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Further enquiries to:
The Administrator
Chair in Public Finance
Victoria University of Wellington
PO Box 600
Wellington 6041
New Zealand

Phone: +64-4-463-9656
Email: cpf-info@vuw.ac.nz

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**TAXES AND ECONOMIC GROWTH IN OECD COUNTRIES:
A META-REGRESSION ANALYSIS**

Nazila Alinaghi and W. Robert Reed
Department of Economics and Finance
University of Canterbury
NEW ZEALAND

Abstract

This paper uses meta-analysis to evaluate the results of 42 studies and 641 individual estimates of the effect of taxes on economic growth in OECD countries. Our analysis addresses a number of difficult coding issues such as: implications of the government budget constraint for interpretations of tax effects; units of measurement for economic growth rates and tax rates; implications of equation specifications that measure short-run, medium-run, and long-run effects; length of time period (annual data versus multi-year periods); and other factors. Our main findings are: Estimates in the literature are characterized by significant (negative) publication bias. Controlling for publication bias, we find that increases in unproductive expenditures funded by distortionary taxes and/or deficits have a significant, negative effect on growth; while increases in non-distortionary taxes to fund productive expenditures and/or government surpluses have a significant, positive effect. The estimated differences in these policies indicate that there is scope for tax policy to have a meaningful impact on economic growth. Finally, we find weak evidence that taxes on labour are more growth retarding than other types of taxes, while the evidence regarding other types of taxes is mixed.

Keywords: Meta-analysis, taxes, economic growth, OECD

JEL classification: H2, H5, H6, O47, O50

* Corresponding author is W. Robert Reed. His email address is bob.reed@canterbury.ac.nz.

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I. INTRODUCTION

This study is a meta-analysis of the effect of taxes on economic growth in OECD countries. Over the decades, there have been hundreds of studies estimating the effect of taxes on economic growth. Prominent examples include Agell, Lindh, and Ohlsson (1997); Mendoza, Milesi-Ferretti, and Asea (1997); Fölster and Henrekson (1999); Kneller, Bleaney, and Gemmell (1999); Daveri and Tabellini (2000); Bassanini and Hemmings (2001); Bleaney, Gemmell, and Kneller (2001); Fölster and Henrekson (2001); Afonso and Furceri (2010); Alesina and Ardagna (2010); and Arnold et al. (2011). Despite the fact that many studies use similar data and study many of the same countries and time periods, estimates vary widely, so that there is no consensus on whether taxes exert an important influence on economic growth and, if they do, how large an effect they have.

There are many possible reasons for this state of affairs. Tax policy is necessarily a two-sided activity. Revenues generated through taxes are used to fund expenditures and/or reduce deficits. As a result, tax effects are always net effects, and will differ depending on how the tax revenues are spent. Relatedly, different types of taxes may have different consequences for economic growth, as may different types of expenditures (Barro, 1990; Barro and Sala-i-Martin, 1992; Futagami et al., 1993; and Deverajan et al., 1996). For example, a distortionary tax on corporate profits used to fund transfer payments may be expected to have different growth effects than a non-distortionary tax on goods and services used to build productive infrastructure. Further, the empirical models used to estimate tax effects may measure short-run, medium-run, or long-run effects depending on the particular ways that regression equations are specified. For these and other reasons, even studies that use similar data can produce dissimilar estimates of tax effects.

In order to make estimates comparable across studies, one must carefully track the factors that can cause tax effects to differ. Once this is done, standard meta-analysis procedures can be used to control for these factors. This allows one to aggregate and compare estimates across studies. That is what this analysis does.

This research has three goals. First, we wish to summarize the extensive literature on taxes and economic growth in OECD countries. As part of this analysis, we check for publication bias, by which some estimates are disproportionately reported, either due to statistical insignificance, or because they are "wrong-signed" (Stanley and Doucouliagos, 2012; Havranek and Irsova, 2012). We then calculate an "overall tax effect" that corrects for publication bias.

Unfortunately, any measure of the "overall effect" of taxes on growth is not particularly informative because it lumps together estimated effects from different kinds of fiscal policies. Accordingly, our second goal is to compare estimated tax effects from two types of policies. On the one hand, we group tax effects that are predicted to have a negative impact on economic growth. An example would be the use of distortionary taxes to fund unproductive expenditures. On the other hand are tax effects that are predicted to positively impact economic growth, such as the use of non-distortionary taxes to fund productive expenditures. The difference in these two sets of estimated tax effects provides a measure of the impact that tax policy can have on economic growth. Our third goal and final goal is to determine whether some kinds of taxes are more growth-retarding than others.

To achieve these goals, this study collects estimates of tax effects on economic growth in OECD countries from 42 studies. Based on a final sample of 641 estimates, we find strong evidence that the empirical literature on estimated tax effects is impacted by publication bias. In particular, there is a tendency to over-report negative estimates. Once we control for this, we calculate that the "overall effect" of taxes on economic growth is small and statistically insignificant. However, as noted above, this "overall tax effect" is not very informative.

When we turn to analysing different types of tax policies, and after controlling for publication bias, we find evidence that the composition of fiscal policy makes a difference. For example, increases in unproductive expenditures funded by distortionary taxes and/or deficits have a statistically significant, negative effect on economic growth. Increases in non-distortionary taxes to fund productive expenditures and/or government surpluses have a statistically significant, positive effect on economic growth. The estimated differences in these policies indicate that there is scope for tax policy to have a meaningful impact on economic growth. Further, we find weak evidence that taxes on labour are more growth-retarding than other types of taxes. Evidence regarding other types of taxes is mixed.

Our analysis proceeds as follows. Section II reports how we collected our sample of estimates. Section III discusses some of the reasons why studies of tax effects can produce different estimates. Section IV presents our empirical results, addressing each of the three goals above. Section V summarizes the main findings of our research.

II. SELECTION OF STUDIES AND CONSTRUCTION OF DATASET

This meta-analysis collects estimated tax effects for all studies that estimate a variation of the following specification:

(1) $$g = \alpha_0 + \alpha_1 tr + error,$$

where g is a measure of economic growth, tr is a measure of the tax rate, and the data are taken from OECD countries.[1] To do that, we conducted a comprehensive search including both electronic and manual search procedures.

The electronic search used three categories of keywords: (i) "TAX" keywords, (ii) "ECONOMIC GROWTH" keywords, and (iii) "OECD" keywords in the following combination: "TAX" *and* "ECONOMIC GROWTH" *and* "OECD". A variety of keywords

[1] We did not include studies that estimate nonlinear tax effects, such as the "growth hills" of Bania, Gray and Stone (2007).

were substituted for each of the three categories. These are reported in APPENDIX 1. Keyword combinations were searched using the following search engines: EconLit, Google Scholar, JSTOR, Web of Science, Scopus, RePEc, EBSCO, and ProQuest. A total of 303 studies were identified in this manner.

The abstracts and conclusions of these studies were then read to eliminate any studies that did not estimate a growth equation with a tax variable, and/or included countries other than OECD countries. Backwards and forwards citation searches were used to locate additional studies. This produced a list of 51 studies, some of which were multiple versions of the same study[2], and included journal articles, conference proceedings, studies from think tanks and research firms, theses and dissertations, and working papers and other unpublished research.

This list was emailed to 64 researchers who had published on the topic of taxes and economic growth. The researchers were asked for help in identifying additional research, including working papers or unpublished studies from PhD students. Based on their responses, a revised list of 54 studies was compiled.

The new list was then read carefully to identify eligible studies. The dependent variable had to be a measure of GDP growth.[3] The growth equation had to include a tax variable that was measured in units of percent of income.[4] The countries included in a given regression equation had to consist entirely of OECD countries, though they could be restricted to a subset of OECD countries such as the G7, EU-15 or a larger set of EU member nations. Further, all estimates had to include multiple countries; i.e., we eliminated single country studies.[5] All estimated tax effects had to report a standard error or associated t-statistic. Finally, only studies

[2] When multiple versions of the same paper included different estimates, we pooled the estimates across versions.
[3] Alternatively, the dependent variable could be the level of income, as long as the explanatory variables included its lag.
[4] Studies where the "tax variable" consisted of all revenues, such as the ratio of total revenues to GDP, were not included.
[5] Time series from individual countries pose problems because relatively short data ranges combined with a relatively large number of confounders leaves few degrees of freedom. As a result, we chose not to include individual country studies in our meta-analysis.

written in English were included. We closed our search on 13 January 2016. The final sample of 42 studies is listed in APPENDIX 2.

Once the final set of estimates was determined, we then went through each equation/estimate and coded a set of regression and study characteristics (see next section). The coding was done independently by at least two coders, including both authors of this study, with a careful reconciliation of any discrepancies or inconsistencies. All search and coding procedures followed the MAER-NET protocols (Stanley et al., 2013).

III. FACTORS THAT CAUSE TAX ESTIMATES TO DIFFER ACROSS STUDIES

The government budget constraint. There are a number of issues that must be addressed before one can obtain meaningful estimates of tax effects. The first has to do with the government budget constraint:

(2) $0 = Taxes + OtherRevenues - Expenditures - Surplus.$

This can be rewritten as:

(3) $0 = tr + \left(\frac{OtherRevenues}{Income}\right) - \left(\frac{Expenditures}{Income}\right) - \left(\frac{Surplus}{Income}\right),$

where for the moment we define the tax rate as the ratio of taxes over income, $tr = \left(\frac{Taxes}{Income}\right)$.

In estimating Equation (1), it should be apparent that the interpretation of α_1 will differ depending on which variable(s) are omitted from Equation (3). If $\left(\frac{Expenditures}{Income}\right)$ is omitted, then α_1 measures the net effect of an increase in expenditures funded by taxes. Alternatively, if $\left(\frac{Surplus}{Income}\right)$ is omitted and expenditures are held constant, then α_1 measures the net effect of an increase in taxes used to cut the deficit (or increase the surplus).

