point change in the size of the tax base, without correcting for the effects of policy-induced changes in the tax system that affect tax revenues, the net elasticity is defined to measure the percentage change in tax revenue, net of the impact of discretionary tax measures. Net elasticity thus reflects only the automatic, or non-discretionary, response to changes in the tax base.
[3] Unemployment-related expenses refer to the code 10.5 “Unemployment” in the COFOG classification of expenditures.

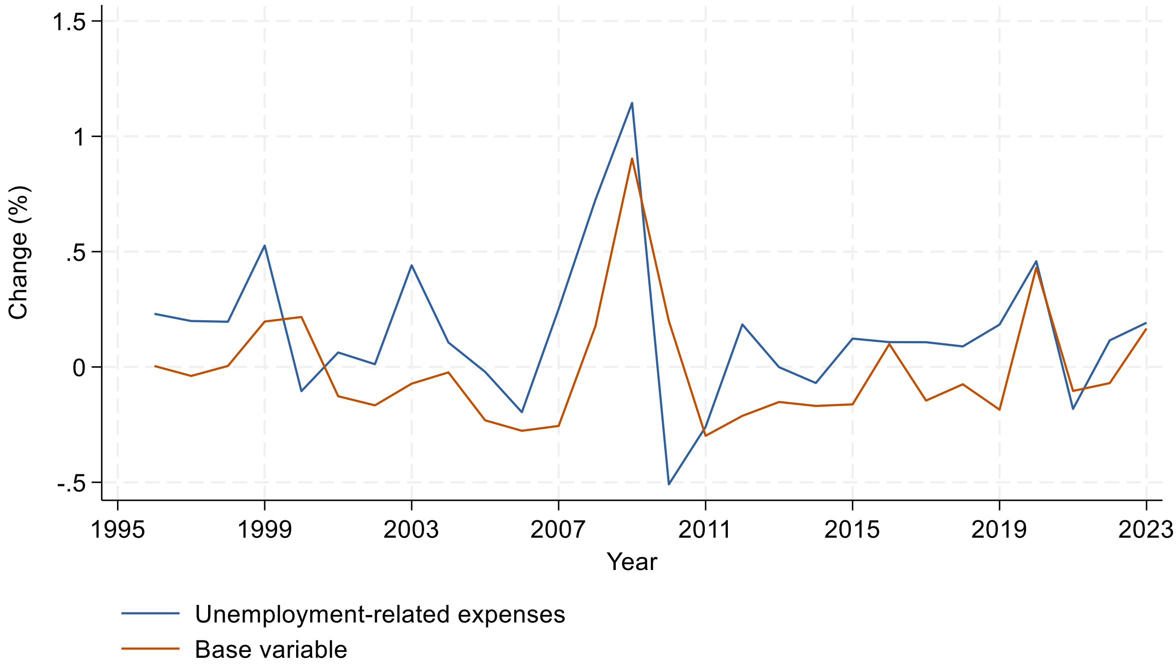

Figure 4. Changes in the unemployment-related expenses and unemployment
Source: Statistics Estonia, author's own calculations

The elasticities of unemployment-related expenses to unemployment found from the regression in different subsets of the time series are presented in Table 2. It appears that the elasticities have decreased over time, as predicted by Figure 4. The estimated elasticity is 0.50 in the full sample, indicating that an increase of 1 percentage point in unemployment is associated with an increase of 0.50 percentage point in unemployment-related expenses. Restricting the sample to 1995–2019 gives a slightly higher elasticity at 0.55, suggesting the response of expenses to unemployment was stronger before the most recent years. However, the elasticity turns negative in the 2010–2019 subsample, implying that unemployment-related expenses no longer increase systematically with unemployment and may even move in the opposite direction.

Table 2. Elasticities of unemployment-related expenses to unemployment

	Error correction model estimates		
	1995-2023	**1995-2019**	**2010-2019**
Unemployment-related expenses	0.50	0.55	-0.21

Notes:
**In the case of error correction model estimations, three-year average estimates are presented.*
***For short-term and long-term estimations together with error correction terms, see Appendix 4.*
Source: Author's own estimations.

This decline in elasticity over time supports the visual evidence from Figure 4, which suggests a weakening in the relationship between unemployment and unemployment-related expenses in more recent years. However, the OECD/EC estimations assume there is unitary elasticity between unemployment-related expenditures and unemployment, and so the findings of this analysis provide new insights into this relationship in Estonia.

2.3. Base elasticities with respect to the output gap

The second part of the two-step approach estimates the base-to-output gap elasticities. In this study, the compensation of employees serves as the base variable for PIT and SOT, gross operating surplus is used for CIT, private consumption serves for indirect taxes, and the number of people unemployed is taken as the base for unemployment-related expenditure. The time series used to estimate the elasticities of the base variables to the output gaps are presented in Figure 5.

The graphs in Figure 5 illustrate the relationships between the base variables and different output gap measures, and demonstrate that the compensation of employees and private consumption follow a pattern similar to that given by measures of the output gap, suggesting there is a positive relationship. However, the fluctuations in private consumption appear to be more aligned with different measures of the output gap than the changes in labour incomes, regardless of which methodology is used to estimate output gap. Gross operating surplus also shows a positive relationship with the output gap, but the fluctuations in it are more volatile, suggesting an elasticity that is greater than 1. Finally, unemployment exhibits a strong negative relationship with the output gap, with sharper fluctuations during downturns in 2009 and 2020, reflecting the sensitivity of the labour market to economic cycles.

