Testing the Growth Effects of Fiscal Policies Using Modified M-estimator

by

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Abstract

This study empirically analyses the growth effects of fiscal variables. Due to various problems, no clear-cut results are available in growth empirics. One reason for this is that the widely used LSE is probably biased and inefficient in the case of non-high-quality data like those available in the field of economics. By introducing the robust modified M-estimator (MME) proposed by *Yohai et al. (1991)*, this study takes this data problem into account. In the case of growth regressions with fiscal variables it can be shown that LSE is biased and inefficient, whereas MME is not. Furthermore, a positive growth effect of transport and communication infrastructure was ascertained. In contrast, no growth effects of taxation are found so that endogenous growth theory is not corroborated in this respect.

JEL Classifications: C23, E62, H50.

Key words: Fiscal Policies, Growth Empirics, Modified M-estimator, Least Squares Estimator, Robustness Theory.

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1 Introduction

According to endogenous growth theory (e.g. Barro, 1990), government policy can influence the growth performance of the economy. This is tested in the present paper. Yet, the aim of this study is twofold. The first aim is to estimate the growth effects of fiscal policies by applying robust methods, which are uncommon but particularly appropriate in the field of economics. The second aim is to show that robust estimation methods are superior to least square estimators (LSE) in the case presented. One main result of this study is that there is a positive growth effect from publicly provided infrastructure of transportation and communication. But generally no strong relationships between fiscal policies and growth performance have been found.

There are already a considerable number of studies which have dealt with the question of public finances and growth. Unfortunately, the main conclusion is that a stable or robust relationship cannot be empirically identified. An early sensitivity analysis of Levine and Renelt (1992) suggests that in linear regressions, no robust relationship between fiscal indicators and growth were able to be determined. Sala-i-Martin (1997), who focuses on government spending, comes to the same conclusion in his sensitivity analysis. The vagueness of these relationships is exemplified by a study of Fölster and Henrekson (2001). Whereas Fölster and Henrekson's (2001) analysis shows a significant negative relationship between government size respectively total taxes on the one hand and economic growth on the other, Agell et al. (2006), using the same data set, come to the conclusion that the correlations are highly unstable and insignificant. Other examples are the studies of Kneller et. al (1999), Bleaney et al. (2001) and De Ávila and Strauch (2003), where the first two studies find no significance with respect to government consumption and transfers, but the last one a negative correlation. The difficulty in grasping the connection between public finances and growth is explained by several reasons such as measurement errors, outliers, heterogeneity of the samples, endogeneity problems, model uncertainty, etc. (e.g. Temple, 1999).

However, in view of the fact that economic data cannot be regarded as high quality data and thus may contain outliers, the least-squares based regression applied widely in growth empirics is not suitable (Zaman et. al., 2001). If outliers are present and data is non-Gaussian, the least-squares-estimator becomes inefficient and probably biased. To cope with this weakness, Temple (2000), Zaman et al. (2001) and Atkinson/ Riani (2004) propose using robust estimators. For example, Temple (1998) and Zaman et al. (2001) show that using a robust estimator instead of a least squares estimator to test the augmented Solow model leads to considerably different conclusions. Therefore the present study uses a robust estimator, i.e. a modified M-estimator (MME) (M stands for generalised maximum likelihood estimator (see Hampel, 2000, 8)) which is, apart from another study of this author (Colombier, 2004), to the best of the author's knowledge, the first time it has been applied to growth empirics. At least, the economic database "IDEAS" does not contrain, at the time of writing, any published article applying MME. The MME used in the present paper is based on the proposal of Yohai et al. (1991).[1]

This study is organised as follows: in section 2 the notion of MME and its advantages are presented. Section 3 briefly outlines a basic endogenous growth model with a public sector, which formulates prior expectations for fiscal growth effects. In section 4 some data and methodological issues are described. Section 5 compares MME and LSE using an example, whereas section 6 reports some empirical results concerning the growth effects of government structure. In section 7 some final conclusions are drawn.

2 Why should one use MME in growth regressions?

In empirical studies of growth factors, usually large sample sizes are available. Thus, there is a great appeal to applying ordinary least squares methods because large samples are thought to have asymptotically Gaussian distributions. However, statisticians have shown that even for high quality data, which deviate only slightly from a Gaussian distribution, least square estimators (LSE) show substantial losses in efficiency (from 10% to 100%) in comparison to good robust procedures (see Hampel, 2000, 2). But usually economic data cannot be deemed as high quality data (see Zaman et al, 2001, 1). For scientific, routine data Hampel (2000, 15) estimates that typically the fraction of gross errors amounts to between 1% to 10% in the exact sciences and to even above 10% in the non-exact

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[1] Note that the term "MM-estimator" in Yohai et al. (1991) is abbreviated to "MME" in this paper.

sciences. Gross errors are data where "something went wrong" as Hampel (2000, 14) put it. Typical examples are measurement or transcription errors. Gross errors are not identical to outliers though they are the main source of outliers. The second main cause for outliers is due to the approximate nature of models. Examples for this kind of outliers are model failures such as the omission of relevant variables or uncommon events like an oil crisis, which are not captured by the estimated model. Occasionally, outliers can increase the precision of regressions. In general, these are good leverages, which exert a high influence on OLS, but are beneficial. In contrast bad leverages can severely bias OLS regressions and can cause inefficient OLS estimates (see Hampel et al., 2000, 19; Hubert et al., 2004). Note that just a single bad leverage can do harm to OLS estimates.

