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Growth Effects of Fiscal Policies:

An Application of Robust Modified M-Estimator

by

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Abstract

In the field of economics only non-high-quality data is usually available, which can cause the widely used LSE to be biased and inefficient. Therefore, the present study introduces the robust modified M-estimator (MME) proposed by *Yohai et al. (1991)*. In the case of growth regressions with fiscal variables it can be shown that LSE is biased and inefficient, whereas MME is not. The robust regressions ascertain a stable positive growth effect of public infrastructure and education. Moreover, this study shows that government size has not been detrimental to growth for OECD countries in the past. No growth effects of taxation have been found so that endogenous growth theory is not corroborated in this regard. Consequently, fiscal policies aiming at promoting growth should focus on infrastructure and education.

JEL Classifications: C23, E62, H50.

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

1 Introduction

The aim of this study is twofold. The first goal 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 goal is to show that robust estimation methods are superior to least square estimators (LSE) in the case presented. One main finding of this study is that there is a stable positive growth effect from publicly provided infrastructure, such as transportation and communication infrastructure, and governmental outlays for education.

There are already a considerable number of studies which have dealt with the question of public finances and growth. Unfortunately, it is difficult to identify a stable or robust relationship empirically. An early sensitivity analysis of Levine and Renelt (1992) suggests that, in linear regressions, no robust relationship between fiscal indicators and growth was able to be determined. Sala-i-Martin (1997), who focuses on government spending, comes to the same conclusion in his sensitivity analysis. The difficulty in grasping the connection between public finances and growth is generally explained by several reasons such as measurement error, outliers, parameter heterogeneity, endogeneity problems and model uncertainty (e.g. Temple, 1999). In contrast to most of these problems outliers have so far received only little attention in growth empirics (e.g. Temple, 2000; Zaman *et al.*, 2001). In view of the fact that economic data cannot be regarded as high-quality data and thus in all likelihood contain outliers, this is rather surprising at first sight. However, Zaman *et al.* (2001, 1-2) give some explanations why most applied economists treat outliers as a minor problem. In particular, there are widespread beliefs among applied economists that large sample sizes make a systemic approach to outliers dispensable and that outliers can be detected by eyeballing them or by unusual-looking OLS residuals. Moreover, applied economists are often unfamiliar with robust estimation techniques, which systematically cope with outliers. But due to a lack of high-quality data in economics 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 (2007) 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.

Against this background I introduce a robust estimation method to study the growth effects of fiscal policies. I apply a robust modified M-estimator (MME) (M stands for generalised maximum likelihood estimator (see Hampel, 2000, 8)) which has, apart from another study of this author (Colombier, 2004), to the best of the author's knowledge, not been applied to growth empirics. The economic database "IDEAS" does not contain, at the time of writing, any published articles applying MME. 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 two examples, whereas section 6 reports further empirical results and shows the findings of some sensitivity analyses. 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. There is a great appeal to applying ordinary least squares methods because large samples are thought to have asymptotically Gaussian distributions. However, statisticians have demonstrated that even for high-quality data, which deviates 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). As a result, LSE is no longer

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

the best unbiased estimator (see Hampel, 2000, 19). Unfortunately, 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 from 1% to 10% in the exact sciences and to even above 10% in the non-exact 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 of 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. Occasionally, outliers can increase the degree of precision of regressions. In general, these are good leverages, which exert a strong influence on LSE, but are beneficial. In contrast, bad leverages, but also vertical outliers - although to a lesser extent -, can severely bias LSE regressions and can cause inefficient LSE estimates (see Hampel, 2000, 19; Hubert *et al.*, 2005).

Statistical robustness theory answers the question of what percentage of outliers an estimator 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 totally bias a least square estimator. Moreover, LSE masks outliers in multiple regressions, as it tends to make the residuals look like a Gaussian distribution (the masking effect) and valuable observations may thereby 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 al., 2005, 266). 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 and is thus a high-breakdown estimator. Moreover, in the case of an exact Gaussian distribution, MME reaches 95% of the efficiency of LSE (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; Zaman et al, 2001; Atkinson, 2007).