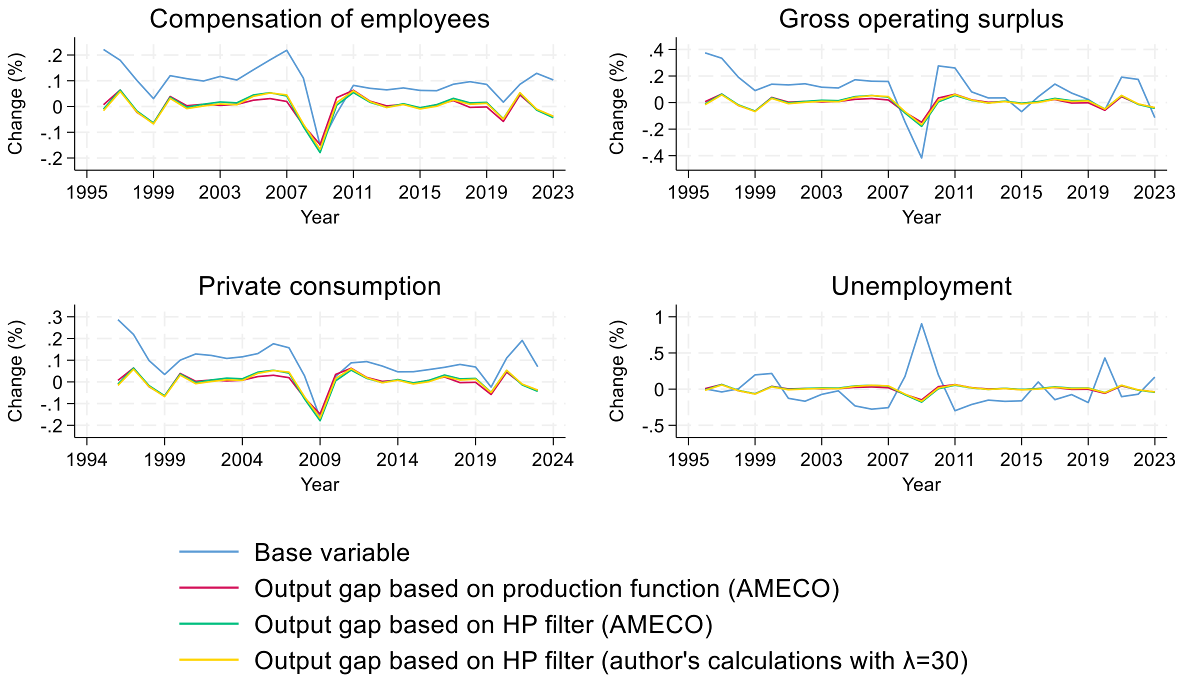

Figure 5. Changes in base variables and output gaps

Source: Statistics Estonia, AMECO database, author's own calculations

The elasticities of the base variables to measures of the output gap are assessed through regression analysis following the same approach that was used for estimating the tax-to-base elasticities. This means that both the first-difference and the ECM models are estimated using the OLS method and also the Prais-Winsten method (for the equations, see page 6). Table 3 presents the estimated elasticities of the base variables to the measures of the output gap derived from the regression analysis, along with the OECD/EC estimates from 2014 for comparison.

The results in Table 3 provide estimates of the base-to-output gap elasticities across different time periods, comparing them to the OECD/EC estimates from 2014. The estimated elasticity for compensation of employees ranges from 0.53 to 0.96, depending on the sample period and the output gap specification. The elasticity appears to increase over time, reaching its highest values in 2010–2019. Comparing the relationship between labour income and the business cycle across different output gap specifications reveals it to be stronger when output gap derived from the HP filter is used, either from AMECO or from the author, than when output gap based on the production function is used.

In any case, these estimates of labour income elasticities remain below the OECD/EC 2014 estimate. Estonia's estimates are not the only ones that are smaller than the OECD/EC estimates though, as a 2023 study in Finland for example that assessed the size of the automatic stabilisers in 1993–2021 found that the elasticity of labour incomes to the output gap was 0.68 (Kellokumpu, Pesola, Savolainen, & Grünbaum, 2023), while the OECD/EC estimate was 0.95 for Finland (Mourre, Astarita, & Princen, 2014). Similarly, a 2021 analysis in Sweden covering the period 1990–2019 estimated the elasticity at 0.77 (Almenberg & Sigonius, 2021), whereas the OECD/EC estimate for Sweden is 0.93 (Mourre, Astarita, & Princen, 2014). This suggests that the elasticity of labour incomes to the output gap may be somewhat overestimated in the OECD/EC studies.

Table 3. Base-to-output gap elasticities

		Error correction model estimates			**Latest OECD/EC**
		1995-2023	**1995-2019**	**2010-2019**	**estimates**
Compensation of employees	Output gap 1	0.53	0.61	0.76	1.08
	Output gap 2	0.73	0.73	0.96	
	Output gap 3	0.75	0.76	0.89	
Gross operating surplus	Output gap 1	2.69	2.62	2.35	0.99
	Output gap 2	2.08	2.15	1.33	
	Output gap 3	2.12	2.15	1.54	
Private consumption	Output gap 1	0.87	0.91	0.62	1.00
	Output gap 2	0.87	0.91	0.56	
	Output gap 3	0.86	0.89	0.54	
Unemployment	Output gap 1	-4.55	-4.19	-7.65	-5.18
	Output gap 2	-4.52	-4.55	-8.44	
	Output gap 3	-4.71	-4.69	-8.59	

Notes:
**Output gap 1 is based on the production function (AMECO), output gap 2 is based on the HP filter (AMECO), and output gap 3 is based on the HP filter as well, but it is calculated by the author with the smoothing parameter λ=30.*
***In the case of error correction model estimations, three-year average estimates are presented.*
****In the case of private consumption and unemployment, the first-difference models give better results for 1995-2023 and 1995-2019, so the short-term elasticities are presented for these subsamples.*
*****The latest OECD/EC estimates are the individual elasticities calculated in 2014, which were also used in the subsequent 2018 revision. However, the 2018 update involved only an adjustment of weights, without any changes to the elasticities themselves.*
******For short-term and long-term estimations together with error correction terms, see Appendix 5.*
Source: Author's own estimations, Price et al., (2014), Mourre et al., (2014).

The elasticities for the CIT base to the output gap are significantly higher than for the other base variables, ranging from 1.33 to 2.69, depending on the sample period and the output gap specification. For every output gap specification, the elasticity of gross operating surplus to the output gap is lowest in 2010–2019, suggesting that corporate profits have become less responsive in recent years. Comparing different output gap specifications additionally shows that this elasticity is lower when output gap derived from the HP filter is used, both from AMECO and from the author's calculations, than when the production function method is used. However, the OECD/EC estimate for this elasticity is 0.99, which is significantly lower than the estimates found in this study. This difference may be partly explained by the particularities of the Estonian corporate income tax system, where taxation is deferred until profits are distributed. As a result, corporate profits in Estonia may respond to economic cycles differently to those in countries with traditional corporate income tax systems, for which the OECD/EC specification was originally designed.

The elasticities for private consumption remain between 0.54 and 0.91. These results suggest that private consumption in Estonia is slightly less cyclical than the standard OECD/EC unitary assumption finds. A notable decline is observed in 2010–2019, when the elasticity falls to 0.54–0.62 depending on the specification of the output gap, which may reflect shifts in consumer behaviour following the financial crisis. Unlike the previous two elasticities, the elasticity of private consumption is largely independent of the output gap specification, and it remains fairly similar across the three different measures of the output gap.

The results for the elasticity of unemployment confirm a strong negative relationship between unemployment and the output gap, with elasticities ranging from -4.19 to -8.59. In the most recent period of 2010–2019, the absolute value of elasticity increased significantly, reaching -7.65 to -8.59, while it was -4.19 to -4.71 in the longer sample. This suggests that unemployment has become even more sensitive to economic fluctuations in recent years, possibly because of structural changes in the labour market such as increased labour market flexibility. However, the elasticity of unemployment to the output gap found in this study is roughly in line with the OECD/EC estimate.

2.4. Combining the estimates to find budgetary sensitivity

The final step is to aggregate the estimated elasticities reported above, using GDP shares as weights[4], to get an estimate of the overall budgetary sensitivity. The results in Table 4 provide estimates of budgetary sensitivity across the different sample periods and output gap measures, indicating how responsive the budget is to changes in economic output relative to its potential. For the detailed calculations see Appendix 6.

