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Tax revenues sensitivity to economic activity

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Abstract

Elasticity of tax revenues with respect to macroeconomic activity is a fundamental piece of information in public finances. However, changing legislative environment effectively conceals the actual response of tax revenues to exogenous stimuli. Therefore in this work we use a novel database of tax revenues at the Ministry of Finance adjusted for the impact of legislative measures and estimate elasticities of individual and total tax revenues. We employ an error-correction approach which allows us to distinguish between immediate and long-term responses of tax revenues to economic activity. We find that the long-term elasticities of health care contributions and value added tax are less than unity while elasticities of labour income tax and corporate income tax exceed unity. The elasticity of social insurance contributions is very close to unity. Covering around 85 per cent of all government tax revenues we find that the elasticity of total tax collection with respect to GDP is below unity. Hence, the tax revenues cannot sustain the pace of growth with potential output in the long-run unless further legislative measures are implemented.

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1. Introduction

Sensitivity of tax revenues with respect to their bases is crucial information in fiscal policy-making. Careful planning of public expenditures strongly depends on expected tax revenues. It also plays a significant role in disentangling short-term cyclical fluctuations in tax revenues from long-term structural developments. In this work we estimate the elasticities of major tax categories to their corresponding bases. This piece of work can thus be understood as an activity aiming at improving the quality of tax projections. However, interest in this topic goes well beyond tax projections. The ongoing discussion on fiscal rules suggests to use the potential output as an anchor for public expenditure growth. However, if the revenues do not match the pace of growth of potential output in the long run, they cannot cover the expenditures without additional legislative measures. This issue leads us to the second objective of the paper. We estimate the elasticity of the aggregate tax bundle to GDP. We also provide the unique database of quantified legislative measures.

The estimates of either individual or aggregate tax elasticities in Slovakia are sparse, hence the quantitative estimates are the main contribution of this work. This work also contributes to discussions on the issue of sustainable long-term expenditure growth. The novelty lies in the used dataset. **We carefully evaluate the impact of changing legislation on the tax revenues and adjust the data so that our estimated elasticities capture the spontaneous response of tax revenues to changing economic conditions.**

More specifically, we estimate the elasticities of the following tax categories: corporate income tax, personal income tax on dependent activity, value added tax, social insurance contributions, health care contributions and selected excise duties. In 2016 the total income from these taxes represented about 84 per cent of total tax revenues[1]. In order to be able to transfer lessons learned to the actual policy practice, such as tax projections, we strictly stick to the data definitions actually used in the official budgetary procedures and forecasts[2].

We apply an error correction model on the adjusted revenue data assuming a well-defined long-term relationship between tax revenues and their bases. Even though we control for the impact of the legislative changes on the tax revenues it is hard to find a stable relationship between the tax and its base in some cases. When we account for a few specific episodes, the estimated models behave reasonably well. However, we do not have satisfactory strong evidence to draw conclusions whether the identified episodes represent a temporary effect or a structural change in the elasticity. Time-varying tax compliance, which is a likely phenomenon in Slovakia, is a factor that we do not interpret as a changing tax elasticity. For this reason we treat these discrepancies as short-lived deviations from a constant-elasticity model rather than a temporary change in the elasticity.

The paper is organized as follows. In section 2 we briefly summarize relevant findings in the literature. In section 3 we focus on the methods that we employ in estimations. In section 4 we describe the data and how we treat the impact of legislative measures. In Section 5 we discuss the empirical findings. The final section summarizes the main contributions of this work.

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[1] Health insurance paid by the state represents the largest omitted part of government tax revenues followed by the excise duty on tobacco products. These two groups together represent about 8 per cent of total tax revenues. We leave out the former revenue because it does not fully depend on the underlying macroeconomic developments but is rather strongly affected by discretionary decisions. The latter is omitted because we could not satisfactorily adjust the time series for legislative changes. The major obstacle is quantification of the pre-stocking effect of tax rate changes.

[2] As the Tax committee requires, see the details on the Tax committee mandate:
http://www.finance.gov.sk/Components/CategoryDocuments/s_LoadDocument.aspx?categoryId=74&documentId=10272
http://www.finance.gov.sk/Default.aspx?CatID=11510

2. Literature review

Research on tax elasticities in Slovakia is scarce despite their high importance in tax policy design. The OECD estimates the elasticities of a few selected tax items particularly to calculate the cyclically-adjusted balance. Estimates for Slovakia first appear in Girouard, André (2005) but most elasticities are set according to standard economic assumptions. Price et al. (2015), an update of Girouard, André (2005), replaces most of arbitrarily set figures with estimates of elasticities for Slovakia. Galabová et al. (2005) apply the OECD method to the Slovak data, but due to different tax bases their results are not a reference for the results in this work. The OECD approach for personal income tax and social security contributions combines tax code information with the income distribution to calculate theoretical reactions of taxes to changes in income. The main shortcoming of this approach is that the actual aggregated tax revenues usually do not coincide with the values that the tax code implies. Tax optimization, frauds, payment discipline are just a selection of potential causes of the discrepancy. Another issue is that it does not distinguish between possible differences in the size of reaction on impact and in the long-term.

An alternative, and a more popular approach in the literature, utilises information in time series of tax revenues and their bases. Selection of such contributions includes Wolswijk (2009), Koester, Priesmeier (2012), Princen et al. (2013), Mourre, Princen (2015), Havránek et al. (2015). Price et al. (2015) use this approach for corporate income tax and value added tax. All these references estimate an error-correction model with actual tax revenue data and their corresponding bases. The error-correction technique builds on the nature of the relationship of tax-base combination. It explicitly assumes a long-term dependence of tax revenues on their bases, which is not a controversial assumption. However, the methodological framework has several shortcomings. First, the aggregated data do not allow to capture the effect of a multiple tax bracket system and switching between neighbouring brackets (e.g. influence of fiscal drag). Second, the aggregated data drops information about the distribution of income and its potential impact on tax payments. Another caveat is the inherent presence of discretionary government interventions. Mourre, Princen (2015), Wolswijk (2009), Koester, Priesmeier (2012) and others treat this issue prior to estimation by estimating the size of legislative measures and adjusting the actual data accordingly.

Some analyses specifically investigate the role of business cycle in tax revenues fluctuations over time. The aim, similarly to the objective of the OECD approach in Price et al. (2015), is to disentangle higher frequency, such as cyclical and one-off, contributions to tax revenue fluctuations from structural effects. Kremer et al. (2006) and Mourre, Princen (2015), Mourre et al. (2014) explicitly target the structural versus business cycle issue.

