Charles University in Prague

Faculty of Social Sciences
Institute of Economic Studies

MASTER THESIS

The importance of tax system structure for economic growth in OECD countries – Extreme Bounds Analysis

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Declaration of Authorship

The author hereby declares that he compiled this thesis independently, using only the listed resources and literature, and the thesis has not been used to obtain a different or the same degree.

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Prague, December 30, 2014

Signature

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Abstract

The thesis examines the importance of tax system structures for economic growth in OECD countries. It aims to find out whether a revenue-neutral tax reform can promote economic growth. In other words, its objective is to identify taxes which are most harmful for economic growth and suggest tax policy implications accordingly. The extreme bounds analysis is employed to examine the robustness of relationship between particular taxes and the growth rate. This method consists in running a number of regressions and observing how the coefficients respond to various model alterations. The results suggest that taxes levied on personal income have a robust negative impact on economic growth. On the other hand, consumption and property taxes appear to be non-significant predictors of economic growth. The policy implication is drawn that a revenue-neutral tax reform shifting the tax burden from personal income towards consumption and property is likely to boost the economy.

JEL classification: H21, H24, H27, O11, O47

Key words: tax system structure, economic growth, extreme bounds analysis, tax reform

Abstrakt

Diplomová práce zkoumá význam struktury daňových systémů pro ekonomický růst v zemích OECD. Jejím cílem je zjistit, zdali příjmově neutrální daňová reforma může významněji podpořit ekonomický růst. Jinými slovy, práce identifikuje typy daní, které nejvíce škodí růstu ekonomiky a vyvozuje návrhy vhodných daňových reforem. K analýze robustnosti vztahu mezi jednotlivými typy daní a růstem je použita metoda extreme bounds analysis. Tato metoda spočívá v opakovaném provádění růstových regresí, přičemž je sledováno chování klíčových proměnných v reakci na změny ve specifikaci modelu. Výsledky naznačují, že zdanění práce má významný negativní dopad na ekonomický růst, zatímco vliv spotřebních a majetkových daní se nezdá být robustní. Na základě zjištění je navržena příjmově neutrální daňová reforma, která by část daňového břemene přesunula z příjmu zaměstnanců na spotřebu či majetek.

Klasifikace JEL: H21, H24, H27, O11, O47

Klíčová slova: struktura daňového systému, ekonomický růst, extreme bounds analysis, daňová reforma

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Acronyms

BACE	Bayesian Averaging of Classical Estimates
CDF	Cumulative Distribution Function
CTPA	Centre for Tax Policy and Administration
EBA	Extreme Bounds Analysis
GDP	Gross Domestic Product
HDI	Human Development Index
LEB	Lower Extreme Bound
M2	Monetary Aggregate
OECD	Organization for Economic Cooperation and Development
R&D	Research and Development
UEB	Upper Extreme Bound
VIF	Variance Inflation Factor

Master Thesis Proposal

Author:	Bc. Petr Choutka
Supervisor:	Ing. Irena Kemény
Defense Planned:	January 2015

Proposed Topic:

The importance of tax system structure for economic growth in OECD countries – the Extreme Bounds Analysis

Topic Characteristics:

Every year governments have to decide what sources they use to finance their expenditures. One of the crucial aspects involved in decision making is that raising taxes generally undermines economic growth. Not only the total tax burden but also the structure of the tax revenue may play an important role. Finding taxes which are most harmful to the economic growth could be of major importance for policy makers. Also, I would like to find out whether tax progressivity matters.

The theoretical motivation for this research is the idea that all taxes are not equally distorting. As Widmalm (1999) points out, among other examples, in case of highly inelastic labor supply neither tax on labor nor tax on consumption affect individual´s decisions and leave growth rate unaffected.

So far authors have focused on the impact of total tax revenue as a share of GDP on the economic growth. Koester, Kormendi (1989) found a significant negative correlation between economic growth and average and marginal tax rates. However, there has been little attention on what the taxes are imposed on. One of those few papers was written by Lee and Gordon.

Lee, Gordon (2005) explore how tax policies affect growth rate during 1970 – 1999. They include corporate tax rates, personal tax rates and overall tax rates as proxies of the tax policy. I would like to expand on their work by including tax progressivity as a potential factor of economic growth. Also, I would like to test whether the relative contribution of individual taxes (personal tax, corporate tax, property tax, VAT) to the total tax burden is a significant determinant of growth.

I choose OECD countries to form the sample for testing my hypotheses. The advantage of using OECD data is that annual data are available for all countries. While Lee, Gordon (2005) had to use averages due to lack of data for some countries, the OECD database allows us to treat the data as panel data

Hypotheses:

1. Hypothesis #1: Countries with higher tax burden tend to experience slower growth.
2. Hypothesis #2: Composition of a tax mix is important for predicting economic growth.
3. Hypothesis #3: Tax progressivity is a significant determinant of economic growth.

Methodology:

First, I will go through numerous papers focused on determinants of economic

growth. I will turn my attention especially to those dealing with OECD countries and not so much to those focusing on developing countries.
I will start with the specification of the growth equation which follows from the standard neo-classical growth model and is extended by variables representing human capital, R&D and quality of institutions. Among others, I will follow Mankiw (1992), Barro (1996) and Bassanini, Scarpetta (2001) to choose independent variables.
Then, I will include variables representing the characteristics of the tax system which include tax revenue as a share of GDP, shares of different taxes on the total tax revenue and index of tax progressivity.
Widmalm (1999) points out that the empirical growth literature does not care much about the sensitivity of proposed determinants to the inclusion of other variables. I will follow his approach and conduct so called extreme bounds analysis (EBA) which was described in Leamer (1983). First, I will run a regression only on a set of base variables in addition to the tax variables. Then, I will re-estimate the model after adding some additional variables. If the estimated coefficient of the tax variable remains to be significant, the correlation is said to be robust. If not, the correlation is considered as fragile and not very reliable. Two–stage least squares estimation will be used to allow for reverse causality.
I will use OECD database as my data source. The sample will be formed by all OECD countries and the observation period is 1990 – 2012.

Outline:

1. Motivation: Little research has been made on the importance of the structure of tax systems for economic growth. Distortion effects of individual taxes have been theoretically described but any relevant evidence is scarce.
2. Literature: I will summarize the literature focused on the tax structure in relation to the economic growth and describe how authors have approached this issue so far.
3. Data: I will describe how and where I gathered all necessary data
4. Methods: I will conduct extreme bounds analysis to figure out whether the average tax rate is significant and robust determinant and whether shares of individual taxes matter. In order to account for reverse causality, I employ a two-stage least squares estimator.
5. Results: I will describe the results with the stress on significant variables. I will draw a comparison between my results and previous papers.
6. Conclusion: I will summarize the findings and try to find some policy implications.

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Author **Supervisor**

1 Introduction

The objective of this paper is to examine the importance of tax system structure for economic growth in OECD countries. Authors dealing with relationship between taxes and economic growth have paid a lot of attention to the effect of the size of government on growth but much less to the fashion in which government revenue is generated and spent. Existing literature describes many channels through which taxes create distortions and also channels through which the generated revenue enhances economic growth. However, the structure of the tax systems is not accounted for. The author aims to find out what type of taxes inhibits economic growth most strongly and what type is the least harmful for economic activity. In other words, I am interested if a revenue-neutral tax reform may have impact on growth of output.

Papers dealing with the analysis of determinants of economic growth have always faced the challenge of choosing the right variables which are significant predictors of economic growth. As Sturm and Haan (2005) point out several models may all appear reasonable to analyze the data, but yield different results about the parameters of our interest. Levine and Renelt (1992) found that conclusions from almost all then existing studies are fragile. They claim that most papers deal with a limited number of variables with the aim of finding really strong relationship between a certain explanatory variable and growth. Finally, they argue that there is little guidance provided by economic theory as to how to specify the model and which variables to include.

One of the methods which deal with the issue of searching for the right model is called Extreme Bounds Analysis (EBA). This procedure was first described by Leamer (1983) and later applied by Levine and Renelt (1992) or Sala-I-Martin (1997) in their papers focused on robustness of econometric models. This method consists in running various models and examining how the parameters of key variables respond to changes in model specification. The relationship between variables of our interest and economic growth is considered to be robust if the parameter remains of expected sign throughout various alterations to the model.

As there are contradictive or inconclusive findings in the existing literature on significance and robustness of tax variables, EBA is an ideal solution to the problem of selecting the right variables for the given empirical model. Two methods are employed to examine robustness of the tax variables – the original version of EBA

developed by Leamer (1983) and the altered version introduced by Sala-I-Martin (1997).

First, I introduce the issue of growth and taxation by summarizing theory and existing literature. Second, I describe the motivation for employing EBA to check robustness and specify the empirical model. Then, I introduce variables included in the model and justify their presence in the regression. After that, I apply the EBA on cross-sectional data, pooled cross-sections data and panel data. After conducting the EBA, conclusions are drawn a policy implications derived.

2 Taxes and economic growth

2.1 General remarks

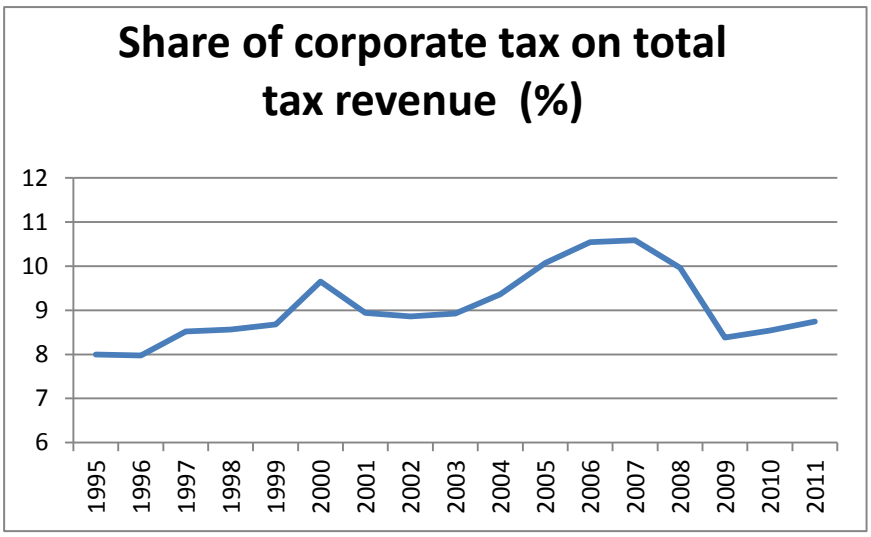
In all OECD countries governments play a vital role in addressing social and economic concerns. By imposing taxes on economic agents governments secure sources to finance their expenditures. The overall level of taxation and composition of the tax structure effects decisions made by households and firms. Households make decisions on levels of savings, consumption, labor supply or investment in education, whereas firms make plans on investment projects or number of jobs created. Governments are aware of the importance of efficiently arranged tax systems and most of them have undertaken substantial structural reforms in their systems. An ideal tax system is designed in such a way that rates of personal income taxes encourage savings, investment, starting new businesses and also motivates individuals to work. Levels of corporate taxes should promote competition and not induce distortions.

Besides levels of overall tax burden it is crucial to consider structures of individual tax systems. Most OECD countries rely on three main sources of tax revenues: personal income taxes including social security contributions, corporate income taxes and taxes imposed on goods and services. Property taxes do not play a significant role in total tax revenues but they are also considered as a potential significant factor in this paper. In the last few decades the general trends of tax systems in OECD countries suggested that revenue share of taxes levied on corporate income have been roughly constant. Figure 1 depicting OECD average share of corporate tax on total tax revenue confirms the trend as there is not a significant change in the pattern. On the other hand, the downward-sloping trajectory of share of the personal income tax on total tax revenue (see Figure 2) suggests there is a trend of reallocating the tax burden away from personal income.