Things become more complicated when finer gradations of taxes and expenditures are used. For example, empirical analyses of fiscal policy sometimes divide taxes into (i) distortionary and (ii) non-distortionary taxes; and expenditures into (i) productive and (ii) unproductive expenditures.

$$(4) \qquad 0 = tr(Non - distortionary) + tr(Distortionary) + \left(\frac{OtherRevenues}{Income}\right) - \left(\frac{Productive\ Expenditures}{Income}\right) - \left(\frac{Unproductive\ Expenditures}{Income}\right) - \left(\frac{Surplus}{Income}\right).$$

If $\left(\frac{Productive\ Expenditures}{Income}\right)$ is omitted, the coefficient on the non-distortionary tax rate variable measures the net effect of an increase in productive expenditures funded by an increase in non-distortionary taxes. As discussed below, it is generally accepted that growth theory predicts a positive value for α_1 in this case. In contrast, if $\left(\frac{Unproductive\ Expenditures}{Income}\right)$ is omitted, the coefficient on the distortionary tax rate variable measures the net effect of an increase in unproductive expenditures funded by an increase in distortionary taxes. In this case, a negative value for α_1 would be expected. As a result, the two "tax rate" variables might legitimately produce opposite signs by virtue of the kind of tax variable that was being investigated, and depending on which other variables in the government budget constraint were omitted.

To address this issue, we go through each estimated tax effect and identify both the operative tax types and the use of the tax revenues implied by the government budget constraint. Tax types and expenditures are then categorized as distortionary/non-distortionary, productive/unproductive, or other according to the taxonomy in TABLE 1, taken from Kneller, Bleaney, and Gemmell (1999).[6] We then use TABLE 2, which is taken from Gemmell, Kneller, and Sanz (2009) and summarizes predictions from growth theory, to predict the effect on

[6] We use the Kneller, Bleaney, and Gemmell (1999) taxonomy because it is broadly representative of the fiscal policy literature. It may be best thought of as representing relative categories. Strictly speaking, any tax that is not lump-sum is distortionary.

growth for the associated fiscal policy actions. In this way, every tax effect is assigned a prediction with respect to its impact on growth (negative, positive, or ambiguous).

We also classify each estimated tax effect according to its tax type. Taxes are classified as Labour taxes, Capital taxes, Consumption taxes, Mixed taxes, Other taxes, and Overall taxes. The classification system for assigning each tax to a tax type is given in TABLE 3.

Units of measurement. The second issue has to do with the units of measurement for the g and tr variables. Each of these variables can be measured in percentage points (e.g., 2%) or in decimals (0.02). This will obviously effect the size of the tax coefficient, α_1. For example, if a one-percentage point increase in the tax rate lowers growth by 0.1%, and if both g and tr are measured in percentage points, or both are measured in decimals, then the corresponding value of α_1 will be -0.1. However, if g is measured in percentage points, and tr is measured in decimals, then the corresponding value of α_1 will be -10. And if g is measured in decimals, and tr is measured in percentage points, then the value of α_1 will be -0.001. Accordingly, we adjust all estimated effects so that $\alpha_1 = X$ means that a one-percentage point increase in the tax rate is associated with an X percentage point increase in economic growth.[7]

Countries. The third issue relates to the specific countries included in a given study. There is a trade-off between including a large number of countries, and including countries that are relatively homogeneous. We focus on studies that limit their estimation to OECD countries. APPENDIX 3 lists the 34 countries of the OECD, ordered by their year of admission to the OECD[8]. Many studies only include a subset of these countries. We further categorize the countries by the groupings G-7, EU-15, and EU, with the idea that the smaller groupings consist of more homogeneous economies. Our meta-analysis controls for these different groupings to

[7] Sometimes it was difficult to determine the units of measurement of the respective variables from the study so as to properly interpret the coefficient. When this would happen, we would contact the original author(s). When there was substantial uncertainty about the interpretation of the coefficient, the estimate was dropped from our analysis.
[8] Latvia, the 35th member, was admitted to the OECD on July 1st, 2016.

identify whether the estimated tax effects vary systematically across the different sets of countries included in the original studies.

Duration of time periods. A fourth issue concerns the time frames of the data employed by the different studies. If the time periods of Equation (1) differ across studies, that could cause estimates of α_1 to differ, even when the underlying effect is the same. For example, suppose there were two growth studies, one used 5-year time periods, the other used annual data. Suppose the former measured the cumulative rate of growth over each five-year period, while the latter reported annual growth rates. All things constant, one might expect α_1 to be larger in the former case. Accordingly, we adjust all growth measures to be (average) annual rates of growth.

Duration of estimated tax effects. A fifth issue is related in that it has to do with the duration of the estimated tax effect as implied by the specification of the regression equation. Let the estimated relationship between growth, g, and the tax rate variable, *tr*, be given by the finite distributed lag model,

(5) $$g_t = \alpha_0 + \alpha_1 tr_t + \alpha_2 tr_{t-1} + \varepsilon_t.$$

If this is the model estimated by the original study, then α_1 and α_2 represent the "short-run/immediate" effects of a one-percentage point increase in taxes in years *t* and *t-1* on economic growth in year *t*.

By adding and subtracting $\alpha_2 tr_t$ to the right hand side, one can rewrite the above as:

(6) $$g_t = \alpha_0 + \tau\, tr_t - \alpha_2 \Delta tr_t + \varepsilon_t,$$

where $\tau = (\alpha_1 + \alpha_2)$. If this is the model estimated in the original study, then the coefficient on the current tax rate, τ, represents the "cumulative/intermediate" effect of a one-percentage point increase in taxes in year *t* and *t-1* on economic growth in year *t*.

An alternative specification to Equation (5) is the auto-regressive, distributed lag model,

(7) $g_t = \alpha_0 + \alpha_1 tr_t + \alpha_2 tr_{t-1} + \gamma g_{t-1} + \varepsilon_t.$

Subtracting g_{t-1} from both sides gives:

(8) $\Delta g_t = \alpha_0 + \alpha_1 tr_t + \alpha_2 tr_{t-1} + (\gamma - 1) g_{t-1} + \varepsilon_t,$

which can be rewritten in error correction form as:

(9) $\Delta g_t = \alpha_0 + \delta(g_{t-1} - \theta tr_t) - \alpha_2 \Delta tr_t + \varepsilon_t$,

where $\delta = (\gamma - 1)$ and $\theta = \frac{(\alpha_1 + \alpha_2)}{(1-\gamma)}$. This specification is common in recent mean group and pooled mean group studies of economic growth. In Equation (9), the coefficient on tr_t in the cointegrating equation, θ, represents the total, long-run effect of a permanent, one-percentage point increase in the tax rate on steady-state economic growth.[9]

Specifications (5), (6), and (9) lead to three different measures of the effect of taxes on economic growth. Our meta-analysis controls for this by noting the specification of the growth equation in the original study and categorizing the duration of the estimated tax effect as short-run, medium-run, or long-run.

Different measures for economic growth and tax rates. A final issue that directly relates to the coding of tax effects has to do with how the economic growth and tax rate variables are defined. Some studies measure economic growth in terms of nominal GDP, some in terms of real GDP. Some measure economic growth in terms of per capita GDP, and some total GDP.[10] When it comes to measuring "the tax rate," most studies use effective tax rates, defined as tax revenues over a given measure of income. Others use statutory tax rates -- typically the top marginal rate. And some studies attempt to distinguish marginal from average tax rates. We use dummy variables to indicate the specific measures underlying a given estimate.

[9] We note that Equation (9) is sometimes estimated using an equivalent, alternative specification: $\Delta g_t = \alpha_0 + \delta(g_{t-1} - \theta tr_{t-1}) + \alpha_1 \Delta tr_t + \varepsilon_t$, where δ and θ are defined as above.

[10] We do not distinguish between real and nominal growth because studies that used (the log of) nominal GDP also included time dummies, so that there was no effective difference between specifying economic growth in nominal or real terms.

Control variables. In addition to the issues identified above, our analysis codes for many other study characteristics, including estimation method; type of standard error; whether the original study was published in a peer-reviewed journal; year of publication; length of sample period; midyear of sample period; inclusion of specific variables such as country fixed effects, human capital, trade openness, inflation, and others. A full list of the variables used in this study is discussed below.

IV. EMPIRICAL ANALYSIS

Preliminary analysis. Our literature search produced a dataset consisting of 713 estimated tax effects. TABLE 4 reports descriptive statistics for both these estimates and the associated *t*-statistics. For the full dataset, the median estimated tax effect is -0.073, implying that a ten percentage point increase in the tax rate is associated with a 0.73 percentage point decrease in annual economic growth. This compares to an average, annual growth rate for OECD countries of approximately 2.5 per cent over the period 1970-2000, a period which roughly corresponds to the "average" sample period of the studies included in this meta-analysis.[11,12] The median *t*-statistic is -1.27.

TABLE 4 immediately identifies a problem in that the minimum and maximum estimated tax effects are -3.52 and 12.72. These values indicate a tax effect size that is considerably outside the bounds of reasonable. While researchers differ in their estimates of the effects of taxes, nobody suggests that a one percentage point increase in the tax rate would lower annual economic growth by over 3 percentage points, or increase it by over 12 percentage points. Accordingly, the subsequent analysis works with a truncated sample of estimates.

We delete the top and bottom 5 percent of estimates and obtain a sample of 641 estimated tax effects. The descriptive statistics for this truncated sample is also reported in

[11] This is calculated by taking the average beginning and average ending dates for the sample ranges of the respective studies.

[12] Growth rate is the average, annual growth rate over the period 1970-2000 for the 22 countries that belonged to the OECD in 1970.

TABLE 4. The range of estimated tax effects for this sample range from a minimum of -0.524 to a maximum of 0.166. The median t-statistic still indicates insignificance, while the sample of t-statistics range from a minimum of -14.50 to a maximum of 7.78, with a mean absolute value of 2.09.

FIGURE 1 plots the 641 estimated tax effects of the truncated sample. If tax effects were homogeneous across studies and differed solely due to sampling error, one would expect a bell-shaped histogram. This is clearly not the case in FIGURE 1. The distribution is skewed to the left, and suggests that there may be sample selection favouring negative estimates, perhaps due to publication bias. We test for publication bias below.