The available estimates for Slovakia using the time series approach cover only a part of the total tax revenues. Price et al. (2015) estimate the elasticity of the value added tax and corporate income tax. Koester, Priesmeier (2017) the elasticity of total tax revenues. Mourre, Princen (2015) include the Slovak data in the panel estimation of EU-wide elasticities of the consumption tax, social security contributions, personal income tax and corporate income tax. However, the authors do not provide the country level results.

3. The methodological framework

Following the trend in the literature[3] the error correction approach is our preferred modelling strategy. The model stipulates that there is a force that ensures the short-term discrepancies between the tax revenue and its corresponding base vanish in the longer term. The speed of adjustment process is captured by the error-correction parameter. We opt for a two-stage

[3] For example Wolswijk (2009), Koester and Priesmeier (2012)

approach, suggested by Engle, Granger (1987), when long-term and short-term relationship are estimated separately.

In the first step we estimate the long-run relationship between a tax revenue and its base

$$T_t = \alpha_0 + \alpha_1 B_t + \varepsilon_t$$

where T_t is a log level of the given tax revenue, B_t is the log level of the corresponding base and ε_t is the measure of current disequilibrium. The parameter α_1 is the parameter of interest, the long-term elasticity of tax revenue with respect to its base. The two variables in the equations are assumed to be nonstationary which may cause the standard OLS estimators biased unless they are cointegrated. Due to short sample we do not perform the Johansen test for cointegration. However, there is a strong presumption that the two variables share a common trend. Recall that the tax revenue series is adjusted for changing legislation which makes the two variables behave similarly by construction. Nevertheless, the literature suggests estimating the above equation by using the dynamic OLS worked out by Stock, Watson (1993) and Phillips, Loretan (1991) rather than the standard OLS method. Although the OLS method delivers consistent estimators if two I(1) variables are cointegrated, dynamic OLS estimator is supposed to be more efficient and also corrects for potential residual autocorrelation. The downside of this approach is that we lose degrees of freedom because we need to include leads and lags of the growth rate of the independent variable[4]. The dynamic specification of equation (1) becomes

$$T_t = \alpha_0 + \alpha_1 B_t + \alpha_2 \Delta B_{t-1} + \alpha_3 \Delta B_{t+1} + \varepsilon_t$$

The short-term equation, in step two, then prescribes that the current growth of tax revenue depends on the current growth rate of the base and the extent of disequilibrium in the past period. The model of short-term elasticity then becomes

$$\Delta T_t = \beta_0 + \beta_1 \Delta B_t + \beta_2 \varepsilon_{t-1} + \epsilon_t$$

The short-term elasticity of the tax $T_t$with respect to base B_t coincides with the parameter β_1 while the speed of convergence towards the long-term impact is given by parameterβ_2.

Besides the empirical strategy decisions, some practical issues emerge that we need to deal with. It turns out that the relationship between tax revenues and their bases may not perfectly fit the above model in every period of the sample. We capture this issue by involving dummy variables in the estimated equations. The dummy variables are strictly significant whenever we keep them in the model. It is, however, uncertain whether this observation implies non-constant elasticities or a transitory deviation from a well-behaved model. For example, improving efficiency of tax collection leads to an increase in the revenue share relative to its base. Nevertheless this fact should not be interpreted as a changing tax elasticity. After all, newly adopted policies aimed at improving tax compliance are a form of legislative measures and our objective is to abstract from such interventions. Efficiency gains in the tax collection are inherently a temporary phenomenon and once the gains fade away the relationship between the revenue and the base returns to its underlying pattern. Varying efficiency of tax collection is indeed the likely factor behind the observed instability of the tax-base relationship in certain periods in Slovakia and for this reason we add temporary dummies to the equations rather than assuming a variation in the estimated elasticities. In such situations we also evaluate the impact of the imposed dummies. The complete baseline model thus consists of the following equations

$$T_t = \alpha_0 + \alpha_1 B_t + \alpha_2 \Delta B_{t-1} + \alpha_3 \Delta B_{t+1} + \alpha_4 DL_t + \varepsilon_t$$

[4] Due to short sample size we enter only one lag and one lead of the first difference of the independent variable.

$$\Delta T_t = \beta_0 + \beta_1 \Delta B_t + \beta_2 \varepsilon_{t-1} + \beta_3 DS_t + \epsilon_t$$

where DS_t and DL_t are dummies capturing nonstandard developments in the data.

In certain cases when we struggle to find a meaningful long-term relationship we estimate the short-term equation without assuming the error-correction mechanism, i.e. we estimate the following equation

$$\Delta T_t = \beta_0 + \beta_1 \Delta B_t + \beta_3 DS_t + \epsilon_t.$$

This issue applies particularly to the excise duties when complications stem mainly from difficulties in defining the appropriate tax base.

Finally, whenever possible we also estimate an alternative model. This robustness exercise includes estimating the model by the standard ECM procedure and/or specifying an alternative measure of either the tax revenue or the base. It helps us gauge the uncertainty of the baseline estimation.

4. The data

Below we estimate the elasticities for seven categories of taxes – social insurance contributions (both employers and employees), health care contributions, personal income tax on dependent activity, corporate income tax, value added tax and two excise duties[5]. **Total revenues from these taxes made up nearly 85 per cent of all government tax revenues in 2015**, see Figure 1. Our sample includes sixteen years from 2000 to 2015.

Along with the choice of tax categories we need to specify the appropriate bases. **We again rely on the actual practices under the Tax committee requirements and approximate the tax bases with available macroeconomic indicators.** In some cases there does not exist a single macroeconomic variable that can serve as an adequate base. Therefore we construct our own base by combining a few variables. In other cases the tax item does not have a well-defined base among the standard macroeconomic variables and we opt to use either GDP or final consumption expenditure of households depending on the nature of the tax. Nominal wages are our chosen base for the personal income tax, health care and social insurance contributions. Gross operating surplus and GDP without labour costs are two alternatives for the corporate income tax. A combination of households' final consumption expenditures, government intermediate consumption, government gross capital formation and gross capital formation of financial corporations[6] is the base for value added tax. Gross domestic product and households' final consumption expenditures in constant prices are the bases for excise tax on mineral oils and spirits respectively. See Table 1 in the Appendix for more details on the data definitions.