Statistical robustness theory answers the question of what percentage of outliers a statistic is able to tolerate before its value rises to infinity and becomes non-robust. For least squares, the breakdown point, which is a global measure for robustness, is equal to zero (see Hampel 2000, 16). Thus, LSE is not robust at all and one outlier can bias a least square estimator totally. Moreover, LSE masks outliers in multiple regressions as it tends to make the residuals look like a Gaussian distribution (the masking effect) and thus, valuable observations may be identified as outliers by conventional outlier diagnostics like Cook's distance plot (the swamping effect) (see e.g. Temple, 2000, 191-192; Hubert et .a al., 2004, 4). In contrast, the robust MME can deal with non-Gaussian distributions and has the maximum breakdown point of 0.5 (see Yohai et al., 1991, 369). This means that MME is robust against a fraction of 50% outliers in the underlying sample. Moreover, in the case of an exact Gaussian distribution, MME reaches 95% of the efficiency of OLS (see Yohai et al., 1991, 369). Since in panel data regressions one is interested in the most coherent part of the sample, the MME with its ability to identify gross errors is superior to LSE. At the same time the virulent problem of parameter heterogeneity is mitigated by using MME because country or time specific effects of the applied data have a greater chance of being verified (see also Temple, 2000, 190). Ultimately, the MME is more efficient than least trimmed squares, which are commonly used in the few economic studies applying robust estimation methods (e.g. Temple, 2000; Zamar et al, 2001; Atkinson/ Riani, 2004).

3 Theory

It is common knowledge that in a neoclassical growth model fiscal policies cannot affect the long-run growth of output. The introduction of endogenous growth models which incorporate government sectors has led to the opposite conclusion that fiscal policies can have an impact on the long-run growth rate of an economy (e.g. Barro, 1990; Barro/ Sala-i-Martin, 1992). This can be shown by a simple model of Barro/ Sala-i-Martin (1992, 648-649), though the model carries restrictive assumptions with respect to the production sphere (see Colombier/ Pickhardt, 2002, 276-278). By assuming producer households and thus, leaving labour as a factor of production aside, the following production function is assumed by Barro/ Sala-i-Martin (1992, 648):

$$y = Ak^{1-\alpha}g^{\alpha} \qquad (1)$$

The per capita output (y) is produced by per capita private capital (k) and a publicly provided input (g). Due to the assumed production technology the publicly provided input is rival. Moreover, since the same production technology is presupposed as in the case of a private good, the exclusion principle should be applicable, too. Therefore the publicly provided input assumed in Barro/ Sala-i-Martin's model corresponds to the unpaid factor and non-rival, i.e. public inputs, as well as indivisible inputs, like transport networks, are not accounted for. In addition the following balanced budget constraint is valid:

$$ng + E = L + tny \qquad (2)$$

The non-productive expenditure (E) and the total amount of publicly provided inputs (ng) are financed by lump-sum taxes (L) and a proportional tax on output (t), where n is the number of producer households. As usual in endogenous growth models an utility maximising representative, infinitely living household with a constant rate of time preference ($\rho>0$) and a constant elasticity of marginal utility ($\theta>0$) are assumed. Furthermore, producer households maximise their present value of net returns and no transitional dynamics are taken into account (see Barro/ Sala-i-Martin, 1992, 645-47). Based on the preceding assumptions the following constant steady state growth rate (γ) will result:

$$\gamma = \tfrac{1}{\theta}((1-t)\underbrace{(1-\alpha)A^{1/(1-\alpha)}(g/y)^{\alpha/(1-\alpha)}}_{=\frac{\partial y}{\partial k}} - \rho) \qquad (3)$$

Thus, equation (3) clearly shows that productive government expenditure affects the long-run growth rate positively, whereas this is the opposite in the case of proportional taxation. According to this model non-productive government expenditure and lump-sum taxes do not affect growth.

4 The empirical model, methodology and data

In order to take into account the long-term notion of models of endogenous growth, five year moving averages of the data are used. In contrast to the usual procedure of taking five or ten year averages (see Temple, 1999, 132), five-year moving averages are chosen to avoid the choice of special periods. However, one should note that five years may be too short since most countries have longer business cycles. On the other hand, it is argued that business cycles may also have important effects on long-term growth and therefore the number of years over which the average is taken should not be too long. Thus, these five year averages are a compromise, which is also due to data availability in the government sector. An objection against the usage of smoothed data is simply that in practice we do not know where this long-term path of economic development might lead and it can only be exact by chance. Thus, in contrast to economic theory the data used do not have to be equilibrium values.