In case of indirect taxes, the share of consumption taxes imposed on specific goods and services in total revenues has declined whereas general consumption taxes were employed to broaden the range of goods and services being subject of taxation. The

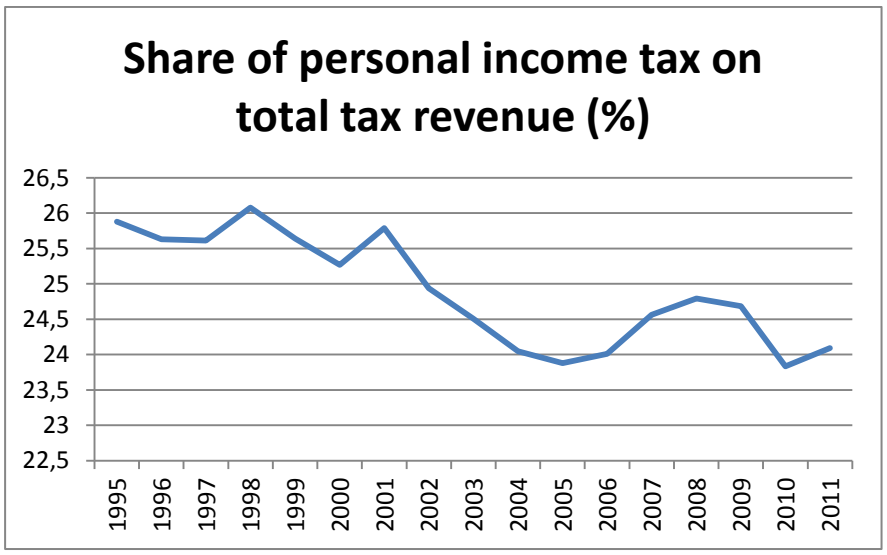
reason is that broadening the base of consumption taxes is more efficient way of generating the same revenue than imposing higher rates on limited amount of goods which may result in growth of the shadow economy. There has been a limited tendency to spread the tax burden to immovable property which poses less tax distortions for the economy. Due to their unpopularity and the fact that they are usually raised by sub-national governments, taxes on residential property have remained a minor source of tax revenues.

Figure 1. Share of corporate tax on total tax revenue – average share for all OECD countries



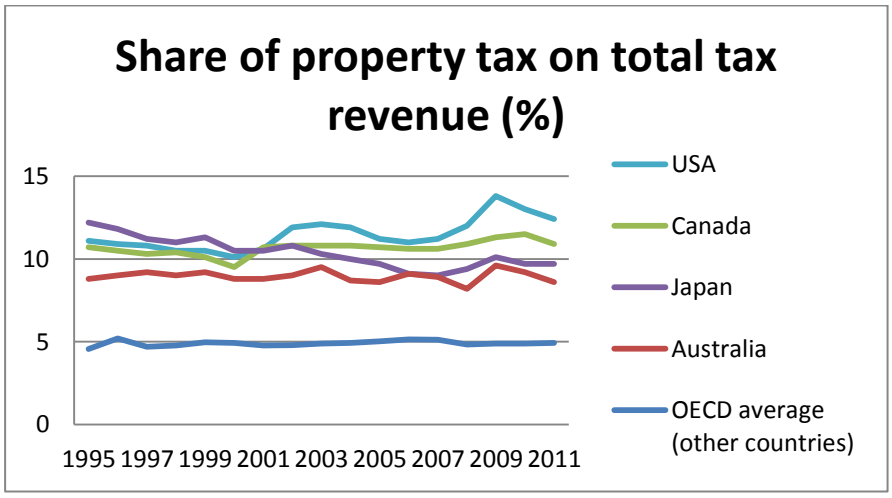
Source: OECD database, author´s calculations

Figure 2. Share of personal income tax on total tax revenue – average share for all OECD countries



Source: OECD database, author´s calculations

Figure 3. Share of property tax on total tax revenue



Source: OECD database, author´s calculations

2.2 Theory

In neoclassical growth models tax structure determines an equilibrium ratio of capital and labor but it does not have any permanent effects on growth rate. But changes in the tax structure imply a shift in the equilibrium value and thus it has transitory growth effects. This argument is supported by findings made by Karras (1999) who shows that higher tax rate permanently reduces the level of output but has no permanent effects on economic growth rate. Thus he proves that the relationship between taxation and growth is best described by the neoclassical framework. Hall and Jorgenso (1966) show that lower effective tax rates are likely to contribute to short-run economic growth caused by a surge of new projects as a response to lower taxation. However, the long-run growth depends on investment in human capital which may be enhanced by higher financial sources obtained by taxation. On the other hand, Heckman et al. (1998) argues that if the financial means are gained through taxation of labor there is a factor which may discourage individuals from education.

There has also been some literature investigating the effect of tax structure on entrepreneurial activity. Cullen and Gordon (2002) show that there are more channels through which tax rates influence risk-taking of entrepreneurs. First, if the effective tax rate on labor income is higher than on income from business activity there is a tax encouragement to starting a new business. Gentry and Hubbard (2000) emphasize that progressivity of the tax system plays a vital role in risk-taking. If the

entrepreneur suffers losses he will be pushed into a lower tax bracket and thus saves money in taxes. On the other hand, profits cause the entrepreneur to move into a higher tax bracket and pay higher tax rate. Also, higher personal taxes pose an incentive to self-employment due to the easier tax evasion. Value-added taxes are considered as less distortionary but they also may discourage risk-taking. If a firm undertakes an unsuccessful project resulting in a negative value added it might have difficulty in receiving a value-added tax rebate from the government.

2.3 Growth models and tax policy

In order to examine the effect of taxation on economic growth, it is vital to consider existing growth models. In economic theory, we basically distinguish two kinds of growth models – exogenous and exogenous. First exogenous growth theories were developed in papers by Solow (1956) and Swan (1956). The so called Solow-Swan model works in the framework of the neoclassical economics and is based on a production function with only two inputs – capital and labor. In this model, growth can be achieved by capital accumulation. However, there is a limit to the generation of growth since we assume productivity of capital to be diminishing. Therefore, exogenous change must come as a technological progress. In other words, labor and capital increase their productivity over time. As the engine of growth in this model is exogenous, the growth rate cannot be by definition affected by government policy. In order to analyze the impact of policy, one needs to work with endogenous growth models as they are able to explain changes which occur through affecting choices made by agents in the economy.

Endogenous growth models analyze various routes through which sustained growth can be achieved. First, one can assume constant returns to capital being the only factor in the production function which will lead to growth rate identical to net amount invested in capital. More complicated growth models include two factors in the production function – physical and human capital. As opposed to labor, human capital can be raised significantly by investment in education and training of workers and thus promote economic growth. Famous models incorporating physical and human capital were developed by Barro, Mankiw and Sala-i-Martin (1992) or Lucas (1988). Another vital determinant of economic growth is technological progress which can take the form of better inputs into the production function. Such an improvement occurs through expenditures on research and development done by firms thriving to exploit market opportunities resulting from successful innovation.

2.4 Optimal taxation

A simple static economy with no products being substitutes or complements to other products, taxation would not be a big issue. In such a case, Ramsey rule can be applied to find the optimal taxation policy, according to which the tax should be equal to the inverse price elasticity of demand. However, taxation affects not only intra-temporal choices but also may pose an incentive to invest, in other words to postpone consumption for later periods. Economic agents make the decision based on tax rate imposed on capital. Existing theoretical models come to different conclusions regarding the capital tax. Models assuming households living for finite horizons conclude that a positive tax on capital is optimal. On the other hand, zero capital tax is optimal for households with infinite horizons – an assumption which may be acceptable if previous generations care about consecutive ones. However, zero tax on capital is not present in most countries. Lucas (1990) analyzed endogenous growth models with respect to investment in human capital. He used US data to demonstrate what growth would have been achieved if there had been no tax on capital and the government revenues would have been raised by higher tax on labor instead. Such a change would result in an immense level effect – due to the fact that the new tax does not cause distortions to the economy. However, no growth effect was observed. King and Rebelo (1990) apply the experiment made by Lucas to open economy and find out that increase in the capital tax is a significant deterrent of economic growth. Moreover, they find this effect to be much stronger in open economies. Jones, Manuelli and Rossi (1993) examine the effect of elimination of all taxes. Assuming an elastic labour supply, they find a strongly significant impact of taxation on growth. Growth rate is reduced by two percentage points due to distortionary effects of taxes.

2.5 Tax progressivity and growth

Progressivity of tax systems is often used by governments to distribute the tax burden more fairly. Progressive income tax is part of tax codes in most countries. Even if the tax rate is the same for all regardless of their income, there is often more or less complicated system of tax allowances which make the income tax de facto progressive. The tax code in the Czech Republic offers a child tax credit, tax deduction for a jobless or low-earning spouse or for money spent on life insurance. As these tax deductions and credit are expressed in absolute terms, i.e. each income earner is allowed to deduce the same amount from their tax liability these allowances make the tax system progressive. The effect of tax progressivity on economic growth has attracted attention as politicians from both sides of the spectrum have been searching for arguments supporting their views.

In order to examine the role of tax progressivity in economic growth, one needs to understand the concepts of average and marginal tax rates. Marginal tax rate can be defined as the tax rate applied to the last unit of the income. In progressive tax systems, marginal tax rates are higher than average tax rates. In other words, every additional unit of income is taxed more. As opposed to the average tax rate, the marginal tax rate can be decreased without affecting government revenues raised through taxes. Koester and Kormendi (1989) conducted a thorough cross-country analysis which aims to identify the effect of average and marginal tax rates on growth of economies. They are interested not only in the growth rate but also in level of economic activity. Concerning the level of economic activity, they argue that one needs to account for endogeneity of average tax rates to GDP per capita (as a result of higher government activity financed by tax revenues). Moreover, there is an interaction between this endogeneity and the fact that economic growth is negatively related to GDP per capita. It has been shown that failure to account for this interaction may lead to a wrong conclusion that higher taxes reduce rate of economic growth. Once this interaction is taken into consideration, empirical evidence shows no impact of either average tax rate or marginal tax rate on economic growth. However, it has been shown that marginal tax rates have a significant effect on level of economic activity once average tax rates are controlled for. Assuming that this hypothesis holds, reduction in tax progressivity should bring the economy to a higher growth path. To obtain a measure of progressivity, I follow Widmalm (1999) and set up the following regression:

$$lnTAX_t = \beta_0 + \beta_1 lnGDP_t + \varepsilon_t$$

Where TAX stands for tax revenues and GDP stands for the gross domestic product for a given country in a given year. Both variables are in national currencies and constant prices. By estimating this regression I obtain elasticities of tax revenue with respect to GDP. As Widmalm (1999) points out this estimation is based on the assumption that there have not been significant tax reforms during the examined period. As the period ranges from 1995 to 2011, the former communist economies have already undertaken the most significant changes in their tax systems. This justifies the usage of the estimation to obtain a measure of tax progressivity.

2.6 Trends in OECD countries

According to the study published by the OECD Economics Department and the OECD Centre for Tax Policy and Administration, there are three major sources of revenue which OECD countries rely on – income taxes (both personal and corporate),

social security payments and consumption taxes. In the recent decades, one could observe a significant shift of tax burden from personal income to corporate income and social security contributions. In case of consumption taxes, the general value added tax imposed on all goods has increased in order to make up for loss of revenue resulting from shrinking range of goods being subject to specific tax treatment. At the same time, income tax has become flatter meaning that the taxes on top incomes were cut as opposed to tax burden of average workers which remained more or less the same.

The study published by OECD draws some implications from trends observed in targeted countries and suggests tax codes amendments which could promote economic growth. It even contains a ranking based on how distortive the individual taxes are in terms of their impact on GDP in the long run. Taxes on immovable property are considered as having the least significant impact followed by consumption taxes, corporate income and personal income taxes. Therefore, an optimal reform for OECD countries would be a shift of tax burden from corporate and personal income to subjects being less prone to distortions. Obviously, there is a space for such amendments as immovable property plays a minor role in generating tax revenues. From 1995 to 2011, only 5% of tax revenues have been collected through property taxes on average in OECD countries. Only the United States, the United Kingdom, Australia, Switzerland and Japan generated on average between 8 and 11 percent of total tax revenues. Taxes levied on immovable property play even less significant role than on other assets. This is caused mainly by combination of two facts – levels of property taxes are often determined by local authorities and they are very unpopular.