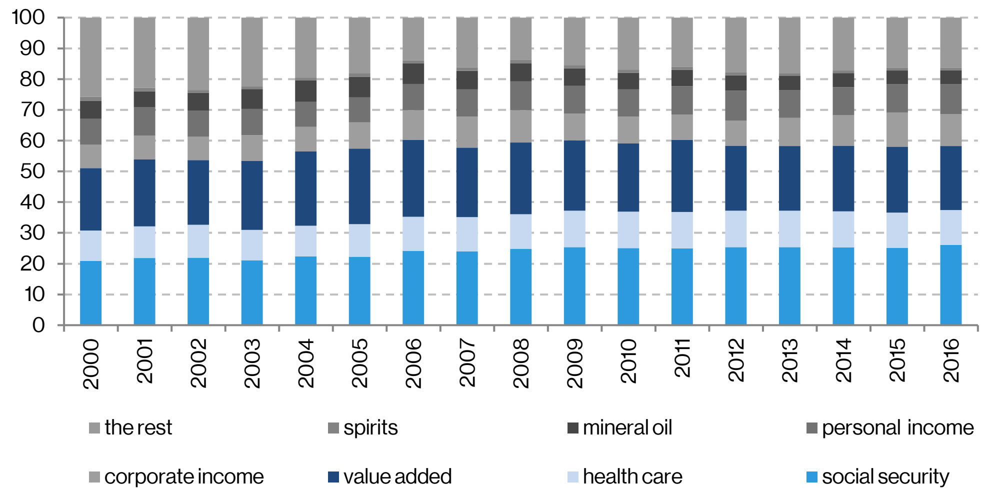
Regarding the accounting principle we stick to the accrual method as this is the method that the budget is based on[7]. The accrual principle limits us to use the annual data because some tax data (notably corporate income tax) is not available on a quarterly frequency. Despite having annual data, we allow the short-run elasticities to differ from their long-run counterparts as the adjustment process, due to, for example, collection lags and loss-carry-forward possibility in income taxes, may stretch beyond one year horizon.

[5] See Table 1 in the Appendix for more details on the data definitions. Table 2 in Appendix contains basic statistics of the data.

[6] Spending on gross capital formation of nonfinancial corporations is excluded from the tax base because most of these corporations are VAT tax payers and do not pay the tax from the entire investment spending.

[7] The cash income is attributed to the period when the activity to generate the tax liability took place or when the amount of taxes was determined in case of some income taxes.

Figure 1: Tax mix 2000 – 2016, (%)



Source: SO SR, MF SR, author's calculations, data

An inherent feature of tax revenue data is that it is strongly affected by discretionary legislative measures such as tax rate changes. However, changes in tax revenues induced by legislation may be incorrectly treated as a reaction to changes in the base. Thus the estimates of elasticities might be misleading. For this reason it is crucial to filter out all discretionary interventions from the tax revenues prior to estimation.

For this reason we prepared a unique database[8] of legislative measures adopted over the sample period and estimated their likely impact on the tax revenues. We use the Prest (1962) proportional adjustment method which is commonly employed in the literature, see for example Wolswijk (2009), Koester, Priesmeier (2012). The method assumes that the effect of a permanent change in the legislation structure increases proportionally with the base over time and adjust the data accordingly[9]:

$$T_j = T_j^u \times \prod_{k=j+1}^{t} \frac{T_k^u}{T_k^u - DM_k}, for\ j < t$$

T_j is the adjusted tax value of year j, T_j^u is the unadjusted value of the tax and DM_k is the impact of discretionary legislative measure implemented in year k. Our comprehensive database of discretionary legislative measures contains not only permanent measures that have effects on the tax proportional to the base over time but also permanent measures that are not proportional to the aggregate base[10]. In such situations we evaluate the impact of the measure in every single year separately and treat these measures as repeated one-offs. On top of that there are genuine one-off measures[11] that are subtracted from the tax revenue without affecting revenues in other years.

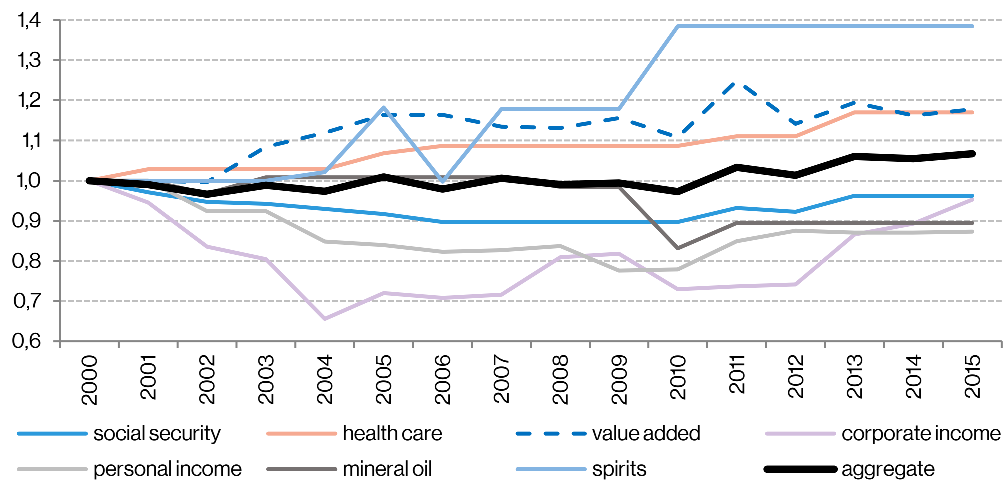
[8] Published as an online appendix to this work.

[9] A change in the tax rate is a good example of such an intervention.

[10] For example a special levy in the regulated sector.

[11] The debt relief programme for hospitals.

Figure 2: cumulative impact of legislation changes, index



Source: author's calculations, data

Figure 2 presents the estimated cumulative impact of legislation on the individual tax revenues as well as on the total government's tax income over the considered period. Despite considerable legislative activity the total impact on the tax revenue has not been large. In fact, the aggregate effect during period 2000 – 2010 was negligible in every single year. Nevertheless, the legislative measures changed the composition of the tax structure. Since 2011 the newly adopted legislation has started to play a more significant role mainly due to corporate profit tax, and social insurance and health care contributions.