The sample which is used for the estimations consists of 21 OECD countries within the time period from 1970 to 2001 (see Appendix). Since it is the purpose of this paper to introduce a new estimation method the analysis focuses on the fiscal variables which are typically used in growth empirics. These are total government expenditure, total revenues, taxation, publicly provided infrastructure and education (Nijkamp/ Poot, 2004).

The tested model is basically the following:

$$\hat{Y}_{i,t} = \beta_0 + \sum_{i=1}^{21} \lambda_i \text{country}_i + \beta_1 I_{i,t} + \beta_2 \hat{L}_{i,t} + \beta_3 X_{i,t} + \beta_4 Z_{i,t}, \quad \text{with: } \lambda_1 = 0. \qquad (4)$$

where: t stands for time and t:= 1971…2001, i stands for country i and i:= 1,…21; λ represent the regression coefficients of the factor variable "country", which should reflect the permanent non-changing growth effects in country i; β_0:= intercept and $\beta_{j>0}$:= regression coefficient. For instance, if one country grows faster on average than the others this should be captured by the country dummy. The left-hand variable corresponds to the per capita growth rate of real gross domestic product (GDP) measured in terms of purchasing power parities (PPP). Three economic control variables are integrated into the model.[2] First of all, the ratio of investment to gross domestic product (I) is accounted for. As usual the export ratio to gross domestic product (X) stands for the degree of openness of an economy. The growth rate of the share of the population between the age of 15 and 64 in respect to the whole population of a country ($\hat{L}$) serves as a proxy for the development of the labour force potential. Moreover, the included fiscal variable(s) (Z) are expressed as ratios to gross domestic product. Fiscal data represent general government level and include social security funds.

Due to the budget constraint in the case of fiscal variables there would be perfect collinearity if every fiscal variable were accounted for in the regression (see Bleaney et al. , 2001, 40). To avoid collinearity, at least one fiscal variable must be left out. However, the existence of this collinearity problem makes it difficult to interpret the coefficients of a fiscal variable. In contrast, to the view held by Bleaney et al. (2001, 40), one cannot be sure that the coefficient of a fiscal variable represents the net effect of this fiscal variable and the mix of those which are omitted from the regression. For example, if the regression coefficient of a fiscal variable is statistically significant, but the mix of the fiscal variables omitted from the regression has no impact on growth then certainly the regression coefficient only reports the influence of the included fiscal variable on growth. Of course the interpretation must be the other way round if the mix of omitted fiscal variables has a growth effect

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[2] Conditional convergence is not accounted for due to various reasons. Most crucially, we have performed a pre-test finding no empirical evidence for conditional convergence between the OECD countries of the sample. The Phillips-Perron tests, with and without a deterministic trend, suggest that the dispersion of the growth rates of labour productivities, measured by the robust median absolute deviation, is stationary across the countries of the sample. In both tests, with and without a trend variable, the null hypothesis of a unit root is rejected at a 1% level (Z-statistics: -25 and -21). These results clearly do not support the hypothesis of conditional convergence between countries of the sample in the observed time period. Moreover, this study does not explicitly test the endogenous growth model. Finally, some authors claim that the standard indicator used for conditional convergence, i.e. the per capita initial GDP, cannot be interpreted unambiguously, which would make this indicator rather useless (see Pack, 1994, 6; Thirlwall, 2003, 45).

and the included fiscal variable has none. Public deficit or surplus constitute an exception because this variable already represents a difference between two fiscal variables. In the end, a solution of the collinearity problem might be to use growth rates of fiscal variables instead of levels.

As the estimation model (4) shows, fixed effect models with country intercepts are used. Since no autocorrelation consistent covariance for the MME-method was available in the statistical package used (S-Plus 6.0) the well-known Cochrane-Orcutt method (see e.g. Gujarati, 2003, 492-94) has been applied. To detect if due to gross errors LSE or MME is biased a Chi-Square test based on Yohai et al. (1991) is performed. Crucial for the performance of LSE is how many outliers which are not good leverages exist in the underlying sample. For this a tolerance band between –2.5 and +2.5 for standardised residuals, in which only regular and good leverage points are supposed to be, has been used. This is a simple and commonly applied method in statistics (e.g. Hubert et. al., 2004).To check for collinearity problems Belsley's condition index is calculated (see e.g. Draper/ Smith, 1998, ch. 16). Furthermore, a test of assessing normality, the Shapiro-Wilk test, is used (Royston, 1995). In order to test the independence of residuals from autocorrelations the Box-Ljung statistic is applied (see e.g. Gujarati, 2003, 813). The endogeneity or reversed causation problem is dealt with instrumented equations. As instruments lagged variables are chosen. Their adequacy is tested by Sargan's method (see e.g. Gujarati, 2003, 713) and the computation of the non-parametric Spearman's rank correlation. Usually, a variable lagged by 5 years is chosen as an instrument for the fiscal variable to avoid cross-sections of data points between the instrumented and lagged fiscal variables. If Spearman's rank correlation was smaller than 90% for at least a single fiscal variable, instruments with a lag smaller than 5 lags have been chosen for all fiscal variables of the corresponding regression. An exception to this rule has been made in the case of the regressions with growth rates of fiscal variables, because all correlations are smaller than 90% (see Table 4).