3 Theory

It is common knowledge that fiscal policies cannot bring about changes to long-run growth of output in a neoclassical growth model. The introduction of endogenous growth models that incorporate the government sector has led to the opposite conclusion that fiscal policies can affect the long-run growth rate of an economy (e.g. Barro and Sala-i-Martin, 1992). This can be shown by a simple model of Barro and Sala-i-Martin (1992, 648-649). By assuming producer households, and thus leaving labour as a factor of production aside, Barro and Sala-i-Martin (1992, 648) get the following production function:

$$y = Ak^{1-\alpha} g^{\alpha} \tag{1}$$

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 and Sala-i-Martin's model corresponds to the unpaid factor (see Colombier and Pickhardt, 2002, 276-278). Non-rival inputs, as well as indivisible inputs like transport networks, are not accounted for. In addition the following balanced-budget constraint is valid:

$$ng + E = L + tny \tag{2}$$

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 infinitely-living, utility-maximising representative household with a constant rate of time preference ($\rho>0$) and a constant elasticity of marginal utility (θ>0) is assumed. Furthermore, producer households maximise their present value of net returns, and no transitional dynamics are taken into account (see Barro and 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, I use five-year moving averages of the data. In contrast to the usual procedure of taking five- or ten-year averages (see Temple, 1999, 132), I use five-year moving averages to avoid the choice of special periods. 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 does not have to comprise 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 and Poot, 2004).

The tested model is basically the following:

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

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). Two economic control variables are integrated into the model.[2] First of all, the ratio of private investment to gross domestic product (I), which is a proxy for capital accumulation in accordance with common practice in growth empirics, is accounted for. The growth rate of the population between the age of 15 and 64 ($\hat{L}$) serves as a proxy for the development of the labour force potential. Moreover, the included fiscal variables (Z) are expressed as ratios to gross domestic product. Fiscal data represents the general government level and includes 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. Since fiscal variables of the sample are highly correlated, expenditure and revenue variables have not been

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[2] Conditional convergence is not accounted for due to various reasons. Most crucially, I 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, 65; Thirlwall, 2003, 45).

simultaneously put into a single regression (see appendix, Table A1). 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 and the included fiscal variable has none. Public deficit or surplus constitutes an exception because this variable already represents a difference between two fiscal variables.

As the estimation model (4) shows, I use fixed-effect models with country intercepts. Since an autocorrelation consistent covariance for the MME method was not available in the statistical package used (S-Plus 6.0), I run additional regressions with a heteroskedasticity autocorrelation consistent covariance matrix (HAC) using the open-source sister of S-Plus, R (version: 2.2.1).[3] The HAC estimator is based on a robust covariance matrix, the median absolute deviation, which has a high breakdown point of 50% (see Hampel, 2000, 20). To detect if, due to gross errors, LSE or MME is biased, I perform a Chi-Square test based on Yohai *et al.* (1991). Crucial to the performance of LSE is how many outliers that are not good leverages exist in the underlying sample. For this, I use a tolerance band between –2.5 and +2.5 for standardised residuals, in which only regular and good leverage points are supposed to be. This is a simple and commonly applied method in statistics (e.g. Hubert et. al., 2005). To check for collinearity problems, I calculate Belsley's condition index (see e.g. Draper and Smith, 1998, ch. 16). Furthermore, I use a test to assess normality, the Shapiro-Wilk test (Royston, 1995). I deal with the endogeneity or reversed causation problem using

[3] For this the R-packages MASS, sandwich, lmtest and zoo have been applied.

instrumented equations. I choose variables lagged by 5 years as instruments for the fiscal variable to avoid cross-sections of data points between the instrumented and lagged fiscal variables. I evaluate the relevance of instruments by applying the non-parametric Spearman's rank correlation. Due to limited degrees of freedom I was not able to run regressions with more than one instrument per fiscal variable so that the application of an over-identifying restriction test, e.g. Sargan's test, to test the validity of an instrument has not been possible. However, except for the case in which a variable exists that simultaneously affects both per capita GDP and the instrument, the chosen instruments can plausibly be assumed to be exogenous and thus valid.

Note that in the case of publicly provided infrastructure, I was not able to perform an estimation with a dummy for each country due to the computer-intensive calculation of MME. In order to keep the method of fixed effects models, though restricted, I estimate groups of countries with respect to per capita GDP growth rate and the population of a country. The groups of countries are found by applying a complete linkage clustering (see appendix, illustration A1).