Table 4. Budgetary sensitivity estimates depending on the sample period and output gap measure

	1995-2023	**1995-2019**	**2010-2019**
Output gap based on production function (AMECO)	0.269	0.281	0.231
Output gap based on HP filter (AMECO)	0.294	0.295	0.244
Output gap based on HP filter (calculated by the author with the smoothing parameter λ=30).	0.297	0.297	0.232

Source: Author's own calculations.

The estimates of budgetary sensitivity are relatively consistent across the sample periods for the output gap based on the production function, with the highest estimate of 0.281 occurring in 1995-2019. Similar patterns are observed for the output gap based on the output trend (AMECO), where the estimates also show a decrease over the shorter 2010-2019 period to 0.244. For the output gap based on the HP filter, there is no variation between the estimates for 1995-2023 and 1995-2019 as both are 0.297, but the estimate is again lower for 2010–2019 at 0.232. However, using the output gap based on the HP filter gives

[4] Like Mourre et al. (2014), this study also uses the average shares of the last 10 years as weights.

the highest value for the budgetary sensitivity at 0.297, which implies that when a negative output gap improves, say from -1.5% to -0.5%, the fiscal position improves by 0.297 percentage points.

The estimates for 2010-2019 generally tend to be lower across all the output gap specifications, which may reflect the effects of the global financial crisis and the subsequent recovery. It suggests that the fiscal response to economic output may have been weaker during this decade, possibly because of fiscal constraints or slower growth following the crisis. Overall, the results indicate that budgetary sensitivity varies depending on the method used to estimate the output gap, with the HP filter method generally showing higher sensitivity.

Comparing the findings of this study with previous research reveals significant variation between the estimates of budgetary sensitivity. The current estimate, in the range of 0.27-0.30, is of the same magnitude as the estimates by Kattai et al. (2003) at 0.35 and the OECD/EC (2005) at 0.30. The estimate found in this study is significantly lower than the current official level of 0.486 from the OECD/EC (2019). According to this estimate, Estonia's budget sensitivity to economic fluctuations is almost the same as the European average of 0.496, but this seems rather unrealistic given the differences in fiscal policies, such as Estonia's flat PIT rate with limited progressivity and its smaller welfare state with relatively modest social benefits. However, these differences in the estimates of sensitivity can largely be attributed to methodological variations as well, as different studies use different output gap measures, sample periods, or estimation techniques. Furthermore, while the EC/OECD studies are based on actual tax revenues, this study uses a time series of tax revenues that has been adjusted for policy effects. In any case, this variability is important for policymaking, as different methods may provide different pictures of how sensitive the budget is to economic output.

3. DISCUSSION: IMPLICATIONS FOR THE STRUCTURAL BALANCE

The overall measure of budgetary sensitivity is a key input in calculating the structural budget balance, which has itself been an important input in assessments of compliance with the Estonian and EU fiscal rules. Structural balance (SB) is calculated as:

$$SB = NB - CC - 1X$$

where NB is the nominal budget balance, CC is the cyclical component, and $1X$ is one-off budgetary measures. The cyclical component is calculated as:

$$CC = \varepsilon \times OG$$

where ε is the budgetary semi-elasticity as the measure of budgetary sensitivity, and OG is the output gap. The structural budget balance is thus determined from four key components, which are the nominal budget balance, the budgetary semi-elasticity, the output gap, and one-off measures. Consequently, any changes in one or more of these underlying components will cause a revision in the structural balance. This section examines how the structural balance changes when one of these components – the budgetary semi-elasticity – is adjusted.

Figure 6 below illustrates Estonia's general government structural budget position for 2012-2024, using different estimates of budgetary sensitivity denoted as ε in the figure. These estimates are the 2019 estimate by the OECD/EC and the estimate obtained by the current study. Figure 6 demonstrates that in 2012-2016, when output was close to its potential level, the choice of measure for budgetary sensitivity affected the structural budget position by only 0.1 percentage point or less. In 2024 however, when the output gap was estimated to be more than -4%, the estimates of structural balance vary by 0.8 percentage points, depending on the estimate of budgetary sensitivity applied. This then implies that the larger the output gap, the more crucial it becomes to measure the sensitivity of the budget to economic fluctuations accurately.

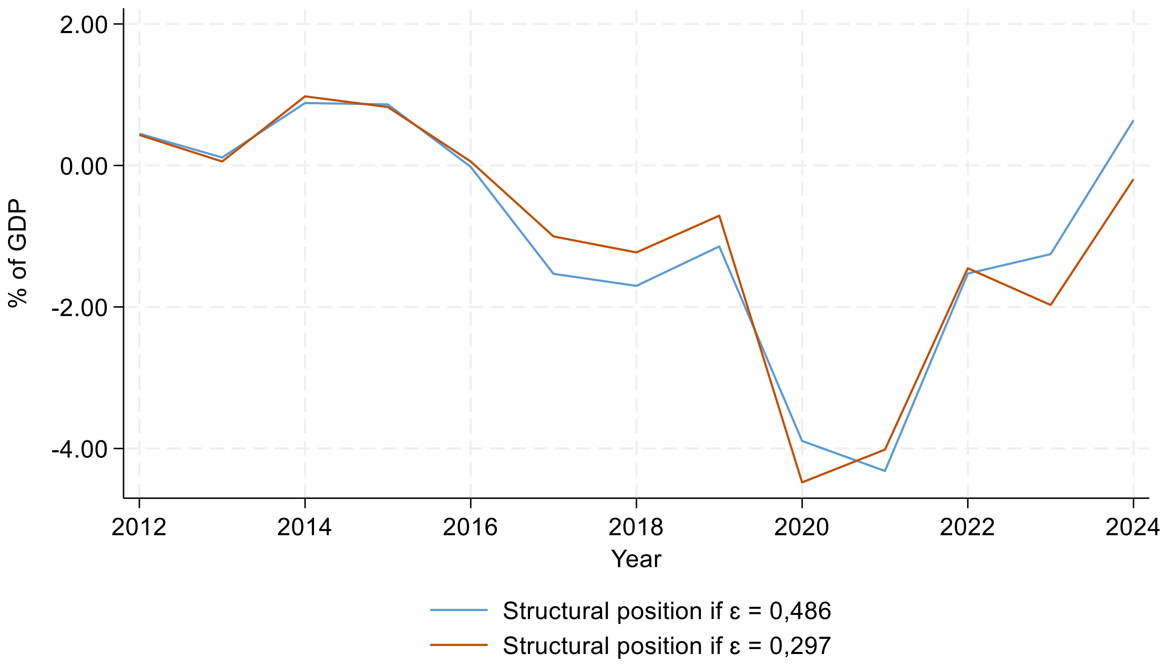

Figure 6. Structural budget balance in Estonia with different measures of budgetary sensitivity
Source: Statistics Estonia, Ministry of Finance, author's own estimations.