A shortcoming of MME is that it needs more computational capacities than OLS. Therefore, in the case of publicly provided infrastructure no estimation with a dummy for each country were able to be performed. In order to keep the method of fixed effects models, though restricted, groups of countries have been estimated with respect to per capita GDP-growth rates and the population of a country (see Appendix, Graph A1).

5 Comparison of MME and OLS

To compare MME with OLS, regressions with the expenditure and revenue ratios are run. The expenditure ratio to GDP serves as a proxy for the government size, whereas the revenue ratio is an indicator for the average tax rate in a country. For both ratios separate regressions are run because they are highly correlated (92%: Spearman's rank correlation).

Insert Tab. 1 about here

A look at the results of the estimations presented in Table 1 shows that the estimated growth effects of government size and of the average tax rate depend on the estimator used. Looking at the estimations with the expenditure ratio (see Table 1, exp_rob, exp_ols) reveals that according to the MME government expenditures have no significant growth effect. In contrast, the OLS coefficient of the expenditure ratio is highly significant, i.e. at a 1% level, with a negative sign. According to the highly significant Chi-Square statistic the OLS regression "exp_ols" is biased. The confidence interval of the coefficient of the expenditure in "exp_ols", which corresponds to [-0.024; -0.002] does not match the MME coefficient of the expenditure ratio, which is –0.004 (see Table 1, exp_rob). Since the MME coefficient is tested as non-biased this confirms the result of the bias test for the OLS regression "exp_ols". In line with robustness theory the OLS regression is biased towards outliers, which are not good leverages. This is indicated by the fact that in the OLS regression only 1.5% of the observations are identified as bad leverages and vertical outliers, whereas the robust MME-regression detects a 5.4% fraction of outliers (see Table 1, exp_rob, exp_ols). Moreover, the Shapiro-Wilk tests in table 1 points to non-Gaussian distributed data. Consequently, the outcome of the OLS regression "exp_ols" should not be trusted too much. Since every economic variable of the MME regression "exp_rob" is significant and has the theoretically expected sign the results of this regression would appear to be trustworthy. According to the latter finding neither total government expenditure nor the financing of it, i.e. revenues plus/minus deficit/surplus, nor both sides of the government budget influence economic growth.

Also, in the case of the estimations with government revenues (Table 1, rev_rob, rev_ols) MME and OLS differ with respect to statistical significance of the fiscal variable. Compared to MME, OLS identifies only a small fraction of possibly harmful outliers, 2.4% of the sample vs. 5.2% of the sample. This certainly shows that OLS regressions tend to mask outliers. Moreover, the Chi-square again indicates that the OLS regression is biased, but only at a 10% level. The probable bias of OLS might be responsible for the implausible result that the investment ratio is not statistically significant (see Table 1, rev_ols). In addition, the confidence interval for the OLS coefficient of the revenue ratio, [-0.018,-0.00017], does not include the value of the MME coefficient for the revenue ratio, which is shown to be non-biased (see Table 1, rev_rob). Once again the MME regression shows plausible results for the economic variables so that the outcome of a non-significant coefficient of the revenue ratio seems to be reliable. This result is in line with the above and suggests that neither the average tax rate nor government size would appear to affect growth.

However, an immediate caveat to the above results comes to one's mind. There may be endogeneity problems virulent for the fiscal variables which can harm both, MME and OLS regressions. Econometrically, this is indicated by a correlation between the endogenous variables and the disturbances. But Sargan's test shows in all cases that the fiscal variables can be used as their own instruments and thus, no endogeneity problem seems to exist (see Table 1). This is not implausible for the expenditure side because in democratic systems government budgets are approved by parliaments in the preceding year and therefore, are based on GDP forecasts. For this reason expenditure figures are rarely changed later on, e.g. due to natural catastrophes. Though the tax rate is set by the government in the endogenous growth model (see section 3) the numerator of the revenue ratio, which is used as an indicator for the average tax rate, corresponds to the revenue side. As revenues depend on economic developments an endogneity problem exists for the average tax rate used in the regression in Table 1. But the results of Sargan's test can reflect the fact that there might be collection lags for some taxes in certain countries. Therefore, instrumented estimations, which are reported in Table 2, have been performed too.

