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Revisiting the Growth Effects of Fiscal Policy: A Bayesian Model Averaging Approach

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Abstract

Motivated by the mixed evidence in previous literature, we reexamine the effects of various types of government spending and taxes, as well as overall budget surplus/deficit, on economic growth. To address the model uncertainty issue that may have plagued earlier studies we employ a Bayesian Model Averaging (BMA) approach. We use a panel data set for OECD countries for the 1990-2013 period, control for country and time specific effects, and allow for a wide range of other potential growth determinants. The results suggest a robust link between only some fiscal variables and economic growth. On the spending side, productive public spending has a robust positive effect on growth. On the revenue side, we document a robust negative effect for the top corporate tax rate, but, maybe surprisingly, not for any income tax variable. Finally, our results suggest that a budget surplus has a robust positive effect on economic performance. We also analyze the timing of effects and conclude that most effects occur with a lag of two years.

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Revisiting the Growth Effects of Fiscal Policy: A Bayesian Model Averaging Approach*

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Motivated by the mixed evidence in previous literature, we reexamine the effects of various types of government spending and taxes, as well as overall budget surplus/deficit, on economic growth. To address the model uncertainty issue that may have plagued earlier studies we employ a Bayesian Model Averaging (BMA) approach. We use a panel data set for OECD countries for the 1990-2013 period, control for country and time specific effects, and allow for a wide range of other potential growth determinants. The results suggest a robust link between only some fiscal variables and economic growth. On the spending side, productive public spending has a robust positive effect on growth. On the revenue side, we document a robust negative effect for the top corporate tax rate, but, maybe surprisingly, not for any income tax variable. Finally, our results suggest that a budget surplus has a robust positive effect on economic performance. We also analyze the timing of effects and conclude that most effects occur with a lag of two years.

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1 Introduction

The effects of fiscal policy on economic growth received renewed attention during the aftermath of the global financial crisis. What role taxes and public spending play as determinants of economic growth continues meanwhile to be widely debated in the theoretical and empirical literature. Neoclassical growth models suggest that taxes and spending have no effect on long-run economic growth, but may have transitional effects on output levels. In contrast, endogenous growth models predict that fiscal policy can have both transitory and permanent effects on economic growth (cf. Barro 1990, Jones and Manuelli 2005). However, the effects predicted by economic theory are heterogeneous across different categories of fiscal policy variables and the timing of the effect (Jones and Manuelli 2005). Public spending may contribute positively to output growth, for example in the form of investment into productive public infrastructure, whereas public consumption could either have no effect or a negative effect. Jones et al. (1993) argue that deviations from optimal (Ramsey) taxes have sizable negative effects on growth rates in models of endogenous growth. Piketty et al. (2014), on the other hand, show that a change in income tax rates may not influence the growth rate.

Empirical studies come to differing conclusions as to which kind of taxes and spending matter for economic growth. For example, Lee and Gordon (2005) focus on top statutory (=marginal) tax rates and provide evidence that top corporate tax rates negatively affect growth in a cross-section of countries. Conversely, Kneller et al. (1999) and Bleaney et al. (2001) analyze the effects of average tax rates, defined as tax revenue from the corresponding taxes as a percentage of GDP. They find, for a panel of OECD countries, that taxes classified as distortionary based on economic theory (i.e. income and corporate taxes) have a negative growth effect while other tax measures have no effect. For the United States, Aschauer (1989) finds positive effects of public investment on output growth, but the robustness depends on the specific measure of spending used and on the time frame (cf. Kocherlakota and Yi 1996). The relation between taxes, public spending, and economic growth is therefore characterized by model uncertainty, which casts doubt on the robustness of existing results.

This paper explicitly addresses uncertainty about the relation between fiscal policy and economic growth by using *Bayesian Model Averaging* (BMA) (cf. Fernandez et al. 2001, and Sala-i Martin et al. 2004). Model averaging assesses the robustness of the relationship between a set of possible growth determinants and economic growth *unconditionally* over the model space. The unconditional parameters do not depend on a particular model as they are averages of conditional parameters of all models within the model space. Thus, model averaging avoids bias stemming from the choice of one particular model.

With this approach we overcome the problem of model uncertainty and address open questions in the empirical literature regarding the relationship between fiscal variables and economic growth. First, we investigate a broader set of fiscal variables to test which have a robust and economically important effect on economic growth. Second, we analyze whether marginal (top) tax rates and average taxes (tax revenue as a percentage of GPD) have different effects on economic growth. Third, we test the timing of the impact of fiscal policy variables on economic growth. Fourth, we allow for a larger set of alternative growth determinants proposed in the empirical growth literature, and the effects of fiscal variables can therefore be interpreted as holding other growth determinants fixed (ceteris paribus). Finally, we test the sensitivity of results allowing for alternative prior specifications, in particular the specification proposed by Kneller et al. (1999) which includes all components of government budget constraints in the empirical model.

We construct and use a panel data set for 28 OECD countries for the period 1990-2013. Our data set has several advantages over previous data sets used. First, to improve the consistency of the data we source all fiscal variables from OECD databases. Second, we aim to increase the generality of our results by using a data set that covers a broader set of OECD countries. Third, the selected period ensures that our results are timely and directly interpretable within currently used measurement and accounting standards (these have changed over time) of fiscal data. We believe that these features increase the relevance of our results to researchers and policy makers.[1]

We identify the effects of fiscal policy variables by assuming that policy variables do not react to future shocks to economic growth. This means that fiscal variables are assumed to be predetermined with respect to future income, which can be motivated by the budgetary process and by the argument that it takes time for policy makers to learn about and react to an economic shock (Blanchard and Perotti 2002, Ramey 2011). Moreover, we explore the timing of effects by comparing results for different lag length of fiscal variables. The findings clearly support the hypothesis of delayed effects from fiscal variables toward economic growth.

Our major findings can be summarized as follows.[2] First, we find a robust ef-

[1] Previous studies mostly use data upto 1995 (Kneller et al. 1999) or cover a significantly smaller set of OECD countries (Gemmell et al. 2011, Gemmell et al. 2014 - these studies also do not use data beyond 2004). In addition these references use data that applies outdated accounting standards or conducts a potentially problematic merging of data with different standards.

[2] All estimated models include country fixed-effect and time fixed-effects, controlling for unmeasured effects that are invariant across countries or over time.

fect of some but not all fiscal variables on economic growth controlling for other growth determinants.[3] Second, the structure of public spending matters for economic growth. Productive government spending has a positive effect on economic growth, whereas other spending categories and overall government consumption do not have robust growth effects. Third, on the revenue side we find that other revenues[4] (as a percentage of GDP) have a negative impact on economic growth, while average taxes previously classified as distortionary do not. Fourth, *marginal* top corporate tax rates have a robust negative effect on economic growth, while the top income tax rate does not have a robust effect. Fifth, budget surpluses have a robust positive effect on growth. Finally, regarding the timing of effects, most fiscal variables affect economic growth with a lag of two years.

These results provide several new insights to the existing literature on the relationship between fiscal variables and economic growth. Nesting the analysis of average and marginal taxes we find that both have growth effects, lending support to Kocherlakota and Yi (1997) and Kneller et al. (1999) as well as Lee and Gordon (2005). Moreover, we find no robust relationship between top income tax rates and economic growth. This is in line with preceding studies (cf. Lee and Gordon 2005, Kocherlakota and Yi 1996) and the theoretical explanation and evidence in Piketty et al. (2014). However, in contrast to Kneller et al. (1999), we find a robust negative effect of other revenues, but no effects of distortionary taxes or other expenditures on economic growth. The documented positive effect of budget surplus is in line with Adam and Bevan (2005) who argue that large budget deficits are detrimental to economic growth.