Overestimating the sensitivity of the budget to cyclical fluctuations can have significant implications for fiscal policy decisions. If budgetary sensitivity is overestimated, the structural budget balance may appear stronger during economic downturns than it actually is, leading policymakers to believe that fiscal policy is more sustainable than it truly is. Governments may consequently adopt looser fiscal policies under the assumption that the budget will automatically adjust more strongly to an economic recovery than it actually does. This could lead to excessive deficits and rising debt levels. Furthermore, if policymakers assume that automatic stabilisers will be more effective at correcting budgetary imbalances than they actually are, the necessary long-term fiscal adjustments might be postponed, leading to long-term sustainability risks in public finances. It is therefore important for the sake of effective fiscal policy to find the most accurate and relevant assessment of the cyclical sensitivity of the budget. However, the accuracy of the calculation of the structural budget position relies strongly on the output gap being measured correctly as well.

4. CONCLUSION

This paper updates the estimate of the Estonian budgetary sensitivity using the latest available data. Estimating the value of budgetary sensitivity is a crucial input for any assessment of the structural balance, which is a key requirement in the domestic fiscal rules. Furthermore, this measure reflects the strength of the automatic stabilisers within the budget. If budgetary sensitivity is low, the budget will not respond automatically to economic fluctuations as strongly, and so more effort will be required from policymakers to implement discretionary policies for a counter-cyclical response.

Like in the previous literature, a two-step method is used to estimate the relationship between budgetary items and the economic cycle. First, tax revenues and unemployment-related expenditures are regressed on their macroeconomic base variables to obtain budgetary-to-base elasticities. Second, the base variables are regressed on the output gap to derive base-to-output gap elasticities. These elasticities are then combined to calculate budgetary-to-output gap elasticities and the overall budgetary sensitivity.

The primary contribution of this paper is its adjustment of annual tax revenues to include the impact of discretionary policy measures in the estimates of elasticities. It does this using the proportional adjustment method, as is common in the literature. A further contribution of this study is that instead of using EU averages or making unitary assumptions, it estimates all the elasticities separately using Estonian data. It uses the longest possible annual time series for this, covering the period from 1995 to the most recent available year, 2023.

The estimate of Estonia's budgetary sensitivity found in this study is around 0.3. This new estimate aligns closely with the finding of 0.35 by Kattai et al. (2003) for 1996–2001 and with the OECD/EC estimate until 2014 of 0.3, but it does not support the upward trend observed in the OECD/EC assessments in 2014 and 2019. This means that the Estonian budgetary balance may not be as sensitive to the economic cycle as the current official estimate of 0.486 suggests. Overestimating budgetary sensitivity can create a false sense of security, as the structural budget balance may appear stronger than it actually is during economic downturns.

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APPENDIX 1. THE DISCRETIONARY TAX MEASURES AND THEIR IMPACTS USED TO CONSTRUCT THE POLICY-ADJUSTED REVENUE SERIES

Year of impact	Description of DTM	Impact (in million euros)
	Measures affecting VAT revenues	
2009	VAT rate increase from 18% to 20% (from July 1 2009)	47.9
2010	VAT rate increase from 18% to 20% (from July 1 2009)	63.9
2009	VAT reduced rate increase from 5% to 9%	21.1
2015	Measures by the EMTA for more effective collection of VAT	100
	Measures affecting CIT revenues	
2000	Income tax reform	-49.9
2005	CIT rate decrease 26% to 24%	-17.8
2006	CIT rate decrease 24% to 23%	-9.3
2007	CIT rate decrease 23% to 22%	-13.7
2008	CIT rate decrease 22% to 21%	-14.7
2015	CIT rate decrease 21% to 20%	-17.8
2018	CIT rate 14% in the case of regularly distributed profit; advance payment of bank income tax; limitation on the tax-free transfer of profits as loans	142.5
2019	CIT rate 14% in the case of regularly distributed profit; advance payment of bank income tax; limitation on the tax-free transfer of profits as loans	83.7
	Measures affecting PIT revenues	
2004	Basic tax-free allowance increase to €1074 (from €767)	-30*
2005	PIT rate decrease from 26% to 24%	-59.7
2005	Basic tax-free allowance increase to €1304	-29.1
2006	PIT rate decrease from 24% to 23%	-32.3
2006	Basic tax-free allowance increase to €1534	-28.7
2007	PIT rate decrease from 23% to 22%	-42.8
2007	Expansion of additional tax-free allowance for children	-23
2008	PIT rate decrease from 22% to 21%	-49.5
2008	Basic tax-free allowance increase to €1726	-24.6
2009	Expansion of additional tax-free allowance for children	-47
2015	PIT rate decrease from 21% to 20%	-71.1
2015	Basic tax-free allowance increase to €1848	-14.3
2016	Basic tax-free allowance increase to €1848	-20.5
2016	Basic tax-free allowance increase to €2040	-27
2017	Basic tax-free allowance increase to €2040	-30.3
2017	Basic tax-free allowance increase to €2160	-17.3
2017	Income tax refund for low-income earners	-36
2018	Establishment of a new general tax-free income	-92.4
2019	Establishment of a new general tax-free income	-151.5
2021	Amendment to the second pillar of the pension system (one-off measure)	296
2022	Amendment to the second pillar of the pension system (one-off measure)	85
2023	Income tax exemption for the average pension	-85.4
2023	Basic tax-free allowance increase to €654 per month	-9.8

Measures affecting SOT revenues		
2003	Establishing unemployment insurance system: 1.5%	35*
2005	Unemployment insurance contribution rate decrease to 0.9%	-20*
2006	Social tax compulsory minimum payment increase 2006 to €90	17.3
2007	Social tax compulsory minimum payment increase 2007 to €128	14.7
2008	Social tax compulsory minimum payment increase 2008 to €173	18.2
2009	Social tax compulsory minimum payment increase 2009 to €278	52.1
2009	Unemployment insurance contribution rate increase to 4.2%	74.1
2013	Social tax compulsory minimum payment increase 2013 to €290	5
2013	Unemployment insurance contribution rate decrease to 3.0%	-54
2014	Unemployment insurance contribution rate decrease to 3.0%	-58
2014	Social tax compulsory minimum payment increase 2014 to €320	20
2015	Social tax compulsory minimum payment increase 2015 to €355	25
2015	Unemployment insurance contribution rate decrease to 2.4%	-21.7
2016	Unemployment insurance contribution rate decrease to 2.4%	-27.3
2016	Social tax compulsory minimum payment increase 2016 to €390	30
2017	Social tax compulsory minimum payment increase 2017 to €430	15
2018	Social tax compulsory minimum payment increase 2018 to €470	20
2019	Social tax compulsory minimum payment increase 2019 to €500	25
2020	Social tax compulsory minimum payment increase 2020 to €540	25*
2021	Social tax compulsory minimum payment increase 2021 to €584	25*
2022	Establishing a lower social tax rate of 20% in certain cases (from April 1 2022)	-43.6
2023	Establishing a lower social tax rate of 20% in certain cases (from April 1 2022)	-63.9
2023	Social tax compulsory minimum payment increase 2023 to €654	25*

