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Timisoara Journal of Economics and Business TJE&B

THE NON-LINEAR EFFECT OF CORPORATE TAXES ON ECONOMIC GROWTH

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DOI: 10.1515/tjeb-2015-0002

The paper deals with the problem of taxation and its potential impact on economic growth and presents some new empirical insights into this topic. The main aim of the paper is to verify an assumed nonlinear impact of corporate tax rates on economic growth. Based on the theory of public finance and taxation, we hypothesize that at relatively low tax rates it is possible that the impact of taxation on economic growth become slightly positive. On the other hand when the tax rates are higher a negative impact of taxation on economic growth could be expected. Despite the fact that the most of the existing studies find a negative linear relationship between these variables, we can also find strong support for a non-linear relationship from several theoretical models as well as some empirical studies. Based on panel data fixed-effects econometric models, we, as well, find empirical evidence for a non-linear relationship between nominal and effective corporate tax rates and economic growth. Our data consists of annual observations for the period 1999 to 2011 for EU Member States. Based on the results, we also estimated the optimal level of the corporate tax rate in terms of maximizing economic growth in the average of the EU countries.

Keywords: **taxation, economic growth, corporate tax, effective tax rate.**

JEL Classification: **H25, E6, O40.**

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1. Introduction

One of the main aims of the economic science is to analyze and find the fundamental causes of economic growth. The first and main question regarding this topic is, whether the fiscal policy even has some impact on economic growth or not. There have been more views on this problem in the literature so far. Based on the older neoclassical growth model (Solow, 1957) there is no place for any significant effect of the fiscal policy on long-run economic growth. The situation will change when we take into account more recently developed endogenous growth models (Romer, 1986; King & Rebelo,1990). Based on these models there are several ways in which the fiscal policy could affect the short-run as well as the long-run economic growth. A significant part of the economic literature so far have supported this view (see, for example, Easterly, Rebelo, 1993; Bleaney, Gemmell & Kneller, 2001; Stokey & Rebelo, 995; Zagler & Dürnecker, 2003).

While the isolated effect of the tax burden on economic growth is mostly negative (Barro, 1990; King & Rebelo, 1990), taking into account the possible positive growth effect arising from higher public spending resulting from higher tax revenues, the impact of taxation is not so clear. In this paper, we argue that, we have reason to believe that the final effect of tax changes on growth depends on the initial value of the tax rate. On the one hand, in the case of rather low tax rates in an economy the impact of a growing tax burden could lead to a limited positive growth effect. On the other hand when tax rates are higher the effect on economic growth is negative. Hence, the relationship between the tax burden and economic growth could be also perceived as non-linear.

The type of relationship probably also depends on what type of taxes and public expenditure is taken into account. We can expect that more distortionary taxes negatively influence growth more than other taxes (for example, Bleaney, Gemmell & Kneller, 2001). Especially corporate taxes are generally considered the most distortionary tax, which greatly affects the optimal economic decisions of economic agents. Moreover corporate taxes directly affect the business environment and are probably the most exposed to international tax competition. Therefore, we decided to analyze the impact of corporate taxes on economic growth in this paper. But there are also other reasons. The changes in corporate tax rates are particularly frequent and the economic justification of corporate taxes is also a frequently discussed issue in theory and practice.

The macroeconomic effect of taxation on economic growth is commonly examined using Neo-Keynesian concepts, assuming that the total aggregate demand is described in the model of a three - sector economy, namely consumption, investment and government spending. Further assumptions used in this case are a fixed level of interest rate and the level of private investment is unchanged. Under these conditions the impact of the flat tax on total income can be expressed by the so-called tax multiplier. The value of the tax multiplier depends on the

marginal propensity to consume. If the marginal propensity to consume is the same for the private and the public spending, and assuming the change in taxes will lead to the same level of change in government spending, a change in a flat tax will not have any influence on the aggregate demand and production as stated for example by Kubátová (2010). Nevertheless, in reality we can expect that the marginal propensity to consume of government expenditure is equal to 1 (purchase of goods and services) and the marginal propensity to consume in the private sector is always less than 1. Accordingly, the negative impact of the tax multiplier on aggregate demand and production is by this assumption always weaker than the positive impact of government spending. But this is only true in the case of a fixed interest rate and a closed economy. In fact, the change in the government spending may influence the level of interest rates in the economy. Thus the increase in government spending could also lead to the effect of crowding out of private investment. The impact of crowding out could partially, or completely, eliminate the positive effect of government spending on total output. The intensity of the crowding out also depends on the situation in the economy. Moreover, there is also another important issue. The growth effect of public expenditure significantly depends on the specific type of expenditure. In general, many authors distinguish between productive and unproductive public expenditure. It is evident that productive expenditure has more intensive and direct impact on the economy. While expenditure on the infrastructure or research and development are mostly identified as productive expenditure, social expenditure is mostly considered as unproductive.