Our results also contribute to an ongoing debate about the timing of growth effects of fiscal policy. One part of the literature focuses on the-long run effects (cf. Kocherlakota and Yi 1997, Bleaney et al. 2001, Romer and Romer 2010) by looking at the sum of the coefficients of lagged fiscal variables. Gemmell et al. (2011) find that the peak effects occur after one to two years, while aggregate effects can take up to eight years to fully materialize. We look further into the timing at which fiscal measures impact growth. We find some evidence for effects of fiscal variables on average yearly growth in the period five years after a change in fiscal policy. This underlines the conclusion that fiscal policy does matter, at least in the medium term, contrary to some previous studies, including Mendoza et al. (1997). More

[3] All fiscal variables except marginal (top) tax rates are measured as share of GDP.

[4] Other revenues comprises non-tax revenue and tax categories for which there is no clear theoretical prediction on the sign of their growth effects. The variable is dominated by non-tax revenues. As minor components the category comprises taxation on international trade and a residual category of taxes that is not classified to any of the major categories in the OECD Public Sector data. The classification of other revenue is due to the categorization established by Kneller et al. (1999).

importantly, we find that the most robust effects occur within two years, in line with the peak identified by the literature.

The remainder of the paper proceeds as follows. Section 2 discusses the empirical model and estimation method. Section 3 gives an overview of the data. Section 4 presents results and section 5 concludes.

2 Empirical Model and Averaging

In this section we briefly introduce the empirical growth model and the model averaging method that we employ to estimate the unconditional distribution of the parameters of interest. The growth rate of country $i = 1, \ldots, N$ in year $t = 0, \ldots, T$ is given by:

$$\Delta y_{i,t} = \theta' x_{i,t-s} + \nu_{i,t} \ , \tag{1}$$

where $\Delta y_{i,t} \equiv y_{i,t} - y_{i,t-1}$ is the difference of log GDP per capita approximating the yearly growth rate of GDP per capita.[5] A model is defined by a selection from the set of possible growth determinants x, including the log of GDP per capita at $t-1$ to control for initial conditions. The error $\nu_{i,t} = \mu_i + \eta_t + \epsilon_{i,t}$ is the composite of a country specific effect μ_i, a year effect η_t, and an idiosyncratic error component $\epsilon_{i,t}$ that is uncorrelated with country and time effects, and also serially uncorrelated.

Our identification assumption is that policy variables are predetermined with respect to future income, i.e., that they do not react to future shocks to economic growth. Extending the argument to all regressors our assumption is that $E[\epsilon_{i,t} x_{i,t-s}] = 0$ for $s > 0$. With this assumption we follow the argument of Blanchard and Perotti (2002) that it takes time for policy makers to learn about an economic shock. The discussion in Ramey (2011) further supports the validity of this assumption. The author argues that government spending might affect the economy even before spending is actually observed in the data because the economy anticipates policies, informed by public discussion during the policy making process.[6]

We estimate the model in equation 1 for different lag lengths of fiscal variables while keeping non-fiscal variables at lag 1.[7] For fiscal variables measured at lag 2 and longer this means that we effectively allow for controls at more recent periods.

[5] Alternatively, we also use the five-year average growth rate defined as $\Delta_5 y_{i,t} \equiv y_{i,t} - y_{i,t-5}$.

[6] While the argument in Ramey (2011) strengthens the credibility of our identification assumption we do not attempt to adjust for this timing. The expected impact of the forward looking behavior on our results would be a downward bias (in absolute size). In light of this discussion one might interpret the robust effects that we find as a conservative estimate.

[7] Appendix A reports results with non-fiscal variables also at different lag lengths. This does not change the main findings regarding fiscal variables.

Using lag 1 of non-fiscal variables may thus contribute to mitigate potential endogeneity because we control for future conditions that may effect policy decisions today (from period $t-2$ perspective). The approach implies that coefficients of fiscal variables should be interpreted as partial direct effects, net of the effects fiscal variables might have on growth indirectly through non-fiscal variables in the model. Thus for models with fiscal variables at lag 2 or greater and with non-fiscal variables (at lag 1) the estimated coefficients are conservative estimates. One should keep in mind, however, that not all models include non-fiscal variables. Instead we use the averaging procedure to identify the robustness of direct effects vs. indirect effects based on the information in the data.

We are interested in the unconditional (with respect to a specific model) posterior distribution of a parameter vector θ given data D. We use Bayesian Model Averaging (BMA) and calculate the distribution $p(\theta|D)$ as the weighted average of the conditional distributions of model specific parameters with weights proportional to the model fit (cf. Leamer 1978). In the context of the panel regressions (1), we simply average parameter estimates obtained using country fixed and time effects. (cf. Sala-i Martin et al. 2004, Raftery 1995). Given K possible regressors there is a set of $J = 2^K$ models M_j ($j = 1, \dots, J$), each a particular linear combination of growth determinants.

We can write the posterior mean of a parameter vector θ as the expectation of the weighted sum of model specific parameter estimates:

$$E(\theta|D) = \sum_{j=1}^{2^K} P(M_j|D)\,\hat{\theta}_j \tag{2}$$

where $\hat{\theta}_j$ is the estimated parameter vector for model j, and $P(M_j|D)$ is the posterior probability of model M_j which is used as a model weight.

The posterior variance is the sum of model-weighted conditional variances and a term measuring the uncertainty over the estimated posterior means:

$$Var(\theta|D) = \sum_{j=1}^{2^K} P(M_j|D)\Big(Var(\theta_j|M_j, D) + (\hat{\theta}_j - E(\theta|D))^2\Big)\,, \tag{3}$$

Draper (1995) points out that inference using model averaging therefore takes uncertainty over estimated effects into account. Posterior standard errors, calculated as the square root of posterior variances (equation 3), measure the precision of our estimates. We report the standardized coefficient, defined as $E(\theta|D)/\sqrt{Var(\theta|D)}$, as a measure of the relative precision of the effect.

The posterior model probabilities or weights can be derived from Bayes rule as:

$$P(M_j|D) = \frac{P(M_j)L(D|M_j)}{\sum_{i=1}^{2^K} P(M_i)(L(D|M_i)} \ , \tag{4}$$

where $P(M_j)$ is the prior model probability summarizing any prior belief or knowledge the researcher might have about a particular model and $L(D|M_j)$ is the marginal likelihood of model M_j. The marginal likelihood of model M_j can be calculated by integrating over the model specific parameters:

$$L(D|M_j) = \int L(D|\theta_j, M_j)P(\theta_j|M_j)\mathrm{d}\theta_j \ . \tag{5}$$

Here $P(\theta_j|M_j)$ is a parameter prior summarizing any prior believes the researcher might have about a particular parameter. The model weights in 4 can be interpreted as probabilities since they are normalized by the sum of weights over all models.

The Bayesian approach outlined above requires a choice of priors. The explicit specification of priors has the advantage that it elicits assumptions that are made in defining and estimating the empirical model. For the slope parameters associated with the explanatory variables, we assume that they are centered at zero and that the variance is proportional to the variation in the sample, the g-prior proposed by Zellner 1986. The slope coefficients therefore are assumed to have conditional distribution $p(\theta_j|M_j) \propto N(0, \sigma^2 g(X_j^{`}X_j)^{-1})$. This g-prior has the benefit that it limits the choice for slope parameter priors to one single number - g. Following the suggestion of Ley and Steel (2009) we choose $g = \min\{1/NT, 1/k^2\}$, where NT is the total number of observations across individuals and time.