Insert Tab. 2 about here

Since the OLS regression in Table 1 confirms the weaknesses ascertained by robustness theory, only MME is applied for the instrumented regressions and the equations in section 6. This procedure is also justified by the fact that according to the Shapiro-Wilk test the hypothesis of a Gaussian distribution is rejected for the residuals of each regression in this paper. Ultimately, as one can immediately see in table 2, the results of the MME-regressions in Table 1 are confirmed.

6 Government structure and growth

So far the effect of aggregated government activities on growth has been analysed. But to emphasise the qualitative aspect of government activities a deeper look at the relationship between the structure of government activities and growth is taken. Government revenues are partitioned into indirect, direct and property taxes. From the point of view of economic theory all taxes should be harmful to growth (see section 3). As direct taxes are mainly income taxes with a progressive tariff this should, according to optimal taxation theory, lead to a greater loss of efficiency and thus obstruct growth even more than the other two taxes. The tax ratios to GDP are used as indicators for the average tax rates of direct, indirect and property taxes.

Insert Tab. 3 about here

A look at Table 3 reveals that no statistically significant effects of tax variables could be ascertained for the original model (tax_rob) and the instrumented model (tax_rob_iv). Apart from the fact that in the instrumented equation (tax_rob_iv) the investment ratio is only significant at a 11% level the equations would appear to be econometrically reasonable. Consequently, the statistically insignificant coefficients of these tax types indicate either no growth effect of these taxes or owing to the collinearity problem of fiscal variables no growth effect of the mix of omitted fiscal variables. As a special case it is also conceivable that a possible negative effect of taxes is exactly offset by the mix of omitted fiscal variables. However, as there is also no significance in the case of total government expenditure this outcome is not very probable.

On the expenditure side we have various publicly provided infrastructure and education which are thought to enhance the production potential of an economy. Optimally, these government outlays should complement private investments and should not crowd out private capital. Otherwise, a reduction in growth rates of GDP can be caused. The infrastructure categories, which are accounted for, correspond to government expenditures for transport and communication systems, for water and sewer systems as well as for energy facilities (see also Appendix). The estimations in Table 3 (infra_rob, infra_rob_iv) with productive government expenditures show that except for transportation and communication infrastructure no significance could be ascertained.

The coefficient for transport and communication infrastructure is significant at a 1% level in one of the equations only (see Table 3, infra_rob). Surprisingly, the sign of the coefficient is negative. This can be interpreted in different ways.[3] First of all, there might be a non-linear relationship between this kind of infrastructure and GDP growth so that the optimum ratio to GDP is exceeded in most of the sample countries. Secondly, some counter-cyclical behaviour of government or simply time-lags of implementation of fiscal policies may be at work. In the counter-cyclical case the causation runs in the other direction – from GDP growth to infrastructure expenditure. Ultimately, the omitted mix of fiscal variables could have a significant influence on growth. Note, if these significant coefficients stand for other government expenditure than infrastructure and education, a negative sign would suggest a positive growth influence of these residual expenditures. But this explanation is a little bit at odds with economic theory because government expenditures which are thought to be non-productive would enhance growth and vice versa. But the equation with instruments for the fiscal variables shows no significance for transport and communication structures (see Table 3, infra_rob_iv). The result also

[3] According to the Box-Ljung test some autocorrelations of the residuals are left in model infra_rob. As it is a long-range autocorrelation, there may be efficiency problems and mild effects on the point estimates, too (see Hampel 2000, 4).

holds if another indicator for the degree of openness, a corrected export ratio, is introduced (see Table 4, infrac_rob_iv).[4]

Insert Tab. 4 about here

This suggests that reversed causation and thus, counter-cyclical fiscal policies, may be at work. As already noted in section 4 some business cycle effects can be present in five year averages.

In view of the significant result for the transportation and communication infrastructure further estimations are performed. In order to mitigate the above-mentioned interpretation problems for regression coefficients of fiscal variables (see section 4), fiscal variables are also estimated in per capita growth rates in real terms measured in PPP. To put private and public capital on an equal footing private capital is also estimated in per capita growth rates. Thus, the growth rates of capital accumulation are accounted for. It is striking that in both regressions with growth rates of private and public capital the indicator for labour force potential is no longer significant (see Table 4, ginfrac_rob, ginfrac_rob_iv). A reasonable explanation could be a contribution of the labour force to the growth rate of capital accumulation, though the correlation in the underlying sample is rather low (6%: Spearman's rank).

The instrumented equation (ginfrac_rob_iv) shows a positive significance of transport and communication infrastructure on growth. Although this effect is only significant at a 10% level this unambiguously points towards a causation that runs from transport and communication infrastructure to GDP growth. However, since the confidence interval for the coefficient of transport and communication ranges from 0.002 to 0.01 a one percentage point increase in government expenditure for transport and communication can cause at a maximum a 0.01 percentage point increase in the per capita growth rate.