FIGURE 2 presents a forest plot of the respective studies using a "fixed effects" weighting scheme. We note for both the present context and below, that "fixed effects" (and "random effects"), mean something entirely different in meta-analyses than they do in panel data econometrics (Reed, 2015). Here it simply means that the estimated tax effects are weighted by the inverse of their standard errors. For each study, a weighted average is constructed, along with a 95 percent confidence interval. Several features of the forest plot are noteworthy. First, most of the studies estimate small effects with tight confidence intervals, though Study 39 (Abd Hakim et al., 2013) is a notable counterexample.

Second, there is a substantial amount of cross-study heterogeneity, indicated by an exceptionally large I^2 value of 98.8%. (Higgins and Thompson, 2002). As discussed above, different studies have different ways of incorporating the government budget constraint, measure tax effects of different durations, study different samples of countries, and so on. The high I^2 value indicates that the differences across studies overwhelm the variation that would be expected solely from sampling error. Finally, the last column calculates the percentage weight that each study receives in calculating the overall weighted average. Study 26 (Hanson, 2010) is weighted substantially more than all the other studies combined (81.39% versus

18.61%). The disproportionately large weight given to one study is not necessarily a concern if that one study is truly, substantially more reliable than the others. However, it may be prudent to use a more dispersed weighting scheme.

Accordingly, the subsequent empirical work emphasizes the "random effects" estimates, where tax effects are weighted by their standard error plus a term that captures the cross-study heterogeneity. Because cross-study heterogeneity is so great, this will have the effect of equalizing the weights given to individual studies. APPENDIX 4 displays the forest plot using random effects. The study weights are much more balanced.

FIGURE 3 reports two funnel plots, with estimates plotted against their standard errors. The top figure displays individual estimates. In the bottom figure, each study is represented by a single point relating its mean estimate to its mean standard error.[13] The solid line in both plots shows the mean of estimated tax effects, and the dotted lines that fan out from the top of the funnel demarcate the 95% confidence area where most of the estimates would fall if the dispersion in estimates was driven solely by sampling error. Publication bias is indicated whenever a disproportionate number of estimates lie on one side of the inverted, V-shaped confidence area. Both funnel plots indicate publication bias, with a preference for negative estimates over positive ones. Further, the wide dispersion at the top of the funnel is consistent with substantial heterogeneity, as previously indicated by the I^2 value.

FAT/PET tests. TABLE 5 reports the results of two tests: the Funnel Asymmetry Test (FAT) to test for publication bias, and the Precision Effect Test (PET), which tests for the significance of the overall effect.[14] Both tests are obtained from estimating the following specification using weighted least squares (WLS),

(10) $\hat{\alpha}_{1,ij} = \beta_0 + \beta_1 SE_{ij}$,

[13] Both funnel plots omit observations where the standard error is greater than 1. This allows the reader to better observe the pattern of points at the top of the funnel.
[14] Detailed discussions of these tests are provided in Stanley and Doucouliagos (2012) and Shemilt et al. (2011).

where $\hat{\alpha}_{1,ij}$ is the estimated tax effect from regression *j* in study *i*. The null hypotheses for the FAT and PET are $H_0\colon \beta_1 = 0$ and $H_0\colon \beta_0 = 0$, respectively.

Our analysis uses four different weights to estimate Equation (10). The *Fixed Effects(Weight1)* and *Random Effects(Weight1)* estimators use weights $\left(\frac{1}{SE_{ij}}\right)$ and $\left(\frac{1}{\sqrt{\left(SE_{ij}\right)^2+\tau^2}}\right)$, respectively, where τ^2 is the estimated variance of population tax effect across studies. This set of weights makes no allowance for the fact that some studies report more estimates than others. As a result, a study with 50 estimates is weighted 50 times more than a study that reports a single estimate, ceteris paribus. To address this, we multiply both sets of weights by $\left(\frac{1}{N_i}\right)$, where N_i is the number of estimated tax effects reported in study *i*. The corresponding *Fixed Effects(Weight2)* and *Random Effects(Weight2)* estimators attempt to give equal weight to each study regardless of the number of tax effects each study reports.

The first four columns of TABLE 5 report the results of estimating Equation (10) with WLS, using the four different weighting schemes described above. The FAT is reported in the first row. For all four estimators, the null hypothesis of no publication bias is rejected at the 1 percent level of significance. The negative coefficients indicate that sample selection favours negative estimated tax effects, perhaps due to researchers choosing to disproportionately report negative estimates, or journals discriminating against positive results. These results are consistent with earlier observations about the histogram of estimated effects and the visual evidence of publication bias from the funnel plots in FIGURE 3.

The first four columns of the second row of TABLE 5 report the PET. All four estimators conclude that the overall tax effect, controlling for publication bias, is statistically insignificant and relatively small in economic terms. For example, the *Random*

Effects(Weight1) estimate indicates that a ten percentage point increase in the tax rate is associated with a 0.01 percentage point decrease in annual GDP growth.

The last two columns report random effects estimates of Equation (10) when the publication bias term (SE_{ij}) is not included, so that the overall estimate is not corrected for publication bias. The corresponding estimates of the overall tax effects are now substantially larger in absolute value, and statistically significant at the 1 percent level. According to the *Random Effects(Weight1)* estimate in Column (5), a ten percentage point increase in the tax rate is associated with a 0.65 percentage point decrease in annual GDP growth. These results indicate that the statistically and economically significant results reported in the literature are a consequence of publication bias that favours negative estimates of tax effects, while suppressing the publication of positive tax effects. As a result, we want to be sure that our subsequent analysis corrects for this.

This section has addressed the first goal of this research, to obtain an "overall estimate" of the effect of taxes on economic growth in OECD countries. We find that a publication-bias adjusted estimate of the overall effect on taxes is statistically insignificant and negligibly small in economic terms. However, our previous discussion on factors that cause tax estimates to differ across studies (cf. Section III) makes clear that any estimate of overall tax effects is not particularly meaningful. The same fiscal policy action can be estimated as a positive or negative tax effect depending on the elements of the government budget constraint that are omitted from the original study's regression equation. Accordingly, the next section undertakes a meta-regression that allows tax effects to vary systematically according to study and data characteristics.

Meta-regression. Section III identified a large number of factors that can affect the estimated size of tax effects. In this section, we compare tax effects associated with fiscal policies that are predicted to have negative growth effects, with those predicted to have positive effects. We also investigate whether some types of taxes are more growth-retarding than others. To do that, it will be necessary to control for the myriad other factors that impact estimates of tax effects.

TABLE 6 reports the variables used in the subsequent meta-regression analysis. The first set of variables were previously discussed and match each tax effect to a prediction. A little more than a fourth of the estimated tax effects allow a definite sign prediction, with 22.8 percent predicted to be negative, 5.9 percent predicted to be positive, and the rest ambiguous. As these three variables comprise the full set of possibilities, at least one variable must be omitted in the empirical analysis. Here and elsewhere we indicate the omitted variable with an asterisk.

The second set of variables assigns each tax effect to one of six types of taxes (Labour, Capital, Consumption, Other, Mixed, and Overall). The most common tax variable is constructed by taking the ratio of total tax revenues over GDP. 34.5 percent of tax effects are of this type. However, many studies disaggregate tax effects into separate types. 18.6 percent of estimated tax effects involve Labour taxes (e.g., personal income taxes, payroll taxes, social security contributions). Another 12.5 percent are associated with Capital taxes (e.g., corporate income taxes, taxes on capital gains and dividends). 13.3 percent are related to Consumption taxes (e.g., ad valorem taxes on goods and services, VAT). The remainder of tax effects mostly involve a mix of different tax types.

Subsequent variables are grouped into numerous categories: Country Group, Economic Growth Measure, Tax Variable Measure, Duration of Tax Effect, etc. Most of the observed tax effects are estimated using data from the larger set of OECD countries (78.8%), as opposed to smaller groupings such as the G-7 countries (11.7%) or EU countries (6.4% and 3.1%). In most cases, economic growth is measured in per capita terms (74.1%). Most taxes are measured as average rates, rather than marginal (91.0% versus 9.0%); are specified in level rather than differenced form (82.8% versus 17.2%); and are effective rather than statutory tax rates (90.6% versus 9.4%). Most estimated tax effects measure the immediate effect of a tax change (70.2%), versus a medium- or long-run effect (5.3% and 24.5%).

Two thirds of the estimated tax effects in our meta-regression come from peer-reviewed journal articles and the mean year of publication was 2007. Almost all of the original studies used panel data to estimate tax effects (99.1%). The average sample length in the original studies was 31.4 years, and the average mid-point was 1985. About two-thirds of the tax effects were estimated using OLS or a related procedure that assumed errors to be independently and identically distributed across observations (such as mean group or pooled mean group procedures). Of the remainder, 15.4 percent used GLS, and 16.8 percent attempted to correct for endogeneity using a procedure such as TSLS or GMM.

Because the standard error plays such a significant role in meta-analysis, we categorized standard errors into three groupings: *SE-OLS* (58.7%); *SE-HET* (24.5%), where standard errors were estimated using a heteroskedastic-robust estimator; and *SE-Other* (16.8%), whenever allowance was made for off-diagonal terms in the error variance-covariance matrix to be nonzero. Lastly, dummy variables were used to indicate the presence of important control variables, the most common of which were country fixed effects (83.3%), and measures of investment (58.5%), initial income (55.9%), human capital, such as educational achievement (44.0%), employment growth (37.8%), and population growth (24.3%).

In our investigation of tax effects, we adopt the following empirical procedure. First we separate out the two sets of tax variables: *Prediction-Negative* and *Prediction-Positive;* and *Labour-Tax, Capital-Tax, Other-Tax, Mixed-Tax,* and *Overall-Tax*. We do this because the two sets of tax variables are significantly correlated. For example, Labour and Capital taxes are significantly associated with tax policies that are predicted to have negative effects. We then combine the two sets of tax variables to check for robustness.

For each set of regressions we also include two sets of control variables. The top panel of each table reports the regression results when all control variables are included in the equation. The bottom panel reports the results when a stepwise procedure is used to select control variables, even while the tax variables are fixed to remain in each equation.[15] Since the tax variables are locked into each regression, the use of the stepwise procedure does not invalidate their significance testing. All regressions also include the publication bias variable, *SE*, and thus control for publication bias.