We can say that the impact of taxes and public expenditure on aggregate demand and an economy's output and growth depends considerably on specific conditions and on the current state of the economy. According to Barro (1990), the Government has the potential to positively or negatively affect the economic growth of the country on long-term. He states that the increase in public expenditure positively affects the marginal productivity of capital and economic growth. On the other side, increases in the tax burden affect economic growth negatively. Barro (1991) has also showed that the positive effect of expenditures dominates in the case of a relatively small overall public sector. When the size of the public sector exceeds a certain threshold the negative impact of taxation will be seen. Hence, this implies a non-linear relationship between the size of the public sector and economic growth. Grossman (1988) has also found non-linear relationship between growth in government and overall economic growth using time-series for the United States. These similar results have been achieved for example by Yavas (1998) and Scully (1994, 2000), while the nonlinearities are present in the form of an inverted U-shape in these studies.

We can assume that in the case of a relatively low tax burden, the size of the public sector is small, hence, any increase in the tax burden, which is reflected in higher public expenditure should have a positive effect on economic growth. On the other hand, if we assume a relatively high tax burden in the economy, further tax increases should reduce economic growth. This

relationship is examined for example by Široký, Tománek, Macháček and Tichá (2008) which we analyze in section 3.

Based on these theoretical assumptions and models examining the optimal level of taxation, our analysis suggests a non-linear impact of taxation on economic growth. The aim of this paper is to verify the hypothesis of a nonlinear impact of corporate tax on economic growth in the EU member states. The main method used is a panel data regression model. Our analysis brings some new empirical insights into this problem using the statutory as well as effective corporate tax rates in the EU countries. Based on our results, we found empirical support for the theoretical approach of the non-linear effect of taxes on economic growth in the EU. This is basically a unique finding, which has not been reported as far as we know on the same or similar sample. We also perform the estimates of potential optimal corporate tax rate maximizing the economic growth in the EU as a whole. In the next section of our paper we summarize the several literature sources dealing with the problem of the relationship between taxation and economic growth. Subsequently, we focus in more detail on the potential existence of optimal level of taxation maximizing economic growth arising from non-linear effects in the form of inverted U-shape between both variables. In the empirical part we use the panel data regression to test the assumed relationship, using several other potential determinates of economic growth as independent variables.

2. Impact of Taxation on Economic Growth - Literature Review

The original neoclassical model of economic growth introduced by Solow (1956) explained the long-term economic growth primarily by the influence of the exogenous technological progress. In this case, taxes or public expenditure could only influence the level of the output, but not the long-term economic growth rate. Later versions of the endogenous models of economic growth, such as the model introduced by Romer (1986), provided a broader scope for examining the possible impact of the fiscal policy on economic growth. The impact of taxation on economic growth based on the endogenous growth models was first analyzed by Judd (1985), Barro (1990) and King and Rebelo (1990). The results of these studies show that economic growth is mostly negatively influenced by the level of the tax burden. Some studies confirm, as well, the negative impact of tax progressivity on economic growth (e.g. Arnold, 2008). Results suggest that, the more progressive the tax is, the more negative the effect on economic growth it has. Similarly, Holcombe and Lacombe (2004) analyzed the impact of income taxes applied at the level of local states in the U.S. Based on their results, they once again confirm the negative impact of taxes on the economic growth of these states. However, the negative impact of taxes on growth was insignificant in those states where local income taxes were relatively small.

Lee and Gordon (2005) investigated this relationship based on data from 70 countries over the period from 1970 to 1997. They found that corporate taxes have a significantly negative

impact on the economic growth of a country. They also conclude that a 10 percentage point decrease in the corporate tax rate could lead to 1-2 percentage points increase in annual economic growth. In contrast, the impact of personal income taxes on growth was in this study insignificant. According to research by Johansson, Heady, Arnold, Brys, and Vartia (2008), increases in corporate taxes influenced economic growth in a mostly negative way. The same effect of corporate taxes is also confirmed by Arnold (2008).