5. Empirical results

5.1. Unit root tests

A prerequisite for applying the methodology described above is that all time series are integrated of order one. It turns out that augmented Dickey-Fuller test does not reject the null hypothesis of unit root in first differences of certain series (Table 3 in Appendix). While tax series data can be treated as stationary at 10 per cent level of significance, the test cannot reject the null hypothesis in the case of base series data. It is well-known that the Dickey-Fuller test has small power in small samples. We also run the Kwiatkowski-Phillips-Schmitt-Shin test which, contrary to the Dickey-Fuller test, assumes that under the null hypothesis the tested series is stationary. We cannot reject the null hypothesis of stationarity in any of the tested series. We suspect that uncertainty about the degree of integration stems from the abrupt change in the growth of data series after 2008. This change is especially obvious in the bases but tax revenues also share this pattern. After all, the ultimate goal is to achieve a stationary linear combination of the revenue-base combination. Visual inspection (see Figure 3 in Appendix) of the shares of tax revenues in their bases do not reveal any significant violation of the stationarity assumption[12]. Therefore we treat all series as integrated of order one. In the estimation of long-term elasticities using nonstationary data we carefully evaluate the properties of residual terms and find strong evidence that the residuals are stationary. We suspect that similar behaviour of the tax revenues and their bases before and after 2008 filters out the impact of crisis and we can proceed without modelling a break in the data.

[12] We do not test the presence of breaks in the data series due to short sample.

5.2. Baseline results

We surmise that the response of social insurance contributions is about as large as the underlying change in the wage base. The rules of social insurance payments are reasonably simple and it roughly holds that one pays the same amount for every additional euro earned. However, existence of ceilings may decrease the elasticity slightly below one. Our point estimates of both long-term and short-term elasticities are mildly above one, although not significantly different from one (1.04 and 1.06 respectively). The point estimates of the elasticities are very close to each other suggesting a very simple mechanism in social insurance payments. There are no significant lags in payments and if for some reason there is a disequilibrium in the short-term response, it is quickly balanced as the error-correction parameter (equal to -1.15) suggests.

Although conceptually very similar to social insurance contributions, our estimates indicate somewhat different behaviour of health care contributions. Again the point estimates of the short-term and long-term elasticities are very similar (0.83 and 0.85 respectively), they are now significantly below one. The mechanism is straightforward. The bulk of response takes place in the very same period and occasional disequilibria vanish in the next period. We conjecture that the discrepancy between the sensitivity of health care contributions and social insurance contributions can be partly explained by the benchmark definition of the tax measure. While our data on social insurance contributions exclude outstanding social insurance, the data on health care contributions includes due payments. Also the rules for self-employed differ to some extent. And finally, the adjustment for the impact of legislative measures is inherently an approximation of the true impact and always carries a degree of uncertainty. Although we paid attention in adjusting the data, the residual effect of legislation may cause minor discrepancies. Price, Dang, Botev (2015) estimate the elasticity of combined health and social insurance at 0.98, which is very close to the estimate in this work when one takes into account the relative size of the two social security components.

Contrary to the two previous tax categories, we suspect that the elasticity of labour income tax should be above one. In the presence of deductible items inadequately indexed to wage growth, personal income tax tends to be progressive. General growth of wages over time causes tax payments to rise disproportionally to their earnings due to insufficient indexation of deductible items and fiscal drag. Our estimate of long-term elasticity is, however, only slightly, yet significantly, above one (1.04). The short- term elasticity is estimated a little higher, at 1.12 and is not significantly different from one[13]. The estimate of error correction parameter dictates very quick dissolution of disequilibria. The estimate in Price et al. (2015) markedly exceeds our estimate, but the size of elasticity at 2.47 seems to be unintuitive.

Estimation of corporate profit tax elasticity appears the most challenging. Loss-carry-forward, various deductions, negative tax bases and other complications of the tax system cause difficulties in selecting the appropriate tax base from a set of accessible macroeconomic indicators. Figure 3 clearly reveals complex behaviour of the effective tax rate defined by gross operating surplus. Until 2007 the effective rate rose, during crisis years 2008 and 2009 it dramatically declined while it has continually risen since 2010. Therefore we allow for dummies in the model in order to capture the nonstandard pattern[14]. Our best specification assumes a different regime for the period starting in 2008. More specifically, we allow for a level shift in the long-term equation during years 2008-2015 compared to the first part of the sample. Similarly, we include a dummy variable[15] in the short-term equation in 2008 which

[13] In presence of mildly progressive tax pattern at the lower tail due to deductible items and fiscal drag, the elasticity is expected to be higher above one. We suspect that the composition effect plays its role when labour growth (low income employees) does not necessarily raise the growth of tax revenues significantly above the growth of base.

[14] In the sensitivity checks below, we explore the role of output gap in explaining the behaviour of the tax. We do not include a cycle variable in the baseline estimation in order to keep the approach consistent across the tax categories.

[15] The dummy is highly significant.

aims at starting a new regime since 2008. Otherwise we do not assume any break in the elasticities themselves. Such model specification points to a rather stable relationship between the tax and its assumed base with the 2008-2009 crisis having a permanent impact on the tax collection at the macroeconomic level. Similarly to arguments explaining the decline in the effective value added tax rate, the CIT noncompliance gap sharply rose during 2009 and 2010[16], which helps to explain the need for special treatment of the period started by the crisis. Positive and rising residuals from the long-term model[17] toward the end of sample indicate that the current pace of tax revenue growth is excessively picking up relative to the longer-term average[18]. Higher standard errors of the estimates and lower coefficient of determination compared to other models point to increased uncertainty in the model. Despite the higher standard errors, the point estimates of both the short-term and long-term elasticity (1.68 and 1.52 respectively) are significantly above one. These estimates are in line with the findings in the literature (Price et al. (2015), Wolswijk (2009), Mourre, Princen (2015) for instance). The higher short-term elasticity reflects the fact that corporate profits at the individual firm level may be very volatile, hence the profit tax payed is volatile as well. In the longer-term, the profit tax response slightly decreases. Its size is determined by the nonlinear effect of the macroeconomic tax base on firm level tax liabilities. There is a rather large number of firms[19] that do not pay tax due to negative tax liability. In good times when aggregate profits in the economy rise, it is very likely that some firms manage to claw back positive tax liability and pay some amount of income tax. As a result the tax revenue gains exceed the growth of the base. Compared to other taxes, the pace of convergence is considerably slower (-0.53) which reflects the complexity of the corporate income tax.