5 Inefficient and biased LS-regressions

In this section I show two regressions with fiscal variables that indicate that LSE is inefficient or biased. First of all, I carry out a regression that tests the effect of the tax burden on growth. The ratio of revenues serves as an indicator for the average tax rate and is commonly applied for this purpose in growth regressions. Looking at Table 1 reveals that at first sight the results of MME and LSE do not differ too much. But two differences are striking. Firstly, all estimates of MME are lower than those of LSE and secondly, as opposed to the MME-estimate, the LSE-estimate of the average tax rate is negative significant at a ten percentage level. Though not highly significant, this result seems to underpin the prediction of endogenous growth theory, which says that the tax burden can hamper growth. However, according to the MME-regression, the percentage of potentially harmful outliers is 2.1 and the test for normality points to non-Gaussian distributed residuals, whereas the LSE regression detects a much lower percentage of outliers, 1.3, and according to the test for normality the residuals would appear to be Gaussian. The findings of the tests for normality epitomise the masking effect of LSE. The reason that MME does not reject the same sample of outliers may also be the swamping effect of LSE. Based on this comparison, it can be inferred that the prediction of endogenous growth theory is not empirically supported with respect to the tax burden.

Insert Table 1 about here*

Turning to a second example, it is demonstrated that LSE can also be biased. Sometimes researchers not only test the possible effects of fiscal policies on economic growth but also on capital accumulation, as the latter is perceived to be one of the main drivers of economic growth (e.g. De Ávila and Strauch, 2003). The estimations in Table 1 show a marked difference between MME- and LSE-results. Not only do MME-estimates report highly positive, significant correlations of transport and communication infrastructure and education (1% level) but also the signs of the MME-estimates with respect to public water and sewer systems and education differ from those of the LSE estimates.[4] This is certainly because of the fact that the LSE-estimate is tested as biased at a 1% level. Thus, the results of the LSE test cannot be deemed trustworthy. Furthermore, there is some evidence that LSE is inefficient because, compared to MME (13.2), only a small amount of outliers could be detected by LSE (see Table 1). Consequently, judging from LSE results would lead to the opposite conclusion than the one that would be drawn from MME regressions. According to the latter, public investment would appear to complement private investment as endogenous growth theory predicts.

Both examples demonstrate that conclusions reached from LSE regressions can be severely distorted because preconditions vital to LSE being the best unbiased estimator, such as

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[4] In the following transport and communication infrastructure are shortened to transport infrastructure.

Gaussian distributed data, are not met. Moreover, all regressions but one seem to have non-Gaussian distributed residuals, which implies that LSE is no longer the best unbiased estimator or even that it could be biased (see tables 1 to 5). In 8 (9) out of 20 cases, the statistic of the bias test has been significant for LSE at at least a 5% level (10% level) (see tables 1 to 5). Thus, usage of MME is strongly recommended and the following analysis focuses on estimations applying MME.

6 Further empirical results

First of all, I report some general results before continuing with the results concerning fiscal policies in sections 6.1 and 6.2.

The adjusted robust R-square displayed in tables 1 to 5 ranges from 18% to 46% and averages 32%. The values of R-square are reasonable for panel data models but apparently lower than in other panel data analyses (e.g. Bleaney *et al.*, 2001; Fölster and Henrekson, 2001). However, the classical R-square, used in these analyses, may be distorted by non-Gaussian distributed data and outliers in economic data. For example, in Table 1 the R-squares of LSE are markedly overestimated. Thus, LSE regressions would appear to put too little emphasis on the approximate nature of the model specification in growth empirics. The robust R-square shows that other government activities such as regulation of markets, which are difficult to encompass in regression analysis, may play a crucial role in economic performance. Besides, due to data availability, another possible growth driver, publicly-funded research, could have been taken into account only indirectly via total government expenditure. Furthermore, the coefficients of economic control variables show the economically plausible sign in all regressions (see tables 1 to 5). In 9 out of 12 cases, the investment ratio is statistically significant at least at a 10% level whereas 95% of them are significant with respect to labour force potential. The instruments of fiscal variables are highly correlated with the original variables so that the chosen instruments can be viewed as strong (see tables 2 to 5).

Expenditure side

For the expenditure side of the government budget I test the effects of government size and productive government expenditures (infrastructure and education) on growth. Optimally, productive government outlays should complement private investment and should not crowd out private capital. Otherwise, they could cause a reduction in growth rates of GDP. The results of these regressions suggest a negative relationship between government size and growth (1% significance level) (see Table 2). It could be deduced that in most OECD countries the optimal level of government size to GDP has been exceeded during the period from 1970 to 2001. This would imply a non-linear relationship between public expenditures and growth.

