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Faculty of Social Sciences
Institute of Economic Studies

MASTER'S THESIS

Estimating Tax Revenue Elasticities in Slovakia

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Declaration of Authorship

The author hereby declares that he compiled this thesis independently, using only the listed resources and literature.

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Abstract

To study the effect a change in a tax base has on the corresponding tax revenue is a useful tool to better predict future tax revenues. This property is called a tax revenue elasticity but generally it does not get as much attention as it deserves, and when it does, key points like using data adjusted for the effects of tax reforms or distinguishing between the short-run (instantaneous) and the long-run (equilibrium) elasticity are often omitted. In my thesis, I am the first one to estimate the tax revenue elasticities for Slovakia. I use a unique dataset adjusted for the effects of tax reforms and tax changes to estimate both the short-run and the long-run elasticities for the three tax categories that account for the majority of each year's tax revenue Personal Income Tax, Corporate Income Tax and Value Added Tax. I obtain a long-run elasticity of 0.98, 1.28 and 0.94 for the Personal Income Tax, the Corporate Income Tax and the Value Added Tax respectively and a short-run elasticity of 3.51 and 1.93 for the Corporate Income Tax and the Value Added Tax respectively. I do not obtain a significant estimate in the case of the Personal Income Tax. Additionally, I find that it takes more than a year for the elasticity to reach its equilibrium value for all the three tax categories and that there is an asymmetric behaviour of the short-run elasticity according to the amount of the tax revenue in the case of the Corporate Income Tax.

JEL Classification	E62, H21, H24, H25
Keywords	tax revenue, tax base, elasticity, Slovakia

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Abstrakt

Skúmanie efektu zmeny v daňovom základe na príslušný daňový príjem je užitočný nástroj pre lepšie predpovedanie budúcich daňových príjmov. Táto vlastnosť sa nazýva elasticita daňových príjmov, no vo všeobecnosti sa jej nedostáva dostatok pozornosti, a ak aj áno, kľúčové body ako použitie dát očistených o efekty reforiem alebo odlíšenie krátkodobej (okamžitej) elasticity od dlhodobej (rovnovážnej) elasticity bývajú zanedbané. Moja práca je prvá, ktorá odhaduje daňové elasticity na Slovensku. Používam ojedinelé dáta

očistené o efekty reforiem a iných zmien v daňovom systéme na odhadnutie krátkodobej a dlhodobej elasticity pre tri druhy daní, ktoré každoročne veľkou mierou prispievajú do celkového daňového príjmu – daň z príjmov fyzickej osoby, daň z príjmov právnickej osoby a daň z pridanej hodnoty. Odhadnuté dlhodobé elasticity sa rovnajú 0.98, 1.28, 0.94 pre daň z príjmov fyzickej osoby, daň z príjmov právnickej osoby a daň z pridanej hodnoty v tomto poradí. Čo sa týka krátkodobej elasticity, odhadnuté hodnoty sa rovnajú 3.51 a 1.93 pre daň z príjmov právnickej osoby a daň z pridanej hodnoty. V prípade dane z príjmu fyzickej osoby nie je môj odhad signifikantný. Tiež som zistila, že v prípade všetkých troch kategórií trvá krátkodobej elasticite viac než rok, než sa dostane na rovnovážnu hodnotu, a že existuje asymetrické správanie krátkodobej elasticity v reakcii na rozdielne daňové príjmy v prípade dane z príjmu právnickej osoby.

Klasifikace JEL	E62, H21, H24, H25
Klíčová slova	daňový príjem, daňový základ, elasticita, Slovensko

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Contents

List of Tables

List of Figures

Master's Thesis Proposal

Author	Edita Ďurovčíková
Supervisor	doc. PhDr. Tomáš Havránek PhD.
Proposed topic	Estimating Tax Revenue Elasticities in Slovakia

Motivation

To ensure a sufficient tax revenue to finance government service delivery is undoubtedly one of the most important tasks of every economy that does not get as much attention as it deserves, and when it does, the effect of tax reforms and tax policy changes is often omitted which leads to inconsistency. This inconsistency then significantly decreases the usability of the estimated elasticities. A clear understanding of the dynamic properties of revenue structures is crucial when trying to ensure a long-term sustainable tax revenue. This can be achieved only by estimating both short-term (instantaneous) and long-term (equilibrium) tax revenue elasticities.

These estimations often suffer from shortage of proper data but correctly estimated tax revenue elasticities are crucial for economies of all countries, especially the emerging ones for which it is typical that their tax systems change frequently.

Unfortunately, a study focusing on estimation these kind of elasticities in Slovakia is still missing. However, there are many studies applied on tax system of other countries which might be very helpful while estimating tax revenue elasticities in Slovakia in the most proper way. In my diploma thesis I will mostly use a paper written by Havránek *et al.* (2016) where they use a special, rare data to implement the effects of tax reforms and tax changes into the estimation. Other papers used while writing my diploma thesis will be for

example papers from the following authors: Bruce *et al.* (2006), Girouard & André (2005), Bouthevillain *et al.* (2001) or Bezděk *et al.* (2003).

Hypotheses

1. Hypothesis #1: The long-term and the short-term tax revenue on Personal Income Tax elasticities are significantly different.
2. Hypothesis #2: The long-term and the short-term tax revenue on Corporate Income Tax elasticities are significantly different.
3. Hypothesis #3: The long-term and the short-term tax revenue on Value Added Tax elasticities are significantly different.
4. Hypothesis #4: The short-term tax revenue on Personal Income Tax elasticity is significantly different from one.
5. Hypothesis #5: The short-term tax revenue on Corporate Income Tax elasticity is significantly different from one.
6. Hypothesis #6: The short-term tax revenue on Value Added Tax elasticity is significantly different from one.

Methodology

In my diploma thesis I will firstly focus on detailed description of a Slovak tax system and its history and the majority of my diploma thesis will be devoted to estimating short-term (instantaneous) and long-term (equilibrium) elasticities of three tax categories that generate the majority of tax revenue in Slovakia - Personal Income Tax, Corporate Income Tax and Value Added Tax. Also I will try to adjust my analysis for tax reform from year 2004 and other tax changes.

Many of the empirical studies on tax revenue elasticities do not adjust the data for the effects of tax reforms and tax changes which breaks the ceteris paribus condition important for a correct identification of the elasticity coefficients. Therefore, the crucial assumption of a successful estimation of tax revenue elasticities is working with valuable data. I will try to obtain the data from the Ministry of Finance of the Slovak Republic, The National Bank of Slovakia and from the Statistical Office of the Slovak Republic.

After obtaining the data I will firstly have to test the null hypotheses about

non-stationarity and cointegration on all the time series in my dataset to find out if OLS is or is not an adequate method of estimation. Otherwise other, more advanced estimation methods will have to be used. Since the Slovakia has been existing only for 23 years, using quarterly rather than annual data could bring more significant results but it would also cause a strong seasonality issue.

After all, the estimation method to be used and the resulting issues to be solved will be strongly implied by the quality of data I will be able to obtain, and therefore I will do my best to start actively seeking the right data as soon as possible.

Expected contribution

Tax revenue elasticities have a widely usage for both fiscal and monetary authorities. They are used for forecasting of future government revenue or for cyclical adjustment of budget deficit and they are also very important for calculating the tax multipliers.

As has already been explained in the Motivation part, it is very important to focus on both the short-run (instantaneous) and the long-run (equilibrium) elasticities to make the estimation of the tax revenue elasticities valuable. Attention has to be paid also to the effects of tax reforms and other tax changes. My master's thesis could be the first paper in Slovakia to focus on all of this utilizing the previous estimations of tax revenue elasticities of other countries to do my estimation in the most proper way.

Outline

1. Introduction of the topic
2. Literature review
3. Taxation in Slovakia (theory)
4. Detailed description of the data and the analysis
5. Evaluation of the results
6. Conclusion

Chapter 1

Introduction

To ensure a sufficient tax revenue to finance government service delivery is undoubtedly one of the most important tasks of every economy that does not get as much attention as it deserves. To better predict the development of the tax revenue in the future, it is valuable to study the response of the tax revenue to a change in the corresponding tax base - the tax revenue elasticity.

Unfortunately, most analyses simply assume these elasticities to be equal one or use data unadjusted for the effects of tax reforms and other tax changes while estimation. This, however, may lead to inconsistency and therefore to a significant decrease in the usability of the results in praxis. Changes in endogenous development of the tax revenue due to a macroeconomic shock must be distinguished from the changes triggered by the changes of tax policies. The threat of inconsistency is much higher for emerging and transiting countries with a frequently changing tax system like Slovakia. On the other hand, these countries have also the lowest probability of tracking adjusted data, and thus we were really lucky to obtain very recent data, first of its kind, from the Institute of Financial Policy, a policy arm of the Finance Ministry of Slovakia (Institute for Financial Policy 2017). Though there already exist papers estimating the tax revenue elasticities using adjusted data for other countries, e.g. Havránek *et al.* (2016) for the Czech Republic, Wolswijk (2009) and Bettendorf & Limbergen (2013) for Netherlands, Koester & Priesmeier (2012) for Germany, Machado & Zuloeta (2012) for eight Latin American Countries - Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, Peru and Venezuela or Bruce *et al.* (2006) for the US states, this thesis is the first one to estimate the tax revenue elasticities using adjusted data for Slovakia.

Controlling for adjusted data, however, is not the only necessary condition for successfully estimated tax revenue elasticities. If we want to fully understand the reaction of the tax revenue to a change in the corresponding tax base, we need to estimate both short-run (instantaneous) and long-run (equilibrium) tax revenue elasticities and also we have to model the path of the adjustment between these two elasticities over time. While the long-run elasticity expresses the overall, long-term reaction of the tax revenue, the short-run elasticity stands for the immediate impact of the change in the tax base and is crucial for getting a closer look at the initial speed of the tax revenue adjustment towards the equilibrium value.

In my diploma thesis I am using quarterly data adjusted for the effects of tax reforms and other tax changes and a two-step error correcting procedure developed by Engle *et al.* (1987) to estimate both the short-run and the long-run tax revenue elasticities for the three major tax categories, which create the highest contribution to each year's tax revenue in Slovakia - Personal Income Tax, Corporate Income Tax and Value Added Tax. Then I am pointing out interesting findings and commenting on possible explanations of these values. Additionally, I am repeating the same procedure using unadjusted data, to show how misleading the results from unadjusted data can be while making decisions about the future tax policy. To get a closer look at the adjustment path of the tax revenue from its short-run value towards its equilibrium value, I am computing a so-called impulse-response function. As the last step of my analysis, I am testing for a possible short-run elasticity asymmetry between the "good times" and the "bad times", i.e. periods with a tax revenue above the equilibrium value and periods with a tax revenue below the equilibrium value.

In my analysis, I find a long-run elasticity of 0.98, 1.28 and 0.94 for the Personal Income Tax, the Corporate Income Tax and the Value Added Tax respectively and a short-run elasticity of 3.51 and 1.93 for the Corporate Income Tax and the Value Added Tax respectively. Additionally, I find a significant asymmetric behaviour of the short-run elasticity according to the tax revenue for the Corprate Income Tax. I also find that in the case of all the three tax categories, it taxes over a year for the elasticity to reach its equilibrium value.