To sum up, apart from the influence of transport and communication infrastructure no growth effect could be found. The results for government spending on transport and communication would at

[4] As small countries tend to have higher export ratios than large countries, the export ratio is corrected by the population size of a country. However, this device is not clear-cut because the correlation between population and export ratio amounts only to –50% (Spearman's rank correlation).

first appear a little bit ambiguous. However, the significance of a negative coefficient in the case of the ratio to GDP seems to be the outcome of reversed causation whereas the positive effect on the growth rate of this infrastructure category corresponds to our expectations.

7 Conclusions

The introduction of the robust MME has demonstrated that in the case of regressions with fiscal data gross errors are present. As statistical robustness theory predicts, the OLS estimates are biased and probably inefficient in the examples performed. This suggests that one source of conflicting results, such as those of Fölster and Henrekson (2001) and Agel et al. (2003) as well as those of Bleaney et al. (2001) and De Ávila and Strauch (2003), is biased and inefficient LSE. Because of this weakness LSE-based studies should be interpreted with some care.

Whereas the non-significant result with respect to government size of this paper is in line with a small majority of recent studies (Kneller et al. 1999; Bleaney et al. 2001, Bassanini et al., 2001, Agell et al., 2006) no growth effects of taxation are ascertained in two out of six recent empirical analyses (Agell et. al., 2006; De Ávila/ Strauch, 2003).[5] But it should be kept in mind that the conflicting results of Fölster and Henrekson (2001) have to be questioned in view of the study of Agell et. (2006). In addition, the recently performed meta-analysis of Nijkamp and Poot (2004) also suggests no significant relationship between government size respectively taxation on the one hand and economic growth on the other.

Furthermore, this study suggests that there is a positive relationship between transport and communication infrastructure and economic growth. A recent study of Colombier (2004), which uses the method of pooled MME regressions, shows that this infrastructure category is, in 10 (7) out of 14 models with difference in regressors and periodicity, significant at a 10% level (5% level). Moreover, the outcome with respect to transport and communication infrastructure is consistent with the results

[5] This statement refers to the following studies: Kneller et al. (1999), Bassanini et al. (2001), Bleaney et al. (2001), Fölster and Henrekson (2001), Agell et al. (2005), De Ávila and Strauch (2003).

found by Kneller et al. (1999) and Bleaney et al. (2001). To sum up, the measured positive growth effect of this infrastructure category seems to be fairly stable.

Since no significant growth effect of taxation is found endogenous growth theory is not corroborated in this respect. Furthermore, it should not be forgotten that the quality of government activities such as regulation of markets is also thought to play a crucial role for economic performance, and the connection between education and economic performance is complex. In addition, this analysis has taken into account public funded research only indirectly via total government expenditures. Further analysis should account for these research activities explicitly. Although the application of robust estimators such as MME is superior to the application of LSE there still remain econometric problems in panel data studies, especially model uncertainty, to a certain degree. Thus, a natural extension of this analysis would be to perform the extreme-bound analysis proposed by Leamer (1983) to mitigate model uncertainty. Ultimately, although panel data analyses are useful in providing macroeconomic orientation they should, due to their shortcomings, be complemented with micro-focused studies.

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Tables

Tab. 1: Government size, average tax rate and growth

Model	exp_rob	exp_ols	rev_rob	rev_ols
Estimator	MME	OLS	MME	OLS
investment ratio	0.109*** (0.019)	0.037** (0.015)	0.110*** (0.020)	0.017 (0.017)
export ratio	0.030*** (0.010)	0.041*** (0.009)	0.061*** (0.011)	0.037*** (0.009)
labour force potential	0.678*** (0.226)	0.493** (0.009)	1.013*** (0.266)	0.334 (0.234)
expenditure ratio	-0.004 (0.004)	-0.013*** (0.004)		
revenue ratio			-0.0004 (0.005)	-0.010** (0.005)
intercept	-0.456** (0.204)	0.633*** (0.151)	-0.892*** (0.212)	0.724*** (0.151)
country intercepts	yes	yes	yes	yes
adj./ rob. R^2 in %	43	67	40	58
No. of obs.	392	392	380	380
Sargan' s test statistic (df = 1)	1.11 (0.29)	0.0 (1.0)	0.02 (0.88)	0.0 (1.0)
Chi-Square test of bias	12.9 (0.98)	48.0*** (0.004)	11.0 (0.99)	36.8* (0.06)
Shapiro-Wilk Normality test	0.87*** (0.0)	0.96*** (0.0)	0.77*** (0.0)	0.95*** (0.0)
Box-Ljung test	371.59 (0.75)	355.23 (0.90)	348.39 (0.87)	353.25 (0.82)
No. of identified outliers (% of observations)	21 (5.4)	6 (1.5)	20 (5.2)	9 (2.4)
Belsley's Condition Index	18.8	-	15.5	-

Notes: Estimation technique: Fixed Effect Models; five year moving averages; Cochrane-Orcutt method in the case of autocorrelations; period: from 1971 to 2001; dependent variable: growth rate of per capita real GDP in purchasing power parities (PPP); ***1% significance level; **:= 5% significance level; *:= 10% significance level; t tests: figures in parentheses are standard errors; Chi-square test: test statistic, figure in parentheses is P value; Sargan's test: figure in parentheses is P value; Belsley's Condition Index (bci): the largest condition index is reported; interpretation: bci <30: collinearity is not a major concern; 30 ≤ bci ≤ 100: collinearity problems exist; 1000 ≤ bci ≤ 3000: severe collinearity problems; Shapiro-Wilk-Test: H0: Gaussian distribution, W test statistic, figure in parentheses is P value; Box-Ljung test: H0: no autocorrelations exist, Box-Ljung test statistic, figure in parentheses is P value.