However, 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 causality runs in the other direction from GDP growth to government expenditure. Moreover, the omitted mix of fiscal variables could have an influence on growth.

*** Insert Table 2 about here***

A regression only gives information about partial correlations but not about causality. In order to approach the causality problem and thus, possible endogeneity or reversed causality, I perform regressions with instrumental variables. From Table 2 it can be seen that the sign of the estimate of government size has changed. Now it is positively significant at a 1% level. In contrast to the previous result without an instrument, this indicates that government size makes a positive contribution to economic growth. Two things can be inferred from this. Firstly, the ascertained significantly negative correlation of the non-instrumented estimation may well be due to counter-cyclical fiscal policies. Secondly, if a non-linear relationship of any kind exists, which is plausible, it has, on average, not yet reached its optimal or critical level. Since the average level of government expenditures to GDP is at about 50%, this level still fosters growth to some extent. Certainly, while this does not imply that an average ratio of, say, 60% is still conducive to growth, this means that in the past government expenditure has not been detrimental to but rather beneficial to growth.

As regards the regressions on infrastructure and education with the per capita growth rate of real GDP as regressand, the coefficients of transport infrastructure and education are not statistically significant (see Table 2). Moreover, the highly statistically significant coefficient of water and sewer systems (1% level) of the instrumented regression in Table 2 indicates that spending on water and sewer systems exert a positive influence on growth. The instrumented regressions with capital accumulation as regressand support the finding of non-instrumented estimations showing positively significant coefficients of transport infrastructure (1% level) and education (5% level) (see Table 1 and Table 2). Consequently, the regressions imply that water and sewer systems directly affect growth, whereas transport infrastructure and education are conducive to growth by contributing to capital accumulation. In public goods theory, transport infrastructure and education would be called "factor-augmenting public input", or more precisely "capital-augmenting public input", while water and sewer systems are similar to an "unpaid factor" (e.g. Colombier and Pickhardt, 2005).

Government expenditure - alternative specifications

Following the procedure of recent empirical growth studies, I do some sensitivity analyses to take into account model uncertainty (e.g. Bleaney et. al., 2001). Accordingly, I perform additional instrumented regressions with a different time period and omitting the investment variable in order to take model uncertainty into consideration. In the case of estimation with capital accumulation as the dependent variable, labour force potential has been included as an additional regressor. The sensitivity analyses for government size support the positively significant coefficient (1% level) found in the regression including government size in Table 2 (see Table 3). The coefficient of the expenditure ratio is astonishingly stable at about 0.06. Thus, a one percentage point increase in the ratio of government expenditure to GDP generates an increase of about 0.06 percentage points in per capita growth of real GDP. This is, albeit positive, a rather minor contribution to growth. Moreover, the findings in Table 1 concerning the growth regression with infrastructure and education are underlined. Not only do the coefficients of transport infrastructure and education remain statistically insignificant, but also the coefficient of water and sewer systems is still positively significant and rather stable between 0.33 and 0.41 (see Table 2 and Table 3). A one percentage point increase in the ratio of water and sewer systems to GDP results in a rise of about 0.37 percentage points in real GDP per capita growth. At first sight this seems to be an enormous effect. But bearing in mind that on average the ratio of expenditures of water and sewers systems amounts only to 1.7% across all countries of the sample this means that a 1% rise in expenditures for water and sewer systems causes per capita growth of real GDP to increase by only 0.01 percentage points on average.

Insert Table 3 about here

In contrast, government outlays for water and sewer systems seem to have hindered capital accumulation from 1976 to 2001. However, since two out of three estimations show no significant coefficient, this finding is not stable (see Table 1 and Table 3). As opposed to water and sewer systems the positive effects of transport infrastructure and education on capital accumulation found in the corresponding regression in Table 2 are supported by the sensitivity analyses in Table 3. Both coefficients vary to a greater extent (transport and communication: from 0.55 to 0.88; education: from 0.22 to 0.34) than in the case of growth regressions but can still be dubbed stable. As a consequence, an overall increase by 1 percentage point in public expenditures for transport infrastructure, water and sewer systems, and education raises the per capita growth rate of real GDP by approximately 0.5 percentage points, which is a considerable surge in the long run. Overall, these regressions provide strong evidence that government outlays for infrastructure and education bring about positive, growth effects, either directly as "unpaid factor" or indirectly as a "capital-augmenting public input".