On the other hand, Piketty, Saez and Stantcheva (2011) found no significant correlation between changes in tax rates for income taxes and economic growth in OECD countries since 1975. Myles (2009) also states that based on the results of the previous regression analysis it is not clear whether personal or corporate taxes have a negative impact on economic growth. On the other hand, based on the assumptions of endogenous growth models it seems likely that it is the corporate tax rate that affects the return on innovation, which has a negative effect on the level of R & D and hence on the economic growth.

Kotlán, Machová and Janíčková (2011) partly demonstrated the negative effect of the tax quota and most of its components on economic growth by a panel data regression analysis, but the results were different for different types of taxes. On one hand, they have shown a statistically significant negative impact of personal income taxes, excise taxes and social contributions. On the other hand they find a very significant positive impact of corporate taxes on economic growth, which is relatively surprising. The authors attributed this finding mostly to higher dependence of corporate tax revenue on the tax burden and the relative ease of corporate tax evasion. Another exception was indicated in the case of five countries with the highest tax burden (Sweden, Denmark, Finland, Belgium and France). The positive effect of taxation on economic growth was recognized in these five countries. Kotlán and Machová (2012) reported that the tax quota is not an appropriate indicator in the case of the corporate tax burden. Hence, the results of an impact on economic growth may be biased in the case of this indicator. In addition, the authors used an alternative indicator and found a negative impact of corporation taxes on economic growth.

Mutascu, Crasneac and Danuletiu (2007) analyzed the relation between taxes and economic growth on a panel data for 25 EU countries. On one hand they found a positive impact of direct taxes on economic growth and on the other hand a negative impact of indirect taxes. They argue that a 1% rise in direct tax burden generates an increase of 1.61% in GDP per capita. Mutascu and Danuletiu (2011) later used a VAR approach in the case of Romania to analyze a similar relationship. They showed that the increase in the real quarterly rate of total taxes in GDP in Romania can significantly stimulate the economy. The existence of non-linear relation between the suboptional long-run growth rate and distortionary tax rates have been supported also by Gupta (2006). However, author stated that when fiscal policy is endogenously chosen at a social optimum, the relation between the rate of growth and tax rates is negative.

While most studies deal with the influence of taxes or public spending separately, the work of Izák (2011) provides a comprehensive analysis of taxation and public expenditure on economic growth. The results confirm a negative impact of distorting taxes and a positive impact of productive public expenditure on growth. Romer and Romer (2010) found, as well, a negative effect of taxes on economic performance in the short-term in the United States after World War II. This effect is primarily assigned to the decrease of investment due to the higher tax burden. In contrast, Stokey and Rebelo (1995) argue that this kind of relationship could be debatable. Their study based on available data did not find any support for the hypothesis of significantly different levels of economic growth before and after World War II, despite a significant change in the tax burden.

3. Optimal level of taxation and the non-linear effect of taxation

When we take into account the possible non-linear effect of taxation on economic growth, the question is what level of taxation and size of government expenditure could maximize the economic growth. Donath and Milos (2008) argue that if government spending is zero there will be very little economic growth mainly because of the problems arisen in enforcing contracts, protecting property and also with infrastructure. Thus a certain level of public expenditure and therefore also an appropriate level of taxation is needed to support higher economic growth. However, the authors also state that economists generally agree that government spending becomes a burden at some level.

Similarly, Lisý (2005) claims that while too high tax rates hamper the development of business activities, too low tax rates do not provide enough tax revenue, which can also cause an economic slowdown. Lisý also claims that according to supply-side economics it is, therefore, crucial to find the optimal overall tax rate. The theoretical model of the optimal tax rate in terms of economic growth was implemented for example by Široký et al. (2008) as we now outline. This model confirms the assumption about the inverted U-shape effect of taxes on economic growth.