The results of this analysis are given in TABLES 7 through 9. TABLE 7 reports the results when the prediction variables (*Prediction-Negative* and *Prediction-Positive*) are included in the meta-regression, while holding out the tax type variables. Across all four estimation procedures, and for both sets of control variables, we estimate a negative and statistically significant coefficient for the variable *Prediction-Negative*, and a positive and statistically significant coefficient for *Prediction-Positive.* These results are consistent with the prediction of growth theory.

The results are only slightly less supportive of growth theory when the tax type variables are added to the specification. TABLE 9 reports the corresponding estimates. The coefficient for *Prediction-Negative* remains negative and statistically significant across all four estimation procedures. *Prediction-Positive* is positive and statistically significant in the two random effects regressions (Columns 3 and 4), but insignificant in the two fixed effects regressions (Columns 1 and 2). As noted above, we consider the random effects estimator to be more reliable, so that the results from TABLE 9 are generally consistent with those from TABLE 7.

[15] We use a backwards stepwise regression procedure that selects variables so as to minimize the Schwarz Information Criterion. We employed the user-written, Stata program *vselect* to implement the stepwise procedure.

Not only do these findings constitute general statistical support in favour of the predictions of growth theory, but the respective coefficients indicate that tax policy can have a substantial economic impact. For example, the difference between the coefficients for *Prediction-Negative* and *Prediction-Positive* range from a minimum of 0.027 (TABLE 9, Bottom panel, Column 1) to a maximum of 0.194 (TABLE 7, Bottom panel, Column 4), with a midpoint value of approximately 0.11.

Let us now consider the following thought experiment: Suppose fiscal policy underwent the following policy switch. Distortionary taxes and unproductive expenditures were reduced by 10 percentage points while, simultaneously, non-distortionary taxes and productive expenditures were increased by the same amount. Using a point estimate of 0.11, our meta-regression results indicate that this would increase annual growth of GDP by 1.1 percentage points. As noted above, the average annual growth rate for OECD countries over the sample range of the studies included in this meta-analysis was approximately 2.5 percent. Thus a 1.1 percentage point increase in annual growth would constitute a substantial increase. Admittedly, this thought experiment is an extreme case, both in the absolute size of the tax changes, and in the swing in fiscal policy from one extreme of the growth pole to the other. Nevertheless, it does indicate that there is a role for tax-based fiscal policy to increase economic growth amongst OECD countries.

The last tax issue addressed in this study investigates whether some types of taxes are more growth-retarding than others. As noted in TABLE 1, Labour and Capital taxes are commonly classified as distortionary, while Consumption taxes are classified as non-distortionary. TABLE 8 estimates a meta-regression with the tax type variables but with prediction variables omitted, while TABLE 9 includes both. As the omitted category is Consumption taxes, we expect the coefficient on Labour and Capital taxes to be negative, whereas there is no sign expectation for the other tax type coefficients.

With respect to Labour taxes, the results from TABLE 8, across all four estimation procedures and with both sets of control variables, show negative and statistically significant coefficients. However, when prediction variables are added to the regression (cf. TABLE 9), the coefficient on *Labour-Tax* becomes insignificant in the preferred random effects regressions. In terms of economic significance, the estimates range from -0.064 (TABLE 8, Top panel, Column 3) to 0.010 (TABLE 9, Bottom panel, Column 4). The more negative estimates indicate that raising revenues from Labour taxes rather than Consumption taxes can have important growth consequences. However, given that some of the preferred *Random Effects* estimates are statistically insignificant, our overall assessment is that these estimates constitute weak evidence that Labour taxes are more growth-retarding than Consumption taxes.

The evidence that Capital taxes are more distortionary than Consumption taxes is even weaker. While the coefficients on the *Capital-Tax* variable are negative in all TABLE 8 regressions, they are insignificant in the preferred random effects estimations. When the prediction variables are added, the respective coefficients are generally insignificant (cf. TABLE 9). One of the regressions even produces a significant positive coefficient (bottom panel, *Random Effects-Weight2*). As a result, we conclude that the evidence that Capital taxes are more distortionary than Consumption taxes is mixed.

<u>Bayesian model averaging of control variables</u>. Having addressed the major goals of this study, we turn to an analysis of the control variables. Not counting the two sets of tax variables, there are 28 control variables. With so many variables, multicollinearity is a problem. For example, when all 28 variables are included with both sets of tax variables and the meta-regression is estimated using the *Random Effects(Weight2)* estimator, as in Column (4) of the top panel of TABLE 9, 5 of the 28 control variables are significant at the 5 percent level. When the backwards stepwise routine is employed, as in the bottom panel of TABLE 9, 9 of the 28 control variables are significant. One of the variables that is significant in the top panel is not

significant in the bottom panel's specification. Thus, variable selection makes a difference. This was not so much a problem when we estimated tax effects, because the variables were locked into the respective specifications without regard to statistical significance. However, it is a problem when trying to decide which control variables to include in the specification.

We use Bayesian Model Averaging (BMA) to address this issue (Zeugner, 2011). TABLE 10 reports the results of an analysis where we lock in the tax variables *Prediction-Negative* and *Prediction-Positive* and then apply BMA to the 28 control variables. All specifications adjust for publication bias. The results differ somewhat depending on the estimation procedure used. However, they are more consistent across analyses than would be the case, say, if we reported the results from specifications that included all variables and those that employed stepwise regression. We report results for both the *Fixed Effects(Weight1)* and *Random Effects(Weight2)* estimators. These two estimators use very different weighting schemes. Previous tables indicated that the estimates from these two estimators sometimes vary substantially. As a result, they provide an indication of robustness across estimation procedures.

We report three summary measures. The Posterior Inclusion Probability (*PIP*) is a weighted probability that uses the likelihood values of specifications to construct a "probability" that a given specification is "true". With 28 control variables, there are 10^{28} possible variable specifications. Variables that appear in specifications with high likelihood values will have larger *PIP* values. By construction, every variable appears in 50 percent of all possible specifications. However, the *PIP* can be very close to 100 percent if the specifications that include a variable have much greater likelihood values than those in which it is omitted.

The Posterior Mean (*Post. Mean*) uses the above-mentioned probability values to weight the estimated coefficients from each specification. Specifications in which a variable is not included assign an "estimated value" of zero to construct the Posterior Mean. Lastly, BMA also calculates the probability that a given coefficient has a positive sign (*Cond. Pos. Sign*). This is constructed in the same manner as the Posterior Mean, except that it uses a dummy variable indicating positive value rather than the estimated coefficient in constructing a weighted average.

TABLE 10 yellow highlights all the control variables that (i) have a *PIP* greater than 50%; (ii) have a Conditional Positive Sign of either 1.00 or 0.00 – indicating that the respective coefficient is consistently estimated to be either positive or negative in the most likely specifications; and (iii) have the same Conditional Positive Sign value for both the *Fixed Effects(Weight1)* and *Random Effects(Weight2)* estimators.

Studies that estimate tax effects for G-7 and EU-15 countries produce consistently less negative/more positive estimates than studies that include a large sample of countries from the OECD. To place the size of the Posterior Mean values in context, it helpful to recall that the median estimated tax effect from TABLE 4 is -0.073. By this standard, the effect of belonging to a G-7 country is relatively large (0.184 and 0.181, respectively). The effect associated with being a EU-15 member, while still positive, is substantially smaller.

We find that studies that measure economic growth using total GDP (*GDP*) rather than per capital GDP, and that employ a marginal (as opposed to average) measure of tax rates (*Marginal*), generally produce tax effects that are less negative/more positive. Compared to the short-run effects of taxes, studies that estimate medium-run tax effects (*Medium-run*) produce estimates of tax effects that less negative/more positive; while studies that estimate long-run, steady-state tax effects (*Long-run*) produce estimates that are more negative/less positive. There is evidence to indicate that more recent studies (*Publication Year*) produce less negative/more positive estimates; as do cross-sectional studies (*Cross-section*) compared to panel studies. However, there is also evidence that studies using more recent data (*Mid-Year*) find more negative/less positive tax effects.

With respect to estimation procedures, studies that use GLS rather than OLS (*GLS*), generally produce more negative/less positive estimates of tax effects. Interestingly, correcting for endogeneity (*TSLS/GMM*) does not appear to have much impact. Meta-regressions using the *Fixed Effects(Weight1)* estimator find that studies that employ TSLS/GMM generally estimate more negative/less positive effects. Meta-regressions using the *Random EffectsWeight2)* estimator find the opposite. However, in both cases, the Posterior Mean values are negligibly small (-0.001 and 0.009), suggesting either that tax policy is not endogenous, or that the instruments that have been employed in previous studies are not effective in correcting endogeneity. There is evidence that it makes a difference how one calculates standard errors, with studies that incorporate serial correlation, cross-sectional correlation and the like in calculating standard errors (*SE-Other*) associated with less negative/more positive effects.

Lastly, we find that studies that include initial income, employment growth, and unemployment rates in the growth equations are likely to produce less negative/more positive estimates; with studies that include country fixed effects, population growth, and inflation producing more negative/less positive tax effects. While the above findings are robust across variable specifications and the two estimation procedures, we again emphasize that the sizes of the associated effects, like those of tax policy itself, are small.

FIGURE 4 provides a visual representation of the BMA analysis for the tax (*Prediction-Negative* and *Prediction-Positive*) and control variables using the *Fixed Effects(Weight1)* estimator.[16] The figure reports estimates from the top 1000 models, with most likely models ordered from left to right. These 1000 models, out of 10^{28} possible models, account for a cumulative probability of approximately 30 percent. Red (blue) squares indicate that the respective coefficient is negative (positive) in the given model. A white square indicates that

[16] Note that in the associated specifications, the variable *Precision* corresponds to the constant term, while the constant term corresponds to the publication bias variable, *SE*.

the variable is omitted from that model. A solid band of the same colour across the figure indicates that the respective variable is consistently estimated to have the same sign across all 1000 models. In addition to confirming the results from TABLE 10, the figure also indicates the variable specifications of the top models. These closely match the *PIP* values in TABLE 10. The corresponding figure for the *Random Effects(Weight2)* estimator is quite similar, and is reproduced in APPENDIX 5.