Revenue side

The finding in section 5 that the overall tax burden does not hamper growth is also supported by the estimations with taxes partitioned into indirect and direct taxes (see Table 1 and Table 4). In both cases no significant correlation could be found (see Table 4). This contradicts the point of view of economic theory, from which all taxes should be harmful. At least, the view held in economic theory that income taxes, i.e. direct taxes, with a progressive tariff lead to a greater loss of efficiency and thus obstruct growth even more than other taxes is mirrored by the fact that the estimate has a negative sign as opposed to the estimate of indirect taxes. However, due to the insignificance of this estimate it is only a rather weak indication.

Insert Table 4 about here

The instrumented regressions with the average tax rate and the tax ratios show some counterintuitive results. Both, the average tax rate and the ratio of indirect taxes are tested positively significant which can be enquired of Table 4. However, the results concerning indirect taxes are unstable, which is shown later on. The coefficient of the average tax rate, 0.07, is similar to the one of the expenditure to GDP ratio, 0.056 (see Table 2 and Table 4). The latter, along with the fact that the expenditure to GDP ratio and the average tax rate is highly correlated (97%), indicates that this result is, in all likelihood, due to collinearity problems.

Revenue side - alternative regressions

Again to cope with model uncertainty, I run some additional regressions with a different time period and omitting the investment ratio. These regressions indicate that neither indirect nor direct taxes hamper economic growth (see Table 5). The results of the alternative estimation clearly show that the positive relationship between indirect taxes and growth found in the non-instrumented estimation is not stable (see Table 4).

Insert Table 5 about here

Thus, I find no causal relationship between direct and indirect taxes on the one hand and growth on the other. In addition, the regression with the shortened time period shows no significant coefficient for the average tax rate (see Table 5). This substantiates our reasoning concerning the finding for the average tax rate in the preceding section, so that the average tax rate would not appear to affect growth. To sum up, these findings provide no evidence that the tax burden has played a vital role in the growth performance of OECD countries.

7 Conclusions

The introduction of the robust MME has demonstrated that in the case of regressions with fiscal data, outliers that can be harmful to LSE are present. As statistical robustness theory predicts, the LSE is either biased or is no longer the best unbiased one and probably inefficient in the examples shown. This suggests that one source of inconsistent results is the fact that LSE is biased and inefficient. For example, whereas Fölster and Henrekson (2001) have ascertained a negative influence of government size on growth, Agell *et al.* (2006) have found no correlation using the same data set. Because of probable bias and inefficiency, LSE-based studies should be interpreted with some care. Consequently, the application of an appropriate, i.e. a robust, estimator such as MME is crucial for the results of empirical analyses.

In contrast to recent studies, this analysis finds a stable positive, albeit small, growth effect of government size.[5] While Fölster and Henrekson (2001) and De Ávila and Strauch (2003) even come to the opposite conclusion, the majority of recent studies suggest no growth effects of government size (Kneller *et al.*, 1999; Bleaney *et al.*, 2001, Bassanini *et al.*, 2001, Agell *et al.*, 2006). Moreover, this study finds that taxes do not affect growth significantly, which is only in line with two out of six recent growth studies (Agell et. al., 2006; De Ávila and Strauch, 2003). A recently-performed meta-analysis of Nijkamp and Poot (2004) confirms

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[5] The comparison refers to the following studies: Kneller *et al.* (1999), Bassanini *et al.* (2001), Bleaney *et al.* (2001), Fölster and Henrekson (2001), De Ávila and Strauch (2003), Agell *et al.* (2006).

this finding. The present analysis strongly suggests that transport infrastructure, water and sewer systems, and education foster economic growth. Nijkamp and Poot (2004), Kneller *et al.* (1999), Bleaney *et al.* (2001) and, concerning education, Bassanini *et al.* (2001) come to the same conclusion. While transport infrastructure and education seem to be good examples of what is called "factor-augmenting public input" in public goods theory, water and sewer systems resemble an "unpaid factor".

To sum up, the findings of this study indicate that government size of the 21 OECD countries included in this analysis has not reached a level that hinders growth. As a consequence, the sheer size of government would not appear to have been responsible for sluggish growth in some European countries. Rather, countries with weak growth performance could think about the mix of growth-enhancing expenditures such as education and infrastructure and other outlays. Moreover, in view of the results of this analysis, policy reforms aiming at enhancing growth only by reducing taxes are probably bound to fail.