Unlike in the case of previous tax categories, the principle of value added tax is very simple. There is a list of taxable products and no matter how much one consumes of a given product, the rate does not change. There are no caps and no exemptions. Of course, not all consumption and investment that are part of national accounts are subject to the value added tax. For this reason the base for value added tax in the baseline estimation is formed so that it excludes parts of consumption that are not subject to the tax. In other words, switching between consumption subject to tax and consumption not subject to tax should not deviate the elasticity from unity because the base is adjusted accordingly. However, the existence of multiple tax rates may render the whole system slightly progressive or regressive with respect to the base. A standard practise is to impose a lower tax rate on products that can be classified as necessities while a higher tax rate applies on products that also include luxury products. Different demand elasticities of luxuries and necessities tend to make the value added tax progressive with respect to the base. Contrary to the theory, our estimates are considerably below unity (0.79 for long-term elasticity and 0.76 for short-term elasticity). **Mostly decreasing effective tax rate (Figure 3) indeed signals a regressive tax system.** Especially the period between 2009 and 2013 seems to deviate from the average pattern[20]. Reversing the trend in subsequent years offers a simple explanation. The estimated VAT gap clearly shows that the efficiency of VAT collection suffered until 2012[21]. Since 2012 a number of actions[22] aiming at improving the efficiency of VAT collection have been put in place which helped to reverse the share of VAT in the base. The elasticity below one is in fact not a rarity. For example Koester, Priesmeier (2012) offer similar conclusions for Germany, Price at al. (2015) estimate the elasticity below unity for Denmark, France, Germany and Israel.

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[16] See Figure 53 in the Stability Programme of the Slovak Republic for 2017 to 2020.

[17] Not reported here.

[18] A recent official tax revenue forecast of the Ministry of Finance elaborates on the specific aspect of 2015 figures. See Paur (2017)

[19] Remeta et al. (2015)

[20] We include a dummy variable for level shift in the long-run equation. In the short- run we assume a one-off deviation from the usual pattern in 2009 and its return to the original level in 2013. The dummies are highly significant.

[21] See Figure 27 in the Stability Programme of the Slovak Republic for 2017 to 2020.

[22] See Box 14 in the Stability Programme of the Slovak Republic for 2017 to 2020.

The definition of an appropriate base is the first and foremost obstacle in estimating elasticities of excise duties. Economic activity is a meaningful proxy for fuel demand hence GDP in constant prices is our preferred base for mineral oil excise duty. As expected, the explanatory power of the baseline model is not very high. Relative to GDP, revenues from mineral oil duty have grown faster and are significantly more volatile. Hence, it is no surprise that both the short-term (1.10) and long-term (1.32) elasticities are estimated above unity. However, the confidence intervals of the point estimates are considerably large and we should interpret the results cautiously. In fact, we cannot reject the hypothesis that the elasticities do not exceed unity.

Table 1: baseline results

long-term	health care contr.	social insurance contr.	PIT, dependent activity	CIT	VAT	mineral oil	spirits	aggregate tax bundle
elasticity	0.85+++	1.04	1.04+	1.52+++	0.79+++	1.32	0.27+++	0.91+
standard deviation	0.02***	0.02***	0.02***	0.08***	0.03***	0.37***	0.18	0.04***
short-term								
elasticity	0.83	1.06	1.12	1.67++	0.76	1.10	1.43	1.02
standard deviation	0.10***	0.12***	0.10***	0.31***	0.14***	0.40**	0.43***	0.11***
error-correction	-1.14	-1.15	-0.93	-0.42	-0.91	-1.38	-1.89+++	-0.64
standard deviation	0.28***	0.28***	0.31**	0.42	0.31**	0.37***	0.27***	0.48
adj. R2	0.86	0.86	0.92	0.66	0.85	0.66	0.81	0.88
stationarity, Z	-3.68	-3.40	-2.66	-2.67	-3.3	-3.72	-5.36	-2.66

Notes: Augmented Dickey-Fuller test for unit root, H0 = non-stationarity *Source: author's calculations*

	1%	5%	10%
significance: parameter=0	***	**	*
significance: parameter=1	+++	++	+

Revenues from spirits excise duty have declined over time despite rising both household income and household expenditures. Due to the nature of the duty, household final consumption expenditure in constant prices serves as a tax base. Therefore, in the long-run the elasticity is very low (0.27) and is not even significantly different from zero. On the other hand, considerable volatility of the revenue data drives the point estimate of the short-run elasticity above unity (1.43). The speed of convergence is also very fast. In the robustness exercise below we find that the results change considerably when we abstract from the cointegration assumption. These findings call for cautiousness.

Finally, we investigate the sensitivity of the sum of the individual tax revenues that we deal with above in response to a change in nominal GDP. Like in the case of some individual tax categories the assumption of a stable relationship between the total tax revenue and nominal GDP is somewhat strong. We observe a declining trend in the effective tax rate until 2012. Corporate income tax and value added tax determined the bulk of the downward trend (Figure

4). Measures[23] aiming at better tax compliance adopted since 2012 have helped to reverse the trend. **It turns out that the overall tax revenues in the long-run do not keep pace with nominal GDP as the elasticity is 0.91[24], yet only weakly statistically different from unity.** Koester and Priesmeier (2017) provide a slightly lower estimate, 0.80. However, the period they cover, 1994 – 2012, is very different from the one used in this work. All the arguments that we mention above about volatility of tax revenues apply to the total tax income and cause the tax revenues in the short-run to respond sensitively to overall economic activity. The short-run elasticity is indistinguishably different from unity and also the point estimate is very close to unity (1.02). The existing disequilibria in the long-term relation vanish in about two years. The benchmark model includes a dummy variable that captures the period of the bottoming effective tax rate in 2011 and 2012[25]. It also turns out that the actual growth of tax collection in 2014 and 2015 exceeds the predicted values. We suspect that the values are only temporarily above the predicted values due to especially huge inflows of European funds money[26].

5.3. Robustness analysis

Our robustness exercise consists of estimating a few different alternatives. For every benchmark models we estimate the same model with a standard ECM technique (OLS estimation of the short-run equation instead of dynamic OLS). In case there is a dummy variable in the benchmark model, we estimate the same model without the dummy and check both the results and statistical properties of such a model. Finally, whenever we have an alternative definition of either the tax measure or the tax base we estimate the benchmark specification with the alternative data.

The baseline model for social insurance contributions and the ECM model are virtually identical in the long-term equation. The ECM model indicates somewhat higher short-term elasticity (1.33). An alternative definition of the tax measure that includes both paid and outstanding contributions of economically active population suggests little lower long-term elasticities. Both the dynamic and standard OLS estimators are significantly below unity although quantitatively they are not too far from the baseline model. On the contrary, the short-term elasticities are slightly above the baseline result[27]. Yet again, the quantitative differences are negligible. **All in all, the baseline results seem to be considerably robust.**

For health care contributions the ECM model predicts very similar results. **Similarly, the alternative estimation technique supports conclusions from the benchmark model.**

The estimation of elasticities of the corporate profit tax is rather tricky. The standard ECM model matches the long-term elasticity of the benchmark model. However, the residuals do not pass the stationarity test and thus we cannot estimate the short-run part of the model. By using the dynamic OLS method to estimate the model without the dummy results in somewhat lower long-term elasticity. The results of the short-term equation do not differ much from the baseline estimate. However, the statistical properties of this model are not satisfactory. Following Sancak et al. (2010) and Mourre et al. (2015) we also investigate the effect of business cycle on the elasticity by adding the output gap[28] estimate to the long-term equation. The coefficient is positive and mildly significant, although not very large. Its point estimate,

[23] See Box 14 in the Stability Programme of the Slovak Republic for 2017 to 2020.