V. CONCLUSION

The literature on taxes and economic growth in OECD countries has produced a large number of frequently conflicting estimates. One reason for the seemingly contradictory findings is that estimates of tax effects are often estimating different things. Because of the government budget constraint, the same tax effect can be estimated to be positive or negative, depending on the other budget categories omitted from the specification. For this and other reasons, it is valuable to collect the estimates from this literature and carefully track the differences across studies so that the estimates can be combined to provide an overall assessment of the growth effects of taxes.

This study combines results from 42 studies containing 713 estimates, all which endeavour to estimate the effect of taxes on economic growth in OECD countries. We drop extreme estimates from both ends of the sample range, and use meta-analysis to analyse a final sample of 641 estimates. We find that estimates in the literature are characterized by significant (negative) publication bias. Controlling for publication bias, the overall effect of taxes on economic growth is negligibly small and statistically insignificant. However, this overall effect is not particularly meaningful because it mixes together many different kinds of tax policies.

To get a better idea of the scope of tax policy to effect economic growth, we categorize tax policies by their predicted effects on economic growth. We estimate that, after adjusting for publication bias, increases in unproductive expenditures funded by distortionary taxes and/or deficits have a statistically significant, negative effect on economic growth. In contrast, increases in non-distortionary taxes to fund productive expenditures and/or government surpluses have a statistically significant, positive effect on economic growth. The difference between these "best" and "worst" tax policies can be economically important. For example, using a midpoint estimate from our meta-regression analysis, we calculate that if distortionary taxes and unproductive expenditures were reduced by 10 percentage points while, simultaneously, non-distortionary taxes and productive expenditures were increased by the same amount, the net effect would be an increase of 1.1 percentage points in annual GDP growth. While this represents an extreme case, both in the absolute size of the tax changes, and in the swing in fiscal policy from one extreme of the growth pole to the other, it does indicate that there is scope for tax-based fiscal policy to increase economic growth.

With respect to particular types of taxes, we find weak evidence that taxes on labour are more growth retarding than other types of taxes. Evidence regarding other types of taxes is mixed. Finally, we find evidence that data and study characteristics account for much systematic variation in tax estimates across studies, though the effects from any one characteristic is generally small. The one exception is that studies that focus their analysis on G-7 countries find less negative/more positive tax effects than those that use a wider sample of OECD countries.

One of the advantages of meta-analysis is that it can avoid some of the pitfalls associated with publication bias and selective reporting of results. Further, it can control for differences across studies that might otherwise mask significant effects. This is particularly relevant when estimating the effects of tax policy. The results of this study indicate that when these factors are taken into account, the combined weight of the evidence from the literature indicates that tax policy can have an economically important impact on economic growth.

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TABLE 1
Matching of Functional and Theoretical Classifications

Functional classification	*Theoretical classification*
Taxation on income and profit Social security contributions Taxation on payroll and manpower Taxation on property	Distortionary taxation
Taxation on domestic goods and services	Non-distortionary taxations
Taxation on international trade Non-tax revenues Other tax revenues	Other revenues
General public services expenditure Defense expenditure Educational expenditure Health expenditure Housing expenditure Transport and communication expenditure	Productive expenditures
Social security and welfare expenditure Expenditure on recreation Expenditure on economic services	Unproductive expenditures
Other expenditures (unclassified)	Other expenditures

NOTE: The categorizations in the table are taken from Kneller, Bleaney, and Gemmell (1999).

TABLE 2
Predicted Tax Effects

Type of Tax	*Omitted Fiscal Category*	*Predicted Effect*
Distortionary	Productive Expenditures	Ambiguous
Distortionary	Unproductive expenditures	Negative
Distortionary	All the expenditures(Pro&Unpro)	Ambiguous
Distortionary	Other Expenditures	Ambiguous
Distortionary	Deficit/Surplus	Ambiguous
Distortionary	Other Revenue	Ambiguous
Distortionary	Distortionary Taxes	Ambiguous
Distortionary	Non-distortionary Taxes	Negative
Distortionary	Intergovernmental Revenue	Ambiguous
Distortionary	Net Utility Expenditures	Ambiguous
Non-distortionary	Productive Expenditures	Positive
Non-distortionary	Unproductive Expenditures	Ambiguous
Non-distortionary	Productive & Unproductive Expenditures	Ambiguous
Non-distortionary	Other Expenditures	Ambiguous
Non-distortionary	Deficit/Surplus	Positive
Non-distortionary	Other Revenue	Ambiguous
Non-distortionary	Distortionary Taxes	Positive
Non-distortionary	Non-distortionary Taxes	Ambiguous
Non-distortionary	Intergovernmental Revenue	Ambiguous
Non-distortionary	Net Utility Expenditures	Ambiguous

NOTE: The categorizations in the table are taken from Gemmell, Kneller, and Sanz (2009), where we combine the original categories of "zero" and "ambiguous" to "ambiguous".

TABLE 3
Types of Taxes

Tax Type	*Examples*
Labour	Personal income tax Payroll tax Social security contributions
Capital	Corporate income tax Capital tax (tax on dividends)
Consumption	Consumption tax Taxes on goods and services Sales tax Value added tax (VAT) International trade tax
Other tax	Property tax Taxes not listed above
Mixed tax	Taxes that are a combination of the above types
Overall tax	Total taxes (e.g., Total Tax Revenues/GDP)

TABLE 4
Descriptive Statistics for Estimated Effects and t-statistics

	Estimated Tax Effects		*t-statistics*	
	Full	***Truncated***	***Full***	***Truncated***
Mean	-0.097	-0.109	2.16*	2.09*
Median	-0.073	-0.073	-1.27	-1.32
Minimum	-3.520	-0.524	-14.50	-14.50
Maximum	12.720	0.166	8.03	7.78
Std. Dev.	0.649	0.147	2.49	2.35
1%	-1.320	-0.480	-7.91	-8.29
5%	-0.530	-0.420	-6.17	-6.18
10%	-0.411	-0.342	-4.72	-4.72
90%	0.078	0.041	1.07	0.67
95%	0.167	0.082	1.67	1.25
99%	0.820	0.143	4.59	3.09
Obs	713	641	713	641

TABLE 5
Funnel Asymmetry and Precision Effect Test (FAT/PET)

	Fixed Effects (Weight1) (1)	***Fixed Effects (Weight2) (2)***	***Random Effects (Weight1) (3)***	***Random Effects (Weight2) (4)***	***Random Effects (Weight1) (5)***	***Random Effects (Weight2) (6)***
(1) FAT	-1.660*** *(-5.47)*	-1.562*** *(-6.00)*	-1.245*** *(-3.31)*	-1.462*** *(-4.60)*	---	---
(2) PET	-0.001 *(-0.58)*	0.000 *(0.16)*	-0.001 *(-0.04)*	0.018 *(1.18)*	-0.065*** *(-4.27)*	-0.053*** *(-4.34)*
Observations	641	641	641	641	641	641

NOTE: Values in Row (1) and Row (2) come from estimating β_1 and β_0, respectively, in Equation (10) in the text. In both cases, the top value is the coefficient estimate, and the bottom value in parentheses is the associated *t*-statistic. The four WLS estimators (*Fixed Effects-Weight1, Fixed Effects-Weight2, Random Effects-Weight1,* and *Random Effects-Weight2*) are described in the "FAT/PET tests" subsection of Section IV in the text. All four of the estimation procedures calculate cluster robust standard errors. *, **, and *** indicate statistical significance at the 10-, 5-, and 1-percent level, respectively.

TABLE 6
Summary Statistics of Study Characteristics

Variable	***Description***	***Mean***	***Min***	***Max***
	PREDICTED TAX EFFECTS			
Prediction-Negative	=1, if the theoretical prediction of the coefficient is negative	0.228	0	1
*Prediction-Ambiguous**	=1, if the theoretical prediction of the coefficient is ambiguous	0.713	0	1
Prediction-Positive	=1, if the theoretical prediction of the coefficient is positive	0.059	0	1
	TAX TYPE			
Labour-Tax	=1, if labour tax	0.186	0	1
Capital-Tax	=1, if capital tax	0.125	0	1
*Consumption-Tax**	=1, if consumption tax	0.133	0	1
Other-Tax	=1, if other type of tax	0.005	0	1
Mixed-Tax	=1, if multiple tax types (but not overall tax)	0.207	0	1
Overall-Tax	=1, if overall tax	0.345	0	1
	COUNTRY GROUP			
G-7	=1, if G7 countries	0.117	0	1
EU-15	=1, if EU-15 countries	0.064	0	1
EU	=1, if EU countries but not EU-15	0.031	0	1
*OECD**	=1, if OECD countries but not G7, EU-15, or EU	0.788	0	1
	ECONOMIC GROWTH MEASURE			
GDP	=1, if dependent variable is GDP growth	0.259	0	1
*PC-GDP**	=1, if dependent variable is per capita GDP growth	0.741	0	1
	TAX VARIABLE MEASURE			
Marginal	=1, if marginal tax rate (as opposed to average tax rate)	0.090	0	1
Differenced	=1, if change in tax rate (as opposed to level of tax rate)	0.172	0	1
ETR	=1, if effective tax rate (as opposed to statutory tax rate)	0.906	0	1
	DURATION OF TAX EFFECT			
*Short-run**	=1, if tax variable measures immediate/short-run effect	0.702	0	1
Medium-run	=1, if tax variable measures cumulative/medium-run effect	0.053	0	1
Long-run	=1, if tax variable measures long-run, steady-state effect	0.245	0	1

Variable	*Description*	*Mean*	*Min*	*Max*
	STUDY TYPE			
Peer-reviewed	=1, if study published in peer-reviewed journal	0.661	0.48	0.75
Publication Year	Year in which the last version of study was "published."	2007	1993	2015
	DATA TYPE			
Cross-section	=1, if data are cross-sectional.	0.009	0	1
*Panel**	=1, if data are panel	0.991	0	1
Length	Length of sample time period	31.4	5	40
Mid-Year	Midpoint of the sample time period	1985	1970.5	2004.5
	ESTIMATION TYPE			
*OLS**	=1, if OLS estimator is used.	0.677	0	1
GLS	=1, if Generalized Least Squares estimator is used.	0.154	0	1
TSLS/GMM	=1, if estimator corrects for endogeneity, e.g. 2SLS, 3SLS, or GMM.	0.168	0	1
	STANDARD ERROR TYPE			
*SE-OLS**	=1, if OLS standard error is considered.	0.587	0	1
SE-HET	=1, if heteroskedasticity standard error is considered.	0.245	0	1
SE-Other	=1, if both heteroskedasticity and autocorrelation standard error are considered.	0.168	0	1
	INCLUDED VARIABLES			
Initial income	=1, if initial level of income included	0.559	0	1
Lagged DV	=1, if lagged dependent variable included	0.167	0	1
CountryFE	=1, if the country fixed effects are included	0.833	0	1
Investment	=1, if investment included	0.585	0	1
Trade Openness	=1, if trade openness included	0.170	0	1
Human Capital	=1, if human capital included	0.440	0	1
Population Growth	=1, if population growth included	0.243	0	1
Employment Growth	=1, if employment growth included	0.378	0	1
Unemployment	=1, if unemployment rate included	0.090	0	1
Inflation	=1, if inflation rate included	0.131	0	1

NOTE: The grouped variables include all possible categories, where the categories omitted in the subsequent analysis are indicated by an asterisk, where applicable.