As income taxes clearly cause greater distortions to the real economy, a shift of tax burden from income towards consumption would likely result in higher growth rates. However, similar to taxes on immovable property, raising taxes on goods and services might not be politically popular. As opposed to income taxes which can be designed in a progressive fashion, consumption taxes take a higher proportion of income from low-earning households. Therefore, such a tax reform would make the tax system less progressive which is not likely to be politically desirable. If the shift occurred from corporate tax to consumption tax, the result would be higher inequality through higher share prices.

As OECD study points out, a tax reform does not have to consist in shifting tax burden from one kind of tax to another. Instead, it is possible to make the tax system more efficient and generate higher revenues at the same time by broadening the tax

base. Excessive tax rates and wide range of tax exemptions is are prerequisites for growth of shadow economy. Thus, an ideal reform for countries which do not aim for greater tax revenues would consist in broadening the tax base and cutting tax rates without affecting the revenues collected through taxes. As for changes only within the groups of income taxes, there is recommendation that tax burden should shift from corporate income to personal income. However, this creates an incentive for top income earners to leave their funds inside corporations where they face lower tax rate.

Also, a suitably designed tax system can be a very powerful tool for utilization of various engines of growth. In order to attract foreign direct investment, corporate tax rates should be decreased, while higher tax on dividends and capital gains can serve as a compensation for lost tax revenues. Making the tax system free of exemptions and levying the same tax rate on all assets may prevent inefficient allocation of capital resulting from tax distortions. Most importantly, uncertainty and unpredictability of economic environment are likely to be among the most important factors taken into consideration by potential investors. Therefore, frequency of changes in structure of the tax system may be more relevant than actual tax rates.

Another determinant of economic growth affected by design of tax system is labor. The ideal adjustment of taxes levied on labor is based on whether the aim is to promote the proportion of people employed or to create an incentive for employed people to work more hours. If the former goal is to be achieved, then average tax rates need to be reduced, while the letter objective can be reached by decreasing marginal tax rates. However, a reduction of marginal tax rates contributes to greater income inequality. Most importantly, these changes must reflect specific conditions such as rate of unemployment or current minimum wage.

2.7 Government and growth

Nowadays, governments are responsible for providing a vast range of services to its citizens. Taxes on various economic activities are levied to finance the services, some of which can have positive effect on economic growth. Therefore, distortionary effects of taxes are accompanied by impulses created by government spending. A wise forward-looking fiscal policy can redirect resources towards areas crucial for long-term prosperity such as education, research and development or infrastructure. However, there are different views on the relationship between overall government spending and economic growth. There is the famous “Wagner´s Law”, according to which the level of government spending tends to grow along with the national income

so that the relative size of government does not change. This view implies that government spending is considered as a result of economic growth rather than its determinant. On the other side of the spectrum, there is the Keynesian approach treating public expenditures as an exogenous variable which can be used as an efficient policy instrument for boosting growth at times of economic hardship.

So we can see that the causality between government spending and economic growth can work in both directions. The evidence for both statements is rare. Beck (1982) finds some evidence for the existence of Wagner´s Law, while Martinez-Mongay (2002) show that public spending positively impacts income per capita. However, it is obvious that composition of the expenditures matters more than the overall level - various determinants have been stressed as key drivers of growth such as investment in human capital (Lucas), research and development (Romer) or infrastructure (Barro). In any case, it would be short-sighted to assume that growth is the only outcome government is focused on. Redistributions of resources to reduce gaps in economic outcomes of various agents in the economy, reallocations aimed at increasing efficiency or attempts to achieve macroeconomic stability are often behind public spending policies.

It is important to point out that this paper does not consider the composition of government spending which is vital for encouraging economic growth. Well targeted policies in areas such as R&D, education or health may contribute significantly to productivity growth. Lucas (1988) shows that investment in education can generate positive externalities, while De Long and Summer (1991) provide evidence that investment in equipment results in positive spillovers. However, the model accounts for some variables which can reflect fiscal policy priorities (research and development spending or tertiary education attainment).

2.8 Historical trends

After the countries were badly hit by the Great Depression in 1930 with catastrophic social consequences, state interventions began to take place. Since then, earned income has been transferred from the high-paid to the low-paid employees. A complex system of social benefits has been developed in order to provide for the unemployed people, retired people or people with disabilities. Banks and other finance institutions became subjects of financial regulation which should reduce the risk of troubles in the financial sector with the potential of hitting the whole economy. Also, key industries have been very often under control of the government. Key macroeconomic variables such as inflation or rate of unemployment were

considered as factors which are not given but can be manipulated through various tools of monetary and fiscal policy. As the capitalist economies grew significantly after the WWII, the positive impact of an interventionist state was rarely questioned.

With the economic slowdown seen in the 1970s and 1980s critics started to argue that the sizeable ever-present government is the main reason of stagnating economies. The critique has not been focused on the government objectives themselves but on the tools which are employed to achieve the objectives. As Katz, Mahler and Franz (1983) point out, it was often claimed that every government expense represented a transfer of money from the inherently productive private sector to the inherently unproductive public sector. Therefore, the amount of resources available for implementation of creative ideas by private enterprises is reduced. However, the evidence supporting the critique described above is quite scarce. Also, there is a reason why the evaluation of the benefits of state interventions is a perilous task. Although the econometrics apparatus is able to detect significant determinants of economic growth, it can hardly incorporate the non-quantifiable standards of freedom or equality which play a crucial role in design of economic policies.

Conservative critique is often based on the idea that the presence of government in the economy is a major obstacle to stronger economic performance. It claims that if the economy is relieved from the huge burden, growth will follow automatically. On the other hand, opponents from the liberal or social democratic background share the view that government intervention is necessary to remove the weaknesses which are inherently embedded in the capitalist system dominated by private sector. In addition, they even argue that the state intervention is vital for survival of the capitalist system itself. The main driving factor behind actions of economic agents is profit generation. Firms and households consider all viable options and choose the one, based on the available information, which appears to be most profitable. In free market economy, output and incomes are determined by the market, i.e. by interactions of various economic agents who seek the most profitable option. Such a system is regulating itself and it does not need any government regulation in order to keep on running. On the other hand, the existence of the public sphere is absolutely essential for the existence of the self-regulating market. Market itself cannot secure the political conditions necessary for its own existence. More specifically, public sector ensures that private property is not breached, contracts are properly enforced and law and order is provided by state authorities.

The relationship between market and government is reciprocal. In a capitalist society, government can hardly exist without a functioning market. To some extent,

government has to preserve conditions in which capital can be invested and tax revenues generated. One can hardly imagine a functioning government in a liberal democracy where there is total lack of economic prosperity. Delivering prosperity is one of the most important factors for securing loyalty of voters. As politicians strive to be reelected, it is in their own interest to ensure that the passed legislation creates an environment in which economic growth can occur. Despite this reciprocal relationship, market poses a separate unit which is to large extent out of control of any state authority. And with a government ignoring and not correcting market outcomes, the achieved aggregate prosperity may not be distributed evenly among voters. Again, such a situation is not desirable for politicians seeking reelection. Conservative critics such as Hayek argue that as taxes go up continuously to finance the activities of expansive governments, there are fewer resources available for private capital investment. In their view, fiscal policies designed to ensure fairer income distribution only inhibit economic growth in the long term. This is due to the fact that such policies take away resources from the class which is most likely to invest their disposable income.

On the other side of the spectrum, liberals and social democrats point out that wider income redistribution results in gains which should be prioritized over gains which contribute to deepening income inequality. It is even argued that smart government expenditures promoting health, human capital and social welfare are vital for labor as a production factor to be more productive and generate profit for owners of capital. Moreover, aggregate demand is strengthened with wider distribution of income and better quality of labor enables incorporating more efficient production techniques. Also, private sector will not invest enough in non-profitable projects which might be crucial from the government point of view. Therefore, capitalist states channel huge amount of resources into infrastructure, research and development or education. In the long term, these investments contribute significantly to generation of profits which are captured by private entrepreneurs. That is when the government steps in and levies taxes to generate revenue for maintaining the quality of production factors.

2.9 Factors affecting economic growth - evidence

Tax systems never affect the economic growth directly but through its impact of agents in the economy – households and firms. Households provide labor and receive wages as a reward. Their net income depends heavily on the design of the tax system, especially personal income taxes. The evidence on how the change in the after-tax income affects labor supply is not consistent. In theory, there are two opposite effects of a wage increase on labor supply. As the real income goes up, households are likely

to consume more leisure and thus work less. On the other hand, the substitution effect causes that it is more costly to rest. The result depends on strength of the two opposing effects. Existing studies show that the impact of a wage increase is insignificant for men. However, Bradley and Heim (2007) have found a significant positive effect for women, especially those married. Also, they show this gap in response has been declining over time.

Tax rates also affect decisions of households and firms on how much of their income is consumed and how much is saved. In other words, decisions made by households and firms determine levels of capital and labor. If levels of capital and labor do not change over time, the only option for the economic growth to occur is by an increase in productivity of production factors. Therefore, promoting technological progress and innovation should be a priority of a reasonable tax system. Most tax codes treat investment in research and development favorably: firms are allowed to deduct expenditures on research from the tax base. Investment in human capital is also heavily supported by many governments. Promoting productivity of production factors is crucial for achieving economic growth in the long-run, as opposed to short-run effects caused by tax-cuts resulting in higher after-tax disposable income. The difference between long-run and short-run effects of tax changes are discussed in the next section in more detail.

2.10 Short-run vs. long-run growth

It is important to distinguish short term fluctuations resulting from tax system amendments and long term effects arising from a persistent change in behavior of economic agents. Short-run and long-run effects are usually associated with the demand side or supply side of the economy. The short-run effects work through the demand side of the economy. Tax cuts are likely to lead to a short term increase in output and employment. The magnitude of the change in growth rate depends on which individuals are most affected by the tax change. If low-income earners are affected, one can expect a significant change in aggregate spending. On the other hand, the response of top-income earners is likely to be negligible. The long-run effects usually occur through changes on the supply-side of the economy. Theoretically, it does not make sense to care about creation of jobs as economy functions at its potential in the long run. Long-run growth takes place through an increase in productivity of inputs – labor or capital. Productivity is usually enhanced by an investment in education or technological progress. The government can significantly influence the long-term trend by pursuing suitable policies – either led by the belief in free market forces or with interventionist intentions. An example of a

free market policy is privatization of certain industries which may work more efficiently in hands of private owners. Or the government may intervene by reallocating resources into areas enhancing quality of production factors through active labor market policy or greater investment in education.

2.11 Literature

Significance and robustness of the total tax revenue as a share of GDP has been examined in many empirical papers focused on determinants of economic growth. Koester and Kormendi (1989) or Agell, Lindh and Ohlsson (1989) present findings that average tax rate has no effect on economic growth. On the other hand, Engen and Skinner (1992) show a strong robust relationship between average tax rate and economic growth. Two studies by Barro (1989, 1991) showed a significantly negative correlation between the ratio of real government consumption expenditure to GDP and economic growth. Easterly and Rebelo (1993) employ various measures of marginal tax rates to explain growth rates but their findings suggest a fragile relationship. Mendoza et al. (1997) concluded that once initial level of GDP is accounted for the coefficients of tax variables show no significance. Folster and Henrekson (2001) find a negative relationship between the size of government and growth. Even if a robust relationship is identified in the regression, one must be aware of the potential reverse causality. This phenomenon is known as the Wagner´s law and it predicts that economic development of countries is accompanied by an increase in government spending in terms of its GDP share.

However, more specific studies are needed to address the issue of tax structure and its impact on growth rate. It seems that the findings of papers dealing with individual taxes provide more conclusive evidence than studies focused only on overall tax burden. Kneller et al. (1999) divides taxes into groups according to their distortions. Distortionary taxes are represented by income and property taxes while non-distortionary taxes involve consumption taxes. They conclude that imposing direct taxes on income and property inhibits economic growth whereas indirect taxes do not. Their findings are confirmed by Gemell et al. (2006). Schwellnus and Arnold (2008) provide evidence for a negative impact of corporate taxes on productivity of firms in OECD countries. Negative relationship between corporate taxes and economic growth is also reported by Lee and Gordon (2005). Significance of tax

progressivity has been examined by Padovano and Galli (2002) who provide evidence of its negative influence on economic growth. Gentry and Hubbard (2000) show a negative link between tax progressivity and business activity. Arnold (2008) examines the relationship between tax structures and economic growth in OECD countries for 1971-2004. His results suggest that income taxes are generally associated with lower growth rates than taxes on consumption or property. The most negative effects on GDP growth are caused by corporate income taxes.