With these prior assumptions, the marginal likelihood in equation (5) can be written as

$$L(D|M_j) = \Big(\frac{1+g}{g}\Big)^{\frac{-kj}{2}} \Big(RSS\Big)^{\frac{-NT}{2}} \tag{6}$$

with RSS being the residual sum of squares.

We also need to specify a prior for the model space $P(M_j)$. We use a hierarchical binomial beta prior found to lead to results that are less sensitive to prior choice by Ley and Steel (2009). The binomial beta prior s proportional to $\Gamma(1+k_j)\Gamma(\frac{K-m}{m} + K - k_j)$ necessitates specifying a prior model size m which we set to $m = K/2 = 9$. This seems to be a natural choice as the expected model size is half of the considered variables and results in a prior inclusion probability for each variable of 0.5.

Finally, we calculate the posterior inclusion probability (PiP) of each regressor as the sum of model weights (equation 4) that include the regressor. This is a measure of importance, the robustness of the determinant, in explaining growth. The criterion for deciding whether a variable has robust effects is that the posterior inclusion probability (PiP) has increased relative to the prior inclusion probability. Given our choice of model prior this implies that a variable is robust if PiP > 0.5. Intuitively, we conclude that the variable is robust if the data provides information that gives more weight to the variable than we expect a priori.

3 Data

The data used in this paper covers eight different fiscal variables and a further ten potential growth determinants. We collect data from several sources to construct an unbalanced panel of data for the years 1990 to 2013 for 28 OECD countries. This section gives a brief description of the data, appendix B provides an overview of all variables and sources, and appendix C lists the included countries. A detailed description of the construction of our data set is published in a separate (online) data appendix.

We believe that our data has several advantages. First, we improve consistency and reliability of fiscal data by relying solely on OECD sources. Second, the data covers a broad set of countries. Third, we avoid the merging of tax data for which measurement and accounting standards have changed and are different before 1990. This leads not only to a more consistent data set but also to results that are timely and are directly interpretable in terms of fiscal measures used today.[8]

We include five different tax measures which can be split into two groups, average taxes and marginal taxes. Following Lee and Gordon (2005) we introduce two marginal tax measures: the top tax rates for corporate and personal income. To establish a series for marginal tax rates from 1990-2013 we combine data from the OECD Tax Data Base provided in online tables for the years from 2000 onwards and in excel sheets for historic (1980-1999) data. This requires, for instance, combining several applicable tax rates on the income of top earners taking into account the individual tax system of each country. Details can be found in the separate data appendix.

Previous studies are based on top statutory tax rates from the World Tax

[8]Previous studies focus on periods in the more distant past or are less general as they cover a smaller set of OECD countries. For example Kneller et al. (1999) use data for 22 OECD countries in the period 1970 - 1995. In more recent studies Gemmell et al. (2011) include 17 OECD countries and Gemmell et al. (2014) 15 OECD countries for the period 1970 - 2004. The two latter studies cover a little more of the recent period but are limited to fewer countries (because their methodology forces them to drop countries with a too short time series).

Database of the Office of Tax Policy Research (OTPR) at the University of Michigan. This database was discontinued in 2007. In addition we find that there are some disagreements between the two data sets. We believe the OECD data to be more reliable and that the continuation of the OECD data post-2007 increases the timeliness and relevance of the data and this study.

Average taxes are measured by tax income by source as a share of GDP using data from the OECD Public Sector, Taxation, and Market Regulation tables. Following Kneller et al. (1999) we divide average taxes into three subgroups: distortionary taxes, other revenue, and non-distortionary taxes (see table 1). The classification into groups is based on the endogenous growth theory of the 1990s (e.g. Barro 1990 and Mendoza et al. 1997 - c.f. Kneller et al. (1999) for details) and has become the standard in some central contributions testing the effects of fiscal policy on economic growth.

A similar classification is applied to government spending as either productive spending, non-productive spending, or other expenditures. For the three spending categories we group data on expenditure by government function from the OECD National Accounts Data (subcategory General Government Accounts, Dataset 11: Government expenditure by function (COFOG)). The Classification of the Functions of Government (COFOG) has experienced changes in definitions and accounting standards. Data using the new standards is available from 1990 onwards. Our focus on this recent data avoids the potentially problematic merging with data for previous periods which follows a different accounting and classification standard.[9] Measuring variables according to recent standards has the addition important advantage that the results can be easily interpreted in the relevant, currently employed categories, and can thus be used to give meaningful policy advice.

We add the budget surplus as a fiscal measure, following Kneller et al. (1999) who argue that it is important to consider all relevant items of the budget equation, as well as following Adam and Bevan (2005), who showed that budget deficits can be detrimental to growth. Together with the three spending and the three average tax items, the surplus describes the complete budget equation. At least one of the items in the budget equation has to be omitted in the empirical model to avoid perfect collinearity. The coefficients on the remaining fiscal categories can then be interpreted relative to the coefficient of the omitted category. We follow the standard practice (e.g., Gemmell et al. 2011 and Gemmell et al. 2014) and drop the two neutral items non-distortionary taxes and non-productive spending from the

[9]Gemmell et al. (2011) point to the difficulties of matching older data. However, their approach relies on the availability of a long time dimension and they continue to merge the data.

empirical model.

Table 1: Classification and Aggregation of Fiscal Measures

Theoretical Classification	Functional Classification (according to OECD)
Fiscal policy variables as percent of GDP (i.e. average taxes and expenditures):	
Distortionary Taxes	Taxes on income, profits, and capital gains (item 1000) + Social security contributions (item 2000) + Taxes on payroll and workforce (item 3000) + Taxes on property (item 4000)
Non-Distortionary Taxes	Taxes on domestic goods and service (item 5000) - Customs and import duties (item 5123) - Taxes on exports (item 5124) - Taxes on internat. trade and transactions (item 5127)
Other revenues	Taxation on international trade (sum of items 5123, 5124, and 5127) + Other taxes (item 6000) + Non-tax revenue (calculated as total revenue - total tax revenue)
Productive Expenditure	General public services + Defence + Education + Health + Housing
Non-Productive Expenditure	Social protection + Recreation + Economic affairs
Other Expenditure	Residual category (including functions not classified by Kneller et al. 1999) + Environmental protection + Public order and safety
Budget Surplus	Total Government Revenue - Expenditure
Government Consumption	Overall government consumption
Top tax rates (marginal taxes):	
Top Corporate Tax Rate	Top statutory corporate income tax rate
Top Income Tax Rate	Top statutory personal income tax rate

Notes: The table lists all fiscal measures used in the analysis. The top part of the table explains how fiscal variables (as share of GDP) by function are aggregated according to the effects fiscal measures are theorized to have on GDP growth. Theoretically taxes can be distortionary or non-distortionary, and expenditures are either productive or non-productive. The effects of some fiscal measures are theoretically uncertain and thus will be grouped into the "other" categories. Finally, as a balancing item of the government budget, the budget surplus is added. All fiscal measures are expressed as a percentage of GDP. The classification closely follows Kneller et al. (1999) (who follow Barro 1990). We also add overall government consumption. The lower part of the table lists marginal tax measures, i.e. top tax rates.

Finally we include overall government consumption as a percentage of GDP from the OECD Economic Outlook No. 99 (2016) as an additional fiscal variable on the spending side. Government consumption is an alternative aggregate of the spending side that has been argued to effect growth potential (Barro 1990), for example by increasing wage pressure and reducing private investment (Alesina et al. 2002). By including it in the analysis we can directly test if government spending as such is bad for economic growth or if the effects depend on the type of spending as proposed by Kneller et al. (1999).