TABLE 7
Meta-Regression Analysis
(*Omitting Tax Type Variables*)

Variable	*Fixed Effects (Weight1) (1)*	*Fixed Effects (Weight2) (2)*	*Random Effects (Weight1) (3)*	*Random Effects (Weight2) (4)*
All Control Variables Included				
SE	-1.150*** *(-4.38)*	-1.172*** *(-5.25)*	-0.581*** *(-3.55)*	-0.508** *(-2.37)*
Prediction-Negative	-0.046*** *(-2.70)*	-0.037** *(-2.42)*	-0.096** *(-2.57)*	-0.115*** *(-3.06)*
Prediction-Positive	0.039*** *(4.38)*	0.041*** *(5.83)*	0.073** *(2.68)*	0.066** *(2.30)*
Control Variables Selected Via Backwards Stepwise Regression				
SE	-1.090*** *(-4.21)*	-1.144*** *(-4.74)*	-0.543*** *(-4.10)*	-0.430*** *(-3.31)*
Prediction-Negative	-0.044*** *(-3.75)*	-0.042*** *(-4.31)*	-0.102** *(-2.58)*	-0.113*** *(-5.69)*
Prediction-Positive	0.039*** *(4.41)*	0.042*** *(5.99)*	0.071*** *(2.80)*	0.081*** *(4.95)*

NOTE: The top panel reports the results of estimating Equation (10) with the addition of the two tax variables, *Prediction-Negative* and *Prediction-Positive.* The bottom panel adds control variables selected through a backwards stepwise regression procedure that selects variables so as to minimize the Schwarz Information Criterion (see Footnote #12). The top value in each cell is the coefficient estimate, and the bottom value in parentheses is the associated *t*-statistic. The four WLS estimators (*Fixed Effects-Weight1, Fixed Effects-Weight2, Random Effects-Weight1,* and *Random Effects-Weight2*) are described in the "FAT/PET tests" subsection of Section IV in the text. All four estimation procedures calculate cluster robust standard errors. *, **, and *** indicate statistical significance at the 10-, 5-, and 1-percent level, respectively.

TABLE 8
Meta-Regression Analysis
(*Omitting Prediction Variables*)

Variable	*Fixed Effects (Weight1) (1)*	*Fixed Effects (Weight2) (2)*	*Random Effects (Weight1) (3)*	*Random Effects (Weight2) (4)*
All Control Variables Included				
SE	-1.108*** *(-4.18)*	-1.144*** *(-5.14)*	-0.725*** *(-3.96)*	-0.612** *(-2.64)*
Labour-Tax	-0.037*** *(-3.38)*	-0.027*** *(-3.13)*	-0.064*** *(-2.73)*	-0.047** *(-2.03)*
Capital-Tax	-0.021** *(-2.44)*	-0.017** *(-2.23)*	-0.009 *(-0.49)*	-0.005 *(-0.19)*
Other-Tax	0.345** *(2.60)*	0.356*** *(2.82)*	0.151 *(1.36)*	0.109 *(0.81)*
Mixed-Tax	-0.049*** *(-6.77)*	-0.045*** *(-8.47)*	-0.099*** *(-3.49)*	-0.070* *(-1.92)*
Overall-Tax	-0.034 *(-1.63)*	-0.039** *(-2.36)*	-0.005 *(-1.05)*	-0.003 *(-0.88)*
Control Variables Selected Via Backwards Stepwise Regression				
SE	-1.147*** *(-4.19)*	-1.219*** *(-4.80)*	-0.651*** *(-4.95)*	-0.528*** *(-3.45)*
Labour-Tax	-0.040*** *(-5.28)*	-0.028*** *(-3.45)*	-0.057** *(-2.32)*	-0.038* *(-1.74)*
Capital-Tax	-0.023*** *(-2.86)*	-0.018** *(-2.58)*	-0.005 *(-0.24)*	-0.001 *(-0.07)*
Other-Tax	0.414** *(2.43)*	0.434** *(2.64)*	0.135 *(1.23)*	0.126 *(0.87)*
Mixed-Tax	-0.051*** *(-6.91)*	-0.046*** *(-8.86)*	-0.085*** *(-2.81)*	-0.052*** *(-3.09)*
Overall-Tax	-0.046*** *(-3.88)*	-0.051*** *(-4.07)*	-0.002 *(-0.53)*	0.000 *(0.18)*

NOTE: The top panel reports the results of estimating Equation (10) with the addition of the five tax variables, *Labour, Capital, Other, Mixed,* and *Overall* taxes. The bottom panel adds control variables selected through a backwards stepwise regression procedure that selects variables so as to minimize the Schwarz Information Criterion (see Footnote #12). The top value in each cell is the coefficient estimate, and the bottom value in parentheses is the associated *t*-statistic. The four WLS estimators (*Fixed Effects-Weight1, Fixed Effects-Weight2, Random Effects-Weight1,* and *Random Effects-Weight2*) are described in the "FAT/PET tests" subsection of Section IV in the text. All four estimation procedures calculate cluster robust standard errors. *, **, and *** indicate statistical significance at the 10-, 5-, and 1-percent level, respectively.

TABLE 9
Meta-Regression Analysis
(*All Tax Variables Included)*

Variable	*Fixed Effects (Weight1) (1)*	*Fixed Effects (Weight2) (2)*	*Random Effects (Weight1) (3)*	*Random Effects (Weight2) (4)*
All Control Variables Included				
SE	-0.963*** *(-4.02)*	-1.024*** *(-4.70)*	-0.647*** *(-4.22)*	-0.525** *(-2.48)*
Prediction-Negative	-0.045** *(-2.44)*	-0.038** *(-2.31)*	-0.085** *(-2.25)*	-0.108*** *(-2.91)*
Prediction-Positive	-0.001 *(-0.11)*	0.005 *(0.43)*	0.062** *(2.07)*	0.060** *(2.03)*
Labour-Tax	-0.031** *(-2.42)*	-0.020 *(-1.48)*	-0.023 *(-0.82)*	-0.011 *(-0.43)*
Capital-Tax	-0.015 *(-0.97)*	-0.009 *(-0.62)*	0.026 *(1.16)*	0.027 *(1.07)*
Other-Tax	0.285** *(2.21)*	0.313** *(2.48)*	0.154 *(1.39)*	0.111 *(0.87)*
Mixed-Tax	-0.045*** *(-3.13)*	-0.038*** *(-2.82)*	-0.062* *(-2.20)*	-0.035 *(-0.99)*
Overall-Tax	-0.031 *(-1.21)*	-0.031 *(-1.52)*	-0.000 *(-0.02)*	0.001 *(0.18)*
Control Variables Selected Via Backwards Stepwise Regression				
SE	-0.925*** *(-3.89)*	-0.997*** *(-4.28)*	-0.623*** *(-5.03)*	-0.402*** *(-2.94)*
Prediction-Negative	-0.039*** *(-6.56)*	-0.040*** *(-3.29)*	-0.089** *(-2.60)*	-0.112*** *(-5.61)*
Prediction-Positive	-0.012 *(-1.29)*	0.007 *(0.53)*	0.063** *(2.08)*	0.070*** *(3.55)*
Labour-Tax	-0.041*** *(-4.57)*	-0.021 *(-1.47)*	-0.023 *(-0.78)*	0.010 *(0.48)*
Capital-Tax	-0.022** *(-2.48)*	-0.008 *(-0.59)*	0.021 *(0.89)*	0.046*** *(3.02)*
Other-Tax	0.316* *(2.00)*	0.368** *(2.38)*	0.145 *(1.33)*	0.075 *(0.60)*
Mixed-Tax	-0.055*** *(-6.26)*	-0.037*** *(-2.97)*	-0.050* *(-1.79)*	-0.017 *(-0.95)*
Overall-Tax	-0.048*** *(-4.03)*	-0.026** *(-2.07)*	0.001 *(0.33)*	0.005*** *(4.42)*

NOTE: The top panel reports the results of estimating Equation (10) with the addition of the seven tax variables, *Prediction-Negative, Prediction-Positive, Labour, Capital, Other, Mixed,* and *Overall* taxes. The bottom panel adds control variables selected through a backwards stepwise regression procedure that selects variables so as to minimize the Schwarz Information Criterion (see Footnote #12). The top value in each cell is the coefficient estimate, and the bottom value in parentheses is the associated *t*-statistic. The four WLS estimators (*Fixed Effects-Weight1, Fixed Effects-Weight2, Random Effects-Weight1,* and *Random Effects-Weight2*) are described in the "FAT/PET tests" subsection of Section IV in the text. All four estimation procedures calculate cluster robust standard errors. *, **, and *** indicate statistical significance at the 10-, 5-, and 1-percent level, respectively.