*Source: Ministry of Finance. Since there are no impact assessments for some changes, then the figures marked * are the author's estimates.*

APPENDIX 2. POLICY-ADJUSTED TAX REVENUES TO TAX BASE REGRESSIONS

Personal income tax to compensation of employees

Tax elasticity							First-difference models						Error correction models								
							Model 1: OLS			Model 2: AR(1)			Model 3: ECM +OLS				Model 4: ECM + AR(1)				
Sample	Tax elasticity	Short-term	Long-term	3y average	R^2 adj	Model	dlbase	R^2 adj	DW	dlbase	R^2 adj	DW	dlbase	ECT	R^2 adj	DW	dlbase	ECT	R^2 adj	DW	N
1995-2023	1.12	1.06	1.22	1.12	0.70	4	1.03***	0.65	1.47	1.02***	0.63	1.84	1.05***	-0.22**	0.69	1.39	1.06***	-0.43***	0.70	1.89	28
1995-2019	1.14	1.09	1.18	1.14	0.77	4	1.09***	0.72	1.45	1.08***	0.70	1.75	1.09***	-0.18	0.73	1.31	1.09***	-0.71***	0.77	1.80	24
2010-2019	1.32	0.97	1.44	1.32	0.83	4	1.29**	0.44	2.24	1.42**	0.58	1.97	1.05**	-1.29**	0.74	1.93	0.97**	-1.38**	0.83	2.03	10

Social tax to compensation of employees

Tax elasticity							First-difference models						Error correction models								
							Model 1: OLS			Model 2: AR(1)			Model 3: ECM +OLS				Model 4: ECM + AR(1)				
Sample	Tax elasticity	Short-term	Long-term	3y average	R^2 adj	Model	dlbase	R^2 adj	DW	dlbase	R^2 adj	DW	dlbase	ECT	R^2 adj	DW	dlbase	ECT	R^2 adj	DW	N
1995-2023	0.93	0.91	0.96	0.93	0.94	4	0.91***	0.89	2.73	0.91***	0.93	2.07	0.92***	-0.62***	0.92	2.15	0.91***	-0.45***	0.94	1.97	28
1995-2019	0.92	0.90	0.96	0.92	0.94	4	0.91***	0.89	2.77	0.90***	0.93	2.09	0.91***	-0.64***	0.92	2.22	0.90***	-0.46**	0.94	2.00	24
2010-2019	0.88	0.74	0.94	0.88	0.64	4	0.43**	0.45	2.44	0.57***	0.78	1.98	0.72***	-0.98**	0.73	1.36	0.74***	-1.17***	0.64	1.84	10

Corporate income tax to operating surplus

Tax elasticity							First-difference models						Error correction models								
							Model 1: OLS			Model 2: AR(1)			Model 3: ECM +OLS				Model 4: ECM + AR(1)				
Sample	Tax elasticity	Short-term	Long-term	3y average	R^2 adj	Model	dlbase	R^2 adj	DW	dlbase	R^2 adj	DW	dlbase	ECT	R^2 adj	DW	dlbase	ECT	R^2 adj	DW	N
1995-2023	0.94	0.75	1.28	0.94	0.35	4	0.75***	0.25	1.78	0.72***	0.23	1.99	0.76***	-0.29**	0.35	1.60	0.75***	-0.42**	0.35	1.95	27
1995-2019	1.03	0.82	1.37	1.03	0.36	4	0.74**	0.23	1.76	0.72***	0.22	1.91	0.82***	-0.38**	0.37	1.60	0.82***	-0.45**	0.36	1.80	23
2010-2019	0.78	0.59	0.95	0.78	0.34	4	0.56	0.20	1.69	0.55	0.20	1.83	0.56*	-0.55	0.31	1.40	0.59*	-0.66*	0.34	1.70	9

Indirect taxes to private consumption

Tax elasticity							First-difference models						Error correction models								
							Model 1: OLS			Model 2: AR(1)			Model 3: ECM +OLS				Model 4: ECM + AR(1)				
Sample	Tax elasticity	Short-term	Long-term	3y average	R^2 adj	Model	dlbase	R^2 adj	DW	dlbase	R^2 adj	DW	dlbase	ECT	R^2 adj	DW	dlbase	ECT	R^2 adj	DW	N
1995-2023	0.97	0.89	1.03	0.97	0.68	3	0.88***	0.59	2.96	0.94***	0.77	2.18	0.89***	-0.58***	0.68	2.15	0.91***	-0.27	0.77	2.00	28
1995-2019	1.04	1.01	1.06	1.04	0.76	3	0.86***	0.58	3.01	0.95***	0.79	2.38	1.01***	-0.91***	0.76	2.11	0.98***	-0.56***	0.82	2.14	24
2010-2019	1.00	1.04	0.98	1.00	0.92	4	1.64**	0.47	2.28	1.35**	0.58	1.67	0.98***	-1.19***	0.90	2.48	1.04***	-1.10***	0.92	2.10	10

*Notes: *, **, *** indicate significance at the 10, 5, and 1 per cent levels respectively.*

The sample uses annual data.

Gross operating surplus in the corporate income tax-to-base regression is lagged by one year.

AR(1) refers to estimations with the Prais-Winsten method, which allows for a correction of the first order autocorrelation in the residuals.

Short-term elasticity refers to the elasticity in year t (denoted by dlbase in the models), elasticity in year t-1 is calculated as (ST + ECT(ST-LT)) and elasticity in year t-2 is calculated as (ST + ECT(ST-LT) + ECT(ST + ECT(ST-LT) - LT)). Tax elasticity refers to three-year average tax elasticity that is an arithmetic average of these three elasticities.

Source: Author's own estimations.

APPENDIX 3. TAX-TO-BASE GROSS ELASTICITY REGRESSIONS

Tax elasticity							First-difference models						Error correction models								
							Model 1: OLS			Model 2: AR(1)			Model 3: ECM +OLS				Model 4: ECM + AR(1)				
Tax category	Tax elasticity	Short-term	Long-term	3y average	R^2 adj	Model	dlbase	R^2 adj	DW	dlbase	R^2 adj	DW	dlbase	ECT	R^2 adj	DW	dlbase	ECT	R^2 adj	DW	N
Personal income tax	0.97	1.05	0.86	0.97	0.65	4	0.98***	0.58	1.72	0.99***	0.57	1.88	1.04***	-0.27*	0.62	1.51	1.05***	-0.50***	0.65	1.80	28
Social tax	0.87	0.79	1.02	0.87	0.93	3	0.80***	0.90	1.91	0.80***	0.89	1.96	0.79***	-0.42***	0.93	2.09	0.78***	-0.41***	0.94	1.90	28
Corporate income tax	0.93	0.88	1.01	0.93	0.36	4	0.79**	0.19	1.45	0.77**	0.19	1.69	0.89***	-0.33**	0.31	1.33	0.88***	-0.47**	0.36	1.53	27
Indirect taxes	0.91	0.86	1.09	0.91	0.7	4	0.80***	0.53	2.83	0.85***	0.69	2.14	0.86***	-0.45**	0.61	2.30	0.86***	-0.25*	0.70	2.04	28

*Notes: *, **, *** indicate significance at the 10, 5, and 1 per cent levels respectively.*

The sample uses annual data from 1995 to 2023.