To complete the set of regressors we add several potential and commonly used growth determinants. We select data close to that used in Kneller et al. (1999) and Lee and Gordon (2005). However, the set of growth determinants in these two papers is limited and a seemingly arbitrary subset. We chose additional regressors closely following Durlauf et al. (2008).[10] We use initial income, gross primary and secondary school enrollment rates, the investment to GDP ratio, the population growth rate, trade as a percentage of GDP, the rate of inflation, life expectancy at birth, and the fertility rate; all from the World Bank's World development indicators (WDI) database. Furthermore we include a corruption index from the Political Risk Services' International Country Risk Guide (ICRG) as a catch-all for the institutional environment.

The dependent variable is the growth rate of GDP per capita approximated as the difference of the logarithm of GDP per capita in constant 2000 $US from the WDI. Initial income is the logarithm of GDP per capita measured in the initial year. As we will be using yearly data for our main results, the initial income then is the first lag.[11]

4 Results

This section reports the model averaging results based on the FE estimates as described in section 2. The key statistic is the posterior inclusion probability (PiP), which indicates whether an aggressor is found to be a robust determinant of economic growth. This is the case if the PiP is larger than the prior inclusion probability (PiP > 0.5). The second important statistic is the unconditional (posterior) mean coefficient. This is the weighted sum of coefficient estimates, as given by equation (2), over models that include the variable. Finally, we show the absolute standardized coefficients, calculated as the ratio of posterior mean and standard error (SE). The absolute value of this ratio serves as a measure of precision of the estimated coefficient, as a Bayesian approximation to the frequentist notion of statistical significance. In particular these standardized coefficients can be interpreted similar to a t-statistic. The literature applies different thresholds considering mean to SE ratio between 1 (Raftery 1995) to a ratio of 2 (Durlauf et al. 2008) as indicators of precision. A ratio of 2 is comparable to statistical significance at the 5 percent level

[10]A fundamental difference with Durlauf et al. (2008) is that we ignore all time invariant variables. They would be lost in the transformation of the FE estimator and are therefore irrelevant in our context.

[11]For additional results using five-year data initial income refers to income in the first year of the five-year period.

in the frequentist sense and can thus serve as a good benchmark.

In the following we present three sets of results: (i) our main findings using yearly data to explore the short run effects over one to three years, (ii) additional results based on yearly data testing the impact of incorporating prior information and of ignoring model uncertainty, and (iii) medium/long-run results using five-year averages.

4.1 Main Results

Table 2 presents our main results. Uneven numbered columns report the unconditional posterior mean coefficients with standardized coefficients in parenthesis below, and even numbered columns the corresponding PiP for averaging over the full model space. The estimated coefficients in table 2 should be interpreted as partial impact effects. Impact, because the coefficients indicate effects fiscal variables have on growth in a specific year. Partial, because as other potential growth determinants are measured in future terms in columns 3-4, the coefficients measure direct additional effects that do not work through any of these control variables.

Effects of Fiscal Policy. Columns 1 and 2 report the results for models with all right-hand side variables entered as one year lags ($t-1$). From the set of fiscal variables only the top corporate tax rate has a PiP larger than 0.5. None of the other fiscal variables has a robust effect on economic growth at this time horizon. This result seemingly challenges previous findings that average taxes and public spending affect economic growth in the short-run.

A possible explanation for the absence of effects is that it takes time for average taxes and expenditures to impact growth. The explanation is supported by our finding that some, but not all, fiscal variables have robust growth effects after two years. The results are tabulated in columns 3-4 where we average over models for which fiscal variables are measured at $t-2$. For initial income and other control variables we continue to use lag 1, as discussed above.[12]

Concerning *marginal taxes* we find that the top corporate tax rate has a robust negative effect on growth. The PiP is equal to 1 indicating a very robust effect, and the coefficient is precisely estimated (standardized coefficient > 2). In contrast, the coefficient of the top income tax rate is not robust. This confirms the findings of Lee and Gordon (2005) but challenges the finding of a negative effect of top income taxes in Gemmell et al. 2011.[13] The finding underlines the importance of addressing

[12] Using the same lag length (lag 2) also for control variables does not change the results for fiscal variables (see table A1 in appendix A).

[13] Kocherlakota and Yi (1996) also do not find a growth effect of the marginal income tax rate.

model uncertainty in order to identify robust growth effects - and it emphasizes the relevance of top corporate tax rates for economic growth.

For *expenditures and average taxes/revenues* we find that productive expenditures and the budget surplus have robust positive effects on economic growth, with very high PiPs. Both effects are also precisely estimated. While the results for the spending side confirm the effects found by previous studies (Kneller et al. (1999), Gemmell et al. 2011), our findings differ regarding the effects of average taxes and revenues. We find a robust negative effect of other revenues, but the effect is not very precisely estimated. Other revenues mostly constitute non-tax revenues of the government. The robust negative effect therefore does not point to negative effects of average taxes. Moreover, we do not find robust adverse growth effects of average distortionary tax revenues.

We conclude that there is little evidence of negative effects of average taxes on economic growth in our data when we account for model uncertainty. The effects of other expenditure and distortionary taxes are not robust, and we find an additional robust but not very precisely estimated effect of other revenues. In contrast, the effects of productive expenditures and the budget surplus found by Kneller et al. (1999) are robust to the inclusion of a large set of covariates and explicit consideration of model uncertainty.[14] Our findings are of particular relevance in the recent political debate concerning the Euro crisis. We show that growth can be achieved with a reduction in budget deficits or productive expenditures.

We also do not find an adverse effect of *overall government consumption*. A direct policy implication is that growth-enhancing policies can be achieved by productive government expenditure even when overall government consumption is increased, as long as it is not financed by deficits or increases in top marginal corporate tax rates but by those taxes and revenues that do not have adverse effects on economic growth.

Finally, we further explore the *timing* of the effects of fiscal variables. Using lag 1 we only find a robust effect of marginal top corporate tax rates. Using lag 2 the PiP of top corporate tax rates increases from 0.62 to 1.00, the coefficient doubles in absolute size and the estimate is very precise. Moreover, we find robust effects of the budget surplus, other revenues, and productive expenditure after two years. This coincides with the peak effects identified in the literature analyzing response function. However, using lag 3, we do not find evidence for effects after two years. Overall the results thus suggest that the effect of fiscal policy occurs after two years

[14] When discussing differences to previous studies one should keep in mind that we partly employ different data and not just a different estimation procedure (the next section explores how the priors implicit in previous approaches affects result with our data).