The thesis is structured as follows: Chapter 2 is focused on a description of the

current tax system in Slovakia and its short but turbulent history, especially the extensive tax reform in 2004, from the point of view of the particular three tax categories. In the Chapter 3 I present different methods and results from papers estimating the tax revenue elasticities of other countries, mostly European, using both adjusted and unadjusted data. In the Chapter 4 I provide a detailed description of the dataset used, the sources used to obtain the most proper data and I comment on possible data limitations. Chapter 5 is devoted to the description of the methodology used and the fundamental tests needed to be done to make sure that the usage of chosen methods is appropriate. In the Chapter 6 I present the results and provide a detailed commentary on the results and possible explanations for the obtained values. The last chapter concludes the thesis.

Chapter 2

The Slovak Tax System, its History and Issues

2.1 The Current Slovak Tax System

In the following section I will provide brief and the most recent information on each of the three tax categories according to 2016 Tax Guideline for Slovak Republic (Accace 2016) and 2015 Tax Report for Slovak Republic (Remeta *et al.* 2015a) issued by the Institute of Financial Policy, a policy arm of the Finance Ministry of Slovakia.

The Personal Income Tax (also called Tax on Individual Income) is a progressive direct tax obliged to be paid by the residents - people who have their permanent residence or habitual abode in Slovakia on their taxable income which consists of their worldwide income. Having habitual abode means being present in Slovakia for at least 183 days during a calendar year, however days spent in Slovakia in purpose of studying, medical treatment or crossing borders are not taken into account (Accace 2016). Residents are divided into two groups according to their annual taxable income. The first group - residents with an annual taxable income, except for the income from capital, up to 176.8 times the subsistence minimum level, which was 35 022.31 EUR in 2016, is taxed at a rate of 19%. The second group consists of residents with an annual taxable income, except for the income from capital, higher than 176.8 times the subsistence minimum level. The annual taxable income above the threshold is taxed at a rate of 25%. The Income from capital is taxed at a flat rate of 19% (Remeta *et al.* 2015a). Moreover, the representatives of constitutional bodies

(e.g. the President, the Prime Minister, members of Parliament) have to pay additional tax of 5% on their annual employment income. As a result of an extensive tax reform in 2004, dividends paid out of profits are not subject to any tax. Non-residents are taxed only on their income generated from Slovak sources. The tax period is one calendar year (Accace 2016).

The Corporate Income Tax is a flat direct tax paid out of corporate profits of two groups of companies. Resident companies, e.g. companies which have their legal seat or a place of effective management in Slovakia, are taxable on their worldwide income at a rate of 22%. Non-resident companies are taxable only on the income generated from the Slovak sources at a rate of 22% (Accace 2016). Dividends paid out of profits are not subject to any tax as a result of the tax reform in 2004. Slovakia disposes of this policy as the only country from the Visegrád Group. Due to a second extensive tax reform starting from 1 January 2014 corporates are obliged to pay a minimum tax on their income (e.g. tax licenses) in the case the tax amount, counted as 22% of their tax base, is lower than the corresponding tax license. Corporates may subtract their tax loses from the tax base during maximum four subsequent tax periods. The tax period may be considered as both calendar year and business/financial year (Remeta *et al.* 2015a).

The Value Added Tax is a flat indirect tax on goods and services at a rate of 20%, however a reduced rate of 10% is applied on a small group of goods, e.g. books, musical instruments or pharmaceutical products (Remeta *et al.* 2015a). A taxable person is every individual or legal entity carrying on an economic activity in Slovakia. As the taxable economic activities are considered the following events: supply of goods and services within the territory of Slovakia, import of goods into the territory of Slovakia and acquisition of goods within the territory of Slovakia from an EU member state (Accace 2016). Some goods, e.g. revenue stamps, and services, e.g. postal services, healthcare services, educational services, services of public television and broadcast, are exempt from the tax obligation. Slovakia has the lowest standard tax rate among the countries of the Visegrád Group, however the variety of goods taxed at a reduced rate of 10% is the smallest among these countries (Remeta *et al.* 2015a).

2.2 History of the Slovak Tax System

During its short history, the tax system in Slovakia went through several important tax reforms and tax changes that had a significant impact on a successful tax collection. The most important features of each reform and tax change between the years 1993 and 2015 are summarized below.

After the separation of Slovakia and the Czech Republic in 1993, a new legislation establishing the Personal Income Tax, the Corporate Income Tax and adjusting the rates for the Value Added Tax came into force. In 1993, the Personal Income Tax was a progressive tax with six income brackets and tax rates varying from 15% up to 47%. Both the income brackets and the corresponding tax rates changed often during the following years. Additional "millionaire tax" was established in 1998 however aborted soon after. In 2002, the number of income brackets was decreased from seven to five with the corresponding tax rates varying from 10% up to 38% (Antalicová *et al.* 2005).

The Corporate Income Tax rate was set at a level of 45% in 1993 but it was decreased to 40% already a year later. In 2000, it was further decreased to 29% and then again to 25% two years later (Krajčír *et al.* 2005b).

The standard rate and the decreased rate for the Value Added Tax were both changing constantly during the first ten years. In 1993 the standard rate was set to 23% and the decreased rate was set to 5% but raised to 25% and 6% respectively already in August 1993. The standard rate was decreased back to 23% in 1996 and kept at this level until 2003, when it was further decreased to 20%. The decreased level was raised to 10% in July 1999. In 2003, it was additionally increased to 14% (Krajčír *et al.* 2005a).

In 2004, the Slovak government introduced an extensive tax reform based on the following five principles:

- principle of justice, focusing on both horizontal and vertical justice in tax assessment and collection
- principle of neutrality, focusing on minimising the effect taxation has on economic processes and decision making of individuals

- principle of simplicity and exactness, focusing on ruling out possible misinterpretation of tax norms
- principle of effectiveness, focusing on elimination of tax avoidance possibilities
- principle of double taxation elimination

The tax reform intended to accomplish the five principles above by transferring the tax burden from direct taxes to indirect taxes, i.e. from production to consumption, replacing progressive income taxation by the flat one and eliminating most of the tax exemptions.

While before the tax reform the tax rates of the Personal Income Tax, the Corporate Income Tax and the Value Added Tax had varied significantly, the tax reform set the tax rates of all the three studied tax categories above at a flat level of 19%. The critics opposed the implementation of the flat rate on the Value Added Tax by stating that the decreased tax rate had served primarily as a tool to simplify the access of basic food and other goods to the socially disadvantaged ones, however as the former Finance Minister of Slovakia Ivan Mikloš (2005) claimed, there had been no significant evidence on the positive effect of maintaining the decreased tax rate.

As a result of the tax reform, Slovakia was the first OECD country having a flat Personal Income Tax. This in combination with a lowered Corporate Income Tax and Slovakia joining the European Union resulted in an increased attractiveness of Slovakia for both domestic and foreign investors. The tax reform also removed almost all tax reliefs for the Personal Income Tax and therefore broadened the corresponding tax base and so achieved its goal of creating a simple and an efficient tax system. Nonetheless, it was unsuccessful in removing the tax burden on the labour due to keeping the Social Security Contributions high. Later it turned out to be broadly revenue neutral. The overall tax revenue before and after the reform has not changes significantly. The decrease in the Personal Income Tax and the Corporate Income Tax revenue was almost fully compensated by the increase in the Value Added Tax revenue. (Remeta *et al.* 2015b).

A decreased Value Added Tax rate of 10% on a small group of goods was

reintroduced in 2007 and the eligible group of goods was widened a year later. A decreased rate of 6% on garage sales purchases was in force between May 2010 and December 2010, however it was abolished already in 2011. In the same year, the standard rate was increased to 20% and it has been in force since then (Ministerstvo financií Slovenskej republiky 2011).

The tax reform from 2004 highly contributed to the fast economy growth in Slovakia. It was successful in making Slovakia one of the fastest growing OECD countries, however after a decade, the problems unsolved by the reform became more apparent. The Slovak tax system still suffered from low tax revenues, poor tax compliance and high tax wedge on low-income workers due to the flat tax rate.

To deal with these problems, another set of tax reforms was implemented in 2013 and it was further widened and slightly changed in 2014. The flat Personal Income Tax was replaced by a progressive tax with two income brackets. The tax rate of 19% was levied on income below 176.8 times the subsistence minimum level, which was 34,401.74 EUR a year in 2013, and 25% on income above this level. The introduced tax rates have been in force since then. The 2013 tax reform also substantially increased restrictions on the allowance and tax deduction. It toughened the definition of the spouse eligible for a tax allowance and decreased the expenses of self-employed individuals, on which a tax deduction can be applied, from 40% of all expenses to 5,040 EUR per year. The reform also toughened the Corporate Income Tax, which remained flat, however it was increased to 23% (Remeta *et al.* 2015b). No further changes have been made to the Value Added Tax rate, but the Slovak government have committed to complexly fight against tax frauds and internal corruption according to the 2012-2016 Action Plan to Combat Tax Fraud (Rokovanie vlády Slovenskej republiky 2012). The minimum level of the assessment base for collection of the Social Security Contributions was increased for self-employed workers and also the ceiling was raised for all employment types. Additionally, the Social Security Contributions for temporary workers were also introduced (Remeta *et al.* 2015b).

In 2014, the Corporate Income Tax was decreased to 22%. Furthermore, a minimum tax amount was introduced. This minimum tax amount depends on various factors, e.g. it varies according to the company's turnover and whether

the company was registered to the Value Added Tax. The number of consecutive years allowed for a forward carrying of a tax loss have been reduced from seven to four years. No further changes of the Personal Income Tax were made in 2014. Concerning the Social Security Contributions, the health contribution rate from dividends was raised from 10% to 14% (Remeta *et al.* 2015b).

2.3 Further Issues of the Slovak Tax System

The tax reforms were partly successful to deal with the remaining problems, however an additional improvement of the tax collection and the tax compliance is still needed. Another big issue of the Slovak tax system is to keep its attractiveness for the foreign investors high even after the increase of the Corporate Income Tax rate in 2013. In the following section, I will briefly describe a few remarkable points suggested by Remeta *et al.* (2015b) to be focused on in the future.

The current Corporate Income Tax rate of 22% is somewhere in the average among the small OECD economies, but it is the highest among the tax rates considering the rest of the Visegrád Group members. This may serve as an incentive for the foreign investors to move their investments to more competitive countries. Therefore, instead of further increasing of the Corporate Income Tax rate, attention should be paid to broadening of the tax base by improving the tax compliance, limiting the number of tax deductible expenses and a better aligning of the tax depreciation allowances with the real depreciation of assets. (Remeta *et al.* 2015b) further suggest reassessing the minimum Corporate Income Tax, because the actual one contributes to the inefficiency, horizontal inequality and it increases administrative and compliance costs.

A poor tax compliance is also the main reason for the low Value Added Tax revenue. To solve this problem, the Slovak government has already introduced the Action Plan to Combat Tax Fraud (Rokovanie vlády Slovenskej republiky 2012).

Another problem that the Slovak tax system has been overlooking so far is a strong tax burden on labour income, especially for the low-skilled workers. High Social Security Contributions increase the employer's labour cost and so lead to higher gains for the employer when he shifts between the labour and

the capital income. To deal with this problem, the Slovak government has already introduced Social Security Contributions exemptions for the low-paid and previously long-term unemployed workers in November 2013. Remeta *et al.* (2015b) believes that a cutback in the Social Security Contributions for all low-skilled workers instead would bring more significant results.