TABLE 10
Bayesian Model Averaging Analysis
(*Control Variables)*

Variable	*Fixed Effects(Weight1)*			*Random Effects(Weight2)*		
	PIP	*Post. Mean*	*Cond. Pos. Sign*	*PIP*	*Post. Mean*	*Cond. Pos. Sign*
G-7	1.00	0.184	1.00	1.00	0.181	1.00
EU-15	0.97	0.032	1.00	0.99	0.066	1.00
EU	0.81	0.064	1.00	0.59	0.000	0.56
GDP	0.99	0.025	1.00	1.00	0.065	1.00
Marginal	0.80	0.006	1.00	0.76	0.023	1.00
Differenced	0.84	-0.018	0.01	1.00	-0.096	0.00
ETR	1.00	0.027	1.00	1.00	-0.091	0.00
Medium-run	1.00	0.081	1.00	0.98	0.052	1.00
Long-run	0.99	-0.015	0.00	1.00	-0.079	0.00
Peer-reviewed	1.00	0.056	1.00	0.63	-0.004	0.00
Publication Year	0.98	0.004	1.00	1.00	0.009	1.00
Cross-section	0.76	0.009	1.00	0.73	0.015	1.00
Length	0.94	-0.002	0.00	0.61	0.000	0.08

Variable	*Fixed Effects(Weight1)*			*Random Effects(Weight2)*		
	PIP	*Post. Mean*	*Cond. Pos. Sign*	*PIP*	*Post. Mean*	*Cond. Pos. Sign*
Mid-Year	0.93	-0.003	0.00	1.00	-0.006	0.00
GLS	1.00	-0.043	0.00	0.84	-0.021	0.00
TSLS/GMM	0.73	-0.001	0.00	0.78	0.009	1.00
SE-HET	0.70	-0.001	0.15	0.73	0.009	1.00
SE-Other	1.00	0.051	1.00	0.69	0.013	1.00
Initial income	0.92	0.013	1.00	0.99	0.048	1.00
Lagged DV	0.89	-0.027	0.00	0.71	0.016	1.00
Country FE	1.00	-0.047	0.00	1.00	-0.062	0.00
Investment	0.82	0.004	1.00	0.78	-0.011	0.00
Trade Openness	0.73	0.003	1.00	0.67	-0.006	0.00
Human Capital	0.84	0.007	1.00	0.87	-0.013	0.00
Population Growth	1.00	-0.050	0.00	1.00	-0.074	0.00
Employment Growth	0.98	0.028	1.00	0.87	0.019	1.00
Unemployment	1.00	0.066	1.00	1.00	0.046	1.00
Inflation	0.75	-0.006	0.00	0.76	-0.009	0.00

NOTE: The column headings *PIP, Post. Mean,* and *Cond. Pos. Sign* stand for Posterior Inclusion Probability, Posterior Mean, and the likelihood-weighted probability that the respective coefficient takes a positive sign. These are described in the "Bayesian model averaging of control variables" subsection of Section IV in the text. The Bayesian Model Averaging (BMA) analysis was done using the R package BMS, described in Zeugner (2011). The WLS estimators *Fixed Effects-Weight1* and *Random Effects-Weight2* are described in the "FAT/PET tests" subsection of Section IV. All specifications included the tax variables *Prediction_Negative* and *Prediction_Positive,* which were forced into all model specifications, and adjusted for publication bias. The table yellow-highlights all the control variables that (i) have a *PIP* greater than 50%; (ii) have a *Conditional Positive Sign* of either 1.00 or 0.00 – indicating that the respective coefficient is consistently estimated to be either positive or negative in the most likely specifications; and (iii) have the same *Conditional Positive Sign* value for both the *Fixed Effects(Weight1)* and *Random Effects(Weight2)* estimators.

FIGURE 1
Histogram of Estimated Tax Effects (Truncated)

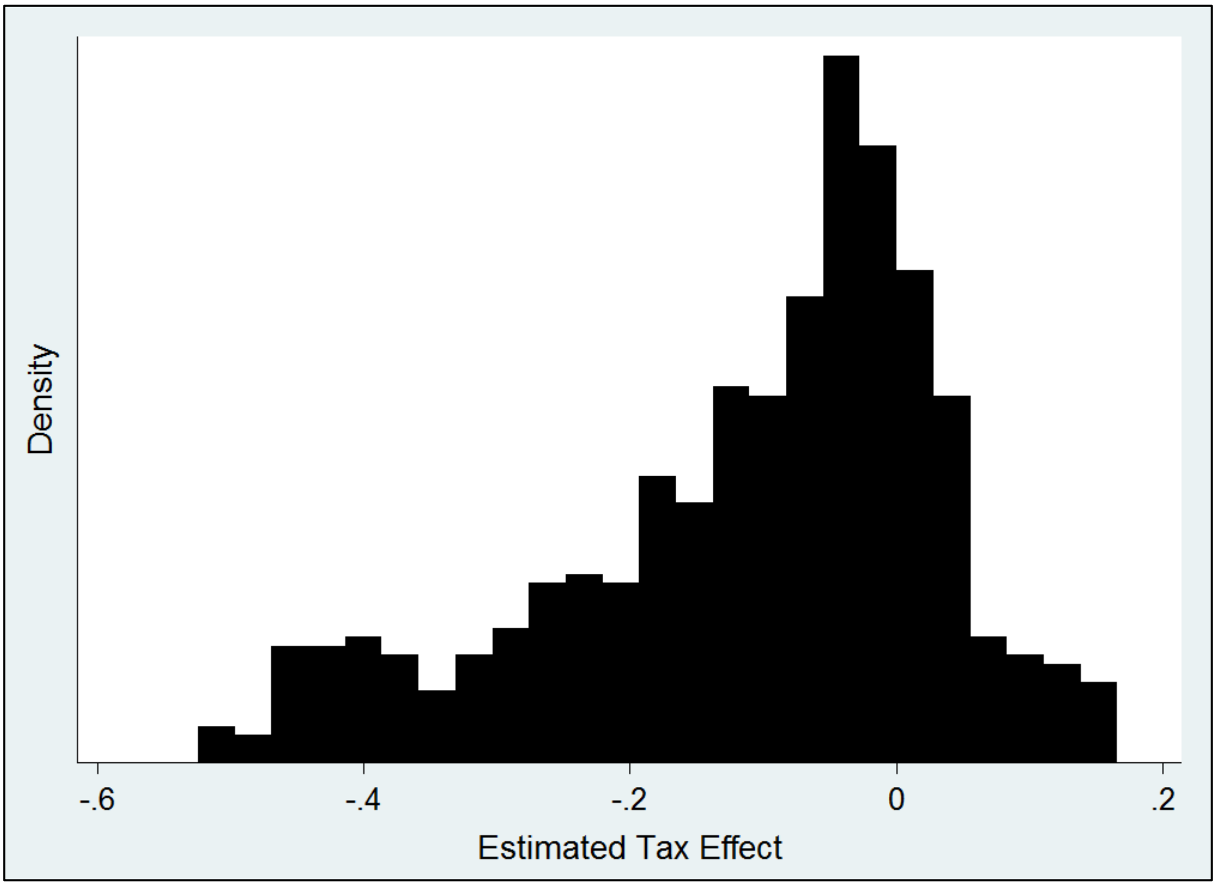


FIGURE 2
Forrest Plot of Studies (Fixed Effects)