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Table 1: Comparison of MME and LSE

Static one-way fixed-effects model with five-year moving averages; Period 1970-2001.

Estimator	MME	LSE	MME	LSE
Dependent variable	Growth rate of real GDP per capita in PPP		Investment ratio	
Labour force potential	0.347** (0.236)	0.475** (0.222)		
Investment ratio	0.091*** (0.033)	0.144*** (0.039)		
Average tax rate	-0.023 (0.025)	-0.047* (0.027)		
Transport			0.547*** (0.083)	0.728 (0.445)
Water & Sewer systems			0.156 (0.123)	-0.822 (0.631)
Education			0.253*** (0.086)	- 0.294 (0.462)
Constant	1.498* (0.860)	0.818 (0.468)	15.326*** (0.559)	20.534*** (3.758)
Rob. Wald- / F-test	251*** (0.0)	15*** (0.0)	196*** (0.0)	22*** (0.0)
adj. / adj. rob. R^2	0.33	0.56	0.32	0.47
No. of obs.	380	380	314	314
No. of potentially harmful outliers (% obs.)	2.1	1.3	13.1	1.6
Normality Test	0.987*** (0.002)	0.995 (0.341)	0.84*** (0.0)	0.95*** (0.0)
Chi-Square test of bias	17.9 (0.81)	6.1 (1.0)	16.7 (0.27)	56.5*** (0.0)
Belsley's condition index	46	46	18	18

Notes: Estimation technique: HAC-estimator to deal with autocorrelations und heteroskedasticity; robust covariance matrix is computed with M-estimator; ***:= 1% significance level; **:= 5% significance level; *:= 10% significance level; t tests: figures in parentheses are standard errors; Robust Wald-test and F-test of country dummies, figure in parentheses is P value; Shapiro-Wilk Normality Test: H0: Gaussian distribution, W test statistic, figure in parentheses is P value; Chi-square test: test statistic, 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.

Table 2: Expenditure side

Static one-way fixed-effects model with five-year moving averages, MME and clustered country dummies in infrastructure' regressions (see appendix); Period 1970-2001.

Dependent variable	Growth rate of real GDP per capita in PPP				Investment ratio
Instrumented	no	no	yes	yes	yes
Labour force potential	0.381* (0.196)	0.625*** (0.247)	0.467** (0.224)	0.513** (0.251)	
Investment ratio	0.099*** (0.035)	0.160** (0.029)	0.073** (0.034)	0.172*** (0.031)	
Expenditure ratio	-0.075*** (0.017)		0.056*** (0.010)		
Transport		-0.145 (0.145)		0.030 (0.119)	0.552*** (0.110)
Water & Sewer systems		-0.015 (0.108)		0.408*** (0.086)	-0.105 (0.119)
Education		-0.026 (0.047)		0.002 (0.056)	0.216** (0.107)
Constant	4.036*** (1.202)	3.162*** (0.376)	-1.645** (0.711)	1.282*** (0.385)	15.846*** (0.735)
Rob. Wald-test	232*** (0.0)	173*** (0.0)	224*** (0.0)	206*** (0.0)	298*** (0.0)
adj. rob. R^2	0.42	0.28	0.30	0.29	0.40
No. of obs.	392	307	352	280	284
No. of potentially harmful outliers (% obs.)	1.3	2.9	3.7	3.6	7.8
Normality Test	0.997 (0.35)	0.98*** (0.0)	0.92** (0.0)	0.93*** (0.0)	0.87*** (0.0)
Chi-Square test of bias	13.3 (0.96)	-1.3 (1.0)	21.4 (0.62)	2.0 (1.0)	2.8 (1.0)
Chi-Square bias LSE	-5.1 (1.0)	1.6 (1.0)	39** (0.02)	17.6 (0.4)	41*** (0.0)
Belsley's condition index	50	20	47	20	19
Spearman's rank correlation			94	transport: 97 water & sewer: 96 education: 96	transport: 97 water & sewer: 96 education: 96

Notes: i) Spearman's rank correlation between fiscal variable and fiscal variable lagged by 5 years, variable in five year averages; ii) To avoid correlation problems between the private investment ratio and the infrastructure variables and education, the regressions with these variables as explanatory ones are run with an investment ratio adjusted to exclude the part that maybe correlated with the infrastructure variables and education (see Table 2, columns 3 and 5); see Notes Table 1.