Tab. 2: Government size and growth – instrumented estimations

Model	exp_rob_iv	rev_rob_iv
Estimator	MME	MME
Instrumented	yes	yes
investment ratio	0.042* (0.022)	0.086*** (0.029)
export ratio	0.051*** (0.010)	0.059*** (0.010)
.bour force potential	0.983** (0.015)	1.005*** (0.318)
expenditure ratio	-0.006 (0.004)	
revenue ratio		0.0 (0.004)
intercept	0.033 (0.419)	-0.424** (0.204)
country intercept	yes	yes
rob. R^2 in %	35	32
No. of obs.	356	332
Sargan' s test statistic (df = 1)	0.19 (0.663)	0.002 (0.96)
Chi-Square test of bias	3.5 (1.0)	8.5 (0.99)
Shapiro-Wilk Normality test	0.97*** (0.0)	0.94*** (0.0)
Box-Ljung test	269.56 (0.99)	305.81 (0.83)
No. of identified outliers (% of observations)	16 (4.5)	18 (5.4)
Belsley's Condition Index	22.8	18.4
Spearman's rank correlation instrumented variable	94	97

Notes: see Table 1.

Tab. 3: Taxes, infrastructure, education and growth

Model	tax_rob	tax_rob_iv	infra_rob	infra_rob_iv
Estimator	MME	MME	MME	MME
Instrumented	no	yes	no	yes
investment ratio	0.105*** (0.022)	0.030[6] (0.019)	0.121*** (0.022)	0.077*** (0.026)
export ratio	0.059*** (0.012=	0.049*** (0.009)	0.069*** (0.009)	0.064*** (0.009)
labour force potential	0.954*** (0.252)	1.114*** (0.247)	1.261*** (0.307)	1.121*** (0.329)
ratio transport & communication			-0.384*** (0.097)	-0.109 (0.095)
ratio water & sewer systems			-0.034 (0.072)	0.053 (0.075)
ratio energy facilities			0.224 (0.225)	0.119 (0.228)
ratio education			0.064 (0.058)	-0.019 (0.060)
ratio indirect taxes	0.027 (0.027)	-0.008 (0.019)		
ratio direct taxes	-0.004 (0.02)	0.009 (0.015)		
ratio property taxes	-0.139 (0.124)	-0.055 (0.079)		
intercept	-0.797*** (0.185)	0.064 (0.145)	-0.589*** (0.185)	-0.193 (0.198)
(grouped) country intercepts	yes	yes	yes	yes
adj./ rob. R^2 in %	42	35	36	28
No. of obs.	400	361	301	299
Sargan' s test statistic (df = 1)	0.08 (0.78)	0.00008 (0.99)	0.003 (0.96)	0.01 (0.93)
Chi-square test of bias	4.5 (1.0)	-5.7 (1.0)	-1.93 (1.0)	4.8 (1.0))
Shapiro-Wilk normality test	0.84*** (0.0)	0.95*** (0.0)	0.96*** (0.0)	0.94*** (0.0)
Box-Ljung test	407.47 (0.37)	280.50 (0.99)	351.89** (0.02)	277.10 (0.80)
No. of identified outliers (% of observations)	18 (4.5)	19 (5.3)	14 (4.7)	15 (5.0)
Belsley's Condition Index	20.1	19.7	16.7	18.9
Spearman's rank correlation instrumented variables	-	indirect taxes: 94; direct taxes: 95; property taxes: 91.	-	transport & communication: 97; energy: 92; education: 98; water & sewer systems: 96.

Notes: Regressions with infrastructure variables are performed with grouped country intercepts (see Appendix); see Notes Table 1.

[6] The investment ratio is significant at the 11% significance level.