Table 2: Growth and Taxes - BMA with Yearly Data, Main Results

Fiscal variables measured at:	$t-1$		$t-2$		$t-3$	
	Mean (1)	PiP (2)	Mean (3)	PiP (4)	Mean (5)	PiP (6)
Fiscal Variables:						
Other Revenues	-0.113	0.37	-0.220	0.68	0.000	0.02
	(0.693)		(1.247)		(0.018)	
Other Expenditures	-0.368	0.31	0.004	0.04	-0.016	0.03
	(0.605)		(0.040)		(0.124)	
Budget Surplus	0.017	0.18	0.243	1.00	0.001	0.02
	(0.397)		(4.574)		(0.096)	
Distortionary Taxation	-0.003	0.04	-0.024	0.16	-0.002	0.03
	(0.107)		(0.365)		(0.100)	
Productive Expenditure	0.031	0.13	0.492	1.00	0.002	0.02
	(0.340)		(4.432)		(0.091)	
Govnmt. Consumption	-0.099	0.36	-0.004	0.05	0.003	0.03
	(0.672)		(0.124)		(0.111)	
Top Corporate Tax Rate	-0.049	0.61	-0.108	1.00	-0.015	0.22
	(1.102)		(4.224)		(0.480)	
Top Income Tax Rate	-0.001	0.04	0.000	0.04	0.000	0.02
	(0.109)		(0.008)		(0.067)	
Other Variables:						
Initial Income	-7.591	0.95	-9.021	1.00	-4.308	0.68
	(2.542)		(3.716)		(1.283)	
Investment Rate	0.000	0.03	0.000	0.04	0.003	0.04
	(0.033)		(0.026)		(0.165)	
Population Growth	-0.013	0.04	-0.067	0.12	-0.003	0.02
	(0.129)		(0.302)		(0.041)	
Primary Schooling	0.000	0.03	-0.001	0.05	0.000	0.02
	(0.041)		(0.100)		(0.061)	
Secondary Schooling	-0.001	0.06	-0.003	0.15	-0.001	0.03
	(0.186)		(0.355)		(0.138)	
Trade	0.055	0.99	0.070	1.00	0.056	0.99
	(3.826)		(5.510)		(3.759)	
Inflation	-0.010	0.13	-0.014	0.19	-0.004	0.06
	(0.334)		(0.420)		(0.205)	
Corruption (ICRG)	-0.008	0.03	-0.044	0.05	-0.114	0.05
	(0.038)		(0.126)		(0.197)	
Life Expectancy	-0.090	0.14	-0.593	0.66	-0.250	0.26
	(0.354)		(1.181)		(0.541)	
Fertility	-1.756	0.45	-0.389	0.15	-4.967	0.88
	(0.810)		(0.357)		(2.078)	
Modelspace	$2^{18} = 262,144$					
Observations (NT)	369		342		314	
All specifications control for country and period fixed effects.						

Notes: The table presents BMA results for three different specifications. The model prior is the hierarchical binomial beta prior with $m = K/2 = 9$ and the parameter prior a g-prior with $g = \min\{1/NT, 1/k^2\}$. In columns 1-2 all right-hand side variables are measured at time $t-1$, in columns 3-4 all fiscal variables are measured at time $t-2$ but initial income and control variables at time $t-1$, and in columns 5-6 all fiscal variables are measured at time $t-3$ but initial income and control variables at time $t-1$. The mean/SE ratio in parenthesis is based on robust and clustered standard errors.

adding further insights to the empirical literature on the timing of effects of fiscal variables (e.g., Romer and Romer 2010, Gemmell et al. 2011).[15]

Effects of Control Variables. With regard to the control variables, most standard growth regressors that the literature identifies as robust in global and cross country settings are not robust in the panel of OECD countries. This is in line with the findings of Eicher et al. (2007), who look at growth determinants in a cross country setting for the OECD, and Asatryan and Feld (2015), who examine growth determinants in OECD countries in a panel data setup. Both find that in the OECD sample only a few variables are robust determinants of economic growth - but none of these two references examines the effects of fiscal policy.

Besides the robust and precisely estimated effect of initial income with a positive sign, we identify only trade as robust growth determinant (table 2). In addition life expectancy and fertility each appear to be robust in one of the three specifications reported. However, since both have much smaller PiPs in the other specifications, the result seems to depend on which lag length the fiscal variables enter.

In contrast trade has a robust and precisely estimated growth effect in each of the three specifications. The effect is positive and thus emphasizes the role of trade as a driver of economic growth. This very robust result should issue a warning in light of the growing skepticism toward free trade among the public but also among many policy makers.

4.2 Prior Information - The Budget Equation and Long Regressions

The main motivation for the present paper is the observation that there is considerable uncertainty in the literature about which fiscal measures (and additional variables) affect economic growth. We deal with this uncertainty by using BMA and average over many models. Our parameter prior ($p(\theta_j|M_j) \propto N(0, \sigma^2 g(X_s^{`} X_s)^{-1})$) entails that each parameter is a priori believed to be centered around 0 reflecting uncertainty. In addition we have carefully chosen uninformative priors that minimize the influence of prior beliefs on posterior estimates (c.f., Ley and Steel 2009). That is, we account for uncertainty and minimize prior influence by letting the

[15]We also explore the consequences of allowing models which include more than one lag of fiscal variables. Using lag 1 and 2, this confirms that the robust effects occur after two years. Using lags 2 and 3 points in the same direction but the PiPs are generally smaller. Note that allowing for three lags leads to a large model space and low PiPs. Intuitively, allowing for very many covariates corresponds to imposing a very high model uncertainty on the empirical framework. Faced with this very high model uncertainty, the data does not contain sufficient information to generate conclusive results.

information contained in the data dominate the results.

Standard regression analysis relies on stronger prior assumptions than the model averaging approach, about which variables may have non-zero effects, and includes these in the model to be estimated - as we discussed earlier. The results are then always conditional on the specific choice of model that is estimated. We can treat any such assumption as prior information in the model averaging procedure to test how the assumption impacts the results. This section tests the effects of imposing commonly-used prior assumptions on the empirical model for economic growth.

The Budget Equation. One of the key arguments in Kneller et al. (1999) is that the specification of the government budget equation in the empirical model matters for the estimates. The effect of fiscal measures in the budget equation can only be estimated relative to omitted items of the budget equation. The implicit prior assumption behind the argument is that the omitted categories have non-zero effects. The budget equation argument of Kneller et al. (1999) can be treated as prior information - henceforth KBG prior.

Table 3 reports model averaging results for a subset of the model space. We report averages of models only that include either none of the fiscal variables that are part of the budget equation (average taxes, expenditures, and budget surplus) or all of them as a group. This corresponds to imposing the KBG prior. [16]

Columns 1 and 2 report results for explanatory variables measured at time $t-1$. When imposing the KBG prior in this way, the government budget items receive very small posterior inclusion probabilities (PiP = 0.02). The same holds for columns 5 and 6, which tabulate results for fiscal variables measured at time $t-3$.

Columns 3-4 report model averaging results for fiscal variables measured at time $t-2$. Imposing the KBG prior now leads to high PiPs for all budget items. The coefficients and precision for the budget surplus, productive expenditure, and top corporate tax rates, those fiscal variables with very high PiPs in table 2, remain similar to what we find without imposing the prior. For other revenues both the coefficient and the precision increases. Moreover, those fiscal items in the budget equation not found to be robust in 2 now have high PiPs, larger coefficients (in absolute terms) and are more precisely estimated. For example the mean coefficient of distortionary taxes raises by a factor of 10 from -0.024 to 0.134. The corresponding measure of precision (the ratio of mean coefficient to standard error) is now just in the range that might be considered to be precise.

[16] The group of fiscal variables includes all those considered by Kneller et al. (1999), but not government consumption or marginal tax rates. However, including government consumption or marginal tax rates simply extends the reported findings for the budget items to those variables (results not reported).

Table 3: Growth and Taxes - BMA with KBG (Budget Equation) Prior and Long Regressions.