To further decrease the burden on the Social Security Contributions, he advocates to finance some social benefits, which are not related to earnings, through the Personal Income Tax rather than the Social Security Contributions, e.g. insurance or family allowances. This is reasonable, since the flat rate of the Social Security Contributions weakens the progressivity of the Slovak tax system.

Another idea is to offer a Personal Income Tax deductibility for education and training instead of decreasing the burden on the low-skilled labour force through lowering the Social Security Contributions. It may bring the same favoured outcome and it would additionally serve as an incentive to increase the productivity of the workers.

Further suggestions include increasing of environmentally-related taxes and property-related taxes, which are low in comparison to the other OECD countries, increasing of taxes on the personal capital income to enhance progressivity, implied by the assumptions that richer households usually earn more capital income, and of course instantly working on improving of the tax compliance, which still remains one of the most significant problems of the Slovak tax system (Remeta *et al.* 2015b).

Chapter 3

Literature Review

The literature studying the tax revenue elasticities is quite broad with multiple estimation methods used. Unfortunately, I was not able to find any literature focusing principally on the estimation of the tax revenue elasticities in Slovakia in detail.

In a paper measuring the cyclically-adjusted budget balances for OECD countries, Girouard & André (2005) set the Personal Income Tax revenue elasticity of Slovakia with respect to earnings to 1.00 without an estimation as a result of a flat uniform tax rate that had been imposed on all sources of income and consumption in Slovakia a year before. But generally Girouard & André (2005) counted the tax revenue elasticities of other countries as the marginal tax rate to the average tax rate ratio. An important thing we have to mention about the paper is, that it estimates the tax-revenue elasticities from the microeconomic point of view. Thus it does not work with an aggregate tax revenue for the whole economy, but with a tax revenue obtained from a representative household - a full-time employed married couple with two children, where one person earns half of what the second person from the couple earns. The overall elasticity is then computed by weighting the marginal and the average tax rates of each household using the log-normal distribution. For this purpose, only cross-sectional data were used, which means that the elasticities were counted only according to the last period and that the past performance of the tax collection was not taken into account. The same methodology was used 9 years later, in an OECD paper estimating new tax and expenditure elasticities for the member countries. Price *et al.* (2014) obtained elasticity of 2.43 for the Personal Income Tax revenue in Slovakia and explained the increased elasticity

as a result of the progressive rate structures and a higher threshold compared to the year 2005. The method used in both cases is very straightforward and simplifying, and definitely not very applicable in our case, since we need to work with aggregated time series data capturing a longer period of tax collection to distinguish between the instantaneous reaction of the tax revenue to a change in the corresponding tax base and the overall, long-run reaction and also to control for the effects of tax reforms plus some other factors.

Since these are the only two papers estimating the tax revenue elasticities for Slovakia we found, we do not have any paper with an appropriate method used to compare our results with. Now, let us have a look at papers estimating the tax revenue elasticities for other countries, which may serve us as a good source of methodology inspiration.

The principal source for my diploma thesis is a paper written by Havránek *et al.* (2016). In the paper, they used a type of an error correction model by Engle *et al.* (1987) and a unique dataset obtained from the Czech National Bank to implement the effects of tax reforms and tax changes into the estimation of both the short-run (instantaneous) and the long-run (equilibrium) tax revenue elasticities for three tax categories, that account for the majority of tax revenue in the Czech Republic - the Personal Income Tax, the Corporate Income Tax and the Value Added Tax. For the estimation they chose the following bases - the sum of total wages and salaries for the Personal Income Tax, the net operating surplus for the Corporate Income Tax and the sum of household consumption and private investment into dwellings for the Value Added Tax. To deal with a small dataset problem due to a short period of available data, they used quarterly data instead of yearly, and therefore additional attention to seasonality had to be paid. As the last step of their analysis, they computed the impulse-response functions to get a closer look at the process of adjustment of the tax revenue elasticities towards their equilibrium values over a time. They estimated the long-run elasticities to be equal to 1.4 for the Personal Income Tax, 1.7 for the Corporate Income Tax and 0.9 for the Value Added Tax and found a slow adjustment process towards the equilibrium value due to a change in the tax base for the Personal Income Tax and the Corporate Income Tax.

Another paper from the Czech Republic written by Bezděk *et al.* (2003) es-

timates the tax revenue elasticities as the first step of the tax bases elasticities with respect to economic fluctuations estimation, using quarterly data. These elasticities were part of a large Czech fiscal policy analysis studying the impact of a business cycle on the Czech fiscal balance using two different methods - the OECD and the ESCB, European System of Central Banks, method. The OECD method works with aggregated data and says that an economic activity influences the tax bases and the unemployment and these further influence the tax revenue and the expenditures. On the other hand, the ESCB method works with less aggregated data, and therefore it allows to take into account the possibility of different trends and fluctuations for different budget components. Incorporation of the tax revenue elasticities with respect to the tax bases estimation is a part of both methods. Both methods also firstly divide the budget components into the cyclical and the non-cyclical ones and use the compound tax elasticities. These are counted as a product of the tax revenue elasticity with respect to the tax base and the tax base elasticity with respect to the business cycle. The tax revenue elasticities of the Corporate Income Tax and the Value Added Tax were estimated using regression analysis and equal 0.4 and 0.8 respectively and the tax revenue elasticity of the Personal Income Tax is derived as a ratio of the statutory marginal tax rate to the average tax rate and equals 2.2.

To study the macroeconomic effects of fiscal policies, the OECD and the ESCB methods were also used by Valenta (2011) in his dissertation thesis. In this case, Valenta obtained tax revenue elasticities of 1.2 and 0.4 for the Personal Income Tax and the Corporate Income Tax respectively and found out that the effect of the tax reform in 2008 decreased the Personal Income Tax revenue elasticity from 1.7 to the mentioned value of 1.2. He did not estimate the tax revenue elasticity of the Value Added Tax directly, but he obtained the private consumption of indirect taxes elasticity equal to 1.0.

Bettendorf & Limbergen (2013) experimented with various alternative definitions of tax bases to estimate the correct tax revenue elasticities of the Personal Income Tax and the Value Added Tax for another European country - Netherlands and found no change in the corresponding elasticities due to different tax bases. Using the two-step error correction model, both short-run elasticities and the long-run elasticity for the Value Added Tax were estimated to be equal to 1.0. The long-run tax revenue elasticity of the Personal Income Tax

was estimated to be equal to 0.89 and therefore significantly below 1.0. At the end they computed the impulse-response function to get a closer look at the process of adjustment between the instantaneous and the equilibrium tax revenue value. Bettendorf & Limbergen are also one of few authors who used data adjusted for the effects of new policies or legislative changes, which notably increased usability of their results in praxis and importantly, it also increased the usability of their estimation method as an inspiration for our estimation.

Both the short-run and the long-run tax revenue elasticities with respect to their bases in Netherlands had been studied already sooner by Wolswijk (2009), also using the two-step error correction model and adjusted data, which have been being collected by the Dutch ministry of finance since 1970. The long-run elasticity for the Value Added Tax was estimated to be equal to 0.9 which is similar to the estimate obtained by Bettendorf & Limbergen (2013). On the other hand, Wolswijk (2009) obtained a much higher estimate for the Personal Income Tax - 1.57. Additionally, he also estimated the tax revenue elasticity of the Corporate Income Tax to be equal to 1.07 in the long-run. Regarding the short-run elasticities, Wolswijk obtained two asymmetric behaviours in the case of the Value Added Tax and the Corporate Income Tax depending on the sign of the error-correction term, which tells us whether the current tax revenue is above or below its equilibrium value. He also emphasised the danger of ignoring the difference between the short-run and the long-run elasticities, which may cause unexpected "budget surprises".

Other authors using adjusted data and again the two-step error correcting procedure by Engle *et al.* (1987) are Koester & Priesmeier (2012) while studying the tax revenue elasticities in Germany. They estimated the short-run and the long-run elasticities for the Personal Income Tax to be equal to 1.41 and 1.75 respectively, explaining the high value by a strongly progressive tax rate structure for the Personal Income Tax in Germany. The short-run and the long-run elasticities for the Corporate Income Tax were estimated to be equal to 0.43 and 0.77, which is significantly below the value obtained using the ESCB method and unadjusted data. The big difference between the short-run and the long-run elasticity values corresponds to a slow response to a shock to the corresponding tax base followed by a delayed overshooting observed, as was shown by simulating the impulse-response functions for both tax categories. The estimated short-run and long-run elasticities for the Value Added

Tax equal 0.9 and 0.79 respectively.

Let us now have a look at some papers estimating the tax revenue elasticities for other than European countries too. To estimate both the short-run and the long-run tax revenue elasticities with respect to GDP for the Personal Income Tax, the Corporate Income Tax and the Value Added Tax in eight Latin American Countries - Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, Peru and Venezuela, Machado & Zulocta (2012) used adjusted quarterly data and again the two-step error correction model, furthermore controlling for the "bad times", i.e. periods with a declining GDP in the regression. Using dynamic OLS in the first step of the procedure, Machado & Zulocta obtained mostly significant estimates of the long-run elasticities for all the three tax categories in all the countries studied. The values of estimates were in a rage from 0.72 for Mexico to 2.99 for Brazil for the Personal Income Tax, from 1.33 for Argentina to 3.59 for Venezuela for the Corporate Income Tax and from 0.33 for Brazil to 2.65 for Venezuela for the Value Added Tax. On the other hand, the short-run elasticity estimates were mostly insignificant, thus statistically indistinguishable from one.

There is also another paper estimating the tax revenue elasticities for the eight countries above plus Bolivia, Dominican Republic and Uruguay written by Fricke & Süssmuth (2014). Since stating the values of the short-run and the long-run tax revenue elasticities for all the eleven countries would be quite lengthy, we mention only the most important thing and that is, that the authors are again using the error correction model used in most of the papers above.

Bruce *et al.* (2006) estimated the long-run and the short-run tax revenue elasticities for the Personal Income Tax and the Sales Tax, two major tax revenue sources relied upon by governments of the US states. In the case of the Personal Income Tax, he obtained the average value of 1.83 for the long-run elasticity and 2.66 and 0.22 for the short-run elasticity when the value of the tax revenue is above and below the equilibrium respectively. In the case of the Sales Tax, the estimates were 0.81, 1.8 and 0.15 for the long-run elasticity, the short-run elasticity with the corresponding tax revenue above the equilibrium and the short-run elasticity with the corresponding tax revenue below the equilibrium respectively. The authors again used the two-step error correction model.

Summing up the results above, we can see that the authors obtained different results according to different methods and different quality of the data they used. We can also see that the most important literature for us, i.e. the literature distinguishing between the short-run and the long-run elasticities, uses the two-step error correcting procedure developed by Engle *et al.* (1987) in most of the cases. The reviewed literature overall implies three important points we should keep in mind during our estimation.