Table 3: Expenditure side – alternative model specifications

Static one-way fixed-effects model with five-year moving averages, MME and clustered country dummies in infrastructure' regressions (see Appendix); instrumented regressions; Period 1970-2001 (if not differently stated).

Dependent variable	Growth rate of real GDP per capita in PPP				Investment ratio	
Alteration	Omitted: Investment ratio	Period: 1976-2001	Omitted: Investment ratio	Period: 1976-2001	Added: Labour Force Potential	Period: 1976-2001
Labour force potential	0.129 (0.171)	0.591*** (0.329)	0.456** (0.203)	0.535** (0.267)	-1.386*** (0.167)	
Investment ratio		0.004 (0.051)		0.156*** (0.029)		
Expenditure ratio	0.057*** (0.009)	0.066*** (0.015)				
Transport			0.039 (0.097)	0.028 (0.103)	0.778*** (0.082)	0.876*** (0.120)
Water & Sewer systems			0.331*** (0.111)	0.364*** (0.094)	-0.026 (0.120)	-0.458*** (0.094)
Education			-0.038 (0.057)	0.005 (0.057)	0.251** (0.113)	0.335*** (0.105)
Constant	-0.413 (0.310)	-0.805 (1.030)	1.758*** (0.313)	1.256*** (0.383)	14.294*** (0.803)	15.943*** (0.599)
Rob. Wald-test	186*** (0.0)	231*** (0.0)	193*** (0.0)	19.2*** (0.0)	180*** (0.0)	224*** (0.0)
adj. rob. R^2	0.22	0.29	0.24	0.40	0.46	0.44
No. of obs.	352	282	280	264	280	226
No. of potentially harmful outliers (% obs.)	6.8	4.3	3.2	4.5	7.9	8.0
Normality Test	0.93*** (0.0)	0.89*** (0.0)	0.92*** (0.0)	0.94*** (0.0)	0.85*** (0.0)	0.91*** (0.0)
Chi-Square test of bias	30.6 (0.13)	22.3 (0.6)	12.9 (0.6)	0.66 (1.0)	-26.5 (1.0)	-9.5 (1.0)
Chi-Square bias LSE	51*** (0.0)	35* (0.08)	29** (0.01)	-1.19 (1.0)	29** (0.01)	32*** (0.004)
Belsley's condition index	32	54	20	18	20	21
Spearman's rank correlation	94	91	94	Transport: 94 Water & Sewer: 89 Education: 97	Transport: 94 Water & Sewer: 89 Education: 97	Transport: 94 Water & Sewer: 89 Education: 97

Notes: to avoid correlation problems between the private investment ratio and the infrastructure variables and education, the regressions with these variables as explanatory ones are run with an investment ratio adjusted to exclude the part that maybe correlated with the infrastructure variables and education (see Table 3, column 5); see Notes Table 1 and Table 2i).

Table 4: Revenue side

Static one-way fixed-effects model with five-year moving averages and MME; dependent variable: growth rate of real GDP per capita in PPP; Period 1970-2001.

Instrumented	no	yes	yes
Labour force potential	0.370*** (0.171)	0.617*** (0.227)	0.499** (0.236)
Investment ratio	0.109*** (0.033)	0.107*** (0.036)	0.057* (0.033)
Average tax rate			0.068*** (0.025)
Indirect Taxes	0.058 (0.082)	0.295*** (0.104)	
Direct Taxes	-0.031 (0.047)	-0.032 (0.055)	
Constant	0.145 (0.847)	0.145 (0.916)	-1.188 (0.808)
Rob. Wald-test	218*** (0.0)	198*** (0.0)	165*** (0.0)
adj. rob. R^2	0.33	0.36	0.30
No. of obs.	403	357	338
No. of potentially harmful outliers (% obs.)	2.0	2.8	3.3
Normality Test	0.987*** (0.0)	0.947*** (0.0)	0.929*** (0.0)
Chi-Square test of bias	0.66 (1.0)	8.5 (1.0)	17.7 (0.82)
Chi-Square bias LSE	9.4 (1.0)	8.2 (1.0)	6.1 (1.0)
Belsley’s condition index	44	43	51
Spearman's rank correlation		Indirect: 94 Direct: 95	97

Notes: see Notes Table 1 and Table 2i).

Table 5: Revenue side – alternative model specifications

Static one-way fixed-effects model with five-year moving averages and MME; instrumented regressions; dependent variable: growth rate of real GDP per capita in PPP; Period 1970-2001 (if not differently stated).