Padovano and Galli (2002) identified three problems that need to be solved in order to examine the relationship between tax rates and growth. First, instability of estimated coefficients might be caused by frequent changes in tax systems. However, this issue concerns mostly developing countries which experienced substantial tax reforms in the past decades. Second, there is a risk of the aggregation bias if the sample consists of countries which possess very different characteristics. Garrison and Lee (1992) show that the significance and robustness of tax variables is different for industrialized countries and non-industrialized countries. Bruno and Easterly (1998) show that also the influence of public spending varies for these two groups of countries. This implies that single coefficient for both groups would lead to inconsistent and fragile conclusions. Since only OECD countries are examined in this paper the issue of aggregation bias does not pose a major trouble. Third, the test should be specified in such a way that inclusion of other policy state does not change significance of the relationship between tax rates and output growth. Existing empirical papers account for public expenditures, effects of monetary policy or human capital accumulation. Omitting these variables would lead to biased estimates of tax rates coefficients.

3 Theoretical considerations

3.1 Motivation behind Extreme Bounds Analysis

So far many variables have been found significantly related to the economic growth rate. However, their selection and significance is often random and based only on the intuition of the researcher who simply selects some variables which appear to matter for growth. As Sala-i-Martin (1997) points out, it is likely to be the case that the researcher finds variable x_1 significant when x_2 and x_3 are included in the model but it is not significant any more when x_4 is included as well. Levine and Renelt (1992) aimed to provide the answer to this problem by applying the extreme bounds analysis developed by Leamer (1983) on a standard growth regression. This approach consists in defining some basic variables which are always included in the model. Then, additional variables are randomly added to the model and the response of the key variables is observed. It the coefficients are robust to model alteration, one can conclude that the variable is likely to be a significant predictor of economic growth. However, due to the strictness of the test which is difficult to pass for any variable, they draw a conclusion that "nothing can be learned from this empirical growth literature because no variables are robustly correlated with growth". Sala-i-Martin points out that the test is simply too strict and instead of rejecting the theory as Levine and Renelt did, one should reject the test.

Sala-i-Martin suggests moving away from this extreme test and examining the whole distribution of the estimated coefficients. Instead of approving or rejecting the variable, a certain level of confidence is assigned to each variable. This measure is based on the probability that the coefficient is found on one side of zero. The argument goes that if the sign of the coefficient remains the same despite conducting a sizeable amount of model alterations, one can declare the variable as significant for growth. Sala-I-Martin follows the model specification adopted by Levine and Renelt which consists of fixed variables included in every regression, variables of interest and additional variables which have the purpose of introducing an alteration to the model and their robustness is not of major interest.

Studies dealing with determinants of economic growth often tend to ignore two issues related to regression analysis. First, the model can be significantly biased if there is an omitted variable which should have been included into the model. And second, extensive data mining is often conducted to find support for a preconceived idea. Those conclusions should be checked by a thorough sensitivity analysis which would examine robustness of the model. Such an analysis is often missing and thus it is not surprising that results from various studies are in direct contradiction. According to Sala-Martin (1997a,b), 60 variables have been found to be significant predictors of economic growth in previous studies. However, Levine and Renelt (1992) show that only few of them pass a thorough sensitivity analysis.

EBA deals with both omitted variable bias and model uncertainty. As opposed to searching for one "true" model, the idea behind EBA is to run the model under various specifications and observe the sensitivity of explanatory variables to these alterations. The aim is to distinguish determinants robustly related to our dependent variable from fragile explanatory variables. The procedure was first described by Leamer (1983) and was later adjusted by Sala-I-Martin (1997a,b). This paper applies both approaches and discusses their differences.

3.2 Approach to the analysis

As described by Chanegriha (2011), the standard way of conducting an EBA is to divide our variables into four groups. The first group is represented by the dependent variable (which is in our case GDP per capita), the second one includes the core explanatory variables which are kept in all models regardless of its specification. The choice of these core variables is based on standard neoclassic growth models. The third group consists of variables of our interest whose robustness we are interested in. And the fourth group is made up of additional potentially significant variables which will be added to or excluded from the model according to the model specification. Our choice of these additional variables was inspired by a wide range of past studies dealing with determinants of economic growth. I follow Chanegriha (2011) and express the model in the following way:

$$(Y)_{it} = \alpha_i + \beta_j X_{it} + \gamma_{jk} I_{kit} + \delta_j Z_{jit} + \varepsilon_{jit}$$

Where

$$X_{it} = \begin{bmatrix} X_{1it} \\ \vdots \\ X_{nit} \end{bmatrix} \qquad \beta = \begin{bmatrix} \beta_1 \\ \vdots \\ \beta_n \end{bmatrix}$$

I_{kit} denotes the k^{th} variable of our interest and Z_{jit} is one variable from Z_{it} .

The model above refers to the panel data analysis and serves as an example for explanation of EBA. Besides panel data model, cross-sectional model and pooled cross-sections model is also employed in the paper. After setting up the model we run regressions for every possible combination of the potentially significant variables. Every regression yields a certain value of the coefficient estimate on the variable of our interest, I_k (being γ_k). The corresponding standard error and the cumulative distribution are also recorded. The procedure is applied for every variable of our interest. After running all regression we obtain coefficient estimates γ_{kj} and standard deviations σ_k. Then we have to find the extreme values of coefficient estimates. The lowest value is denoted as $\gamma_k^{max}$and the highest value is denoted as γ_k^{min}. However, the extreme values are not identical with the desired extreme bounds which are crucial for the decision whether the variable of our interest is robust or fragile and thus sensitive to changes. Following Leamer (1983) we obtain the lower extreme bound by subtracting two standard deviations from the lowest value of γ_k, that is:

LEB = γ_k^{min}- 2 σ_k

The upper extreme bound can be found by adding two standard deviations to the highest value of γ_k, that is:

UEB = γ_k^{max}+ 2 σ_k

After obtaining the extreme bounds there are basically two approaches which can be applied to determine the robustness of variables of our interest. According to Leamer (1983) the variable is considered to be robust if the values of extreme bounds are of the same sign. On the other hand, if the lower extreme bound for I_k is negative and its upper extreme bound is positive the variable I_k is said to be fragile because the alterations in the model lead to different kinds of relationship between the dependent variable and variable of our interest. This approach was applied by Levine, Renelt

(1992) in their sensitivity analysis of cross-country growth regressions. Their conclusion was that only very few variables are robustly correlated with growth. The simple explanation for this result can be that only very few variables are systematically correlated with growth. The other reason is, as suggested by Sala-I-Martin (1997), that this sensitivity test proposed by Leamer (1983) is simply too difficult for any variable to pass. Sala-I-Martin criticizes the fact that the variable of our interest is significant only when all regressions yield a coefficient with the same sign. Only one regression yielding a coefficient with a different sign causes the variable to be fragile. McAleer et al. (1985) refer to this problem as "one rotten apple" when talking about "families of models". Instead of focusing only on the extreme bounds Sala-I-Martin suggests analyzing the entire distribution of the estimates of the parameter. According to this approach a variable is considered robust if a significantly large confidence interval does not include zero. In other words, if a significantly high number of coefficient estimates can be found on one side of zero. The major advantage of this method is that a discovery of just one regression yielding a coefficient with a different sign does not imply insignificance of the examined variable. Sala-I-Martin intuitively explains his approach by pointing out that "if 95 percent of the density function for the estimates of $\beta_1$lies to je right of zero and only 52 percent of the density function for $\beta_2$lies to the right of zero, one will probably think of variable 1 as being more likely to be correlated with the dependent variable than variable 2.

His approach consists in constructing a weighted cumulative distribution function, denoted CDF (0). This statistic computes the fraction of the cumulative distribution function which can be found on each side of zero. It always gives the larger of CDF (0) and 1-CDF (0). So the value of this statistic lies always between 0.5 and 1. According to Sala-I-Martin the value of CDF should not be lower than 0.9 for a variable to be considered robust. Sala-Martin provides two versions of the model depending on the distribution of the coefficients. If we assume regression coefficients to follow a normal distribution, the CDF (0) is calculated as follows:

For CDF calculation, we need two parameters – mean and variance of coefficients γ_{kj}. The mean value is calculated as:

$$\bar{\gamma}_k = \sum_{j=1}^{M} W_{kj}\hat{\gamma}_{kj}$$

Where W_{kj} stand for weights computed as:

$$W_{kj} = \frac{L_{kj}}{\sum_{j=1}^{M} L_{kj}}$$

Where L_{kj} is an integrated likelihood computed for each model specification. The justification behind this weighting scheme is that more weight is given to models which are considered as the true ones.

The average variance is calculated as:

$$\bar{\sigma}_k^2 = \sum_{j=1}^{M} W_{kj}\hat{\sigma}_{kj}^2$$

Where the weights are the same as in the calculation of $\bar{\gamma}_k$. Having obtained the parameters, we can compute the t-ratio as $\bar{t}_k = \frac{\bar{\gamma}_k}{\bar{\sigma}_k}$. The CFD is then computed as $\emptyset(\bar{t}_k)$, where $\emptyset$ represents the cumulative density of normal distribution.

3.3 Selection of variables

Before conducting the Extreme bounds analysis the observed variables are divided into four groups. The first group is represented by the dependent variable which is growth rate of GDP per capita. The second group consists of variables which will be included in every regression. The choice of these core variables can be inspired by existing papers dealing with the EBA. Levine, Renelt (1992) include investment share of GDP, the initial level of real GDP per capita, secondary-school enrollment rate and annual rate of population growth. As Levine and Renelt point out their choice of core variables is consistent with most of growth studies they examined such as Barro (1990) or Romer (1990). I do not follow entirely the choice of their variables as I do not consider secondary-school enrollment and annual rate of population growth as important indicators for OECD countries in the last two decades. Human capital is one the main sources of growth in many endogenous growth models.

However, the inclusion of these indicators might make sense for explaining growth in developing countries but for the most developed countries we need a better representation of human capital. The conventional measures include accumulated years of schooling as suggested by Nehru, Swanson and Dubey (1993), Romer (1990) suggested the ratio between literate adults and total number of adults and Psacharopulos and Arriagada (1986) proposed average years of schooling as a proxy for human capital. One of the most comprehensive measures of human capital which also takes into account quality of health care is the human development index (HDI). The value of the index is composed of three indicators of human development – per capita income, life expectancy and years of schooling. However, one can easily see from the ranking that the value of the index is highly correlated with GDP per capita of individual countries. Including HDI is likely to introduce a significant multicollinearity in the model which is not desirable. Instead, I use tertiary school enrollment ratio as a proxy of human capital in OECD countries.

Investment to GDP (both private and public investments are considered) ratio is widely accepted indicator of economic growth in economic theory as well as in empirical growth studies. The neoclassical model of Solow (1956) highlights the savings or investment ratio as an important driving force behind economic growth. A higher saving rate implies that the steady-state level of output per effective worker increases which in turn raises the growth rate. De Long and Summers (1992) or Mankiw, Romer and Weil (1992) can be named as examples of growth studies reporting a significant positive effect of investment ratio. However, we need to account for reverse causality as positive growth prospects are likely to attract new investments. Blömstrom, Lipsey and Zejan (1993) show that much of the positive effect of investment ratio on growth reflects the reverse relation between growth prospects and investment. Therefore, I replace the suspected endogenous variable with its lagged values. Such practice is common in existing literature and has been applied by Vergara (2010) or Clemens, Radelet, Bhavnani and Bazzi (2012) among other papers.