	BMA with Budget Equation Prior						Long Regressions		
Fiscal variables at:	$t-1$		$t-2$		$t-3$		$t-1$	$t-2$	$t-3$
	Mean (1)	PiP (2)	Mean (3)	PiP (4)	Mean (5)	PiP (6)	Coef. (7)	Coef. (8)	Coef. (9)
Fiscal Variables:									
Other Revenues	-0.002	0.01	-0.297	0.85	0.000	0.00	-0.257	-0.321	-0.205
	(0.071)		(1.966)		(0.002)		(-1.42)	(-1.92)	(-1.44)
Other Expenditures	-0.005	0.01	0.142	0.85	0.000	0.00	-0.441	0.237	-0.115
	(0.060)		(0.274)		(0.001)		(-0.53)	(0.55)	(-0.17)
Budget Surplus	0.001	0.01	0.248	0.85	0.000	0.00	0.124	0.273	0.163
	(0.076)		(3.168)		(0.002)		(3.02)	(3.69)	(1.89)
Distortionary Taxation	-0.001	0.01	-0.134	0.85	0.000	0.00	-0.039	-0.092	-0.152
	(0.064)		(1.091)		(0.002)		(-0.34)	(-0.64)	(-0.94)
Productive Expenditure	0.002	0.01	0.490	0.85	0.000	0.00	0.280	0.529	0.306
	(0.075)		(3.237)		(0.002)		(2.22)	(3.50)	(1.50)
Govnmt. Consumption	-0.131	0.45	-0.002	0.06	0.003	0.03	-0.267	-0.033	-0.007
	(0.954)		(0.052)		(0.094)		(-1.98)	(-0.29)	(-0.05)
Top Corporate Tax Rate	-0.059	0.71	-0.100	0.98	-0.015	0.22	-0.081	-0.111	-0.066
	(1.538)		(2.613)		(0.479)		(-2.02)	(-2.67)	(-1.44)
Top Income Tax Rate	-0.001	0.04	0.000	0.06	0.000	0.02	-0.012	-0.008	0.004
	(0.112)		(0.026)		(0.049)		(-0.27)	(-0.16)	(0.07)
Other Variables:									
Initial Income	-6.398	0.88	-9.952	0.97	-4.237	0.68	-11.97	-10.83	-11.20
	(1.747)		(2.560)		(1.144)		(-3.10)	(-3.31)	(-2.86)
Investment Rate	0.001	0.02	0.001	0.06	0.003	0.04	0.030	0.037	0.095
	(0.047)		(0.053)		(0.144)		(0.41)	(0.63)	(1.21)
Population Growth	-0.004	0.02	-0.057	0.12	-0.002	0.02	-0.254	-0.413	-0.264
	(0.051)		(0.272)		(0.032)		(-0.51)	(-0.85)	(-0.46)
Primary Schooling	0.000	0.02	-0.001	0.07	0.000	0.02	0.012	0.006	0.030
	(0.038)		(0.079)		(0.053)		(0.24)	(0.12)	(0.51)
Secondary Schooling	-0.001	0.06	-0.003	0.16	-0.001	0.03	-0.012	-0.021	-0.018
	(0.194)		(0.369)		(0.127)		(-0.84)	(-1.47)	(-1.12)
Trade	0.057	1.00	0.065	1.00	0.056	0.99	0.044	0.059	0.050
	(2.241)		(2.457)		(1.859)		(1.69)	(2.38)	(1.69)
Inflation	-0.007	0.09	-0.016	0.23	-0.004	0.05	-0.070	-0.060	-0.078
	(0.225)		(0.390)		(0.143)		(-0.94)	(-0.79)	(-0.72)
Corruption (ICRG)	-0.003	0.02	-0.068	0.08	-0.108	0.05	-0.526	-1.048	-2.441
	(0.013)		(0.121)		(0.168)		(-0.32)	(-0.60)	(-1.32)
Life Expectancy	-0.089	0.13	-0.477	0.57	-0.249	0.26	-0.513	-0.777	-0.860
	(0.319)		(1.043)		(0.524)		(-1.12)	(-1.71)	(-1.34)
Fertility	-2.653	0.63	-0.617	0.22	-5.025	0.88	-2.479	-2.417	-4.855
	(1.465)		(0.428)		(2.123)		(-1.10)	(-1.25)	(-1.82)
Modelspace	16384								
Observations (NT)	369		342		314		368	342	314
Countries (N)	28		28		27		28	28	27
All specifications control for country and period fixed effects.									

Notes: In columns 1,2 and 7 all right-hand side variables are measured at time $t-1$, in columns 3,4 and 8 all fiscal variables are measured at time $t-2$ but initial income and control variables at time $t-1$, and in columns 5,6 and 9 all fiscal variables are measured at time $t-3$ but initial income and control variables at time $t-1$. Mean/SE ratio in parenthesis in columns 1-6, and t-statistics in parenthesis in columns 7-9. T-statistics and Mean/SE ratios based on robust and clustered standard errors.

Long Regression. Another possible prior is to assume that all regressors might have non-zero effects and must be included in the regression. This leads to exactly one model which includes all regressors - the long regression. In columns 7-8 we report the results for this most common approach to regression analysis. Since these results are not based on BMA, we cannot judge the robustness of regressors, instead we follow the standard (frequentist) practice and discuss the significance of the estimates as indicated by the t-statistics reported in parentheses.

Out of the fiscal variable, the budget surplus, productive expenditure, and top corporate tax rates are significant at the 5 percent level, and other revenues and government consumption at the 10 percent level, at various lag lengths. The most striking difference, besides the significant effect of government consumption, is that for the listed variables the coefficients and significance does not change as drastically with changing lag lengths as in the BMA results. Compared to the long regression BMA can, hence, lead to important additional insights, specifically when it comes to the timing of effects.

Discussion. Imposing the theoretically informed KBG prior can lead a researcher to conclude that the effects of some taxes and government spending categories are robust based on the PiPs. For example, distortionary taxes receive a high PiP here but not when considering the full model space (column 4 in table 2). The size of the standardized coefficients offers additional information about particular effects. However, we see that the precision also increases for the effect of distortionary taxes when imposing the KBG (budget equation) prior. Similarly, running one simple regression with all covariates can lead to differing results. The evidence thus issues a warning to researchers about imposing prior information, as this can have a strong impact on results.

4.3 Five-Year Averaged Data

In this section we test the robustness of our main results and the findings in the literature using five-year averages of yearly growth rates as the outcome variable. So far all our results have been computed using yearly data, but much of the literature uses averages over a five-year period instead. Averaging over five years shifts the focus to the relation with long-term growth. In a large part of the literature right-hand side variables are measured as averages over the same period as GDP growth (except for a few initial values). This raises serious concerns about endogeneity because the contemporaneity of regressors violates the identification assumption of predeterminedness. We therefore present results using averages of right-hand side variables alongside results based on initial values of all regressors.