[24] The weighted sum of individual elasticities gives the same result.

[25] We elaborate more on the consequences of the dummy variable in the next section.

[26] See Paur (2017).

[27] In order to obtain statistically satisfactory results we needed to treat the period 2001-2003 with a dummy variable. The effective tax rate in this period differs from the standard pattern and we could not associate the behaviour with any legislative measure.

[28] We use the official Ministry of Finance estimate of the output gap.

0.04, indicates that the tax revenue in booms only slightly outperforms the revenue during a downturn. Nevertheless, the estimated long-term elasticity becomes slightly lower. Since the tax base is not adjusted for the business cycle, this finding suggests that the baseline elasticity captures part of the business cycle impact and the actual elasticity may come below the baseline estimate. **All in all, the long-term elasticity is stable across different specifications of the model and estimation techniques.** Estimates of the short-run elasticity also do not vary much[29]. The short-term elasticities somewhat depend on the assumed tax base, nevertheless the differences are not substantial.

As indicated above, the estimates of elasticities of excise duties are less reliable. The ECM estimation does not result in statistically satisfactory results and for this reason we estimate a model without the explicit assumption of the long-term relation between the tax revenue and the corresponding base. The robustness check thus consists of OLS estimation of a model specified in first differences. The equivalent of short-run elasticity of mineral oil is very close to the benchmark estimate. On the other hand, the sensitivity of tax on spirits is only about half of the benchmark estimate.

The estimate of long-term elasticity of total tax revenues with respect to nominal GDP does not depend on the estimation technique. The alternative ECM model and dynamic OLS without any dummy variable yield the same results, although the dummy variable improves the statistical properties significantly. The model without the dummy variable does not pass the Dickey-Fuller test for stationarity hence we do not estimate the short-run equation. **Both the short-run elasticities and error-correction coefficients are virtually identical in the two alternative models.**

6. Conclusions

In this work we estimate the sensitivity of tax revenues to their bases. Namely, we explore the following seven tax revenues – social insurance contributions, health care contributions, personal income tax, corporate income tax, value added tax, excise duties on spirits and mineral oil – which together add up to nearly 85 per cent of all tax revenues in 2015. We pay close attention to adjusting the official data for the effects of the legislative measures taken during the sample period 2000-2015. Our results thus reflect genuine reactions of the assumed tax measures to changes in their bases.

We find that reactions of revenues from health care contributions and value added tax are less than unity while the reaction of both personal income tax and corporate income tax exceeds unity. The elasticity of social insurance contributions slightly exceeds unity but we cannot differentiate it statistically from unity. The estimation of elasticities of excise duties is a rather difficult task due to nonexistence of an appropriate tax base. Hence our results are subject to a higher degree of uncertainty. **Covering more around 85 per cent of all government tax revenues we find that the tax income cannot keep the pace of growth with potential output.** Tax revenues that we do not cover in this analysis are unlikely to make up for the lagging growth. However, we do not have evidence that the omitted (adjusted) tax revenues grow as fast as the potential output in the long run due to their nature.

Perhaps due to using annual data our dynamic models are considerably simple. In most cases the long-term elasticities are not far from their short-run counterparts and the adjustment mechanism is very fast. **The explanation power of the models and robustness exercise suggest that given the estimation technique employed, the conclusions are reasonably robust.**

[29] Although the statistical properties of the model without the dummy variable and including the output gap are not satisfactory.

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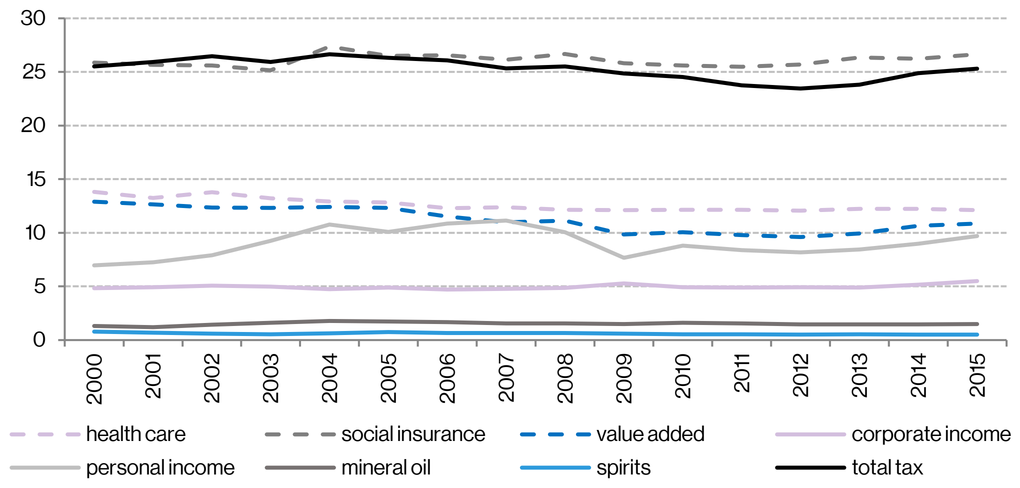
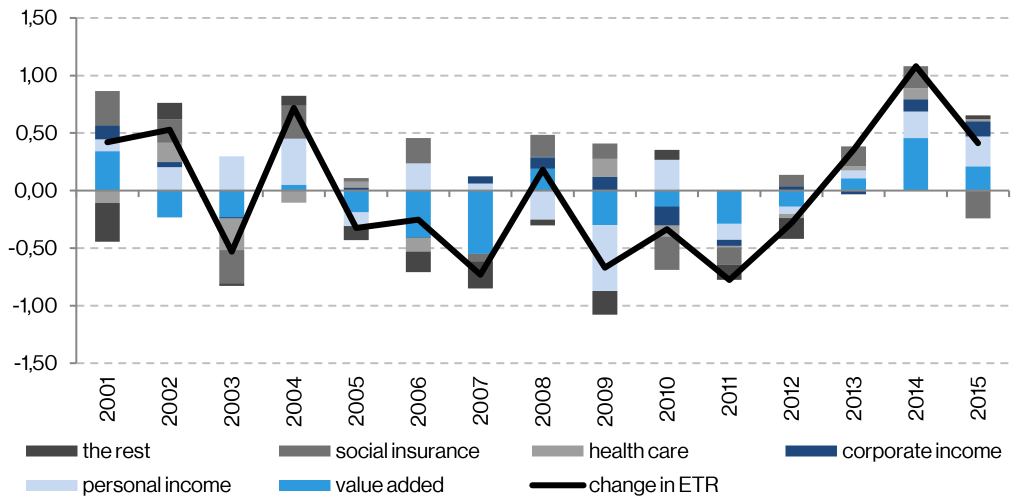
Appendix