Firstly, we can see, that while some of the authors studied the tax revenue elasticities simply with respect to GDP, others tried to find close proxies to the true tax bases. We are aware of the impossibility to find the perfect proxy for our tax bases, but we are also aware of the importance of finding as close proxy as possible. Secondly, we find that it is crucial to distinguish between the long-run and the short-run tax revenue elasticities if we want to fully understand the relationship between the tax base and the tax revenue and the process of the tax revenue elasticity adjustment over a longer period of time, because while the short-run elasticity captures the immediate response of the tax revenue to a change in the corresponding tax base, the long-run elasticity stands for the overall, long-term response. And thirdly, authors using data adjusted for the effects of tax reforms and other tax changes proved significant differences between the results implied by adjusted and unadjusted data and therefore increased the usability of their results in praxis. These significant differences also determine the importance of distinguishing between the macroeconomic shocks and the tax policy shocks to the tax bases. The last point is especially important for emerging and transition countries. Unfortunately, these countries are also the ones with the lowest probability of actively collecting these kind of data, if we compare it to Germany or Netherlands from our literature review.

In the following section, I am going to show how I used and implemented the three points above into my data collection and methodology to estimate the tax revenue elasticities in Slovakia in the most proper way.

Chapter 4

Description of the Data

In my estimation, I decided to work with data between the years 2000 and 2015. During this period, the Slovak tax system went through several important changes. Since 2000, the Personal Income Tax has changed the most, going from a progressive tax with a frequently changing number of tax brackets during the first ten years to a flat tax at a rate of 19% and then back to a progressive tax with two tax brackets. The Corporate Income Tax has always been flat, however its tax rate was gradually decreasing from 40% to 29%, 25% and further to 19%, then it increased to 23% and again decreased to 22 over past years. The Value Added Tax rate registered a decrease of its standard rate from 23% to 19% and a following increase back to 20% with its decreased rate of 14% been abolished in 2004 and again re-introduced three years later at a rate of 10%. A decreased rate of 6% was also applied on garage sales purchases during a short period in 2010.

The reason I chose to work with a shorter period of data is simply due to availability of good-quality data and also due to a period of turbulent tax changes before 2000. Because of the short period of data used, I worked with quarterly data instead of yearly, therefore additional attention to seasonality had to be paid.

For our research, we obtained three different types of data from the following sources:

Firstly, the quarterly tax revenues from the Corporate Income Tax and the Value Added Tax were counted from the monthly revenues obtained directly

from the database of the Institute for Financial Policy, a policy arm of the Finance Ministry of Slovakia. The tax revenue from the Personal Income Tax was counted as a sum of tax revenues from dependent activities and tax revenues from self-employees and other income.

Secondly, we had to find the most convenient proxies like various GDP components or macroeconomic variables for the three tax bases, since the true values of the tax bases are almost impossible to obtain. Fricke & Süssmuth (2014) mention only one paper using the real tax base values while estimating the tax revenue elasticities for gambling taxes, whose tax base structure consists simply of casino gross revenues and so they are much less complicated that the tax bases of the tax categories studied by us. Our proxies for the tax bases were chosen according to the definitions of particular tax bases, the proxies used by Havránek *et al.* (2016) and Bouthevillain *et al.* (2001) and the data available. For the Personal Income Tax we chose the sum of wages and salaries as its tax base. For the Corporate Income Tax we chose the gross operating surplus plus mixed income and for the Value Added Tax we chose the final households' consumption. All the data were obtained from the Slovak quarterly national accounts which are part of databases Slovstat, STATdat. and DATAcube. administrated by the Statistical Office of the Slovak Republic.

Thirdly, to obtain consistent tax revenue elasticities, it was crucial to adjust our data for the effects of tax reforms and tax changes. Unfortunately, these kind of data are very rare, especially for emerging and transiting countries, and therefore we were very lucky to access a new original dataset from the Institute for Financial Policy, which included also yearly tax revenues adjusted for the effects of legislative changes (Institute for Financial Policy 2017). The people from the Institute for Financial Policy, because of their own experience, also recommended to remove the turbulent period between the years 1993 and 1999 from the data for our estimation, which is another reason why we chose to work with a shorter period of data.

To increase the size of our dataset, we decided to work with quarterly data instead of yearly data. But since we need to work with quarterly data, we had to make additional adjustments of the dataset. Another issue was the accrual accounting method used for the adjusted revenues, since our unadjusted quarterly revenues were accounted using the cash method and accrual quarterly

revenues are not available. We therefore took the residuals between the annual adjusted and unadjusted accrual revenues and the proportion of each quarterly revenue to the corresponding yearly revenue. Then we counted the product of the residuals and the proportion for each quarter and summed these amounts with corresponding cash quarterly revenues.

We see possible weaknesses of our dataset arising from two problems. The first one is simply the short period of available data, but according to almost zero data availability in other Central and Eastern European countries, we are truly aware of the luck we had in obtaining at least these data. We solved this problem partly by using quarterly data instead of yearly, but still a longer period of data could lead us to more significant results. The second problem arises from the transformation of the adjusted yearly tax revenues into the quarterly ones. The transformation was always made in a yearly interval, which means that if a tax reform or other tax change came into force at year t, the adjustment is made in all quarters of the year t, irrespective of the quarter when the reform or the tax change came into force. This practical obstacle is not a problem in the case of the Personal Income Tax, as all the observed changes took place at the beginning of a year, and negligible in the case of the Corporate Income Tax, since there were only three changes that did not happen at the beginning of a year. There are however more (but still few) changes that happened during a year considering the Value Added Tax. As a result of our transformation, we may therefore have lower-quality data in the case of the Value Added Tax.

Other variables were being created during the estimation process. As the most important, we can mention the seasonal dummy variables and other two dummy variables, one capturing the effect of Slovakia joining the European Union in May 2004 and the other one capturing the effect of the Great Recession in the late 2000s and early 2010s. Additionally, we also used the logarithms of the tax revenues and tax bases, its lags and leads, but we talk about these more in the following chapter.

Chapter 5

Methodology

Now that we have adjusted our data, we can proceed to the estimation of the tax revenue elasticities for the Personal Income Tax, the Corporate Income Tax and the Value Added Tax. As we explained before, it is crucial to work with adjusted data to come to reasonable results, especially for a young country with a frequently changing tax system like Slovakia. But simply out of curiosity, we repeat the whole estimation also with unadjusted data and compare the results. Furthermore, to completely understand the response of the tax revenue to a change in the tax base, we need to estimate both the short-run, i.e. instantaneous, and long-run, i.e. equilibrium, tax revenue elasticities. While the short-run elasticity shows only the immediate response of the tax revenues, the long-run elasticity represents the whole long-term response. The short-run elasticity is also important to obtain a deeper view into the process and the speed of the adjustment.

Since we work with time series data, before concluding anything, we have to test our dataset for stationarity. For this purpose, we use the augmented Dickey-Fuller test with the null hypothesis of non-stationarity. For both adjusted and unadjusted data, we obtain high p-values, as we can see in the Table 5.1, and therefore we do not have enough evidence to reject the null hypothesis.

As a result, we might be afraid that we would have to choose a different estimation method than Ordinary Least Squares, since we may obtain biased estimates. However, according to Engle *et al.* (1987), the non-stationarity of vectors (e.g. the adjusted Personal Income Tax revenue and the Personal Income Tax base in our case) may not be a problem, if the product of these

Table 5.1: Augmented Dickey-Fuller Test for Stationarity

Variable	Test Statistic
PITbase	-1.965
CITbase	-2.283
VATbase	-2.180
PITrevenue_adj	-1.554
CITrevenue_adj	-1.978
VATrevenue_adj	-1.168
PITrevenue	-1.231
CITrevenue	-1.498
VATrevenue	-1.364
10% Critical Value	-2.596

vectors is stationary. Engle and Granger work on the presumption that some pairs of time series move simultaneously over the time with possible disruptions in the short run. They compare their behaviour to the market forces, which push values of economic variables to their equilibrium levels in case of disruption in the short run. This property of simultaneous movement over a time is called cointegration, it was firstly introduced by Granger (1981) and it allows us to use Engle's and Granger's two-step error correcting approach, one of the methods from the group of error correction models, for the estimation, which sticks to equilibrium constraints in the long run, still allowing dynamic behaviour in the short-run. The error correction models generally work with an assumption that the residuals between the long-run equilibrium and the previous-period value influence the short-run value, in our case the short-run elasticity, from the current period. The advantage of the two-step procedure by Engle *et al.* (1987) is, that it is very straightforward, easy to interpret and it uses only one least squares equation for each step of the procedure.

To check for cointegration, we use two different tests - the Engle-Granger test and the Johansen test. As we can see in the Table 5.2 below, both tests bring the same results with all six trace statistics exceeding the absolute value of their 5% critical values. Thus we can reject the null hypothesis of no cointegration for the whole dataset in both cases and proceed to the two-step error correcting procedure.

In the first step of the procedure, we estimate the long-run tax revenue elasticities using the dynamic Ordinary Leased Squares - DOLS estimation by Stock

Table 5.2: Cointegration Tests

Variable	Engle-Granger test	Johansen test
PITbase & PITrevenue_adj	-6.452	60.2541
CITbase & CITrevenue_adj	-4.692	34.2641
VATbase & VATrevenue_adj	-5.593	37.8339
PITbase & PITrevenue	-5.937	45.2484
CITbase & CITrevenue	-4.559	35.1704
VATbase & VATrevenue	-6.145	33.8588
5% Critical Value	-3.435	15.41

& Watson (1993), which is able to deal with endogeneity of regressors. The first regression is sometimes also called the "co-integrating regression".

When we began our estimation, we solely regressed the logarithms of the tax revenues on the logarithms of the corresponding tax bases and the differences in logarithms of particular lags and leads, expecting that all other factors like seasonality or significant economic changes influence the tax revenue fully by influencing the tax base. As a result, we did not intend to include any of these variables in our regressions. The unsatisfactory outcome of the first regressions however made us realise, that since we do not work with perfect proxies for the tax bases, our proxies may not capture all the effects of the variables mentioned above, and for this reason we decided to include them in our regression. The additional explanatory variables are seasonal dummies q1, q2, q3 representing the first three quarters, a dummy EUentry representing the remaining effect of Slovakia joining the European Union in May 2004 , thus equal 1 for the time period after 2004q1, and a dummy crisis representing the remaining effect of the Great Recession and therefore equal 1 for the time period after 2007q4. The final regressions look as follows:

$$\begin{aligned} logPITrevenue\_adj_t = {} & \beta_0 + \beta_1 logPITbase_t + \beta_2 \Delta logPITbase\_lag_t \\ & + \beta_3 \Delta logPITbase\_lead_t + \delta_1 crisis_t + \delta_2 EUentry_t \\ & + \delta_3 q1_t + \delta_4 q2_t + \delta_5 q3_t + \epsilon_t \end{aligned} \tag{5.1}$$

$$\begin{aligned} logCITrevenue\_adj_t = \beta_0 &+ \beta_1 logCITbase_t + \beta_2 \Delta logCITbase\_lag_t \\ &+ \beta_3 \Delta logCITbase\_lead_t + \delta_1 crisis_t + \delta_2 EUentry_t \\ &+ \delta_3 q1_t + \delta_4 q2_t + \delta_5 q3_t + \epsilon_t \end{aligned} \tag{5.2}$$

$$\begin{aligned} logVATrevenue\_adj_t = \beta_0 &+ \beta_1 logVATbase_t + \beta_2 \Delta logVATbase\_lag_t \\ &+ \beta_3 \Delta logVATbase\_lead_t + \delta_1 crisis_t + \delta_2 EUentry_t \\ &+ \delta_3 q1_t + \delta_4 q2_t + \delta_5 q3_t + \epsilon_t \end{aligned} \tag{5.3}$$