The third core variable used in my EBA is the initial level of GDP per capita. The idea behind inclusion of this indicator is that poor countries with lower initial per capita GDP are further below their steady-state point and thus tend to grow faster

than richer countries. Levine and Renelt (1992) show that the initial income level has a statistically significant correlation with cross-country growth differentials. I also include tax revenue as a share of GDP in the group of core variables. In order to examine the effect of tax structure we need to control for the overall tax burden. To sum it up there are three core variables which are part of every regression – investment share of GDP, initial level of GDP per capita and tax revenue as a share of GDP.

The third group of variables consists of potentially significant indicators which have been found significant in existing literature. The first variable is export-to-GDP ratio which is an indicator of country openness. The theoretical reasons suggesting a strong positive link between openness and economic growth are well known – transfer of technology, diffusion of knowledge and greater exposure to competition. Further, I include inflation rate as a proxy for macroeconomic stability. Theory suggests that higher levels of inflation reduce capital formation as it imposes greater risk and uncertainty on investors. Friedman (1977) argues that inflation causes distortion to the valuable information contained in prices and thus it poses an obstacle to economic activity. Another variable which may play a significant role for economic growth is innovation and R&D activity. New ideas and technology increases productivity and enables more efficient processes and methods. In the endogenous growth models developed by Romer (1987, 1990) technological advance results from R&D activity and growth rate can remain positive in the long run only if there is a continuous flow of new ideas. The strong relationship between innovation and economic growth has been empirically confirmed by numerous studies such as Lichtenberg (1993) or Ulku (2004). As a measure of innovation I use total R&D expenditure as a share of GDP. Another variable which could be considered as significant is development of the financial sector. Depth of the financial sector contributes significantly to capital accumulation and diffusion of new technologies. It ensures that savings are mobilized and channeled to large investments and provides valuable information on potential projects. As a measure of financial depth I use monetary aggregate M2 as a share of GDP.

The fourth group of variables is composed of indicators of our interest, i.e. those variables whose significance and robustness is the major concern of this paper. I

examine the significance and robustness of various tax shares such as taxes on labor, goods and services, corporate income and property. The importance of tax progressivity for economic growth is also explored. Social system contributions are added to the income tax because the sum of both income taxes and social contributions represent better the tax burden on labor (without this inclusion Czech Republic would belong to countries with the lowest income tax despite labor being heavily taxed).

3.4 Focus tax variables

The first type of tax considered in the analysis is the tax levied on income – personal income in case of households and capital gains in case of firms. In most developed countries, the personal income taxes are designed in a progressive fashion. Even if there is a single tax rate applicable to all income earners, modern tax codes tend to contain various tax allowance and exemptions which make the personal income tax effectively progressive. For example, the taxpayers in the Czech Republic are eligible for a tax allowance expressed in an absolute value implying that low income-earners are relieved greater share of their gross income. Moreover, employees with children are allowed to apply other tax credits. On the other hand, the top income earners are more likely to apply tax deductions based on payments for mortgage interest, life insurance or private pension insurance. Therefore, at high levels of income the effective tax rate might eventually go down with increasing income. Moreover, high income earners who face greater tax burden are more likely to search for ways of reducing their taxable income. Conservative critique of income tax progressivity is based on the idea that earnings reduction by progressive taxes causes people to work less and enjoy more leisure instead. This argument is questioned by other economists such as Thurow (1980). He claims that with rising marginal tax rates households must offer more labor to retain the same standard of living. Similarly, lowering marginal tax rates results in higher preference for leisure.

The effect of corporate taxes on income distribution and economic growth is less evident. It is crucial to identify who effectively pays the corporate income tax – owners of the corporation, workers or customers purchasing the product. While the former option would suggest a progressive effect on income distribution, tax burden borne by workers and customers makes the tax system more regressive. Regarding the impact of corporate income taxation, it is claimed that it prevents investment from being directed to corporate sector. Those who consider corporate taxes to be paid by

consumers point out that consumption taxes may appear to be beneficial for economic growth.

An indispensable source of government revenue in all OECD countries is social contribution payment. As these contributions are collected through flat rates imposed on gross income and their usage on social benefits tends to be only slightly progressive, it is often argued that the impact on income redistribution is much weaker than intended. As Heilbroner and Thurow (1981) point out, the purpose of social payment contributions is not to redistribute income from high-income to low-income earners but from younger to older generation. Regarding the effect of social contribution on economic growth, one may assume it is not significantly different from impact of the income tax discussed above. Additionally, Feldstein (1997) claims that social security payments may induce workers not to save enough as they rely on provision of adequate pension from the government.

Another important group of taxes consists of taxes imposed on goods and services. Most countries in Western Europe employ the so called value-added tax, while US, Canada or Australia raise money through the sales tax. There are also excise taxes levied on consumption of specific products such as alcohol, tobacco or fuel. Traditional view is that consumption taxes are necessarily regressive – having greater impact on low-income earners. The reason is that people with lower income are much more likely to consume a greater income share, while high-income earners generally save more. Governments try to weaken the regressivity by applying exemptions or lower tax rates on items which take the largest proportion of low-income earners budget – typically food or medicine. However, various exemptions and more tax rates create opportunities for tax evasion and decrease the tax system efficiency. The view that regressivity is embedded in consumption taxes has been challenged by several authors. Browning and Johnson (1979) point out that larger income proportion of lower income groups consists of transfers regularly indexed for inflation. This nature effectively distributes the burden among all income earners in a progressive fashion. Regarding the impact of consumption taxes on economic growth, it has been argued that levying taxes on consumption creates a disincentive to consume, shifts disposable resources towards investment and thus promotes growth.

Property taxes form the last group of taxes with a significant potential of generating government revenues. Their contribution to the government budget is not sizeable in

most countries. The design of the property tax is to some extent responsibility of local governments which are recipients of the tax revenue. Empirical evidence and theoretical support on the impact of property taxes on income distribution and economic growth is not conclusive. As property taxes are levied on accumulated wealth, one may conclude that their effect on redistribution is regressive. However, property taxes are usually imposed on necessities rather than luxury goods, thus taking a substantial proportion of income from poor households. Relationship between property taxes and economic growth is ambiguous as well. The impact on economic growth may be similar to that of consumption taxes, result being that more resources are available for investment. On the other hand, property taxes create a disincentive to accumulate capital, a factor considered crucial for economic growth.

3.5 Alternative approach

The approach proposed by Sala-I-Martin inspired Doppelhofer (2000) to develop so-called Bayesian Averaging of Classical Estimates (BACE) to check the robustness of explanatory variables. Similarly to Sala-I-Martin this approach examines the sensitivity of coefficient estimates by varying specifications of the model. The major difference is that there are no fixed variables which appear in all regressions and the number of variables changes. This model penalizes additional regressors added to the model by using weights following from the Schwarz criterion. However, the approach based on BACE suffers from a few drawbacks. First, one needs a balanced data set which means that number of observations in all regression must be the same. Second, number of variables cannot exceed number of observations. And third, as Doppelhofer points out, with k explanatory variables there are 2^k possible combinations to be tested. If the number of potential explanatory variables exceeds a certain threshold, the number of possible regressions becomes unfeasible. Also, the issues of heterogeneity and outliers are not tackled under this approach. For above mentioned reasons, the original version of EBA proposed by Leamer (1983) and later slightly altered by Sala-I-Martin (1997) is employed for the sensitivity analysis.

However, EBA suffers from shortcomings as well. Moosa and Cardak (2005) argue that the procedure is focused on the point estimation and is not concerned with hypothesis testing and interval estimation. Also, this procedure creates an incentive to find a large group of models, all of which (or most of which in case of Sala-I-Martin version of EBA) yield the same results. If such a large group of models is found, one may conclude it is a clear proof of robustness. However, a slight alteration to the

model in a different way may lead to a completely different inference. McAleer et al. (1985) go much further with the critique of EBA by arguing that the cons of econometrics are not removed by employing EBA. Moreover, they point out that it even prevents the researcher from asking crucial questions about the regression. They do not consider EBA to be better than the conventional procedures because EBA only replaces arbitrary selection of regressions by arbitrary partition of variables.

As Levine and Renelt (1992) point out, another objection to the EBA is that it introduces multicollinearity, inflates standard errors of the coefficients and exaggerates the range on the coefficients. However, Leamer (1983) argues that the issue of multicollinerity arises due to the problem of weak-data availability. If there are no robust correlations in the regression model it simply means that the differences in growth rates between individual countries cannot be explained by variation in any variable. Even if we find such a robust partial correlation we cannot be sure about the causality between the explanatory variable and growth rate. However, identifying channels of causality is not an issue of this paper. Levine and Renelt suggest that one can give the results more credibility by imposing three restrictions on the EBA. First, they restrict the number of explanatory variables in each equation. Second, the group of potential significant variables Z is small, i.e. the objective is not to search over a large data set for any variable which may possibly cause the examined variable to lose its significance. And third, variables which may measure the same phenomenon are excluded from the Z group of variables.

4 Empirical evidence

The approach of studies analyzing importance of tax systems for economic growth varies. Most often, authors use cross-section regressions with averages over the observed time period. The other approach consists in taking averages over sub-periods and thus allowing variation over time. The length of sub-periods varies but in order to make economic sense, it should be close to length of a business cycle. The reason is that one needs to smooth out fluctuations and thus more easily uncover potential growth patterns. In this study, I employ both approaches as both of them provide valuable information on the topic. For the sub-period averages, I use length of 4 years. Also, I aim to fill a significant gap in the literature by applying the EBA on tax structure panel data.

The sample consists of 32 OECD countries (Chile and Mexico omitted due to some data unavailability). The data are annual and range from 1995 to 2011. Data were downloaded from the publicly available OECD database. GDP per capita is expressed in USD in constant 2005 prices, investment, expenditures on research and development, trade volume and quasi-money are measured as a proportion of GDP. The individual taxes are represented as percentage of total tax revenues. Inflation rate is derived from the GDP deflator and level of education is measured as a proportion of people having attained tertiary education. In case of cross-sectional analysis explaining average growth rate over the whole period, the measure of tax progressivity is used as well. As data on this variable are not published in the OECD database, the progressivity indices were obtained using the regression mentioned in the section 2.5. For each model, sections below contain description and justification of the selected model, tables with results of the EBA, histograms showing robustness or fragility of variables and comments on the outcome of the model.

For the analysis, I use the R software which offers the recently developed ExtremeBounds package. The analysis performed by the package supports both versions of the EBA – Leamer´s version focused only on the upper and the lower bounds of the estimated coefficients and Sala-I-Martin´s version which analyzes the entire distribution. For the Sala-I-Martin´s EBA, a model with normal distribution of coefficients as well as the generic model is conducted. The package allows the user to include non-linearities in the model, to specify groups of potentially multicollinear variables which are never included in the same model or to put a limit on the value of

the variance inflation factor. To make the results clearer and more intuitive, the user is allowed to generate histograms that show probability density of individual variables.

4.1 Cross-sectional data

The simplest approach towards analysis of economic growth determinants is the cross-sectional model. This model aims to explain the average growth rate through variables which are averaged over the observed time period. The advantage of this approach is that the results are not affected by business cycle fluctuations. On the other hand, this model does not allow for variation over time. In order to examine the importance of tax structure for long-term growth, I set up the model as follows:

$$Y = \alpha + \beta_B B + \beta_F F + \beta_P P + \varepsilon$$

Where Y stands for the average growth rate from 1996 to 2011, B represents the group of basic variables included in every regression, F includes variables related to individual taxes which we are focused on and P contains all remaining variables which might be potentially significant.

I specify number of additional variables that will be included in each estimated regression in addition to the variables of our interest. I follow Levine and Renelt (1992) and allow for up to three additional variables to be included in the model. In order to tackle multicollinearity in the model, I put a limit on the variance inflation factor (VIF) of the coefficients. Multicollinearity occurs when two or more variables in the regression are highly correlated, which leads to unreliable and unstable coefficient estimates. The VIF is defined as $1/(1-R^2)$. By imposing a limit on the level of the VIF, only estimates with the VIF lower than the selected value will be included in the analysis. Applying a common rule of thumb, I set the cut-off value for the VIF to 5. Another way of dealing with presence of multicollinearity in the model consists in specifying mutually exclusive variables which will never be included in the same model. This is especially relevant when two or more predictor variables measure the same phenomenon. As I avoided including more variables representing a similar concept during the selection process, I can ignore this part of setting the model. The issue of multicollinearity arises also as a result of the fact that richer countries tend to rely more on income tax as a source of their revenues. One has to be aware of this reverse causality when drawing conclusions from the regression results.