If we assume a situation where the state provides public services labeled as G_{t-1}, which are paid for with tax revenues labeled as τY_{t-1}, that the private sector produces goods and services $(1-\tau)Y_{t-1}$ and assume a balanced public budget, it is possible to express the economy's output at time t in the form:

$$Y_t = a(G_{t-1})^b \left[(1-\tau)Y_{t-1}\right]^{1-b} \quad (1)$$

Total output is then divided between the private and public sector. We can divide the equation by Y_{t-1} to express the annual change in the output. Consequently, we can express the effect of growth in government expenditure and tax rate on the economic growth (labeled as g) as follows:

$$\frac{\partial g}{\partial G} = aG^{b-1}b(1-\tau)^{1-b}Y_{t-1}^{-b} \quad (2)$$

and

$$\frac{\partial^2 g}{\partial G^2} = aG^{b}(1-\tau)^{-b-1}b(1-\tau)Y_{t-1}^{-b} \quad (3)$$

From this expression it is obvious that an increase in government expenditure has a positive but gradually decreasing impact on economic growth. On the other hand, the impact of tax rates on economic growth can be expressed as follows:

$$\frac{\partial g}{\partial \tau} = aG^{b}(1-\tau)^{-b}(b-1)Y_{t-1}^{-b} \quad (4)$$

and

$$\frac{\partial g}{\partial \tau^2} = aG^{b}(1-\tau)^{-b}(b-1)Y_{t-1}^{-b} \quad (5)$$

This means that the actual increase in the tax rate negatively affects economic growth. This effect increases with the level of tax rate. Because of the assumption of a balanced budget we can substitute the level of the public services G with the expression τY. Then we get this equation:

$$1 + g = a\tau^{b}(1-\tau)^{1-b} \quad (6)$$

And for the change of g we can apply:

$$\frac{\partial g}{\partial \tau} = a\tau^{b-1}(1-\tau)^{-b}(b-\tau) \quad (7)$$

Široký et al. (2008) further states that the economic growth depends on the difference (b-τ). In the case where the tax rate τ is less than the constant b, any increase in the tax rate increases also economic growth. If the opposite is true, the increase in the tax rate affects economic growth negatively. The growth maximizing tax rate can be then determined as $\tau^* = b$.

For a fixed tax rate higher than τ*, real economic growth is lower than the potential growth rate and the ratio between the public and the private sector is, then, suboptimal. The exact level of the optimal tax rate could be different for each country. According to Scully (2000), the optimal tax rate maximizing economic growth in the U.S. is at around 19.3 %.

A similar nonlinear effect of taxation on growth is also presented in Husnain (2011), who analyzes the optimal tax rate in Pakistan, India, Sri Lanka and Nepal between the years 1975 and 2008. Based on the results of regression analysis, the author found suboptimal levels of taxation in all of these countries and recommended increases in the tax quota by between 10-30 %, to maximize economic growth.

Chao and Grubel (1998) expected that the zero level of taxation could ensure a certain small level of economic growth. The situation with a non-zero tax rate and higher public expenditure is

connected with higher economic growth. Nevertheless, any proportional increase in the tax burden will cause a less than proportional increase in economic growth. The optimal level of taxation is in the paper determined in a similar manner to Široký et al. (2008).

The non-linear impact of taxation on growth is also empirically supported by Jaimovich and Rebelo (2012). They found that marginal increases in tax rates have a small growth impact when tax rates are low or moderate. However, when the taxes are high the impact on economic growth is large and negative. The authors argue that this non-linearity is fully consistent with the empirical evidence on the effects of taxation on investment, innovation and economic growth.

The non-linear relationship between taxes and economic growth seems to be similar to the Laffer curve, which reflects the impact of the level of taxation on tax revenue. However, the Laffer point of optimal taxation leads to maximal tax revenue, but does not maximize the economic output or growth. As stated by Lisý (2005), the optimal tax rate in terms of economic growth is not identical to the Laffer point because the main objective of economic policy is not the maximization of public revenue, but the optimization of economic growth. The optimal tax rate from the perspective of economic growth is, therefore, lower than that indicated by the Laffer point of optimal taxation.

4. Data and Methodology

To analyze the relationship between corporate taxes and economic growth we used regression analysis on data from the EU member states. Since we used panel data regressions, all variables include the cross-sectional component as well as time-series component. Panel data contains observation on selected variables for 26 EU Member States, except Estonia (due to the unavailability of data), for the period between the years 1999 and 2011. Due to the nature of the data, and based on the results of Hausman test (in *Table 1*), we chose to apply fixed effects panel data regression.