The response variable stands for logarithm of the adjusted or non-adjusted tax revenue and is a function of the explanatory variables explained above. The estimate of the logarithm of the tax base represents the long-run tax revenue elasticity. To estimate the short-run tax revenue elasticities, we move to the second stage of our error correcting procedure with the second regressions looking as follows:

$$\begin{aligned} \Delta logPITrevenue\_adj_t = \beta_0 &+ \beta_1 \Delta logPITbase_t + \beta_2 \Delta logPITrevenue\_adj_{t-1} \\ &+ \beta_3 \epsilon_{t-1} + \delta_1 crisis_t + \delta_2 EUentry_t \\ &+ \delta_3 q1_t + \delta_4 q2_t + \delta_5 q3_t + u_t \end{aligned} \tag{5.4}$$

$$\begin{aligned} \Delta logCITrevenue\_adj_t = \beta_0 &+ \beta_1 \Delta logCITbase_t + \beta_2 \Delta logCITrevenue\_adj_{t-1} \\ &+ \beta_3 \epsilon_{t-1} + \delta_1 crisis_t + \delta_2 EUentry_t \\ &+ \delta_3 q1_t + \delta_4 q2_t + \delta_5 q3_t + u_t \end{aligned} \tag{5.5}$$

$$\begin{aligned} \Delta logVATrevenue\_adj_t = \beta_0 &+ \beta_1 \Delta logVATbase_t + \beta_2 \Delta logVATrevenue\_adj_{t-1} \\ &+ \beta_3 \epsilon_{t-1} + \delta_1 crisis_t + \delta_2 EUentry_t \\ &+ \delta_3 q1_t + \delta_4 q2_t + \delta_5 q3_t + u_t \end{aligned} \tag{5.6}$$

The response variable in our regression stands for the difference of the logarithms of the tax revenues between the current and the previous period. The estimate of the first explanatory variable, the difference of the logarithms of the tax bases between the current and the previous period, stands for the short-run tax revenue elasticity. The second explanatory variable, the lagged difference of the logarithms of the tax revenues between two consecutive periods, shall capture potential tax collection shocks. We also include the lagged Newey-West residual (Newey & West 1987) from the first step of our estimation to the regression, whose inverse value stands for the speed of the short-run elasticity adjustment towards its equilibrium value. Alternatively, we can explain the estimate of the lagged residual as a percentage of the difference between the equilibrium elasticity value and the actual value that is closed each period. Moreover, we again include dummy variables representing the remaining effects of Slovakia joining the European Union in 2004 and the Great Recession in 2008 and the seasonal dummies for the first three quarters.

As has already been said, the Newey-West residuals used (Newey & West 1987) are robust to autocorrelation, or alternatively serial correlation, thus they should reduce the inconsistency of the standard error estimates. Anyway, just to be sure, we test for potential autocorrelation. For this purpose we use the Durbin-Watson test.

Koester & Priesmeier (2012) said, that the long-run and the short-run elasticities give us only particular snapshots of the overall process of adjustment in time. So far we have found out the immediate response of the tax revenue to a change in the corresponding tax base - the short-run elasticity, the overall response - the long-run elasticity, and the estimates of the lagged residuals in the second regression also gave us a hint about the speed of the adjustment towards the long-run elasticity value, also called the equilibrium elasticity value. Still we do not know how the path of the adjustment exactly looks like. To find this, we have to construct a so-called impulse-response function. The impulse-response functions capture the response of an internal variable to an external impulse over a time holding all other effects constant. The internal variable in our case is the tax revenue and the external impulse is a change in the corresponding tax base. Inspired by Koester & Priesmeier (2012) and Havránek *et al.* (2016), we bootstrapped our model using 10,000 iterations to compute the impulse-response function and the 95% confidence interval for each of the

three tax categories studied.

Some authors, e.g. Wolswijk (2009) or Bruce *et al.* (2006) took an advantage of a long period of data available for their countries and studied the theory of an asymmetric behaviour of the short-run elasticities for different signs of the residuals from the first step of the error correcting procedure. According to this theory, the response of a tax revenue to a change in the corresponding tax base may vary for the "good times", i.e. when the tax revenue is above its equilibrium value, and the "bad times", when the tax revenue is below its equilibrium value. To test for the null hypothesis of zero difference between the "good times" and the "bad times", we generate a new dummy variable which equals 1 for the periods with a positive value of the residual and 0 for the periods with a negative value of the residual. Then we adjust our regression from the second step of the error correcting procedure for this dummy variable. The resulting regression looks as follows:

$$\begin{aligned}\Delta logPITrevenue\_adj_t = {} & \beta_0 + \beta_1 \Delta logPITbase_t + \sigma_1 GoodTimes * \Delta logPITbase_t \\ & + \beta_2 \Delta logPITrevenue\_adj_{t-1} + \beta_3 \epsilon_{t-1} + \sigma_2 GoodTimes * \epsilon_{t-1} \\ & + \delta_1 crisis_t + \delta_2 EUentry_t + \delta_3 q1_t + \delta_4 q2_t + \delta_5 q3_t + u_t \end{aligned} \tag{5.7}$$

$$\begin{aligned}\Delta logCITrevenue\_adj_t = {} & \beta_0 + \beta_1 \Delta logCITbase_t + \sigma_1 GoodTimes * \Delta logCITbase_t \\ & + \beta_2 \Delta logCITrevenue\_adj_{t-1} + \beta_3 \epsilon_{t-1} + \sigma_2 GoodTimes * \epsilon_{t-1} \\ & + \delta_1 crisis_t + \delta_2 EUentry_t + \delta_3 q1_t + \delta_4 q2_t + \delta_5 q3_t + u_t \end{aligned} \tag{5.8}$$

$$\begin{aligned}\Delta logVATrevenue\_adj_t = {} & \beta_0 + \beta_1 \Delta logVATbase_t + \sigma_1 GoodTimes * \Delta logVATbase_t \\ & + \beta_2 \Delta logVATrevenue\_adj_{t-1} + \beta_3 \epsilon_{t-1} + \sigma_2 GoodTimes * \epsilon_{t-1} \\ & + \delta_1 crisis_t + \delta_2 EUentry_t + \delta_3 q1_t + \delta_4 q2_t + \delta_5 q3_t + u_t \end{aligned} \tag{5.9}$$

The significance of the estimate $GoodTimes * logbase$ determines a difference in short-run elasticities for the "good times" and the "bad times" and the significance of the estimate $GoodTimes * \epsilon$ determines a different initial speed of the adjustment of the tax revenue towards the equilibrium value.

In the following chapter, we present the results of our estimation and give possible explanations of the values observed.

Chapter 6

Results

In the following chapter, I am going to present the results of the two-step error correcting procedure invented by Engle *et al.* (1987) with a closer detail available in the corresponding tables. While presenting the estimates for the long-run and the short-run elasticities, I am proceeding category by category, always showing the estimation results using both adjusted and unadjusted data. Then I am commenting on the differences between the two results and other important or interesting values and trying to come up with a possible explanation for the particular results.

Using the augmented Dickey-Fuller test, we were not able to reject the null hypothesis of non-stationarity for neither the tax bases, nor the adjusted and unadjusted tax revenues. Testing for cointegration, we have rejected the null hypothesis of no cointegration at 1% level for both adjusted and unadjusted data using both Engle-Granger test and Johansen test, which means that we can use the Engle's & Granger's error correction model.

6.1 Long-run Elasticities Estimation

In the first step of the procedure, we estimated the long-run tax revenue elasticities using DOLS and the Newey-West robust residuals. The results are following:

Considering the Personal Income Tax, we have obtained a long-run elasticity of approximately 0.98 using adjusted data, which is lower than the estimate we obtained from unadjusted data by 0.06. Both results are significant at 1%

level. We can interpret the results as follows: If we increase the tax base by 1%, the tax revenue will increase by 0.98%, which is lower than a proportional change. On the other hand, the estimate from the unadjusted data predicts higher than a proportional change. According to a progressive structure of the Personal Income Tax in Slovakia, we would expect the long-run elasticity to be slightly higher than 1, however we are not the only paper that estimated the long-run elasticity of a progressive tax revenue to be significantly below one. Bettendorf & Limbergen (2013) obtained similar results. A possible explanation for our result can be that a majority of our data comes from a period of a flat tax rate (2004-2012). Other possible explanations include tax evasion and a short period of data available.

A big difference between the results can be seen considering the dummy variable capturing the effect of Slovakia joining the EU in 2004. 2004, however, is not only the year of Slovakia joining the EU. It is also the year of the most extensive tax reform in the history of Slovakia, when the tax rates of all the three tax categories studied were set at a flat rate of 19%. Our dummy variable may therefore contain the effects of both Slovakia joining the EU and the tax reform. We do not have to be aware of this while using adjusted data, since the effect of the tax reform is already subtracted from the tax revenues. However, in the case of unadjusted data, the dummy variable stands for both effects. As can be seen, our theory is supported by the results. While in the case of adjusted data the corresponding estimate is significant at 5% level, we obtain a highly significant estimate with a t-statistics equal approximately -4.00, while using the unadjusted data. The negative signs of the estimates of seasonal dummies that capture the first three quarters can be explained by salary bonuses paid out to employees in the pre-Christmas season, i.e. the fourth quarter, yet these estimates are significant only in the case of the second quarter. This is probably because of the short period of data used.

Table 6.1: Long-run Elasticity - Personal Income Tax

	Adjusted	**Unadjusted**
log PITbase	0.978***	1.038***
	(0.160)	(0.146)
log PITbase_lag	-2.173	-0.808
	(1.522)	(1.038)
log PITbase_lead	-0.032	0.084
	(0.534)	(0.470)
crisis	-0.061	-0.013
	(0.087)	(0.075)
EUentry	-0.145**	-0.268***
	(0.069)	(0.065)
q1	-0.455	-0.107
	(0.397)	(0.256)
q2	-0.445***	-0.328***
	(0.159)	(0.099)
q3	-0.288	-0.130
	(0.208)	(0.140)
Constant	-8.416**	-9.831***
	(3.404)	(3.118)
N	64	64

**** p<0.01, ** p<0.05, * p<0.1*
Standard errors in parentheses.

In the case of the Corporate Income Tax, we observed a bigger difference between the estimates of using adjusted and unadjusted data. The long-run elasticity resulted to be equal to 1.28 using adjusted data and 1.16 using unadjusted data. Both results are significant at 1% level. If we compare this elasticity to the one of the Personal Income Tax revenue, we can infer, that Slovak government could increase its tax revenue more effectively if it focused on widening of the Corporate Income Tax base rather than the Personal Income Tax base. Focusing on widening of the Corporate Income Tax base and improving the tax collection instead of further increasing tax rate seems like a good idea also due to a fact, that Slovakia has the highest Corporate Income Tax rate among the members of the Visegrád Group (Remeta *et al.* 2015b).