Growth regressions tend to suffer from the presence of endogeneity. In case of strong endogeneity present in the model, the model gives biased and inconsistent estimates of the effect of explanatory variables on the dependent variable. The impact of investment on economic growth is a good example. A significant relationship between investment and economic growth has been confirmed in many studies. However, it has also been shown that the causality runs in both directions. Not only do countries grow thanks to the flow of investment, but investments are more likely to be made in countries with higher growth rates. In our model, all the base variables are potentially endogenous. In addition to investment, per capita income and tax revenues might be affected by growth rates. It is obvious that the level of GDP per capita is higher as a result of growth in previous years. Therefore, it is standard to use only initial levels of per capita income to avoid endogeneity. In case of tax burden, government is likely to generate higher tax revenues in a growing economy. So the causality between tax revenues and economic growth runs in both directions as well. One way of dealing with this issue is to express tax revenues as a percentage of GDP. When GDP goes up as a result of higher growth rates, tax revenues rise in the same proportion (other things being equal). In our model, we are mainly interested in coefficient estimates of variables representing tax revenues generated by individual taxes. In a growing economy, growth of consumption, incomes, corporate gains and property is not likely to deviate significantly from the GDP growth rate. However, as the countries develop and experience economic growth, they tend to rely more heavily on income tax and social security contributions. Therefore, there might be a reverse causality between economic growth and income tax share on total tax revenue. As the sample of countries in this study includes only OECD countries, i.e. countries which have already been through the stages of rapid tax system structure changes, one may suppose that the reverse causality does not require further consideration. For the above discussed reasons, endogeneity is not a serious issue for the purpose of our analysis.

Another issue in estimating importance of individual taxes is over-identification of the model. Kneller et al. (1999) identified that this phenomenon is present due to the "government budget constraint". As I control for the total tax burden, any change in revenues raised by one type of tax will automatically lead to lower revenues collected through another type of tax. If shares of all possible taxes entered the growth

regression in addition to overall tax revenue, the result would be an over-identified model. In other words, if there is a growth effect from one type of tax then there is a simultaneous growth effect from another type, under the assumption that tax revenues are held constant. Kneller et al. suggest introducing an implicit constraint which is incorporated in the regression. The constraint reflects the simple fact that all tax shares sum up to one. Without including this constraint, there is linear relationship between variables leading to a biased estimation. However, to make things simple, it is possible to include the constraint by excluding one variable which is considered as part of residuum. When excluding the share of income taxes from the regression, one could draw a conclusion that the shift of tax burden from taxes with negative coefficient towards income would likely promote economic growth and vice-versa. In my analysis, I do not include data on corporate taxes.

The results of the analysis are shown in Tables 1-4.

First, we have a look at the results of Leamer´s version of the EBA summarized in table 3. The drawbacks of this approach have been thoroughly discussed in previous sections. Leamer´s EBA is only focused on the highest and the lowest value of coefficient estimates – the so called extreme bounds. If the extreme bounds are of opposite sign the examined variable is automatically considered as fragile. This is the case for all observed variables in our analysis. If I followed Leamer I would have to conclude that no variable of our interest is a significant predictor of economic growth. It is obvious that in order to examine the significance of the relationship more thoroughly, I need to employ the more sophisticated approach proposed by Sala-i-Martin. As opposed to Leamer, Sala-i-Martin´s version of EBA looks at the entire distribution of coefficient estimates. Table 4 shows what part of the distribution can be found on both sides of zero. In other words, it shows the probability that the coefficient estimate of the examined variable in a randomly selected regression will be positive (negative). I examine both cases - one in which the estimation coefficients are assumed to be normally distributed and the other which does not place any assumption on the coefficient distribution.

The results for the basic variables show that only the initial level of per capita income is statistically significant, albeit at the 90% significance level. This result is in accordance with the convergence hypothesis which says that countries further from

the steady state level should experience higher growth rates. Level of investment seems to have rather positive effect on economic growth, albeit not significant. However, even if one finds a significant positive relationship between investment and growth, there is an issue of reverse causality discussed in previous sections. The importance of total tax burden for growth seems to be non-existent. This result comes as no surprise since the distortion effects of taxation are offset by multiplication effects of the government spending. The existing literature provides mixed evidence on the relationship between overall tax level and economic growth. Once I accounted for the effect of the total tax revenue, I can move on to examining significance of the tax structure, i.e. distribution of tax burden among factors in the economy. Two results are definitely worth mentioning. First, taxes on personal income appear to have a statistically significant negative effect on growth rate. Second, a positive effect has been shown in case of consumption taxes. This implies that a redistribution of tax burden from income towards consumption would ceteris paribus enhance economic growth rate. This result is in line with the conclusion drawn by Arnold (2008) who has shown that taxes imposed on personal income have a more negative impact on growth than taxes levied on consumption. Also, this conclusion supports the recommendations of the OECD Economics Department study discussed in section 2.6. Finally, there is no significant relationship between taxes on property and corporate income, progressivity and economic growth. However, the distribution of coefficient suggests that the effect of progressivity on growth is rather negative. On the other hand, one may conclude that reallocation of tax burden towards property and corporate income is positive for economic growth.

Table 1. Cross-sectional model – values of estimated coefficients

Beta coefficients:							
	Type	Mean coef	se (mean)	Min coef	se (min)	Max coef	se (max)
(Intercept)	free	2,499	2,93	-3,412	2,477	14,07	4,124
INV	free	0,065	0,072	-0,113	0,069	0,18	0,071
TAX_REV	free	-0,002	0,039	-0,105	0,036	0,062	0,037
GDP_CAP	free	0,000	0,000	0,000	0,000	0,000	0,000
INC_TAX	focus	-0,074	0,035	-0,131	0,032	-0,026	0,078
PROP_TAX	focus	0,065	0,066	-0,042	0,076	0,161	0,058
CONS_TAX	focus	0,071	0,053	-0,052	0,049	0,132	0,05
PROG	focus	-1,522	1,678	-3,154	1,654	1,035	1,582

Source: OECD database, author´s calculations

Table 2. Cross-sectional model – distribution of estimated coefficients

Distribution of beta coefficients:				
	Type	Pct(beta<0)	Pct(beta>0)	Pct(sign.)
(Intercept)	free	31,549	68,451	15,775
INV	free	16,620	83,380	7,324
TAX_REV	free	58,028	41,972	3,944
GDP_CAP	free	94,366*	5,634	33,521
INC_TAX	focus	100,000**	0,000	56,154
PROP_TAX	focus	16,154	83,846	19,231
CONS_TAX	focus	6,154	93,846*	20,000
PROG	focus	96,154**	3,846	0,000

Source: OECD database, author´s calculations

Table 3. Cross-sectional model – Leamer´s version of EBA

Leamer´s Extreme Bounds Analysis				
	Type	Lower Extr. Bound	Upper Extr. Bound	Robust/Fragile
(Intercept)	free	-14,589	22,876	fragile
INV	free	-0,265	0,322	fragile
TAX_REV	free	-0,178	0,135	fragile
GDP_CAP	free	0,000	0,000	fragile
INC_TAX	focus	-0,197	0,127	fragile
PROP_TAX	focus	-0,194	0,275	fragile
CONS_TAX	focus	-0,161	0,242	fragile
PROG	focus	-6,395	4,136	fragile

Source: OECD database, author´s calculations

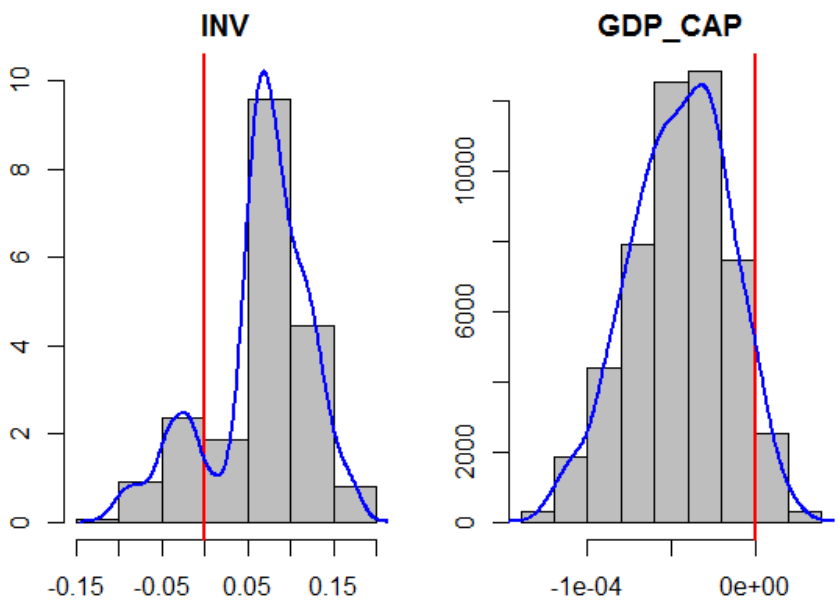
Table 4. Cross-sectional model – Sala-i-Martin´s version of EBA

Sala-i-Martin´s EBA					
	Type	N:CDF(beta<0)	N:CDF(beta>0)	G:CDF(beta<0)	G:CDF(beta>0)
(Intercept)	free	20,759	79,241	33,845	66,155
INV	free	18,265	81,735	23,380	76,620
TAX_REV	free	52,331	47,669	50,594	49,406
GDP_CAP	free	91,206*	8,794	84,610	15,390
INC_TAX	focus	98,027**	1,973	95,961**	4,039
PROP_TAX	focus	16,627	83,373	21,109	78,891
CONS_TAX	focus	9,217	90,783*	13,362	86,638
PROG	focus	81,732	18,268	79,095	20,905

Source: OECD database, author´s calculations

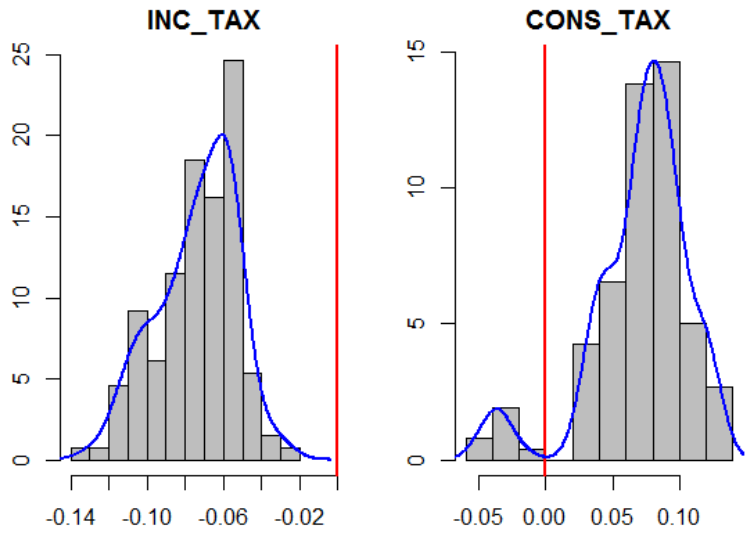
The figures 4-7 provide a set of histograms presenting the results graphically. Each histogram shows the distribution of a regression coefficient related to a certain variable. Variables considered as robust from the point of view of the EBA deviate significantly from zero to either side. Distribution of the income tax regression coefficient clearly suggests the robustness of negative relationship between income tax and growth rate to model alterations. The histogram illustrating the impact of consumption tax on growth shows that the examined relationship is not as robust as in case of the income tax and the coefficient sign is more likely to change when the model is specified differently.