Alterations	Omitted: Investment ratio	Period: 1976-2001	Omitted: Investment ratio	Period: 1976-2001
Labour force potential	0.336* (0.197)	0.695** (0.346)	0.292* (0.172)	0.8333** (0.355)
Investment ratio		0.028 (0.048)		0.065 (0.052)
Average tax rate	0.081*** (0.024)	0.029 (0.034)		
Indirect Taxes			0.146 (0.096)	0.201 (0.33)
Direct Taxes			0.004 (0.052)	-0.011 (0.073)
Constant	-0.600 (0.657)	0.946 (1.307)	1.239** (0.608)	-0.233 (1.719)
Rob. Wald-test	235*** (0.0)	169*** (0.0)	78*** (0.0)	143*** (0.0)
adj. rob. R^2	0.23	0.30	0.18	0.31
No. of obs.	338	281	357	295
No. of potentially harmful outliers (% obs.)	5.2	3.6	5.3	3.7
Normality Test	0.92*** (0.0)	0.924*** (0.0)	0.943*** (0.0)	0.93*** (0.0)
Chi-Square test of bias	29.8 (0.15)	24.9 (0.41)	6.92 (1.0)	36.1* (0.07)
Chi-Square bias LSE	42*** (0.01)	24 (0.45)	28 (0.27)	30 (0.23)
Belsley's condition index	42	68	32	52
Spearman's rank correlation	97	97	Indirect: 94 Direct: 95	indirect: 93 direct: 94

Notes: see Notes Table 1 and Table 2i).

Appendix

Data

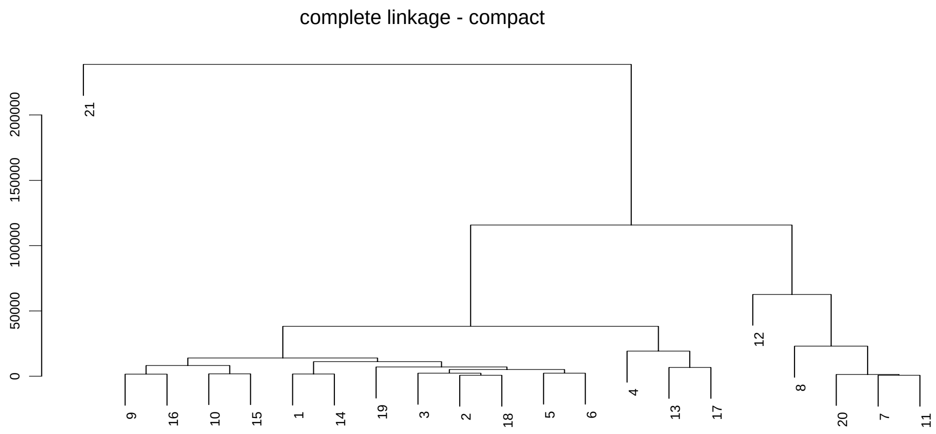
Fiscal data stem from the Government Finance Statistics, 2004 (GFS) of the International Monetary Fund (IMF), whereas economic data come from Economic Outlook No. 74, 2004, and the Annual National Accounts, 2004, of the OECD. For a detailed description of public expenditure categories see Classifications 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 packages S-Plus 6.0 and R 2.2.1.

Cluster Analysis

In order to construct groups of countries, a complete linkage clustering with respect to 8 year averages of per capita real GDPgrowth rates in PPP terms and the population over the period from 1970 to 2000 is performed. Based on 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.

Illustration 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.

Table A1: Robust correlation matrix of fiscal variables

Fiscal variable	Average tax	Expenditure	Water & Sewer	Transport
Average tax	1.00	0.97	0.70	0.77
Expenditure	0.97	1.00	0.73	0.81
Water & Sewer	0.70	0.73	1.00	0.61
Transport	0.77	0.81	0.61	1.00
Education	0.42	0.59	0.33	0.47
Indirect taxes	0.67	0.55	0.17	0.44
Direct taxes	0.59	0.73	0.68	0.71

Table A1 *continued*

Fiscal variable	Education	Indirect taxes	Direct taxes
Average tax	0.42	0.67	0.59
Expenditure	0.59	0.55	0.73
Water & Sewer	0.33	0.17	0.68
Transport	0.47	0.44	0.71
Education	1.00	-0.15	0.84
Indirect taxes	-0.15	1.00	-0.07
Direct taxes	0.84	-0.07	1.00