Tab. 4: Growth effects of the growth rate of infrastructure and education

Model	infrac_rob_iv	ginfrac_rob	ginfrac_rob_iv
Estimator	MME	MME	MME
Instrumented	yes	no	yes
investment	0.160*** (0.034)	0.209*** (0.010)	0.210*** (0.012)
corr. export	0.231*** (0.042)	0.112*** (0.033)	0.120*** (0.034)
labour force potential	0.992** (0.396)	0.207 (0.258)	-0.405 (0.296)
transport & communication	-0.014 (0.126)	0.0003 (0.003)	0.006* (0.003)
water & sewer systems	0.145 (0.093)	-0.001 (0.003)	-0.0007 (0.003)
energy facilities	0.045 (0.261)	-0.0004 (0.001)	-0.001 (0.001)
education	-0.103 (0.073)	-0.017 (0.033)	-0.007 (0.012)
intercept	-0.122 (0.162)	0.339** (0.049)	0.239*** (0.049)
grouped country intercept	yes	yes	yes
rob. R^2 in %	23	54	54
No. of obs.	299	275	273
Sargan' s test statistic (df = 1)	0.03 (0.86)	0.003 (0.96)	0.44 (0.51)
Chi-square test of bias	-0.06 (1.0)	-5.7 (1.0)	2.0 (1.0)
Schapiro-Wilk normality test	0.94***(0.0)	0.77*** (0.0)	0.97*** (0.0)
Box-Ljung test	265.37 (0.59)	254.38 (0.89)	276.11 (0.59)
No. of identified outliers (% of observations)	15 (5.0)	10 (3.6)	11 (4.0)
Belsley's Condition Index	13.4	6.0	5.9
Spearman's rank correlation instrumented variables	transport & communication: 97; water & sewer systems: 96. energy: 92; education: 96;	-	transport & communication: 70; water & sewer systems: 76; energy facilities: 70; education: 80.

Notes: Regressions are performed with grouped country intercepts (see Appendix), corrected export ratio (see fn. 4) and equations ginfrac_rob and ginfrac_rob_iv are run with growth rates of private investment and infrastructure; see Notes Table 1.

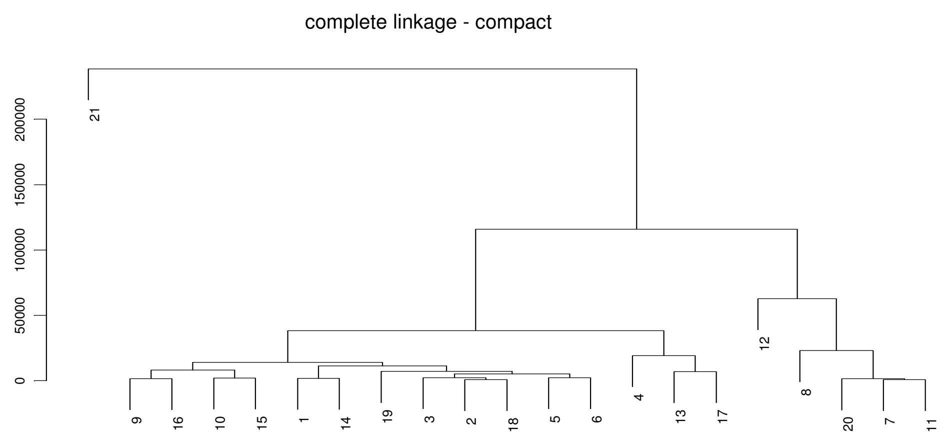
Appendix

Data

Fiscal data stem from the Government Finance Statistics, 2004 (GFS) of the International Monetary Fund (IMF), whereas economic data come from Economic Outlook No. 74, 2004, and the Annual National Accounts, 2004, of the OECD. For a detailed description of public expenditure categories see Classifications of the Functions of Government (COFOG), United Nations Statistics Division. The sample includes the following countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Republic of Korea, Netherlands, New Zealand, Portugal, Spain, Switzerland, Sweden, UK and USA. Other industrialised OECD countries, which include Iceland, Luxembourg and Norway have not been chosen due to some peculiarities. Norway is an oil-producing country, whereas Luxembourg and Iceland are much smaller in population than the smallest country of the sample, New Zealand (2003: 4 million inhabitants, Luxembourg: 450,000 and Iceland: 289,000). All estimations are carried out with the statistical package S-Plus 6.0.

Cluster Analysis

Fig. A1: Dendrogram of country groups



1: Australia; 2: Austria; 3: Belgium; 4: Canada; 5: Denmark; 6: Finland; 7: France; 8: Germany; 9: Greece; 10: Ireland; 11: Italy; 12: Japan; 13: Korea; 14: Netherlands; 15: New Zealand; 16: Portugal; 17: Spain; 18: Sweden; 19: Switzerland; 20: United Kingdom; 21: USA.

In order to construct groups of countries a complete-link clustering with respect to 8 years averages of per capita real GDPgrowth rates in PPP terms and the population over the period from 1970 to 2000 are performed (see e.g. Backhaus et al., 2000, ch. 7). According the cluster analysis the following country groups are constructed:

A: Austria, Belgium, Denmark, Finland, Sweden, Switzerland; B: Australia, Netherlands; C: Canada; D: Greece, Portugal; E: France; Italy; F: Germany; G: Ireland, New Zealand; H: Japan; I: Korea, Spain; J: United Kingdom; K: USA.