AR(1) refers to estimations with the Prais-Winsten method, which allows for a correction of the first order autocorrelation in the residuals.

Short-term the elasticity refers to elasticity in year t (denoted by dlgap in the models), elasticity in year t-1 is calculated as (ST + ECT(ST-LT)) and elasticity in year t-2 is calculated as (ST + ECT(ST-LT) + ECT(ST + ECT(ST-LT) - LT)). Tax elasticity refers to three-year average tax elasticity that is an arithmetic average of these three elasticities.

Source: Author's own estimations.

APPENDIX 4. UNEMPLOYMENT-RELATED EXPENDITURES TO UNEMPLOYMENT REGRESSIONS

Tax elasticity							First-difference models						Error correction models								
							Model 1: OLS			Model 2: AR(1)			Model 3: ECM +OLS				Model 4: ECM + AR(1)				
Sample	Tax elasticity	Short-term	Long-term	3y average	R^2 adj	Model	dlbase	R^2 adj	DW	dlbase	R^2 adj	DW	dlbase	ECT	R^2 adj	DW	dlbase	ECT	R^2 adj	DW	N
1995-2023	0.50	0.73	-1.43	0.50	0.54	4	0.79***	0.38	2.04	0.79***	0.38	2.01	0.73***	-0.12***	0.53	2.09	0.73***	-0.11***	0.54	2.01	28
1995-2019	0.55	0.73	-0.98	0.55	0.46	3	0.80***	0.36	2.03	0.80***	0.36	2.00	0.73***	-0.11**	0.46	2.01	0.73***	-0.10**	0.46	1.96	24
2010-2019	-0.21	0.04	-0.38	-0.21	0.66	4	-0.60	0.06	0.97	-0.50	0.07	1.49	-0.04	-0.72***	0.66	0.86	0.04	-0.81***	0.66	1.66	10

*Notes: *, **, *** indicate significance at the 10, 5, and 1 per cent levels respectively.*

The sample uses annual data.

AR(1) refers to estimations with the Prais-Winsten method, which allows for a correction of the first order autocorrelation in the residuals.

Short-term elasticity refers to the elasticity in year t (denoted by dlbase in the models), elasticity in year t-1 is calculated as (ST + ECT(ST-LT)) and elasticity in year t-2 is calculated as (ST + ECT(ST-LT) + ECT(ST + ECT(ST-LT) - LT)). Tax elasticity refers to three-year average tax elasticity that is an arithmetic average of these three elasticities.

Source: Author's own estimations.

APPENDIX 5. BASE-TO-OUTPUT GAP REGRESSIONS

Compensation of employees

Base-to-output gap elasticity								First-difference models						Error correction models								
								Model 1: OLS			Model 2: AR(1)			Model 3: ECM +OLS				Model 4: ECM + AR(1)				
Output gap measure	Sample	Tax elasticity	Short-term	Long-term	3y average	R^2 adj	Model	dlgap	R^2 adj	DW	dlgap	R^2 adj	DW	dlgap	ECT	R^2 adj	DW	dlgap	ECT	R^2 adj	DW	N
With respect to potential GDP based on production function (AMECO)	1995-2023	0.53	0.53	0.52	0.53	0.62	4	0.60***	0.47	1.38	0.64***	0.52	1.71	0.50***	-0.27*	0.52	1.36	0.53***	-0.43**	0.62	1.73	28
	1995-2019	0.61	0.61	0.60	0.61	0.68	4	0.67***	0.52	1.24	0.73***	0.61	1.75	0.56***	-0.32**	0.59	1.27	0.61***	-0.43**	0.68	1.75	24
	2010-2019	0.76	0.50	1.18	0.76	0.73	4	-0.19	-0.05	1.76	-0.29	0.23	1.41	0.14	-0.35**	0.56	1.44	0.50**	-0.44***	0.73	1.43	10
With respect to potential GDP based on output trend (AMECO)	1995-2023	0.73	0.62	0.84	0.73	0.77	4	0.73***	0.59	1.24	0.73***	0.62	1.64	0.62***	-0.34**	0.66	1.14	0.62***	-0.65***	0.77	1.74	28
	1995-2019	0.73	0.67	0.81	0.73	0.79	4	0.80***	0.64	1.11	0.82***	0.69	1.65	0.66***	-0.38**	0.72	1.08	0.67***	-0.55***	0.79	1.68	24
	2010-2019	0.96	0.70	1.31	0.96	0.84	4	0.25	0.66	-0.10	0.66	0.10	1.17	0.61	-0.56***	0.62	0.35	0.70***	-0.52***	0.84	1.21	10
With respect to potential GDP based on HP-filter (λ=30)	1995-2023	0.75	0.63	0.86	0.75	0.76	4	0.72***	0.55	1.24	0.73***	0.60	1.64	0.61***	-0.34***	0.64	1.16	0.63***	-0.64***	0.76	1.74	28
	1995-2019	0.76	0.68	0.85	0.76	0.79	4	0.79***	0.61	1.11	0.81***	0.68	1.67	0.65***	-0.39***	0.71	1.11	0.68***	-0.55***	0.79	1.70	24
	2010-2019	0.89	0.65	1.21	0.89	0.82	4	0.01	-0.13	1.14	-0.03	-0.11	1.13	0.38	-0.46**	0.46	0.56	0.65***	-0.51***	0.82	1.25	10