Table 6.2: Long-run Elasticity - Corporate Income Tax

	Adjusted	**Unadjusted**
log CITbase	1.281***	1.165***
	(0.360)	(0.405)
log CITbase_lag	0.492	0.214
	(1.049)	(0.956)
log CITbase_lead	-1.786	-1.895
	(1.333)	(1.383)
crisis	-0.299*	-0.119
	(0.175)	(0.188)
EUentry	-0.143	-0.039
	(0.199)	(0.217)
q1	-0.428**	0.460**
	(0.199)	(0.175)
q2	-0.054	0.125
	(0.276)	(0.259)
q3	-0.394	-0.339
	(0.329)	(0.329)
Constant	-16.340**	-13.646
	(8.004)	(9.004)
N	64	64

**** p<0.01, ** p<0.05, * p<0.1*
Standard errors in parentheses.

The biggest difference between the estimates using adjusted and unadjusted data can be seen in the case of the Value Added Tax. Using adjusted data, we estimated the elasticity to be equal to 0.94, and using unadjusted data, we obtained elasticity of 1.16. Both estimates are significant at 1% level. Hence the same as for the Personal Income Tax, rising the tax base by 1% would bring us less than a proportional increase of the corresponding tax revenue according to the results from unadjusted data, and more than a proportional increase according to the results from adjusted data. This is an important finding, since using only unadjusted data might make government think, that increasing the tax base would lead to higher than a proportional increase in the tax revenue, even if it was not true.

Furthermore, in both cases we observed a negative effect of the Great Recession on the tax revenue, which corresponds to the decreased consumption in the period of the Great Recession. We obtained significantly negative estimates for all three quarters. The first and third quarter is significant at 1% level, the second quarter is significant at 5% level. This is again reasonable, because of increased consumption in the pre-Christmas period.

Table 6.3: Long-run Elasticity - Value Added Tax

	Adjusted	**Unadjusted**
log VATbase	0.944***	1.161***
	(0.226)	(0.233)
log VATbase_lag	0.996	0.807
	(1.176)	(1.170)
log VATbase_lead	0.263	0.339
	(0.940)	(0.973)
crisis	-0.120*	-0.171**
	(0.068)	(0.069)
EUentry	-0.081	-0.046
	(0.124)	(0.127)
q1	-0.264***	-0.255***
	(0.062)	(0.175)
q2	-0.130**	-0.122*
	(0.060)	(0.061)
q3	-0.209***	-0.205***
	(0.058)	(0.577)
Constant	-7.442	-12.440**
	(5.041)	(5.202)
N	64	64

**** p<0.01, ** p<0.05, * p<0.1*
Standard errors in parentheses.

6.2 Short-run Elasticities Estimation

In the second step of the procedure, we estimated the short-run elasticities using the lagged residuals from the first regression and got a closer look at the process of the tax revenue elasticity adjustment. The observed results are following:

Considering the Personal Income Tax, we observed a negative short-run elasticity of -1.51 for adjusted data and a positive value of 0.05 for unadjusted data. Both results are however insignificant and therefore statistically indistinguishable from one. The estimate of the lagged residual equals -0.94 in the case of adjusted data and -0.53 in the case of unadjusted data and it is statistically significant at 1% level in both cases. The negative value is favourable, because it tells us, that if the instantaneous value is above the equilibrium, the process of adjustment will push this value downwards and thus to the long-run equilibrium. Alternatively we could interpret this value as the speed of the tax revenue elasticity adjustment towards its steady state. Generally, the higher the absolute value of our estimate is, the faster the adjustment to the steady state is. In our case, the value of -0.94 means that the adjustment is really

fast and that we could say that 94% of the gap between the current value and the steady state vanishes within one period, i.e. three months. However, this interpretation is a little bit misleading in our case, since our regression also includes the lagged difference between the logarithms of the tax revenues for two consecutive periods, which also influences the speed of the adjustment. The estimate of this variable equals -0.06 for adjusted data and -0.14 for unadjusted data, yet it is insignificant in both cases. Because of the insignificance, we cannot conclude the precise speed of the adjustment now and we will come back to this issue in the next part of our analysis.

The value of the estimates for the European Union entry dummy variable and for the Great Recession dummy variable are statistically indistinguishable from zero for both types of data. We observed some significant estimates with negative values among our quarterly seasonal dummies, which is compatible with the period of salary bonuses in the pre-Christmas season.

Table 6.4: Short-run Elasticity - Personal Income Tax

	Adjusted	**Unadjusted**
Δlog PITbase	-1.508	0.050
	(1.050)	(0.739)
Δlog PITrevenue, lagged	-0.056	-0.137
	(0.142)	(0.149)
residual, lagged	-0.939***	-0.532***
	(0.215)	(0.182)
crisis	-0.033	-0.005
	(0.053)	(0.037)
EUentry	0.010	0.009
	(0.057)	(0.040)
q1	-0.569*	-0.156
	(0.306)	(0.216)
q2	-0.668***	-0.530***
	(0.107)	(0.081)
q3	-0.103	0.040
	(0.182)	(0.142)
Constant	0.376**	0.167
	(0.167)	(0.120)
N	62	62

**** p<0.01, ** p<0.05, * p<0.1*
Standard errors in parentheses.

In the case of the Corporate Income Tax, we estimated the short-run tax revenue elasticity of 3.51 and 3.26 using the adjusted and unadjusted data respectively. Both results are significant at 1% level and 5% level respectively.

The observed value is very high and it goes against our intuition, that the instantaneous response of the tax revenue to the change in the corresponding tax base should be smaller than the overall long-run response. We are, however, not the only paper that estimated the short-run elasticities to be higher than the long-run ones. Bettendorf & Limbergen (2013) estimated the long-run tax revenue elasticity to be equal to 0.89 and therefore significantly below one even though the Personal Income Tax in Netherlands is progressive, while the short-run elasticity was estimated to be equal to approximately one. The unreasonably high value we observed is probably a result of a weak relationship between the tax revenue and the corresponding tax base considering only a three-month long period, which points out another weak point of our dataset.

According to the estimate of the lagged residual with a value of -0.98 for adjusted data and -0.92 for unadjusted data, both significant at 1% level, we can conclude a fast process of adjustment towards the steady state. The speed of the adjustment is again influenced also by the lagged difference of the logarithms of the tax bases between the current and the previous period. The estimates of these variables equal 0.12 for adjusted data and 0.11 for unadjusted data and they are insignificant in both cases.

The effects of Slovakia joining the European Union and the Great Recession are again insignificant. Considering the seasonal dummy variables, the negative estimates for the second quarter and the third quarter are significant at 1% level and 5% level respectively for adjusted data and at 1% level and 10% level respectively for unadjusted data. The negative signs in comparison with the fourth quarter are again consistent with a period of higher spending and therefore higher corporate revenues in the pre-Christmas season.

Table 6.5: Short-run Elasticity - Corporate Income Tax

	Adjusted	**Unadjusted**
Δlog CITbase	3.506***	3.258**
	(1.214)	(1.239)
Δlog CITrevenue, lagged	0.118	0.107
	(0.129)	(0.130)
residual, lagged	-0.978***	-0.920***
	(0.179)	(0.173)
crisis	0.053	0.064
	(0.111)	(0.113)
EUentry	0.031	0.036
	(0.126)	(0.128)
q1	-0.004	0.019
	(0.212)	(0.216)
q2	-0.906***	-0.856***
	(0.295)	(0.301)
q3	-0.563**	-0.516*
	(0.271)	(0.276)
Constant	0.270	0.230
	(0.179)	(0.183)
N	62	62

**** p<0.01, ** p<0.05, * p<0.1*
Standard errors in parentheses.

In the case of the last category studied - the Value Added Tax, we again observed higher values for the short-run elasticities than for the long-run ones, but the differences are not as big as in the case of the Corporate Income Tax revenue elasticities. The estimated value of the short-run elasticity equals 1.93 and it is significant at 5% level in the case of the adjusted data. In the case of the unadjusted data, we observed a short-run elasticity of 1.67 significant only at 10% level. The higher than a proportional increase in the tax revenue can be explained by the following theory. The increase in a tax base is implied by a larger spending and this can be implied by increased welfare among the population. As a result, people decrease their consumption of basic commodities on which a lowered tax rate is imposed and they start purchasing more luxury goods instead.

As we expected, the estimates of the lagged residuals have negative values of -0.95 and -0.96 for adjusted and unadjusted data respectively and they are significant at 1% level in both cases. The speed of the adjustment towards the steady state is therefore again fast but also influenced by the lagged difference of the logarithms of the tax bases between the current and the previous period. The estimate of this variable is slightly positive, 0.08 in the case of the adjusted

data and 0.10 in the case of the unadjusted data, and insignificant in both cases.

The effects of Slovakia joining the EU and the Great Recession are also statistically indistinguishable from zero. As well as in the case of the previous two tax categories, we again observed some significantly negative values of the seasonal dummy variables. Namely, we observed significant estimates for the first quarter and the third quarter at 1% level using both adjusted data and unadjusted data. The negative values of the estimates correspond to the pre-Christmas period of an increased consumption.

Table 6.6: Short-run Elasticity - Value Added Tax

	Adjusted	**Unadjusted**
Δlog VATbase	1.927**	1.670*
	(0.900)	(0.913)
Δlog VATrevenue, lagged	0.085	0.103
	(0.129)	(0.133)
residual, lagged	-0.947***	-0.964***
	(0.179)	(0.184)
crisis	0.021	0.009
	(0.041)	(0.042)
EUentry	-0.005	-0.003
	(0.045)	(0.046)
q1	-0.476***	-0.478***
	(0.065)	(0.066)
q2	0.008	0.011
	(0.056)	(0.056)
q3	-0.289***	-0.290***
	(0.053)	(0.054)
Constant	0.162***	0.174***
	(0.050)	(0.051)
N	62	62

**** p<0.01, ** p<0.05, * p<0.1*
Standard errors in parentheses.

6.3 Testing for Autocorrelation

According to Newey & West (1987), the residuals used should be robust to autocorrelation. However, we rather decided to test for this properties, just to make sure.

For this purpose we used the Durbin-Watson test to test whether the error terms in our regressions follow an autoregressive process of order one. Since we have 9 variables estimated and over 60 observations, we used these values to find

the lower bound of 1.108 and the upper bound of 1.771 in the Durbin-Watson 1% significance tables. Generally, if the observed value of the test statistics is lower than the corresponding lower bound, we can reject the null hypothesis of no autocorrelation at 1% level. Secondly, if the observed value of the test statistics is higher that the upper bound we cannot reject the null hypothesis of no autocorrelation. And thirdly, if the observed value of the test statistics lies between the lower bound and the upper bound, the test is inconclusive. But conservatively, we should say that we cannot reject the null hypothesis. The values of the test statistics that we observed were higher than the upper bound or slightly lower than the upper bound, and therefore we cannot reject the null hypothesis of no autocorrelation. This is a favourable outcome for us.