Figure 4. Cross-sectional model - distribution of estimated coefficients for investment and initial per capita income



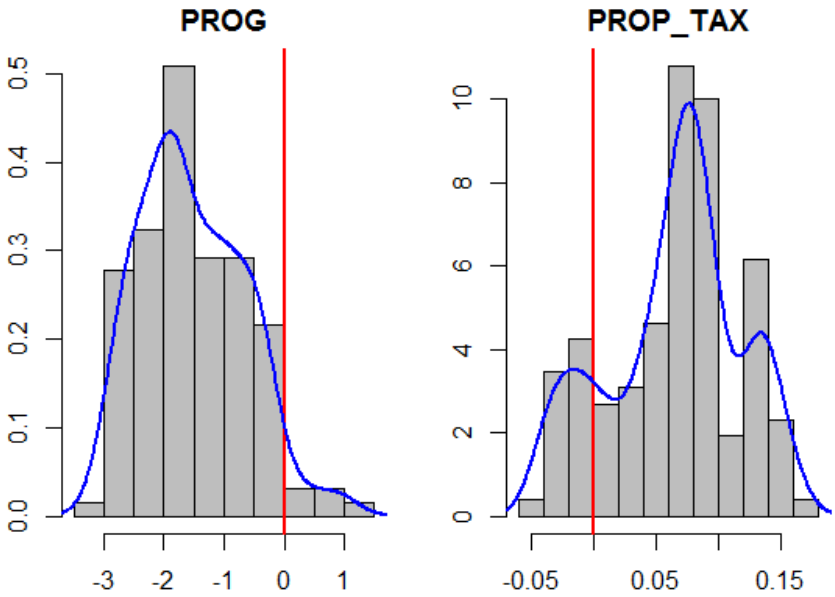
Source: OECD database, author´s calculations

Figure 5. Cross-sectional model - distribution of estimated coefficients for income tax and consumption taxes



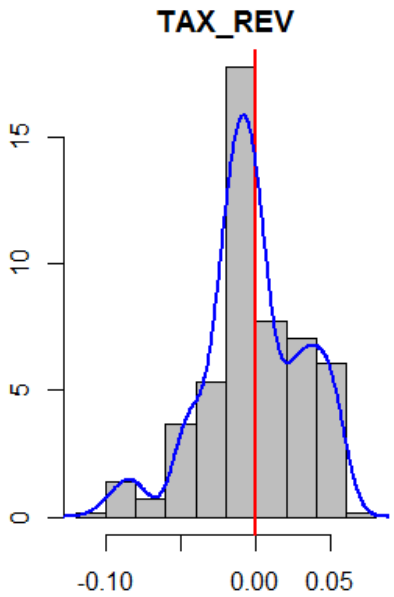
Source: OECD database, author´s calculations

Figure 6. Cross-sectional model - distribution of estimated coefficients for tax progressivity and property taxes



Source: OECD database, author´s calculations

Figure 7. Cross-sectional model - distribution of estimated coefficients for tax revenues



Source: OECD database, author´s calculations

4.2 Pooled cross-sections model

A more sophisticated approach consists in dividing the examined period into several sub-periods. As a result, one allows for variation over time while business cycle fluctuations are smoothed out. Employing time dummy variables enables us to account for growth effects related to specific world-wide economic conditions which are not expressed in any variable. The model looks as follows:

$$Y = \alpha + \beta_B B + \beta_F F + \beta_P P + \beta_D D + \varepsilon$$

The included variables are the same as in the previous simple cross-sectional model. Also, there are 3 additional dummy variables representing 4-year periods. The results are summed up in the tables 5 – 8. As in the previous model, the Leamer´s version of the EBA analysis declares all variables as fragile. This result comes as no surprise since only one out of many regressions with an opposite sign implies that the variable is not considered robust. Table 4 provides us with an insight into the whole coefficient distribution. According to the results of the Sala-i-Martin´s EBA, the initial per capita income and investment are statistically significant predictors of

economic growth, both with expected signs, i.e. rich countries tend to experience slower growth, while level of investment contributes to higher growth rates. The overall tax burden does not seem to have any impact on economic growth as can be seen from Figure 9 – the coefficient distribution is heavily concentrated around zero and not a significant part can be found on any side. Concerning the variables of our interest, the results resemble those of the previous model. Taxes imposed on personal income seem to inhibit economic growth, while property taxes and consumption taxes are either not significant or even contribute positively to growth.

Table 5. Pooled cross-sections model – values of estimated coefficients

Beta coefficients:							
	Type	Mean coef	se (mean)	Min coef	se (min)	Max coef	se (max)
(Intercept)	free	-0,78	2,367	-5,94	1,916	9,374	3,797
INV	free	0,105	0,052	0,018	0,054	0,185	0,052
TAX_REV	free	0,003	0,032	-0,62	0,035	0,059	0,031
GDP_CAP	free	0,000	0,000	0,000	0,000	0,000	0,000
INC_TAX	focus	-0,069	0,029	-0,124	0,03	-0,009	0,064
PROP_TAX	focus	0,075	0,055	-0,017	0,066	0,184	0,059
CONS_TAX	focus	0,046	0,041	-0,065	0,046	0,083	0,035

Source: OECD database, author´s calculations

Table 6. Pooled cross-sections model – distribution of estimated coefficients

Distribution of beta coefficients:				
	Type	Pct(beta<0)	Pct(beta>0)	Pct(sign.)
(Intercept)	free	60,000	40,000	29,778
INV	free	0,000	100,000**	58,667
TAX_REV	free	44,444	55,556	0,000
GDP_CAP	free	96,889**	3,111	39,556
INC_TAX	focus	100,000**	0,000	80,645
PROP_TAX	focus	12,903	87,097	25,806
CONS_TAX	focus	7,527	92,473	21,505

Source: OECD database, author´s calculations

Table 7. Pooled cross-sections model – Leamer´s version of EBA

Leamer´s Extreme Bounds Analysis				
	Type	Lower Extr. Bound	Upper Extr. Bound	Robust/Fragile
(Intercept)	free	-16,229	16,816	fragile
INV	free	-0,087	0,286	fragile
TAX_REV	free	-0,130	0,120	fragile
GDP_CAP	free	0,000	0,000	fragile
INC_TAX	focus	-0,184	0,115	fragile
PROP_TAX	focus	-0,160	0,300	fragile
CONS_TAX	focus	-0,156	0,194	fragile

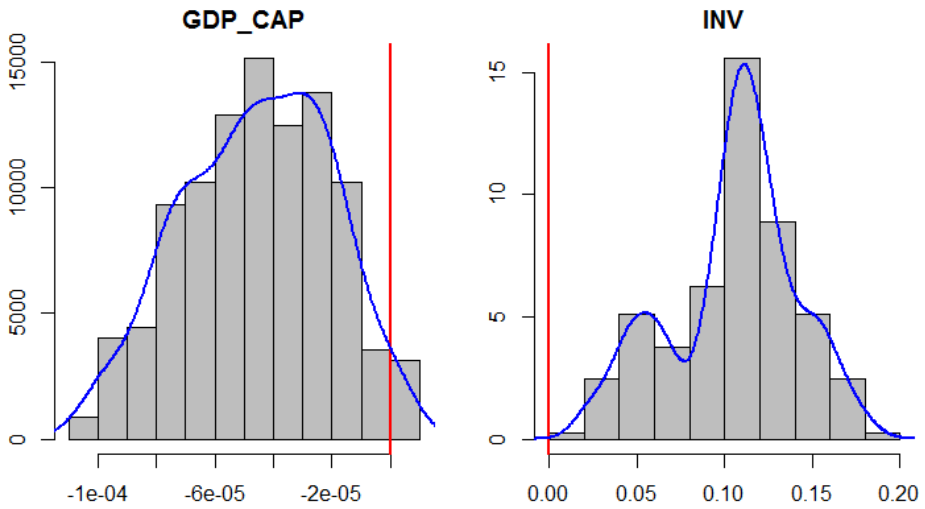
Source: OECD database, author´s calculations

Table 8. Pooled cross-sections model – Sala-i-Martin´s version of EBA

Sala-i-Martin´s EBA					
	Type	N:CDF(beta<0)	N:CDF(beta>0)	G:CDF(beta<0)	G:CDF(beta>0)
(Intercept)	free	62,215	37,785	62,638	37,362
INV	free	2,260	97,740**	5,288	94,712*
TAX_REV	free	45,933	54,067	46,206	53,794
GDP_CAP	free	94,091*	5,909	88,182	11,818
INC_TAX	focus	99,014**	0,986	97,496**	2,504
PROP_TAX	focus	8,946	91,054*	16,149	83,851
CONS_TAX	focus	13,077	86,923	17,735	82,265
PROG	focus	81,732	18,268	79,095	20,905

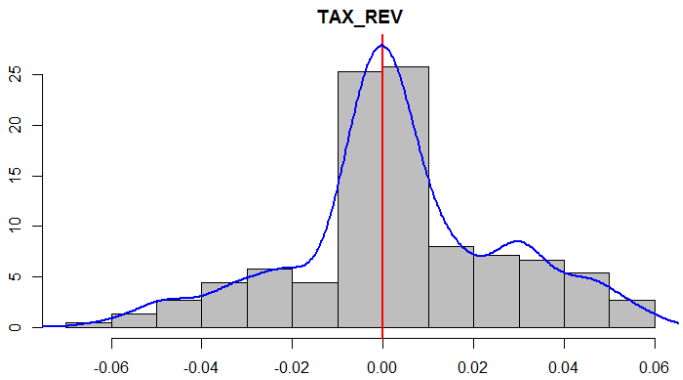
Source: OECD database, author´s calculations

Figure 8. Pooled cross-sections model - distribution of estimated coefficients for initial per capita income and investment



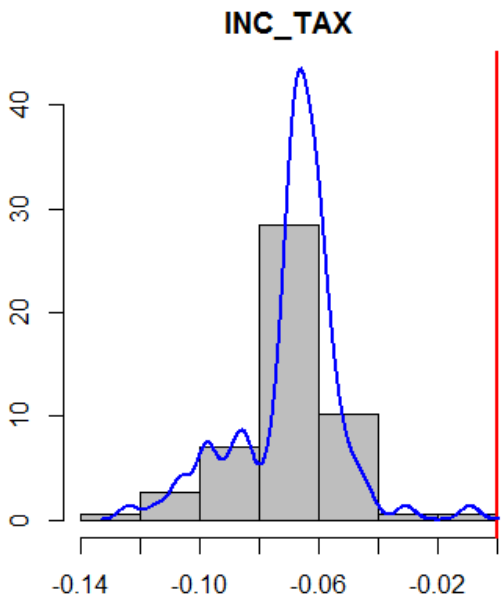
Source: OECD database, author´s calculations

Figure 9. Pooled cross-sections model - distribution of estimated coefficients for tax revenue



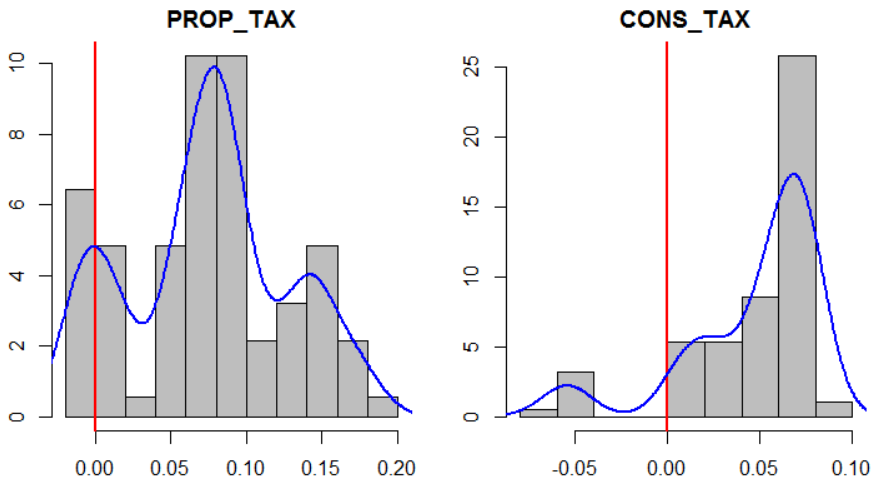
Source: OECD database, author´s calculations

Figure 10. Pooled cross-sections model - distribution of estimated coefficients for income tax



Source: OECD database, author´s calculations

Figure 11. Pooled cross-sections model - distribution of estimated coefficients for property tax and consumption tax



Source: OECD database, author´s calculations

4.3 Panel data model

The last approach is based on the analysis of panel data. To the best of my knowledge, such approach has not been applied yet to the analysis of tax structure. The model is set up in the following way:

$$(Y)_{it} = \alpha_i + \beta_j B_{it} + \gamma_{jk} F_{kit} + \delta_j P_{jit} + \varepsilon_{jit}$$

Where B, F and P represent groups of variables specified in previous sections (i.e. basic, focus and potentially significant variables). The results of the Hausman test suggest that the fixed effects estimator is preferred to the random effects estimator.