Table 1 . Results of the Hausman tests

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	76.46	6	0.0000

***Source**: Authors' calculations.*

All variables were tested for weak stationarity using the set of panel unit-root test (Levin-Lin-Chu, 2002; Im, Pesaran & Shin, 2003; Breitung, 2000; and Fisher ADF and PP tests). Variables that have a unit-root based on the majority of panel unit-root tests at level are integrated of the first order, thus we used the first differences of these variables in the regression models. Estimated coefficients in the models where corrected for heteroscedasticity using White's robust standard errors. Based on the results of relevant tests we can also confirm that the final models do not

contain any signs of autocorrelation or multicollinearity. Economic growth, as the dependent variable, was quantified using the annual percentage change in GDP.

All independent variables and their sources are summarized and characterized in *Table 2*.

Table 2. Variables used in the regression analysis

Variable	Description	Source
Dependent variable:		
ΔGDP	Annual GDP change in % (GDP growth rate)	World Bank. World development indicators database (WDI). Available at: http://data.worldbank.org/
Independent variables:		
EATR	Effective average corporate tax rate calculated by Devereux-Griffith methodology.	Spengel, Elschner, & Endres (2012). Effective tax levels at the industry level using the Devereux/Griffith methodology.
STR	Statutory corporate tax rate	European Union (2012). Taxation trends in EU 2012. http://epp.eurostat.ec.europa.eu/cache/ity_offpub/ks-du-11-001/en/ks-du-11-001-en.pdf
FDI	FDI inflows/GDP	World Bank database (WDI). Available at: http://data.worldbank.org/
R&D_EXP	R&D expenditure (public and private)	World Bank database. (WDI). Available at: http://data.worldbank.org/
PUBLIC_DEBT	Public debt (% GDP)	World Bank database (WDI). Available at: http://data.worldbank.org/
UNEMP	Unemployment (in %)	World Bank database. (WDI). Available at: http://data.worldbank.org/
STR_NEIGH	Average of statutory corporate tax rates in neighbouring countries	EU. 2012. Taxation trends in EU 2012. Available at: http://epp.eurostat.ec.europa.eu/cache/ity_offpub/ks-du-11-001/en/ks-du-11-001-en.pdf
GDP	GDP level per capita in PPP	World Bank database (WDI). Available at: http://data.worldbank.org/
OPENNESS	Openness of economy (Export + Import)/HDP	World Bank database (WDI). Available at: http://data.worldbank.org/
CORRUPT	Corruption perception index (higher value means a lower level of corruption)	Transparency International. Available at: http://archive.transparency.org/policy_research/surveys_indices/cpi/2007

Other control variables used in the models were included based on theoretical and empirical assumptions. These data were obtained primarily from the freely available World Bank database or from the publication Taxation trends in the EU, published by the European Union. Several descriptive statistics for all variables used are further summarized in the *Table 3*. According to a significant part of the literature FDI can promote economic growth (Hansen & Rand, 2006; de Mello, 1999; Romer, 1990). It is assumed that FDI has a positive impact on growth due to the effect on human capital. FDI could also lead to technology transfer and that could be crucial for economic growth of the country (Barro, 1990). This is also related to the creation of dynamic comparative advantages leading to technological progress. But FDI could contribute to economic growth only when a sufficient absorptive capability of the advanced technologies is available in the host country (Borensztein et al., 1998).

In the case of expenditure on research and development we also expect a positive impact on economic growth in line with the endogenous growth model (Romer, 1986). However, this effect should be significant in the long-run. The growth in R&D expenditure in this period could cause higher economic growth in the future, thus it would be necessary to use some lags for this variable in the regression. The rates of unemployment together with the GDP level are used as controls for the current situation in the economy in respect to the economic cycle. Higher unemployment should have negative consequences for production. However, we are of course aware of a reverse relationship in this case.

High public debt could mostly lead into certain constraints regarding to fiscal policy. Countries with higher debt have limited possibilities of increasing government investments and a significant part of their revenues is spent on interest. Most of the authors also perceived the relationship between public debt and economic growth as non-linear. The results of Checherita-Westphal and Rother (2012) suggest that the negative growth effect of public debt may start from level of around 70 to 80 percent of GDP. Minea and Parent (2012) find more complex non-linearities and prove that public debt affects the economic growth negatively only when the debt to GDP ratio is in the interval from 90 to 115 percent. However, the non-linear relationship between debt and growth could be given by the growth-maximizing tax rate and the impact of debt could be perceived as irrelevant (Greiner, 2012).