Table 4: Growth and Taxes - BMA with Five-Year Data

	Averages/Initial values		Initial values only			
g-prior:	$g = 1/k^2$		$g = 1/k^2$		UIP: $g = 1/NT$	
	Mean (1)	PiP (2)	Mean (3)	PiP (4)	Mean (5)	PiP (6)
Fiscal Variables:						
Other Revenues[b]	-0.717	0.99	-0.202	0.61	-0.209	0.72
	(4.139)		(1.063)		(1.231)	
Other Expenditures[b]	-0.051	0.07	-0.086	0.13	-0.067	0.20
	(0.201)		(0.299)		(0.274)	
Budget Surplus[b]	0.230	0.84	0.025	0.35	0.039	0.60
	(1.919)		(0.640)		(0.973)	
Distortionary Taxation[b]	-0.208	0.70	-0.016	0.14	-0.020	0.25
	(1.310)		(0.300)		(0.357)	
Productive Expenditure[b]	0.447	0.86	0.159	0.72	0.197	0.89
	(2.030)		(1.320)		(1.922)	
Govnmt. Consumption[b]	-0.086	0.37	-0.068	0.37	-0.109	0.61
	(0.676)		0.664)		(1.018)	
Top Corporate Tax Rate[a]	-0.008	0.15	-0.030	0.50	-0.036	0.66
	(0.351)		(0.868)		(1.115)	
Top Income Tax Rate[a]	-0.003	0.08	-0.033	0.49	-0.041	0.67
	(0.204)		(0.858)		(1.124)	
Other Variables:						
Lagged Income[a]	-13.61	1.00	-9.61	0.99	-9.97	1.00
	(5.887)		(3.805)		(4.531)	
Investment Rate[b]	-0.025	0.21	-0.124	0.81	-0.140	0.94
	(0.444)		(1.657)		(2.369)	
Population Growth[b]	-0.013	0.05	0.037	0.09	0.069	0.21
	(0.098)		(0.197)		(0.284)	
Primary Schooling[b]	0.005	0.08	-0.008	0.13	-0.008	0.22
	(0.225)		(0.295)		(0.311)	
Secondary Schooling[b]	-0.001	0.07	-0.001	0.11	-0.003	0.23
	(0.185)		(0.253)		(0.361)	
Trade[b]	0.007	0.22	0.053	0.98	0.050	0.99
	(0.462)		(3.195)		(3.440)	
Inflation[b]	-0.014	0.13	-0.001	0.07	-0.001	0.17
	(0.325)		(0.081)		(0.059)	
Corruption (ICRG)[b]	0.035	0.05	0.039	0.06	0.082	0.16
	(0.079)		(0.118)		(0.172)	
Life Expectancy[a]	-0.044	0.09	-0.963	0.87	-1.050	0.96
	(0.229)		(1.997)		(2.758)	
Fertility[a]	-1.982	0.54	-1.073	0.36	-1.292	0.51
	(0.946)		(0.651)		(0.819)	
Modelspace	$2^{18} = 262,144$		$2^{18} = 262,144$			
Observations (NT)	87		83			
Countries (N)	28		27			
All specifications control for country and period fixed effects.						

Notes: The table displays results for long regressions and BMA using five-year data. The model prior is the hierarchical binomial beta prior with $m = K/2 = 9$. In columns 1-4, the parameter prior is a g-prior with $g = \min\{1/NT, 1/k^2\}$, which evaluates to $g = 1/k^2$. In columns 5-6 we use the uniform information prior (UIP) $g = 1/NT$. Mean/SE ratio in parenthesis. Models in columns 3-6 include only initial values of explanatory variables. In columns 1-2 regressors are measured either as initial values or averages following the most common approach in the literature (but violating the identification assumption), indicated as follows:
[a] initial values of five-year period in columns 1-6, [b] average over five-year period in columns 1-2 but initial values of five-year period in columns 3-6.

Table 4 presents the results using five-year averages of growth and averages or initial values of explanatory variables. Columns 1-2 display BMA estimates for models with, following the literature, most regressors entering as contemporaneous averages. Where the literature suggests otherwise we measure regressors as initial values. This is the case for lagged income, marginal tax rates, life expectancy, and fertility.

From the set of fiscal variables other revenues, the budget surplus, distortionary taxes, and productive expenditure, have PiPs above 0.5. The most notable difference to our main results reported in table 2 is the high PiP for distortionary taxes and the low PiP for the top corporate tax rate. Furthermore, the estimated coefficient of other revenues is quantitatively very large compared to the other estimated coefficients. Given the endogeneity concerns, these results likely do not reflect the correct effects.

To explore the endogeneity issue further columns 3-6 show regression estimates with five-year averages of growth as the dependent variable, but exclusively using initial values of regressors. The initial values in this specification fulfill the identification assumption of predeterminedness, in contrast to the contemporaneous averages used in columns 1-2 (and in much of the literature).

Columns 3-4 present the results using the same prior setting as before. PiPs for fiscal variables are now much lower so that only other expenditure and productive expenditure appear to be robust. However, the g-prior suggested by Ley and Steel (2009) results, here, in $g = 1/K^2$, which might be too restrictive in this setting with the much smaller sample size that results from using the five-year intervals.

We also find robust negative effects of government consumption and the top income tax rate on average growth, while both variables where not robust in the main results with yearly growth. The result reveals the difference between average growth rates and growth in a specific year. Government consumption and the top income tax rate may have effects on average growth rates but do not seem to impact growth in one specific year.

With respect to control variables, the effect of initial income remains negative and robust throughout. The positive effect of trade also remains robust when measured as initial values (columns 2-6). In addition we find robust negative effects of the investment rate and of life expectancy. The negative sign on the mean coefficient of investment stands in contrast to the non-robust effect found with yearly data. A potential explanation for the negative sign on the mean coefficient of investment is that in the relatively rich OECD countries investment is saturated and has few additional effects.

Discussion. Overall the results in this section issue a warning of using averaged data. Initial values may be an alternative to derive additional information in combination with yearly data. Averaging growth and using initial values can limit the impact of business cycle correlations and reveal effects on growth in the mid- to long-run. Using yearly data allows plausible identification assumptions while maximizing sample size, and enables us to identify the timing of when fiscal variables impact growth more precisely. Together the results offer interesting insights into the effect, and their timing, of marginal taxes, average taxes, and public spending on economic growth.

5 Conclusions

In this paper we analyze the effects of fiscal policy on economic growth. Our empirical approach accounts for model uncertainty about which fiscal variables matter. We also allow for a range of other potential growth determinants, and control for country and time fixed effects. We present unconditional effects by averaging across models, using panel data for 28 OECD countries and the period 1990-2013.

Our findings are as follows: First, we find that only a select subset of fiscal variables can influence growth. Second, on the spending side, consistent with previous studies (Kneller et al. 1999), we show that productive government expenditure has a robust positive effect, while overall government consumption does not have a statistically significant effect on growth. Third, on the income side, we document that top marginal corporate tax rate, as well as other revenues, (defined as non-tax revenues and taxes on international trade) negatively affect economic growth, while the effect of average taxes classified a priori as distortionary found by previous studies is not robust. Moreover, the effect of the budget surplus is robust and positive (consistent with Adam and Bevan 2005). Finally, with respect to the timing of effects, we find that the strongest effects of fiscal variables on growth occur after two years.

With model averaging we can address several issues in the empirical literature that examines the relation between fiscal policy and economic growth. First, we avoid bias due to the choice of one particular model or imposing other priors that limit the model space. Second, we nest the analysis of average and marginal taxes. Third, we allow for a large set of other possible growth determinants. Finally, we study the timing of growth effects of fiscal variables. The findings point to an important short term impact of fiscal policy on economic growth with delayed onset.

Our results have policy implications that are highly relevant to current political debates. Most importantly, they indicate that fiscal policy can stimulate growth if government expenditure takes the form of productive investments and is financed by taxes on personal income and profits or taxes on domestic goods and services.

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Appendices

A Additional results

Table A1 reports some additional results. The specifications correspond to the model used to estimate the main results in table 2, with the small difference that all variables enter at the same lag length, i.e., control variables enter always at the same lag as fiscal variables. The specification at $t-1$ in columns 1-2 is thus identical. This does not change our main findings regarding fiscal variables. Moreover, initial income remains robust through all specifications and trade is robust at lag 1 and lag 2. However, the set of other control variables that is robust changes slightly when they enter at lag $t-2$ and $t-3$.

First of all neither life expectancy nor fertility appear robust in table A1. Second, when measured at time $t-2$ a few additional standard growth regressors have robust effects. We find that the investment rate and secondary schooling have a robust negative effect, and inflation a robust positive effect. Third, when measured at time $t-3$ only the effect of the investment rate is robust.