Table 9. Panel data model – values of estimated coefficients

Beta coefficients:							
	Type	Mean coef	se (mean)	Min coef	se (min)	Max coef	se (max)
INV	free	0,576	0,051	0,479	0,055	0,661	0,046
TAX_REV	free	0,213	0,096	-0,009	0,103	0,413	0,1
GDP_CAP	free	0,000	0,000	-0,001	0,000	0,000	0,000
INC_TAX	focus	-0,344	0,123	-0,474	0,137	-0,167	0,125
PROP_TAX	focus	0,346	0,426	-0,076	0,308	1,164	0,545
CONS_TAX	focus	0,533	0,223	0,177	0,252	0,799	0,223

Source: OECD database, author´s calculations

Table 10. Panel data model – distribution of estimated coefficients

Distribution of beta coefficients:				
	Type	Pct(beta<0)	Pct(beta>0)	Pct(sign.)
INV	free	0,000	100,000**	100,000
TAX_REV	free	0,444	99,556**	63,556
GDP_CAP	free	99,111**	0,889	77,333
INC_TAX	focus	100,000**	0,000	92,473*
PROP_TAX	focus	11,828	88,172	2,151
CONS_TAX	focus	0,000	100,000**	68,817

Source: OECD database, author´s calculations

Table 11. Panel data model – Leamer´s version of EBA

Leamer´s Extreme Bounds Analysis				
	Type	Lower Extr. Bound	Upper Extr. Bound	Robust/Fragile
INV	free	0,372	0,752	robust
TAX_REV	free	-0,212	0,608	fragile
GDP_CAP	free	-0,001	0,000	fragile
INC_TAX	focus	-0,742	0,081	fragile
PROP_TAX	focus	-1,035	2,233	fragile
CONS_TAX	focus	-0,318	1,237	fragile

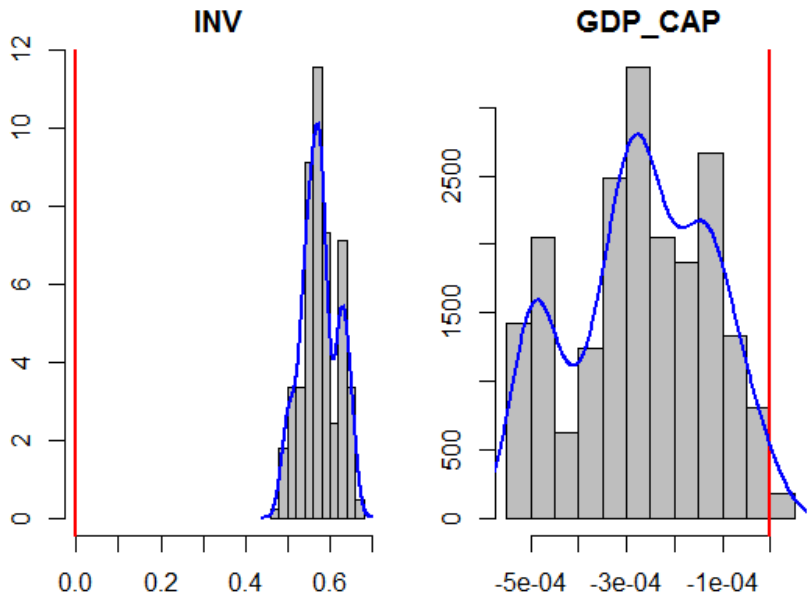
Source: OECD database, author´s calculations

Table 12. Panel data model – Sala-i-Martin´s version of EBA

Sala-i-Martin´s EBA					
	Type	N:CDF(beta<0)	N:CDF(beta>0)	G:CDF(beta<0)	G:CDF(beta>0)
INV	free	0,000	100,000**	0,000	100,000**
TAX_REV	free	1,372	98,628**	5,594	94,406*
GDP_CAP	free	99,997**	0,003	96,641**	3,359
INC_TAX	focus	99,736**	0,264	99,120**	0,880
PROP_TAX	focus	21,691	78,309	28,719	71,281
CONS_TAX	focus	0,860	99,140**	2,706	97,294**

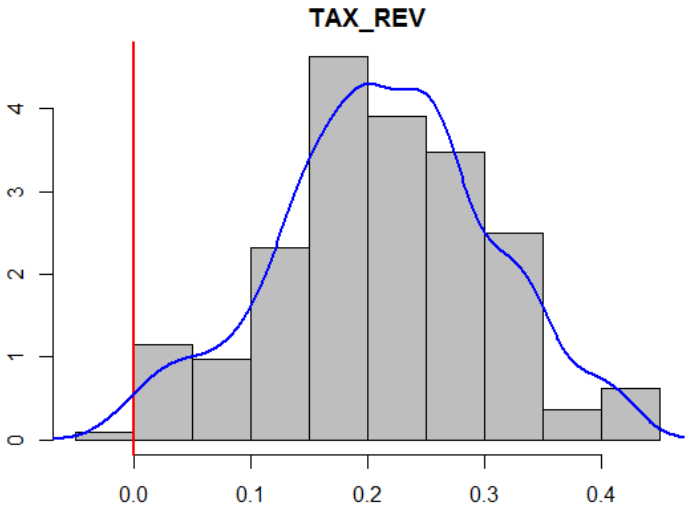
Source: OECD database, author´s calculations

Figure 12. Panel data model - distribution of estimated coefficients for investment and initial per capita income



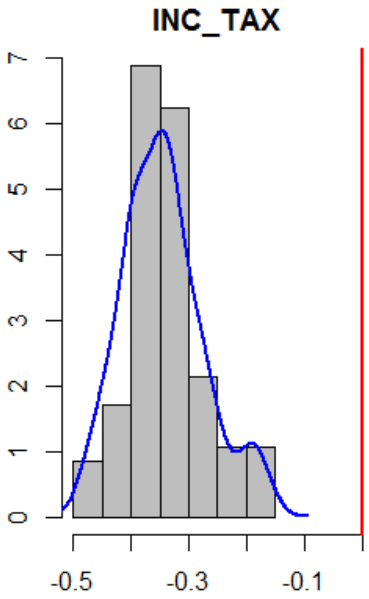
Source: OECD database, author´s calculations

Figure 13. Panel data model - distribution of estimated coefficients for tax revenue



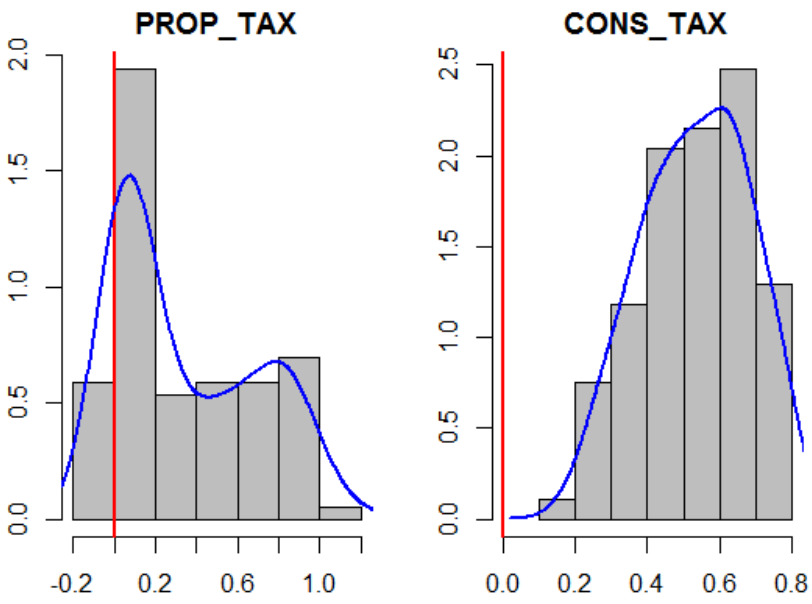
Source: OECD database, author´s calculations

Figure 14. Panel data model - distribution of estimated coefficients income tax



Source: OECD database, author´s calculations

Figure 15. Panel data model - distribution of estimated coefficients for property tax and consumption tax



Source: OECD database, author´s calculations

5 Policy implications

First, it is vital to point out that an ideal tax reform which would positively impact economic growth is often very different from what is optimal from the political point of view. Some taxes simply tend to be less popular than others and their real impact on economic activity is often not a major factor. For example, taxes levied on property are among those least popular because they are directly taken out of people´s pockets. On the other hand, the consumption taxes become just part of goods or services price and so they are paid indirectly without tax authority engagement with the people. Personal income taxes belong to the group of direct taxes but in case of employees, the deduction of tax from the gross salary is made by the employer. So the loss of money is not felt in the same way as in case of the property tax. Despite being somewhat subjective and not supported by evidence, the above mentioned facts about popularity of various taxes are strongly reflected in design of tax systems.

The study has shown a robust negative relationship between income taxes and economic growth. On the other hand, the level of consumption taxes was found to be positively associated with the growth rate. This implies that a neutral-revenue tax reform which transfers the tax burden from personal income towards consumption is likely to promote economic growth. This conclusion is consistent with the recommendations published by the CTPA. As discussed above, such a change might not be popular among voters because consumption tax cannot be designed in a progressive fashion unlike the income tax. As the evidence on corporate taxes and property taxes is not conclusive, it is hard to draw a policy implication for these taxes. However, we can infer that the reallocation of tax burden from income tax to these taxes would likely bring a positive impulse for economic growth. Ideally, the loss of revenue resulting from the income tax cuts shall be compensated by a broader consumption tax base instead of an increase in tax rates.

6 Conclusion

I have studied the relationship between tax system structure and economic growth in OECD countries from 1995 to 2011. As theory does not provide conclusive result on the effect of overall tax burden on economic growth, it came as no surprise that the tax level was not a significant predictor of economic growth in any model. On the other hand, this study has shown that the tax structure matters for economic performance and that a revenue-neutral tax reform can be beneficial for growth. Specifically, a negative relationship has been found between share of revenue collected through personal income tax and economic growth. The robustness of the relationship was confirmed by the coefficient which did not change its sign in more than 95% cases of model alterations. On the other hand, the consumption tax seems to be the least harmful for economic growth. In some models, the relationship was even robustly positive. However, the interpretation should not be that growth can be enhanced by a sole increase in consumption taxes. The implication is rather that a tax reform which shifts the tax burden from the harmful taxes to consumption is likely to result in economic growth. The findings are more or less consistent with the empirical work by Arnold (2008) who examined the relationship between tax structures and economic growth in OECD countries in the period 1971-2004.

As opposed to traditional searching for the true model which would include all relevant variables and exclude all non-relevant at the same time, my objective was to employ a thorough sensitivity analysis to identify which taxes are more or less likely to be negatively associated with economic growth. The additional variables included in the model were not objects of my analysis. Their purpose was to find out whether the relationships identified in the regression are robust to model alterations. When the sign of the income tax coefficient remained negative for more than 95% of model specifications, while the sign of the consumption tax coefficient was positive in about 90% of model specifications, I can conclude that the income tax is much more likely to have a negative impact on economic growth than consumption tax. In case of the panel data model, one should be cautious about interpretation of the robust positive impact of consumption tax on growth. As the total tax revenues are already accounted for, this result suggests that a reallocation of tax burden from personal income towards consumption should result in higher growth rate.

More generally, this paper has summarized current theoretical support and provided empirical evidence for the claim that the tax structure matters for economic growth. The results of employed regression models have shown that once the overall tax burden is accounted for, it does make a difference whether majority of tax revenues come from income tax or consumption taxes. The examined period was rather short due to the reasons discussed above.

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