Table 3. Basic descriptive statistics for the variables used in the regression models

	GDP growth	EATR	STR	FDI	Unemployment	Public Debt	STR Neigh	GDP	R&D Exp.	Openness	Corruption
Mean	2.32	24.79	27.5	6.18	8.28	52.82	28.51	26096	1.44	107.27	6.36
Median	2.49	24.85	28	3.87	7.5	50.7	29.5	25622	1.24	96.5	6.4
Min./ Max.	-17.55/ 12.85	8.8/ 41.2	10/ 56	-161/ 172	1.8/ 21.7	6.1/ 170.6	10/ 48.1	5337/ 89011	0.22/ 4.13	0/ 333.53	2.6/ 10
Std. Dev.	3.64	7.37	8.21	16	3.99	27.87	7.59	12787	0.92	52.67	2.02
Obs.	363	364	364	354	361	364	364	364	346	364	351

Source: Authors' calculations.

Another factor that could have a potential effect on economic growth is the openness of the economy. This effect has been proved to be positive by several studies (Edwards, 1998; Frankel & Romer, 1999 or Chang, Kaltani & Loayza 2009). The last control variable used in the models is the level of corruption estimated by the Corruption Perception Index calculated by Transparency International. The effect of corruption on growth is mostly found to be negative (Mauro, 1995 or Li et al., 2000). Despite this fact, there are also several studies reporting insignificant or positive effects on growth (Drury, Krieckhaus & Lusztig, 2006 or Egger & Winner, 2005).

According to the stated theoretical assumptions, we expect a significant non-linear effect of both effective and statutory tax rates on economic growth. To verify this expected relationship, we also included the square of variables indicating the effective and statutory tax rates in the model. In the case of both squares of variables we expect a negative impact on the dependent variable.

A potential problem arising from the methodology used in the paper is possible endogeneity, which could negatively affect the relevance of results. This is another reason why we decided to use the tax rates as the independent variable instead of tax revenues on GDP. We believe that there is no significant inverse causality between setting the corporate tax rates and economic growth. The governments are mostly not significantly influenced by the current economic growth when setting the tax rates. This assumption is empirically supported with the results of Granger causality tests summarized in *Table 4*.

Table 4. Granger causality tests for corporate tax rates and GDP growth

	F-statistic	
	Lag = 2	Lag = 3
STATUTORY TAX RATE does not Granger Cause **GDP GROWTH**	3.39**	3.24**
GDP GROWTH does not Granger Cause **STATUTORY TAX RATE**	2.71*	2.49*
EFFECTIVE AVERAGE TAX RATE does not Granger Cause **GDP GROWTH**	4.37**	4.18***
GDP GROWTH does not Granger Cause **EFFECTIVE AVERAGE TAX RATE**	1.22	1.40

Source: Authors' calculations.

On one hand, we can see that it is likely that the statutory as well as effective tax rates Granger cause the economic growth. On the other hand, Granger causality in the opposite direction seems to be rather unlikely.

We conducted several panel data regressions, while statutory and effective tax rates have been used separately in different models, due to the significant correlation between both indicators. The results of all regression models are summarized in *Table 5*. The fixed effects models have been used in all regressions except the first model, where we applied pooled data regression. In first two models all independent variables have been included. The results suggest a non-linear impact of statutory as well as effective corporate taxes on economic growth. While there is evidence of a positive effect of the corporate tax rates variables, the square of these two variables has a negative effect on the annual change in the GDP in both cases. Both variables are significant at all conventional levels of significance. Some variables used have proven to be insignificant. Especially the corruption and the corporate tax in the neighboring countries are statistically insignificant at all levels of significance. All statistically insignificant variables have been excluded from further fixed effects models.