Gross operating surplus

Base-to-output gap elasticity								First-difference models						Error correction models								
								Model 1: OLS			Model 2: AR(1)			Model 3: ECM +OLS				Model 4: ECM + AR(1)				
Output gap measure	Sample	Tax elasticity	Short-term	Long-term	3y average	R^2 adj	Model	dlgap	R^2 adj	DW	dlgap	R^2 adj	DW	dlgap	ECT	R^2 adj	DW	dlgap	ECT	R^2 adj	DW	N
With respect to potential GDP based on production function (AMECO)	1995-2023	2.69	2.71	2.66	2.69	0.81	4	2.56***	0.73	1.46	2.53***	0.74	1.79	2.74***	-0.29**	0.77	1.39	2.71***	-0.53***	0.81	1.87	28
	1995-2019	2.62	2.71	2.51	2.62	0.83	4	2.56***	0.73	1.32	2.55***	0.74	1.83	2.70***	-0.31**	0.77	1.22	2.71***	-0.53***	0.83	1.82	24
	2010-2019	2.35	3.43	0.75	2.35	0.92	3	4.68***	0.72	1.74	4.89***	0.80	1.43	3.43***	-0.48***	0.92	1.66	3.09***	-0.53***	0.90	1.56	10
With respect to potential GDP based on output trend (AMECO)	1995-2023	2.08	2.39	1.79	2.08	0.84	4	2.21***	0.67	1.26	2.25	0.70	1.75	2.39***	-0.33**	0.74	1.13	2.39***	-0.67***	0.84	1.93	28
	1995-2019	2.15	2.46	1.86	2.15	0.85	4	2.15***	0.65	1.17	2.25***	0.70	1.79	2.37***	-0.37***	0.74	0.99	2.46***	-0.66***	0.85	1.76	24
	2010-2019	1.33	2.19	0.50	1.33	0.84	4	3.31	0.21	0.81	2.23	0.16	1.12	2.47**	-0.66***	0.80	0.61	2.19***	-0.65***	0.84	1.20	10
With respect to potential GDP based on HP-filter (λ=30)	1995-2023	2.12	2.41	1.84	2.12	0.83	4	2.27***	0.66	1.26	2.29***	0.69	1.74	2.44***	-0.32***	0.73	1.15	2.41***	-0.66***	0.83	1.93	28
	1995-2019	2.15	2.43	1.86	2.15	0.85	4	2.22***	0.65	1.16	2.30***	0.69	1.79	2.42***	-0.37***	0.74	1.02	2.47***	-0.63***	0.85	1.79	24
	2010-2019	1.54	2.33	0.77	1.54	0.84	4	4.01**	0.45	1.23	4.53***	0.54	1.15	2.96***	-0.60***	0.83	0.80	2.33***	-0.65***	0.84	1.21	10

Private consumption

								First-difference models						Error correction models								
Base-to-output gap elasticity								Model 1: OLS			Model 2: AR(1)			Model 3: ECM +OLS				Model 4: ECM + AR(1)				
Output gap measure	Sample	Tax elasticity	Short-term	Long-term	3y average	R^2 adj	Model	dlgap	R^2 adj	DW	dlgap	R^2 adj	DW	dlgap	ECT	R^2 adj	DW	dlgap	ECT	R^2 adj	DW	N
With respect to potential GDP based on production function (AMECO)	1995-2023	0.87	0.87			0.80	2	0.89***	0.80	1.54	0.87***	0.80	1.81	0.90***	-0.11	0.81	1.47	0.88***	-0.13	0.80	1.74	28
	1995-2019	0.91	0.91			0.83	2	0.92***	0.83	1.73	0.91***	0.83	1.77	0.92***	-0.06	0.83	1.65	0.91***	-0.07	0.83	1.72	24
	2010-2019	0.62	0.42	0.80	0.62	0.49	3	0.36	0.18	1.68	0.05	-0.07	1.68	0.42**	-0.69**	0.49	1.33	0.27	-0.70**	0.35	1.52	10
With respect to potential GDP based on output trend (AMECO)	1995-2023	0.87	0.87			0.83	2	0.89***	0.84	1.52	0.87***	0.83	1.83	0.89***	-0.10	0.84	1.46	0.86***	-0.13	0.84	1.77	28
	1995-2019	0.91	0.91			0.87	2	0.92***	0.87	1.71	0.91***	0.87	1.78	0.91***	-0.06	0.87	1.64	0.91***	-0.07	0.86	1.74	24
	2010-2019	0.56	0.21	0.78	0.56	0.80	4	0.15	-0.07	1.67	0.15	-0.07	1.66	0.20	-0.80***	0.77	1.19	0.21*	-0.86***	0.80	1.48	10
With respect to potential GDP based on HP-filter (λ=30)	1995-2023	0.86	0.86			0.82	2	0.88***	0.82	1.52	0.86***	0.82	1.83	0.88***	-0.11	0.83	1.45	0.85***	-0.14	0.83	1.77	28
	1995-2019	0.89	0.89			0.85	2	0.90***	0.85	1.71	0.89***	0.85	1.78	0.90***	-0.06	0.85	1.63	0.89***	-0.07	0.85	1.74	24
	2010-2019	0.54	0.20	0.74	0.54	0.84	4	0.24	0.04	1.72	0.20	-0.01	1.78	0.21**	-0.86***	0.85	1.42	0.20**	-0.89***	0.84	1.57	10

Unemployment

								First-difference models						Error correction models								
Base-to-output gap elasticity								Model 1: OLS			Model 2: AR(1)			Model 3: ECM +OLS				Model 4: ECM + AR(1)				
Output gap measure	Sample	Tax elasticity	Short-term	Long-term	3y average	R^2 adj	Model	dlgap	R^2 adj	DW	dlgap	R^2 adj	DW	dlgap	ECT	R^2 adj	DW	dlgap	ECT	R^2 adj	DW	N
With respect to potential GDP based on production function (AMECO)	1995-2023	-4.55	-4.55			0.52	2	-4.69***	0.54	1.82	-4.55***	0.52	1.93	-4.57***	-0.02	0.52	1.79	-4.38***	-0.03	0.51	1.92	28
	1995-2019	-4.19	-4.19			0.47	2	-4.55***	0.51	1.67	-4.19***	0.47	1.86	-4.49***	-0.03	0.50	1.62	-4.00***	-0.05	0.45	1.82	24
	2010-2019	-7.65	-3.85	-14.80	-7.65	0.57	3	-0.51	-0.12	1.84	0.02	0.04	1.49	-3.85*	-0.40***	0.57	1.81	-3.00*	-0.34***	0.66	1.56	10
With respect to potential GDP based on output trend (AMECO)	1995-2023	-4.52	-4.52			0.67	2	-4.40***	0.64	2.14	-4.52***	0.67	2.02	-4.37***	-0.05	0.65	2.11	-4.47***	-0.04	0.67	2.02	28
	1995-2019	-4.55	-4.55			0.71	2	-4.35***	0.66	2.15	-4.55***	0.71	2.02	-4.35***	-0.03	0.66	2.11	-4.52***	-0.03	0.69	2.02	24
	2010-2019	-8.44	-4.86	-13.18	-8.44	0.64	3	-4.48	0.15	1.38	-4.94	0.17	1.48	-4.86**	-0.52**	0.64	1.64	-2.89	-0.46***	0.72	1.46	10
With respect to potential GDP based on HP-filter (λ=30)	1995-2023	-4.71	-4.71			0.70	2	-4.60***	0.62	2.05	-4.71***	0.64	1.97	-4.58***	-0.06	0.73	1.44	-4.67***	-0.05	0.65	2.00	28
	1995-2019	-4.69	-4.69			0.66	2	-4.53***	0.64	2.03	-4.69***	0.66	1.95	-4.55***	-0.04	0.64	2.00	-4.66***	-0.04	0.65	1.96	24
	2010-2019	-8.59	-4.83	-15.44	-8.59	0.66	3	-3.04	0.03	1.46	-2.56	0.05	1.37	-4.83**	-0.41***	0.66	1.75	-3.26**	-0.34***	0.76	1.42	10

*Notes: *, **, *** indicate significance at the 10, 5, and 1 per cent levels respectively.*

The sample uses annual data from 1995 to 2023.