6.4 Impulse-response Functions

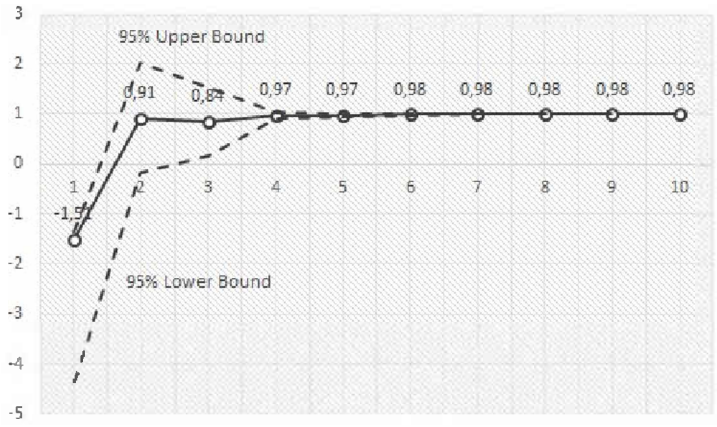
As a result of a difference between the estimates arising from adjusted and unadjusted data that has been proven in the section above, we are going to use only adjusted data in the remaining section of our analysis, since we do not consider the results arising from unadjusted data important anymore.

Now that we have found the long-run tax revenue elasticity, the short-run tax revenue elasticity and the approximate speed of the adjustment of the short-run elasticity towards the equilibrium, the only thing left we have to focus on, is modelling the exact path of this adjustment. Since the significant estimates of the short-run elasticities are lower than the long-run ones, the path of the adjustment may proceed in various ways. It may be decreasing during the whole adjustment process, it may be oscillating around its equilibrium value, it may be decreasing over a period and then start to oscillate, etc. To avoid speculations, we computed the impulse-response function and constructed the 95% confidence interval using the bootstrapping method with 10000 iterations.

Firstly, we look at the adjustment path of the short-run Personal Income Tax revenue elasticity. Unfortunately, our estimate of the short-run elasticity is insignificant, but we can comment on the observed adjustment process anyway. We observed a negative short-run elasticity of -1.51 and a long-run elasticity of 0.98. After one period, i.e. three months in our case, the elasticity increases to a value of 0.91, which means that approximately 97% of the gap between the short-run elasticity and the long-run elasticity closes within first three months.

In the second period, the elasticity slightly decreases to 0.84 and since then it quickly converges to its equilibrium value of 0.98, which is fully reached after approximately fifteen months. According to this information, the period of the adjustment seems quite long. This might be a little bit misleading and therefore we have to mention that the elasticity achieves a very close value to the equilibrium value already after nine months. The initial speed of the adjustment observed from the impulse-response function corresponds to the speed of the adjustment based on the estimate of the lagged residual from the second-step of the error correcting procedure, which equals 0.94. We can say this because, as has already been mentioned, the estimate of the lagged residual from the second stage of the error correcting procedure does not fully captures the speed of the adjustment due to lagged difference of the logarithms of the tax bases between the current and the previous period included in the regression. Additionally, we can say that the effect of the lagged difference mentioned on the speed of the adjustment is very low.

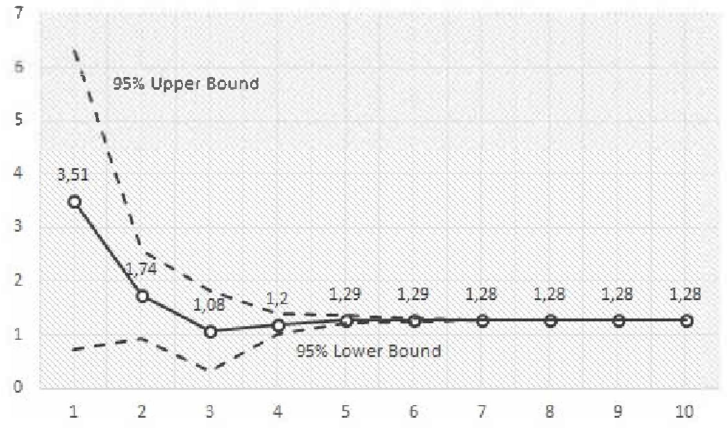
Figure 6.1: Impulse-response Function - Personal Income Tax



Secondly, we can proceed to the adjustment path of the Corporate Income Tax revenue. In this case, we observed both high long-run elasticity and even much higher-short run elasticity. The observed long-run elasticity equals 1.28 and the observed short-run elasticity equals 3.51. During the first three months, the elasticity decreases to 1.74, which means that approximately 79% of the gap between the short-run and the long-run elasticity is closed within the first three months. In the consecutive periods, the value of the elasticity alternately decreases and increases and thus oscillates around the equilibrium value. If we compare the initial speed of the adjustment from our impulse-response func-

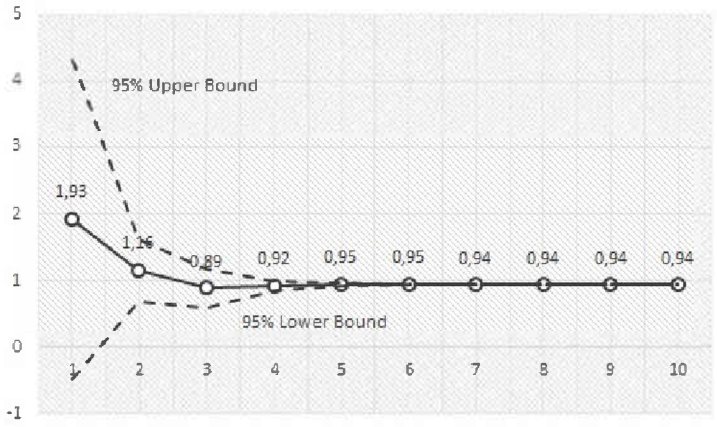
tion to the estimate of the lagged residual from the second stage of the error correcting procedure, which equals -0.95, we can say that the lagged difference of the logarithms of the tax bases between the current and the previous period included in the regression significantly decreases the speed of the adjustment. The time necessary for the elasticity to reach its equilibrium value is similar to the time in the case of the Personal Income Tax. The elasticity reaches value of 1.29 after approximately nine months and the equilibrium value of 1.28 after approximately fifteen months.

Figure 6.2: Impulse-response Function - Corporate Income Tax



Thirdly, we have a look at the impulse-response function for the Value Added Tax revenue. We observed a long-run tax revenue elasticity of 0.94 and a short-run tax revenue elasticity of 1.93 from the error correcting procedure. The percentage of the gap between the short-run and the long-run elasticity closed within the first three months equals approximately 78%, which is again lower than the estimate of the lagged residual observed in the second stage of the error correcting procedure. The elasticity proceed to its minimum value of 0.89 after six months and then it starts to oscillate towards the equilibrium value, which is reached after approximately a year and a half. The value of the elasticity, however, gets very close to the true long-run equilibrium value already after a year.

Figure 6.3: Impulse-response Function - Value Added Tax



6.5 Testing for Asymmetric Behaviour of the Short-run Elasticities

As the last step of our analysis, we got inspired by Wolswijk (2009) and Bruce *et al.* (2006) who studied asymmetric behaviour of the short-run elasticities and the initial speeds of the adjustment towards the equilibrium value during the "good times" and the "bad times", i.e. periods with the tax revenue above its equilibrium value and periods with the tax revenue below its equilibrium value. Unlike us, Wolswijk (2009) and Bruce *et al.* (2006) disposed of datasets capturing a long period of time, which allowed them to obtain a significant difference between the "good times" and the "bad times" in the case of the Corporate Income Tax and the Value Added Tax for Wolswijk (2009) and in the case of the Personal Income Tax and the Sales Tax for Bruce *et al.* (2006).

Probably also due to a short period of data that we have, we did not obtain any significant asymmetric behaviour in the case of the Personal Income Tax and the Value Added Tax, and therefore we can present a unique short-run tax revenue elasticity of 1.93 for the Value Added Tax from the second step of the error correcting procedure for all the periods as the conclusive result of our analysis. In the case of the Personal Income Tax, we unfortunately did not obtain a significant estimate of the short-run tax revenue elasticity.

Regarding the Corporate Income Tax, we did not find any asymmetric behaviour considering the initial speed of the adjustment of the tax revenue to-

wards its equilibrium value, but we obtained a significant difference of the short-run tax revenue elasticity in the case of the "good times" and the "bad times". The results are however a little bit hard to interpret, since the estimate of the short-run elasticity in the case of the "bad times" is insignificant. We can therefore only say that the difference of the short-run tax revenue elasticity between the periods of the tax revenue below the equilibrium value and above the equilibrium value equals 1.95 with a 5% significance level. However we cannot comment on the particular values of these two elasticities due to the insignificance.

If we left the high p-value out of consideration, we could say that the elasticity equals 2.05 for the "bad times" and 4.00 for the "good times". The value of the elasticity for the "good times" is quite close to the value of the short-run elasticity we obtained, when we did not control for the asymmetric behaviour. If we therefore combined the significant elasticity from the beginning of our analysis with the significant difference between the elasticities during the "good times" and the "bad times", we could say that the short-run tax revenue elasticity for the Corporate Income Tax in the case of the "good times" may be around 3.51 and in the case of the "bad times" may be around 1.56. Of course, we did not come to a perfect conclusion, speaking of accuracy, but still these numbers can give us a closer hint at the asymmetric behaviour of the short-run Corporate Income Tax revenue elasticity.

Table 6.7: Asymmetric Behaviour

	PIT	CIT	VAT
Δlog base	-1.984*	2.049	0.857
	(1.178)	(1.358)	(1.070)
GoodTimes*Δlog base	0.351	1.952**	1.939
	(0.405)	(0.970)	(1.204)
Δlog revenue, lagged	-0.071	0.177	0.100
	(0.148)	(0.128)	(0.127)
residual, lagged	-1.062***	-1.225***	-0.799***
	(0.286)	(0.239)	(0.258)
GoodTimes*residual, lagged	0.490	0.655	-0.612
	(0.536)	(0.476)	(0.478)
crisis	-0.045	0.076	-0.014
	(0.055)	(0.109)	(0.044)
EUentry	0.025	0.029	0.008
	(0.059)	(0.123)	(0.044)
q1	-0.656**	0.047	-0.511***
	(0.321)	(0.209)	(0.066)
q2	-0.703***	-0.872***	-0.004
	(0.193)	(0.288)	(0.058)
q3	-0.174	-0.555**	-0.315***
	(0.193)	(0.264)	(0.054)
Constant	0.402**	0.181	0.218***
	(0.173)	(0.185)	(0.058)
N	62	62	62

*** $p<0.01$, ** $p<0.05$, * $p<0.1$
Standard errors in parentheses.

6.6 Comparison of Results

Now that we are finished with our analysis, we devote this subchapter to a comparison of our results and the results of some of the authors using adjusted data and the two step error correcting procedure by Engle *et al.* (1987) like us. Namely these are Havránek *et al.* (2016) for the Czech Republic, Wolswijk (2009) for Netherlands and Koester & Priesmeier (2012) for Germany. To better understand the observed values, we should have a brief look at the tax systems of these three European countries.