The negative sign of the coefficient on investment at lags 2 and 3 is somewhat surprising. It stands in contrast to the non-robust effect at $t-1$. When investment is measured in the same period (i.e., period t), the results (not reported) reveal a strong robust positive correlation with growth. The pattern provides some support for a positive short run relation of the investment rate and economic growth. A potential explanation for the finding is that in the relatively rich OECD countries investment is saturated and has few additional effects.

Table A1: Growth and Taxes - BMA with Yearly Data,
Same Lag Length for all Variables

rhs variables measured at:	$t-1$		$t-2$		$t-3$	
	Mean (1)	PiP (2)	Mean (3)	PiP (4)	Mean (5)	PiP (6)
Fiscal Variables:						
Other Revenues	-0.113	0.37	-0.256	0.80	-0.185	0.60
	(0.693)		(1.568)		(1.079)	
Other Expenditures	-0.368	0.31	-0.011	0.07	-0.003	0.02
	(0.605)		(0.082)		(0.044)	
Budget Surplus	0.017	0.18	0.207	1.00	0.002	0.05
	(0.397)		(5.002)		(0.187)	
Distortionary Taxation	-0.003	0.04	-0.022	0.17	-0.003	0.03
	(0.107)		(0.356)		(0.132)	
Productive Expenditure	0.031	0.13	0.341	0.98	0.000	0.02
	(0.340)		(3.300)		(0.001)	
Govnmt. Consumption	-0.099	0.36	-0.025	0.17	-0.001	0.02
	(0.672)		(0.361)		(0.065)	
Top Corporate Tax Rate	-0.049	0.61	-0.050	0.72	-0.001	0.04
	(1.102)		(1.341)		(0.165)	
Top Income Tax Rate	-0.001	0.04	-0.030	0.45	-0.016	0.24
	(0.109)		(0.772)		(0.513)	
Other Variables:						
Initial Income	-7.591	0.95	-12.33	1.00	-9.623	1.00
	(2.542)		(5.620)		(4.487)	
Investment Rate	0.000	0.03	-0.236	1.00	-0.260	1.00
	(0.033)		(4.962)		(6.175)	
Population Growth	-0.013	0.04	-0.137	0.22	-0.038	0.06
	(0.129)		(0.440)		(0.217)	
Primary Schooling	0.000	0.03	0.001	0.07	0.000	0.02
	(0.041)		(0.106)		(0.067)	
Secondary Schooling	-0.001	0.06	-0.019	0.62	-0.001	0.05
	(0.186)		(1.072)		(0.173)	
Trade	0.055	0.99	0.020	0.63	0.000	0.02
	(3.826)		(1.102)		(0.055)	
Inflation	-0.010	0.13	-0.087	0.81	-0.001	0.02
	(0.334)		(1.604)		(0.082)	
Corruption (ICRG)	-0.008	0.03	0.538	0.25	0.047	0.03
	(0.038)		(0.479)		(0.139)	
Life Expectancy	-0.090	0.14	-0.061	0.15	-0.275	0.35
	(0.354)		(0.319)		(0.661)	
Fertility	-1.756	0.45	-0.527	0.21	-0.151	0.07
	(0.810)		(0.424)		(0.224)	
Modelspace	$2^{18} = 262,144$					
Observations (NT)	369				368	
Countries (N)	28				28	
All specifications control for country and period fixed effects.						

Notes: The table shows BMA results for models which always use the same lag length for all right-hand side (rhs) variables. The model prior is the hierarchical binomial beta prior with $m = K/2 = 9$ and the parameter prior a g-prior with $g = \min\{1/NT, 1/k^2\}$. In columns 1-2 all right-hand side variables are measured at time $t-1$, in columns 3-4 all right-hand side variables are measured at time $t-2$, and in columns 5-6 all right-hand side variables are measured at time $t-3$. Mean/SE ratio in parenthesis, based on robust and clustered standard errors.

B Variable Definitions

Table B1: Data Description and Sources

Variable	Description	Source
Growth	Difference of natural logarithm of GDP per capita (in constant 2000 $US).	World Development Indicators
Initital Income	Lag of log GDP per capita (in constant 2000 $US). I.e. if growth is change of log GDP per capita from $t - s$ to t then initial income is measured at $t - s$.	World Development Indicators
Distortionary Taxes	Sum of tax revenue from the following categories: Taxes on income, profits and capital gains, social security contributions, taxes on payroll and workforce, taxes on property. Measured as revenue as a percentage of GDP.	OECD Public Sector, Taxation and Market Regulation (PSTMR) tables
Non-Distortionary Taxes	Tax revenue from taxes on domestic goods and services minus tax revenue from customs and import duties, taxes on exports, and taxes on international trade and transactions.	OECD PSTMR tables
Other Revenues	Tax revenue from taxation on international trade, other taxes plus non-tax revenue. Measured as revenue as a percentage of GDP.	OECD PSTMR tables
Productive Expenditure	Combined expenditure within the following categories of government function (COFOG): general public services, Defence, Education, Health, and Housing. Measured as a percentage of GDP.	OECD National Accounts
Non-Productive Expenditure	Combined expenditure within the following categories of government function (COFOG): Social protection, Recreation, and Economic affairs. Measured as a percentage of GDP.	OECD National Accounts
Other Expenditure	Combined expenditure within the following categories of government function (COFOG): Environmental protection, and Public order and safety. Measured as a percentage of GDP.	OECD National Accounts
Budget Surplus	Total general government budget surplus as a percentage of GDP.	OECD National Accounts
Government Consumption	Overall government consumption as a percentage of GDP.	OECD Economic Outlook No. 99 (2016)
Top Corporate Tax Rate	Top statutory corporate income tax rate. In percentages.	OECD Tax Data Base
Top Income Tax Rate	Top statutory personal income tax rate. In percentages.	OECD Tax Data Base
Investment	Investment as a percentage of GDP.	World Development Indicators
Population Growth	Growth rate of the total population (residents). In percentages.	World Development Indicators

Table B1 continued

Variable	Description	Source
Primary Schooling	Ratio of the total primary school enrollment (gross enrollment) to the population within the age group that corresponds to primary education years. In percentages.	World Development Indicators
Secondary Schooling	Ratio of the total secondary school enrollment (gross enrollment) to the population within the age group that corresponds to secondary education. In percentages.	World Development Indicators
Trade	Sum of exports and imports as percent of GDP. World Development Indicators.	
Inflation	Annual change of prices (based on consumer price index). In percentages.	World Development Indicators
Corruption	Index of the absence of corruption. Higher values indicate less corruption.	Political Risk Services' International Country Risk Guide (ICRG) https://www.prsgroup.com/about-us/our-two-methodologies/icrg
Life Expectancy	Life expectancy at birth in years.	World Development Indicators
Fertility Rate	Fertility rate as births per woman.	World Development Indicators

Further details on construction of the fiscal data set can be found in the "not for publication" appendix.

C List of Countries

List of countries in the yearly data set used for baseline results. Countries in italics are not included in the analysis based on five-year data:

Table C1: List of Countries

Austria	Germany	*Japan*	Slovenia
Belgium	*Greece*	Luxembourg	Spain
Czech Republic	Hungary	Netherlands	Sweden
Denmark	Iceland	Norway	*Switzerland*
Estonia	Ireland	Poland	*Turkey*
Finland	*Israel*	Portugal	United Kingdom
France	Italy	Slovak Republic	United States