AR(1) refers to estimations with the Prais-Winsten method, which allows for a correction of the first order autocorrelation in the residuals.

Short-term elasticity refers to the elasticity in year t (denoted by dlgap in the models), elasticity in year t-1 is calculated as (ST + ECT(ST-LT)) and elasticity in year t-2 is calculated as (ST + ECT(ST-LT) + ECT(ST + ECT(ST-LT) - LT)). Tax elasticity refers to three-year average tax elasticity that is an arithmetic average of these three elasticities.

Source: Author's own estimations.

APPENDIX 6. DERIVING THE SEMI-ELASTICITY VALUES

Elasticities of individual revenue and expenditure categories

		Revenue												Expenditure		
		Personal income tax			Social tax			Corporate income tax			Indirect taxes			Unemployment-related expenditure		
Sample	**Output gap measure**	**Revenue-to-base elasticity** *a*	**Base-to-output gap elasticity** *b*	**Revenue-to-output gap elasticity** *c = a * b*	**Revenue-to-base elasticity** *d*	**Base-to-output gap elasticity** *e*	**Revenue-to-output gap elasticity** *f = d * e*	**Revenue-to-base elasticity** *g*	**Base-to-output gap elasticity** *h*	**Revenue-to-output gap elasticity** *i = g * h*	**Revenue-to-base elasticity** *j*	**Base-to-output gap elasticity** *k*	**Revenue-to-output gap elasticity** *l = j * k*	**Revenue-to-base elasticity** *m*	**Base-to-output gap elasticity** *n*	**Revenue-to-output gap elasticity** *o = m * n*
1995-2023	With respect to potential GDP based on production function (AMECO)	1.12	0.53	0.59	0.93	0.53	0.49	0.94	2.69	2.53	0.97	0.87	0.84	0.50	-4.55	-2.28
	With respect to potential GDP based on output trend (AMECO)	1.12	0.73	0.82	0.93	0.73	0.68	0.94	2.08	1.96	0.97	0.87	0.84	0.50	-4.52	-2.26
	With respect to potential GDP based on HP-filter (λ=30)	1.12	0.75	0.84	0.93	0.75	0.70	0.94	2.12	1.99	0.97	0.86	0.83	0.50	-4.71	-2.36
1995-2019	With respect to potential GDP based on production function (AMECO)	1.14	0.61	0.70	0.92	0.61	0.56	1.03	2.62	2.7	1.04	0.91	0.95	0.55	-4.19	-2.3
	With respect to potential GDP based on output trend (AMECO)	1.14	0.73	0.83	0.92	0.73	0.67	1.03	2.15	2.21	1.04	0.91	0.95	0.55	-4.55	-2.5
	With respect to potential GDP based on HP-filter (λ=30)	1.14	0.76	0.87	0.92	0.76	0.70	1.03	2.15	2.21	1.04	0.89	0.93	0.55	-4.69	-2.58
2009-2019	With respect to potential GDP based on production function (AMECO)	1.32	0.76	1.00	0.88	0.76	0.67	0.78	2.35	1.83	1.00	0.62	0.62	-0.21	-7.65	1.61
	With respect to potential GDP based on output trend (AMECO)	1.32	0.96	1.27	0.88	0.96	0.84	0.78	1.33	1.04	1.00	0.56	0.56	-0.21	-8.44	1.77
	With respect to potential GDP based on HP-filter (λ=30)	1.32	0.89	1.17	0.88	0.89	0.78	0.78	1.54	1.2	1.00	0.54	0.54	-0.21	-8.59	1.8

Shares of revenue and expenditure categories and the decomposition of the semi-elasticity of the budget balance to the output gap

		Shares of revenue and expenditure categories (% of total revenue/expenditure)					Elasticities				Weights (% of GDP)		Semi-elasticity		
		Revenue				Expenditure									
		Personal income tax	Social tax	Corporate income tax	Indirect taxes	Unemployment-related expenditure	Revenue	Expenditure	Revenue-to-GDP ratio	Expenditure-to-GDP ratio	Total revenue	Total expenditure	Revenue	Expenditure	Budget balance
Sample	Output gap measure	*A*	*B*	*C*	*D*	*E*	*p*	*q*	*r = p - 1*	*s = q - 1*	*F*	*G*	*s = r * F*	*t = s * G*	*u = s - t*
1995-2023	With respect to potential GDP based on production function (AMECO)	14.9	29.9	4.4	32.1	1.68	0.618	-0.038	-0.382	-1.038	39.1	40.3	-0.149	-0.418	**0.269**
	With respect to potential GDP based on output trend (AMECO)	14.9	29.9	4.4	32.1	1.68	0.682	-0.038	-0.318	-1.038	39.1	40.3	-0.124	-0.418	**0.294**
	With respect to potential GDP based on HP-filter (λ=30)	14.9	29.9	4.4	32.1	1.68	0.689	-0.04	-0.311	-1.04	39.1	40.3	-0.122	-0.419	**0.297**
1995-2019	With respect to potential GDP based on production function (AMECO)	13.9	29.6	4.2	32.9	1.51	0.687	-0.035	-0.313	-1.035	38.8	38.9	-0.121	-0.403	**0.281**
	With respect to potential GDP based on output trend (AMECO)	13.9	29.6	4.2	32.9	1.51	0.719	-0.038	-0.281	-1.038	38.8	38.9	-0.109	-0.404	**0.295**
	With respect to potential GDP based on HP-filter (λ=30)	13.9	29.6	4.2	32.9	1.51	0.725	-0.039	-0.275	-1.039	38.8	38.9	-0.107	-0.404	**0.297**
2009-2019	With respect to potential GDP based on production function (AMECO)	13.9	29.6	4.2	32.9	1.51	0.618	0.024	-0.382	-0.976	38.8	38.9	-0.148	-0.38	**0.231**
	With respect to potential GDP based on output trend (AMECO)	13.9	29.6	4.2	32.9	1.51	0.654	0.027	-0.346	-0.973	38.8	38.9	-0.134	-0.379	**0.244**
	With respect to potential GDP based on HP-filter (λ=30)	13.9	29.6	4.2	32.9	1.51	0.623	0.027	-0.377	-0.973	38.8	38.9	-0.146	-0.378	**0.232**

*Notes: The parameters (p) and (q) are derived as: (p) = (A * c + B * f + C * i + D * l) / 100; (q) = (E * o)/ 100.*