Figure 3: tax shares in bases, %



Source: SO SR, MF SR, author's calculations, data

Figure 4: decomposition of the change in aggregate effective tax rate, p.p



Source: author's calculations, data

Table 1: data definitions

tax measure	note	base
social insurance	contributions of economically active population (employers + employees), accrual	volume of nominal wages
	contributions of economically active population (employers + employees) + outstanding, accrual	volume of nominal wages
health care	contributions of economically active population, accrual	volume of nominal wages
personal income tax	labour income tax on dependent activity, accrual	volume of nominal wages
corporate income tax		gross operating surplus, current prices
		gross domestic product less labour costs, current prices
value added tax		adjusted household final consumption expenditure + adjusted government intermediate consumption + adjusted government gross fixed capital formation + gross capital formation of financial corporations, current prices
		household final consumption expenditure + government intermediate consumption + government gross fixed capital formation + gross capital formation of financial corporations, current prices
excise tax - mineral oil		gross domestic product, constant prices
excise tax - spirits		household final consumption expenditure, constant prices
total tax revenue	sum of the above individual tax revenues	gross domestic product, current prices

Notes: Nominal wage for the sake of this work is calculated as annual level of employment multiplied by the level of average wage in the economy. Household final consumption expenditure as part of the value added tax is adjusted by the fraction of consumption that is not liable to value added tax (such as home production). Similarly government intermediate consumption and gross capital formation are adjusted for the effect of state owned companies that are registered VAT payers.

Table 2: data statistics

		growth, % p.a.	standard deviation	auto-correlation	cross-correlation with base	cross-correlation with alternative base
health care	adjusted contributions	5.7	4.0	0.16	0.83	
	unadjusted contributions	6.7	4.3	0.16	0.78	
	wage base	6.5	4.2	0.59		
social insurance	adjusted contributions	6.8	5.2	0.16	0.85	
	adjusted contributions, with outstanding	6.8	5.3	0.18	0.82	
	unadjusted contributions	7.1	4.6	0.18	0.83	
	unadjusted contributions, with outstanding	7.1	5.6	-0.04	0.60	
	wage base	6.5	4.2	0.59		
personal income tax	adjusted tax	7.2	7.6	0.13	0.65	
	unadjusted tax	6.3	8.3	-0.02	0.54	
	wage base	6.5	4.2	0.59		
corporate income tax	adjusted tax	10.8	15.2	0.18	0.79	0.74
	unadjusted tax	7.4	12.3	0.09	0.53	0.52
	GDP-based base	6.5	6.1	0.33	0.98	
	GOP base	6.5	6.7	0.23		
value added tax	adjusted tax	4.4	5.6	-0.08	0.50	0.47
	unadjusted tax	6.5	7.5	0.00	0.61	0.54
	unadjusted base	6.4	4.0	0.65		
	adjusted base	6.2	4.1	0.65		
mineral oil	adjusted tax	5.8	9.6	-0.12	0.37	
	unadjusted tax	5.1	9.6	0.19	0.36	
	GDP base	3.8	3.5	0.22		
spirits	adjusted tax	-0.7	11.1	0.23	0.37	
	unadjusted tax	1.6	13.3	-0.02	0.46	
	household final consumption expenditure	3.0	2.8	0.65		

Source: SO SR, MF SR, author's calculations

Table 3: Unit root tests

		level	1st difference	
tax category	period	ADF	ADF	KPSS
social insurance contributions	2000 - 2015	-0.91	-2.77*	0.31*
health care contributions	2000 - 2015	-0.87	-3.07**	0.38**
personal income tax, dependent activity	2000 - 2015	-1.36	-1.99	0.36
corporate income tax	2000 - 2015	-1.82	-2.97*	0.29
value added tax	2000 - 2015	-1.88	-3.65**	0.22
spirits	2000 - 2015	-2.08	-3.24**	0.11
mineral oil	2000 - 2015	-1.47	-3.61*	0.28
tax bundle	2000 - 2015	-1.48	-2.83*	0.34
base				
nominal wage	2000 - 2015	-0.23	-1.97	0.37*
gross operating surplus, current prices	2000 - 2015	-0.40	-2.91**	0.44*
gross domestic product less labour costs, constant prices	2000 - 2015	-0.42	-2.58*	0.30
household final consumption expenditure, constant prices	2000 - 2015	-0.28	-1.95	0.36*
adjusted VAT base	2000 - 2015	0.07	-2.01	0.45*
un-adjusted VAT base	2000 - 2015	-0.48	-2.65*	0.21
gross domestic product, current prices	2000 - 2015	-0.73	-2.31	0.43*
gross domestic product, constant prices	2000 - 2015	-1.20	-3.02**	0.42*

Notes: The null hypothesis of the Dickey Fuller test is that the series has a unit root unlike the KPSS test which states that under the null hypothesis the series is stationary.

Source: author's calculations

Schwarz information criterion is used to select the appropriate number of lags, the maximum number of lags is limited to 3.