The government of the Czech Republic heavily reformed the existing tax system and established the Personal Income Tax, the Corporate Income Tax and the Value Added Tax as a replacement for previously used tax categories after the separation of Slovakia and the Czech Republic in 1993. As a result of the reform, the Personal Income Tax was a progressive tax with six brackets with the corresponding tax rates varying from 15% up to 47%. The Corporate Income Tax had a flat tax rate of 45% and the Value Added Tax had a standard tax rate of 23% and a decreased tax rate of 5%. As time went by, the number

of tax brackets of the Personal Income Tax decreased as well as the upper tax rate. The lower tax rate remained almost constant over the time with only one exemption and that was a period between the years 2006 and 2007, when the rate was equal to 12%. The progressive structure of the Personal Income Tax was abolished in 2008 however a solidarity tax, which has a similar function as a progressive tax system, was established in 2013 and has been in force since then. The Corporate Income Tax structure has remained flat during the whole existence with its tax rate gradually decreasing over time and currently equal to 19%. Both the standard rate and the decreased rate changed few times and in 2015 two types of decreased rate equal to 15% and 10% were introduced. The standard rate equals 21% now (Jirsová 2014).

Unlike the Czech Republic, Netherlands have been disposing of a more stable and progressive tax system with higher tax rates. The tax rate setting for the Personal Income Tax is much more complicated than in the case of Slovakia and the Czech Republic. The personal taxable income is firstly divided into three boxes - income from work and home, income from substantial interests in companies and income from savings and investment, out of which the first box is taxed at a progressive rate and the others are taxed at a fixed rate of 25% and 30% respectively. The tax on the income from work has four brackets with the corresponding tax rates varying between 36.55% and 52% for an under AOW-age person and between 18.65% and 52% for the above AOW-age person. The Corporate Income Tax is also taxed progressively using two brackets with corresponding tax rates of 20% and 25%. The standard and the decreased Value Added Tax rate equals 21% and 6% respectively (PKF International Limited 2016b).

As well as Netherlands, Germany also has a long history of a progressive tax structure. The Personal Income Tax has currently four brackets with the corresponding tax rates varying from 14% up to 45%. The tax payers are additionally obliged to pay a so-called solidarity surcharge at a rate of 5.5%. If the tax payers are a married couple, they can count up their yearly taxable incomes and then follow the tax bracket distribution for married couples, where the thresholds between the particular tax brackets are twice as large as in the case of the tax brackets for individuals. In praxis this means, that a person with a yearly income belonging to a certain bracket can pay a tax rate of a lower income bracket, if the taxable income of his husband/wife is sufficiently low.

The Corporate Income Tax has a flat tax rate of 15%, but again the solidarity surcharge at a rate of 5.5% has to be paid. All business enterprises operating in Germany must additionally pay a Trade Tax with a tax rate varying from 7% up to 19.25% according to the orders of a particular municipality. The standard and the decreased rate for the Value Added Tax in Germany equal 19% and 7% respectively (PKF International Limited 2016a).

In the Table 6.8, we can see a comparison of the long-run tax revenue elasticities obtained by the chosen authors. In the case of the long-run elasticity, all the four authors obtained significant results at 1% level.

Because of a strongly progressive tax structure of the Personal Income Tax in Netherlands and Germany, we would expect the corresponding elasticities to be the highest among our group. This is true, as we can see in The Table 6.8. If we compare the elasticities for Slovakia and for the Czech Republic, the lower elasticity in the case of Slovakia might be surprising at the first sight, since unlike the Czech Republic, Slovakia has a progressive tax structure of the Personal Income Tax. On the other hand, the taxpayers in the Czech Republic with a taxable income above a certain level are obliged to pay an additional solidarity tax, which affects the tax revenue elasticity the same way as the progressive tax structure. Additionally, if we look at the datasets used for the estimation, we can see that fourteen years out of the nineteen year period used for the estimation in the case of the Czech Republic capture a period of a progressive tax rate structure, which is approximately 74% of the dataset. In the case of the Slovak dataset, this fraction only equals 44%. Due to a relatively long period of a flat tax rate in Slovakia, we find the lower value of the elasticity absolutely reasonable.

If we look at the Corporate Income Tax revenue elasticity, we would again expect the elasticities of Netherlands and Germany to be higher due to a progressive tax structure and a varying Trade Tax rate for the two countries respectively. The results are opposite and very surprising, especially the low value in the case of Germany. Authors themselves admit, that this values is much lower than values obtained in other German papers. Since Slovakia and the Czech Republic have never had a progressive tax structure in the case of the Corporate Income Tax, we would intuitively expect the elasticities to be around one. One of possible reasons, why it is not so, are various tax deductions that

make the flat Corporate Income Tax rate result into a progressive one in reality.

Considering the Value Added Tax revenue elasticities, we obtained values close to the values of other authors, which corresponds to the similarity of the Value Added Tax structure.

Table 6.8: Long-run Elasticities Comparison

	PIT	**CIT**	**VAT**
Slovakia, 2017	0.98***	1.28***	0.94***
Czech Republic, 2015	1.45***	1.69***	0.87***
Netherlands, 2009	1.57***	1.07***	0.90***
Germany, 2012	1.75***	0.77***	0.79***

The Table 6.9 shows values of the estimated short-run tax revenue elasticities. The comparison in this case is not as clear and straightforward, since some authors studied also the asymmetric behaviour, some did not, some estimates resulted to be insignificant, some resulted to be significant only at 5% or 10% level, etc. And generally, the obtained values are very dissimilar across the table. Since our estimate of the elasticity for the Personal Income Tax is insignificant, we do not think it makes any sense to compare it with estimates of other authors.

Considering the Corporate Income Tax, we obtained an uncommonly high short-run tax revenue elasticity in comparison with both our estimated long-run elasticity and the short-run elasticities of other factors. As we have already said, this is probably a result of using quarterly data that provide too short period to observe a true relationship between the tax revenue and the tax base in the case of the Corporate Income Tax.

Also the short-run elasticity for the Value Added Tax is higher than the long-run one in our case. However, we are not the only one who obtained a higher short-run elasticity than the corresponding long-run elasticity. The short-run elasticity for the Value Added Tax in the case of Germany is also lower, and so is the short-run elasticity for the Personal Income Tax in the case of Netherlands. Wolswijk (2009) states the low flexibility of employment in the short-run as a possible reasoning. We can explain the high value for the Value Added Tax revenue elasticity as follows. Increase in spending increases the Value Added

Tax base. The increase in spending can be implied by an increase in individuals' wealth. As a result of this, people will decrease a consumption of the basic goods on which the decreased rate is applied and start consuming more luxury goods instead. And if the people get very irrational in the short-run and change their consumption a lot, it can result in a high value of the short-run tax revenue elasticity for the Value Added Tax. This euphoria resulting from the increased wealth diminishes as the time goes by, and therefore also the elasticity decreases over time until it gets to its equilibrium value, which is lower than the instantaneous value.

Table 6.9: Short-run Elasticities Comparison

	PIT	**CIT**	**VAT**
Slovakia, 2017	-1.51	3.51***	1.93**
Czech Republic, 2015	0.31*	0.59	0.45
Netherlands, 2009	1.89***	0.64***/1.10***	0.12/0.90**
Germany, 2012	1.41***	0.43*	0.90***

Chapter 7

Conclusion

The main point of this master's thesis was to estimate the correct values for the Personal Income Tax revenue elasticity, the Corporate Income Tax revenue elasticity and the Value Added Tax revenue elasticity in Slovakia as a useful tool to better predict the tax revenue in the future that is often omitted in reality. Studying papers dealing with the same problem for other countries, we realized three crucial points.

Firstly, to obtain a true relationship between the tax revenue and the corresponding tax base, it is important to find as close proxy for the tax base as possible. Secondly, if we want to distinguish between the changes in the tax base resulting from macroeconomic changes and changes in tax policies, it is crucial to work with data adjusted for the effects of tax reforms and other tax changes. This point is especially important for emerging countries with a frequently changing tax system like Slovakia, however these countries also have the lowest probability of actively collecting this kind of data. Therefore, we were very lucky to obtain a new unique adjusted dataset, first of its kind, from the Institute for Financial Policy. Thirdly, if we want to fully understand the development of the tax revenue elasticity over time, we have to estimate both the short-run, also called instantaneous, tax revenue elasticity and the long-run, also called equilibrium, tax revenue elasticity. For this purpose, we used a two-step error correcting procedure developed by Engle *et al.* (1987). Additionally, we computed so-called impulse response functions to track the development of the tax revenue elasticities over time. As the last step of our analysis, we tested for a possible asymmetric behaviour of the short-run tax revenue elasticities for periods with the tax revenue above and below the equi-

librium value. The results were following:

In the case of the Personal Income Tax, we obtained a long-run elasticity of 0.98 significant at 1% level. Since the Personal Income Tax has a progressive structure in Slovakia, we would expect this value to be above 1. Still 56% of our dataset captures a period of a flat tax rate, which probably pushes the value of the elasticity downwards. The estimate for the short-run tax revenue elasticity was unfortunately insignificant.

In the case of the Corporate Income Tax, we obtained a long-run elasticity of 1.28. Because the Corporate Income Tax has disposed of a flat tax rate during its whole history since the separation of Slovakia and the Czech Republic, the most probable value of the elasticity would be around 1. However, particular tax deductions may influence the tax revenue elasticity in a similar way as the progressive tax structure, which results in an increased tax revenue elasticity. Considering the short-run tax revenue elasticity, we obtained an unusually high value of 3.51, probably resulting from a fact that a three month period is too short to show the true relationship between the tax revenue and the corresponding tax base.

The estimate for the long-run tax revenue elasticity in the case of the Value Added Tax equals 0.94 which is close to the values obtained in other papers. In the short-run, we obtained a tax revenue elasticity to be equal to 1.93, which is higher than the long-run estimate. We can explain this high value by a decreased consumption of basic goods on which the decreased rate is implied and thus an increased consumption of more luxury goods as a result of increased wealth which increases the Value Added Tax base. We also expect this euphoria to diminish as times goes by, which results in a lower tax revenue elasticity in the long-run.

Computing the impulse-response functions, we also studied the adjustment process of the short-run tax revenue elasticities towards their equilibrium values. We found the fastest process of adjustment for the Personal Income Tax. In this case, the process of adjustment lasts approximately fifteen months, however the value of the elasticity gets very close to its equilibrium value already after nine months. The adjustment process in the case of the Corporate Income Tax lasts a little bit longer. The elasticity reaches its value after approximately

eighteen months, however a value very close to the equilibrium value is reached already within one year. The adjustment process takes the same time also in the case of the Value Added Tax too.

As the last step of our analysis, we tested for a possible asymmetric behaviour of the short-run tax revenue elasticity in the "good times" and the "bad times", i.e. in the periods with a tax revenue above its equilibrium value and the periods with a tax revenue below its equilibrium value. In this task we were highly limited by the short period of data available, still we found a significant asymmetric behaviour in the case of the Corporate Income Tax. Unfortunately, we cannot tell exact values of the short-run tax revenue elasticities in the "good times" and the "bad times" due to insignificance. We can only tell that the difference between these two values equals approximately 1.95.

Taken together, we were the first to ever carry out an estimation with a further analysis of the tax revenue elasticities for Slovakia and additionally, we did it with data adjusted for the effects of tax reforms and other tax changes, which is a very unusual approach in the case of the countries of Central and Eastern Europe. However, we are still aware of the limited possibilities arising from a relatively short period of data available. It would definitely be valuable to repeat this kind of analysis with a bigger dataset in a few years, which would probably increase the significance of the short-run estimates and let us test for the asymmetric behaviour in a more proper way.

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