Table 5. Regression analysis results

Independent variables	(1) Cross-section POOLED	(2) Cross-section FE	(3) Cross-section FE	(4) Cross-section FE	(5) Cross-section FE	(6) Period FE	(7) Period FE	(8) Period & Cross-section FE	(9) Period & Cross-section FE
C (Fixed effects)		0.14 (0.03)	1.39 (1.12)	-5.89* (-1.96)	-2.79 (-1.22)	1.92 (1.19)	0.47 (0.34)	-4.53* (2.64)	-2.89 (-1.3)
STR	**0.43*** **(4.42)**				**0.51**** **(2.54)**		**0.26**** **(2.36)**		**0.62*** **(3.19)**
STR^2	**-0.01*** **(-4.03)**				**-0.01**** **(-2.21)**		**-0.01*** **(-3.93)**		**0.02*** **(-3.33)**
EATR		**0.8**** **(2.41)**	**0.12*** **(1.92)**	**0.89*** **(2.93)**		**0.13** **(0.891)**		**0.95*** **(3.29)**	
EATR^2		**-0.02**** **(-2.51)**		**-0.02*** **(2.88)**		**-0.01**** **(-2.17)**		**-0.02*** **(-3.52)**	
FDI	0.03*** (2.98)	0.03** (2.83)	0.04*** (6.04)	0.04*** (5.68)	0.04*** (5.77)	0.02 (1.15)	0.02 (1.64)	0.02 (1.53)	0.02 (1.52)
D(PUBLIC DEBT)	-0.35*** (-7.44)	-0.35*** (-6.57)	-0.389 (-7.49)	-0.39*** (7.63)	-0.39*** (-7.47)	3.03 (1.48)	-0.19*** (-4.59)	-0.1** (-2.00)	-0.1** (-2.04)
UNEMP.	-0.01 (-0.1)	-0.34*** (-2.29)	-0.26* (-1.87)	-0.31** (-2.18)	-0.28** (-2.02)	0.09 (1.41)	0.07 (1.19)	-0.38*** (-2.79)	-0.336** (-2.55)
D(R&D_EXP)	-5.12** (-2.37)	-6.43*** (-2.94)							
D(R&D_EXP(-2))			8.08*** (3.39)	7.69*** (3.27)	8.29*** (3.45)	3.03 (1.48)	2.65 (1.29)		6.95*** (2.68)
STR_ NEIGHBOUR	-0.06* (-1.95)	-0.08 (-1.33)							
GDP	-0.0001*** (-3.84)	-0.0001* (-2.28)							
OPENNESS	0.01*** (2.62)	0.03 (1.21)							
CORRUPT.	-0.03 (-0.2)	-0.19 (-0.35)							
Observations	306	306	263	263	263	263	263	263	263
R-squared	0.41	0.543	0.539	0.561	0.548	0.529	0.535	0.684	0.669
F-statistic		9.17	9.05	9.53	9.04	17.26	17.69	11.69	10.91
Durbin-Watson stat.	1.58	1.90	1.87	1.95	1.90	1.45	1.47	2.01	1.93
Akaike crit.	5.01	4.92	5.02	4.98	5.01	4.93	5.02	4.73	4.77

Source: Authors' calculations.

*Notes: Regressions are estimated by cross section fixed effects over the period 1999-2011 across potentially 26 EU countries, although missing observations reduced to 306 and 263 observations; (.) denotes t statistics and */**/*** means significance at the 10%/ 5%/ 1% levels. Standard errors have been corrected for heteroscedasticity.*

The nonlinear relationship between the corporate tax rate and economic growth was further validated by other fixed effects' regression models. We applied cross-section fixed effects and

period fixed effects models separately as well as the models with both dimensions fixed. Both, the level of the tax rate as well as the squared value of the tax rate, were significant at least at the 5% level in seven out of nine models. However, the vast majority of the results support our assumption about a non-linear effect of taxation on growth. There is a relatively strong evidence for the inverted U-shape effect between both variables. These results are in line with theoretical assumptions about growth-maximizing tax rate (see, for example, Široký et al., 2008, or Greiner, 2012) and they are also in certain way similar to the findings of Scully (2000), Husnain (2011) or Jaimovich and Rebelo (2012).

All fixed effects models which were used explain more than 52% of the variability of the dependent variable and are highly statistically significant based on the F-statistics.

The first difference of R&D expenditure has an estimated coefficient with opposite sign to what was expected in first two models. But this negative impact is evident only in the short-term. In fact, it is more appropriate to assume the positive effect of R&D expenditure on growth in the medium or long term as expected for example by Romer (1986). When we take into account the time delays of two years or more the growth effect of R&D expenditure turns positive.

Similarly, the inflows of foreign direct investment have positive effect on economic growth based on the most of our regression results. These findings are in line with the results of several previous studies such as Hansen and Rand (2006), de Mello (1999).

Based on these results, we can also estimate the approximate level of growth-maximizing corporate tax rate. According to our data the turning point is approximately at 25.9% for the effective corporate tax rate and 29.7% for the statutory corporate tax rate. Since the tax rates exceed these levels, any increase in the tax rate should have negative impact on economic growth. It should also be noted that these estimates are valid for the average of the EU, not for each EU country separately. Thus, any EU country has its own individual optimal level of corporate tax rate, which may significantly differ from our estimates.