** denotes that the null hypothesis cannot be rejected at 10% level of significance, ** indicates significance at 5% level and *** indicates significance at 1% level.*

Table 4: social insurance

	EAP contributions		EAP contributions + outstanding		
	baseline	ECM	DOLS	ECM	DOLS without dummy
long-run elasticity	1.04	1.02	0.96+++	0.96+++	1.02
standard deviation	0.02***	0.16***	0.02***	0.01***	0.03***
short-run elasticity	1.06	1.33+	1.09	1.13	1.10
standard deviation	0.12***	0.14***	0.08***	0.07***	0.12***
error-correction	-1.15	-1.05	-1.09	-1.08	-1.04
standard deviation	0.28***	0.26***	0.29	0.24**	0.24
autocorrelation, F	0.03	0.01	0.10	0.03	0.32
heteroskedasticity, chi2	1.80	2.18	0.05	0.28	4.55
stationarity, Z	-3.40**	-3.55**	-2.71*	-3.27*	-3.19***

autocorrelation, Durbin test, H0: no autocorrelation

heteroscedasticity, Breusch-Pagan test, H0: no heteroskedasticity

stationarity, Dickey-Fuller test, H0: nonstationary

significance levels: 10% 5% 1%
** ** ****

Source: author's calculations

Table 5: health care

	baseline	ECM
long-run elasticity	0.85+++	0.86+++
standard deviation	0.02***	0.01***
short-run elasticity	0.83	0.84
standard deviation	0.10***	0.10***
error-correction	-1.14	-1.07
standard deviation	0.28***	0.28***
autocorrelation, F	0.01	0.82
heteroskedasticity, chi2	0.31	0.84
stationarity, Z	-3.68***	-3.36**

autocorrelation, Durbin test, H0: no autocorrelation

heteroscedasticity, Breusch-Pagan test, H0: no heteroskedasticity

stationarity, Dickey-Fuller test, H0: nonstationary

significance levels: 10% 5% 1%
** ** ****

Source: author's calculations

Table 6: value added tax

	adjusted base			unadjusted base		
	baseline	ECM	DOLS without dummy	DOLS	ECM	DOLS without dummy
long-run elasticity	0.79+++	0.78+++	0.76+++	0.81+++	0.81+++	0.76+++
standard deviation	0.03***	0.02***	0.06***	0.03***	0.03***	0.05***
short-run elasticity	0.76	0.81	0.82	0.60++	0.66++	0.77
standard deviation	0.14***	0.14***	0.26***	0.16***	0.15***	0.20***
error-correction	-0.91	-0.92	-0.71	-0.5	-0.61	-0.51
standard deviation	0.31**	0.3**	0.29**	0.37	0.3*	0.29
autocorrelation, F	0.16	0	4.44*	0.01	0.48	6.67**
heteroskedasticity, chi2	0.01	0	4.98*	0.42	0.45	0.32
stationarity, Z	-3.30**	-3.44***	-1.87	-3.39**	-3.06**	-2.34

autocorrelation, Durbin test, H0: no autocorrelation
heteroscedasticity, Breusch-Pagan test, H0: no heteroskedasticity
stationarity, Dickey-Fuller test, H0: nonstationary
significance levels: 10% 5% 1%
* ** ***

Source: author's calculations

Table 7: corporate income tax

	GOP base				GDP base	
	baseline	ECM	DOLS without dummy	DOLS with output gap	DOLS	ECM
long-run elasticity	1.52+++	1.53+++	1.28++	1.28++	1.54+++	1.57+++
standard deviation	0.08***	0.09***	0.12***	0.10***	0.08***	0.09***
short-run elasticity	1.67++		1.56+	1.56	1.90++	1.84+++
standard deviation	0.31***		0.29***	0.33***	0.31***	0.27**
error-correction	-0.42		-0.39++	-0.10++	-0.38	-0.55
standard deviation	0.42		0.21*	0.29	0.41	0.33
autocorrelation, F	1.63		4.05*	3.11	0.44	1.07
heteroskedasticity, chi2	0.18		0.31	0.82	0.03	0.60
stationarity, Z	-2.67*		-1.77	-1.86	-3.00**	-2.84*

autocorrelation, Durbin test, H0: no autocorrelation
heteroscedasticity, Breusch-Pagan test, H0: no heteroskedasticity
stationarity, Dickey-Fuller test, H0: nonstationary
significance levels: 10% 5% 1%
* ** ***

Source: author's calculations

Table 8: personal income tax

	baseline	ECM
long-run elasticity	1.04+	1.05++
standard deviation	0.02***	0.02***
short-run elasticity	1.12	1.18
standard deviation	0.10***	0.10***
error-correction	-0.93	-0.53+
standard deviation	0.31***	0.20***
autocorrelation, F	0.01	0.27
heteroskedasticity, chi2	0.01	0.08
stationarity, Z	-2.66*	-2.94**

autocorrelation, Durbin test, H0: no autocorrelation

heteroscedasticity, Breusch-Pagan test, H0: no heteroskedasticity

stationarity, Dickey-Fuller test, H0: nonstationary

*significance levels: 10% * 5% ** 1% ****

Source: author's calculations

Table 9: mineral oil

	baseline	no long-run
long-run elasticity	1.32	
standard deviation	0.37***	
short-run elasticity	1.10	1.13
standard deviation	0.40**	0.44**
error-correction	-1.38	
standard deviation	0.37***	
autocorrelation, F	0.04	0.8
heteroskedasticity, chi2	0.09	0.04
stationarity, Z	-3.72***	-4.81***

autocorrelation, Durbin test, H0: no autocorrelation

heteroscedasticity, Breusch-Pagan test, H0: no heteroskedasticity

stationarity, Dickey-Fuller test, H0: nonstationary

*significance levels: 10% * 5% ** 1% ****

Source: author's calculations

Table 10: spirits

	baseline	no long-run
long-run elasticity	0.27+++	
standard deviation	0.18	
short-run elasticity	1.43	0.69
standard deviation	0.43***	0.67
error-correction	-1.89+++	
standard deviation	0.27***	
autocorrelation, F	2.38	0.59
heteroskedasticity, chi2	0.32	1.19
stationarity, Z	-5.36***	-3.18**

autocorrelation, Durbin test, H0: no autocorrelation

heteroscedasticity, Breusch-Pagan test, H0: no heteroskedasticity

stationarity, Dickey-Fuller test, H0: nonstationary

significance levels: 10% 5% 1%
** ** ****

Source: author's calculations

Table 11: aggregate tax revenue

	baseline	ECM	DOLS without dummy
long-run elasticity	0.91+	0.93++	0.88++
standard deviation	0.04***	0.02***	0.05***
short-run elasticity	1.02	1.10	
standard deviation	0.11***	0.11***	
error-correction	-0.64	-0.41	
standard deviation	0.48	0.28	
autocorrelation, F	0.00	0	
heteroskedasticity, chi2	0.09	0.07	
stationarity, Z	-2.66*	-3.33*	

autocorrelation, Durbin test, H0: no autocorrelation

heteroscedasticity, Breusch-Pagan test, H0: no heteroskedasticity

stationarity, Dickey-Fuller test, H0: nonstationary

significance levels: 10% 5% 1%
** ** ****

Source: author's calculations