One of the shortcomings of the models above is that the impact of taxes on GDP was measured during the same period. According to the economic theory, the relationship of tax rates to economic growth is dynamic by nature. Consequently, it is more realistic to assume the lagged impact of tax rates and public expenditure on economic growth. Hence, the lagged values of variables were also incorporated into the models. We used the estimated effects of statutory and effective tax rates at time t-1 and t-2 on the GDP growth at time t. The results of these models with a significance of variables are shown in *Table 6*. Thus the growth maximizing tax rate may slightly differ when we take to the account the lag values.

Based on the resulting model, it is clear that effective corporate tax rates affect economic growth expressed as an annual percentage change of GDP. The effect is positive to a certain threshold tax rate above which the effect turns to being negative. Thus, this finding is important for the prediction of tax policy changes on the real economy. In addition, our results also confirm several theoretical assumptions that are not directly related to taxation. For example, we can

confirm that foreign direct investment promotes economic growth in EU countries. Moreover, the positive influence was also indicated in the case of R&D expenditure, when we take into account a two-year lag for this variable.

Table 6. The effect of lagged value of corporate tax rate on economic growth

Variable	lags:	0 year lag	1 year lag	2 year lag
EATR	regression coefficient	0.8928	0.6919	0.8475
	p-value	0.0153	0.0008	0.0222
EATR^2	regression coefficient	-0.0173	-0.0138	-0.0158
	p-value	0.02	0.0024	0.0306
EATR - optimal level		**25.9%**	**25.1%**	**26.8%**
STR	regression coefficient	0.5069	0.3511	0.4583
	p-value	0.02	0.0004	0.011
STR^2	regression coefficient	-0.0081	-0.0056	-0.007
	p-value	0.04	0.0021	0.0105
STR - optimal level		**29.7%**	**31.3%**	**32.7%**

Source: Authors' calculations.

Conclusions

While most of the previous studies have shown a linear negative relationship between the tax burden and economic growth, we assume the existence of a non-linear relationship. This is supported by the economic theory as well as some empirical evidence. Based on our panel data regression results, we can also empirically confirm the assumption. The results suggest that in the case of relatively low tax rates, any increase in the tax rate will have a positive impact on economic growth. On the other hand, when the tax rate exceeds a certain threshold the impact on growth turns negative. This effect was demonstrated in the case of statutory as well as effective corporate tax rates. These findings are consistent with the theoretical assumptions of the optimal level of taxation or the optimal size of the public sector, stated by Široký et al. (2008), Chao and Grubel (1998) and others. Furthermore, our findings to some extent also support the results of several previous empirical studies which found evidence for positive effect of corporate taxes on economic growth such as Mutascu, Crasneac and Danuletiu (2007) or Kotlán, Machová and Janíčková (2011).

The partly positive impact of taxes on growth probably relates to higher public expenditure linked to higher levels of taxation. Particularly the increase in productive public expenditure, such as investment in infrastructure or R&D expenditure intensively accelerates economic growth in subsequent periods. The positive effect exceeds the negative effect of the higher tax burden only at a relatively lower corporate tax burden. In this case, it is possible that companies still do not significantly respond to increases in the tax burden by reducing production or by

transferring the tax bases to other tax jurisdictions. Although this positive impact gradually decreases with the rising level of the effective and statutory tax rates. This could be connected with the problem of decreasing efficiency of public expenditure as well as increasing distortions due to higher tax rates. The negative effect of taxation prevails when tax rates exceed a certain threshold, which can be identified as the optimal level of tax rate.

One potential issue of research in the future lies with potential spillover effects, for example the tax rate of country A affecting not only its own growth rate but that of neighbouring countries. Thus it may be that a lower tax rate impacts on own country growth by attracting companies from neighbouring countries. In this case the optimal tax rate taking account of such spillover affects may be different to that from an analysis which excludes them. Another factor which may be worth exploring is the extent to which firms actually pay taxes at the official rate and to what extent they avoid such taxes. It is important too that firms realize that there are advantages to them in paying tax. Higher growth generates higher sales. This is clearly a rich area to explore, and our contribution in this paper is to emphasize and estimate the nonlinear effects of corporate taxation on growth.

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