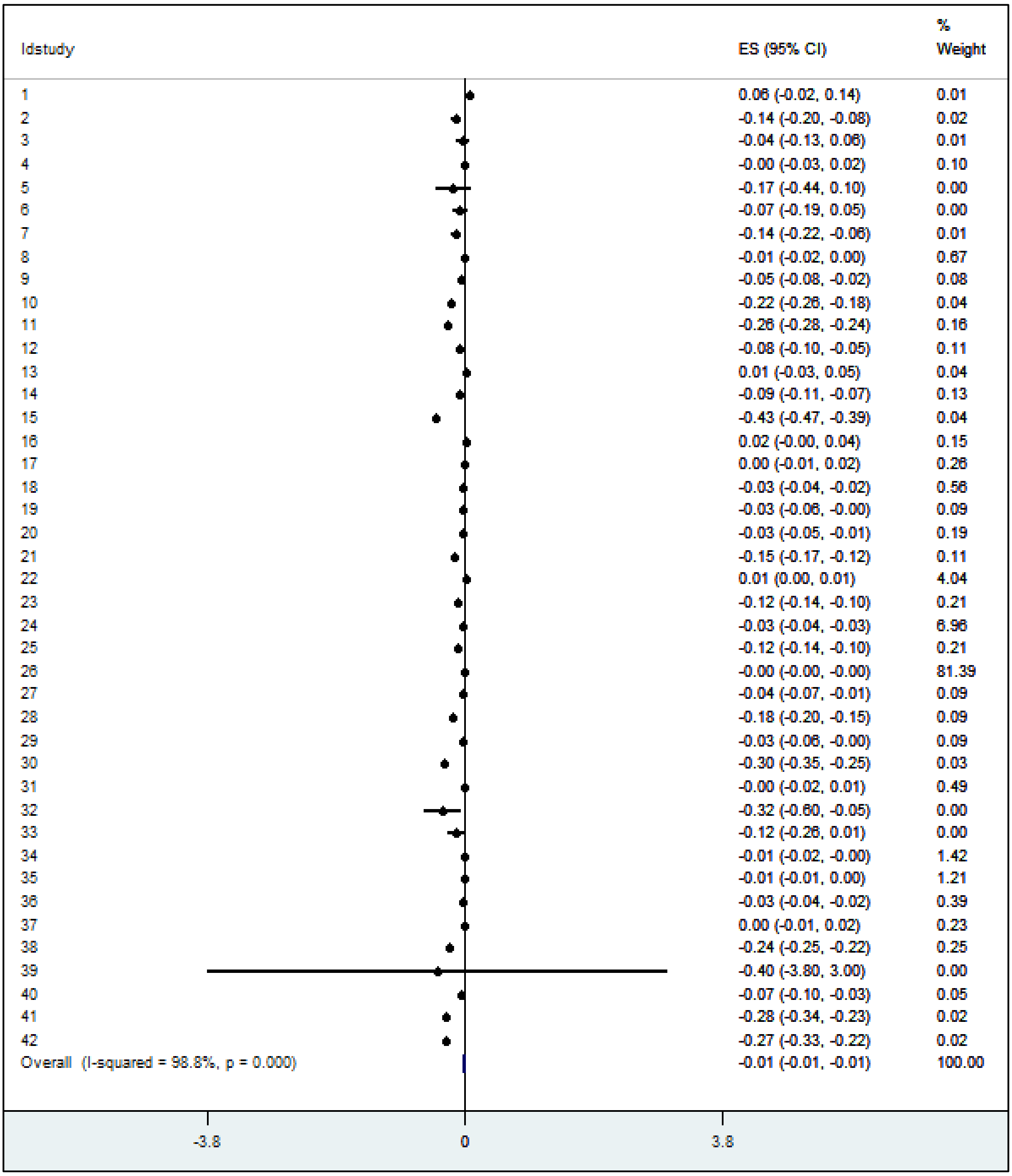
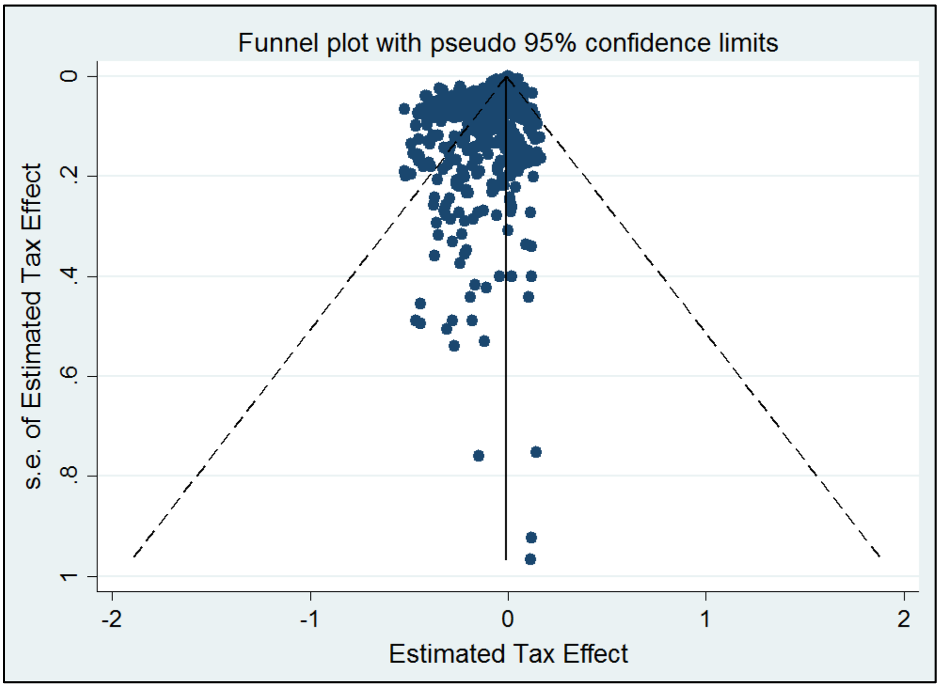


FIGURE 3
Funnel Plot

A. All estimates



B. Mean of Study Estimates

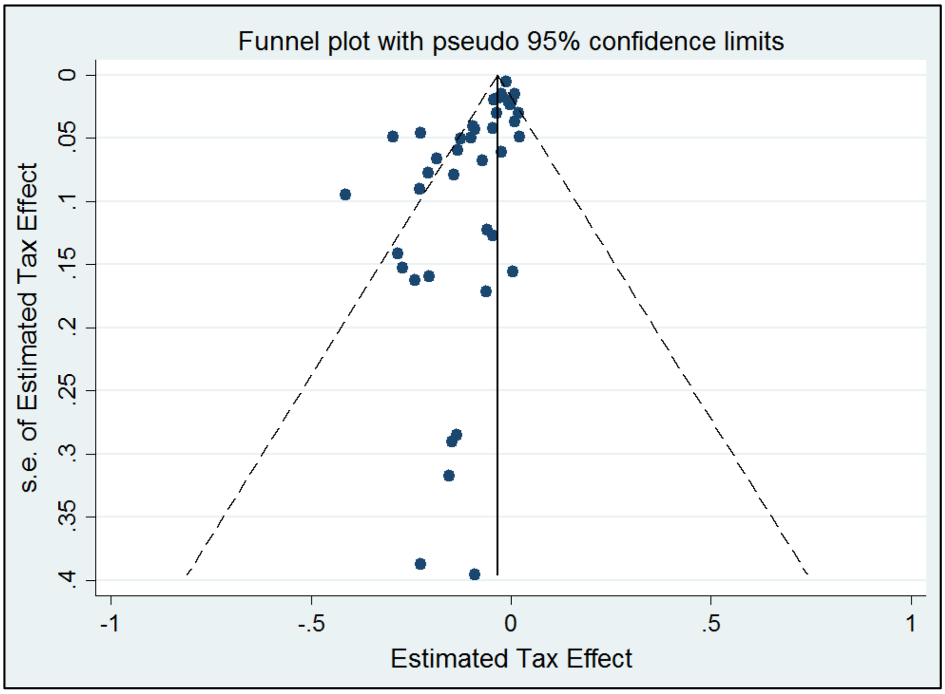
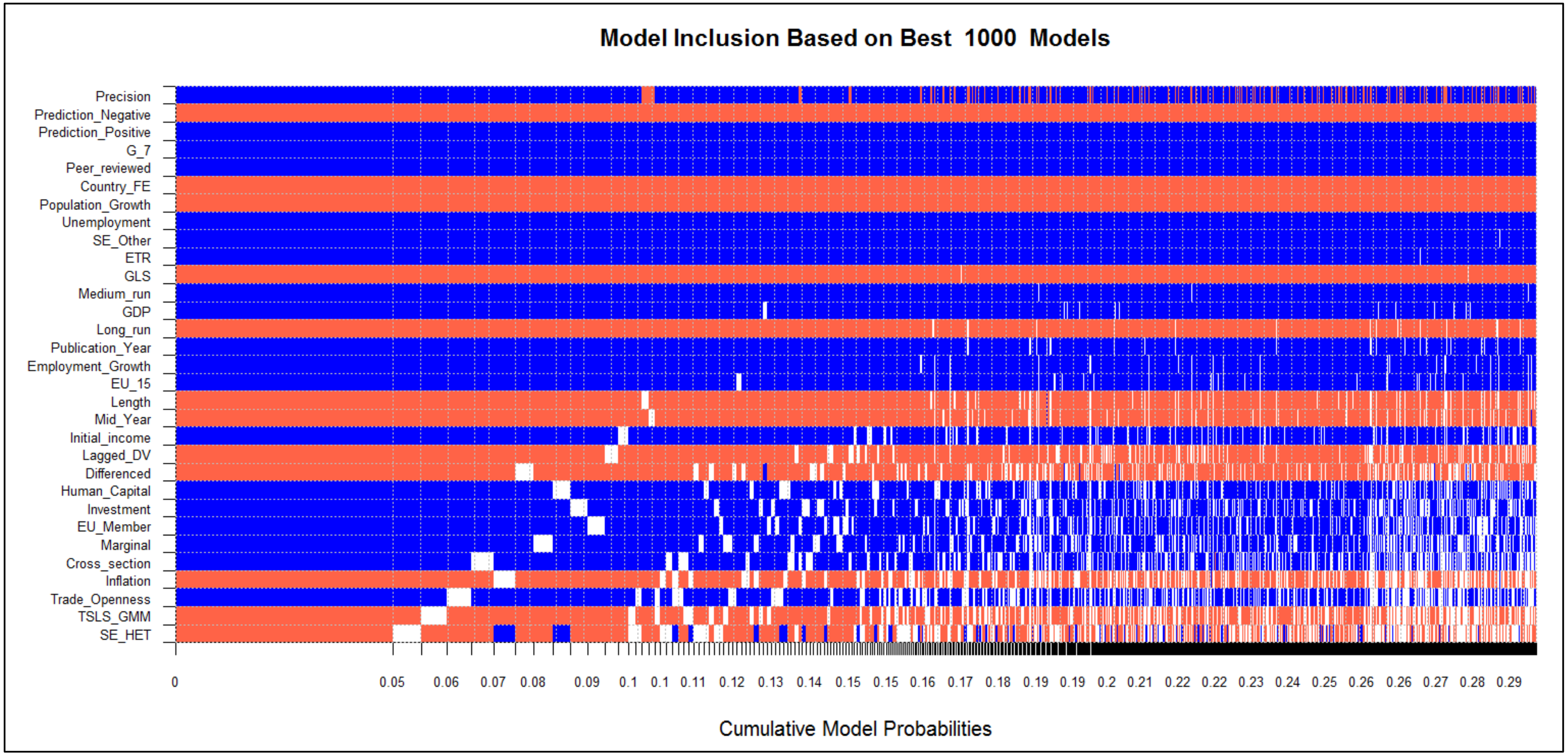


FIGURE 4
Visual Representation of BMA Analysis (*Fixed Effects-Weight1*)



NOTE: Each column represents a single model. Variables are listed in descending order of posterior inclusion probability (PIP) and have all been weighted according to the *Fixed Effects – Weight 1* case. Blue indicates that the variable is included in that model and estimated to be positive. Red indicates the variable is included and estimated to be negative. No colour indicates the variable is not included in that model. Further details about this plot is given in Zeugner (2011).

APPENDIX 1
List of Terms Used in Electronic Search by Category

TAX	ECONOMIC GROWTH	OECD
Tax(es) /Tax rate(s)/Taxation	Economic growth	OECD countries
Tax policy(policies)	Growth	EU countries
Tax ratios	Economic indicators	G-7 countries
Tax changes	Long-term growth	High income OECD countries
Tax rate change	Long-run growth	Industrial countries
Fiscal policy(policies)		Rich countries
Tax structures/Fiscal structures		Europe
Fiscal decentralization		Cross-national study
Public finances		

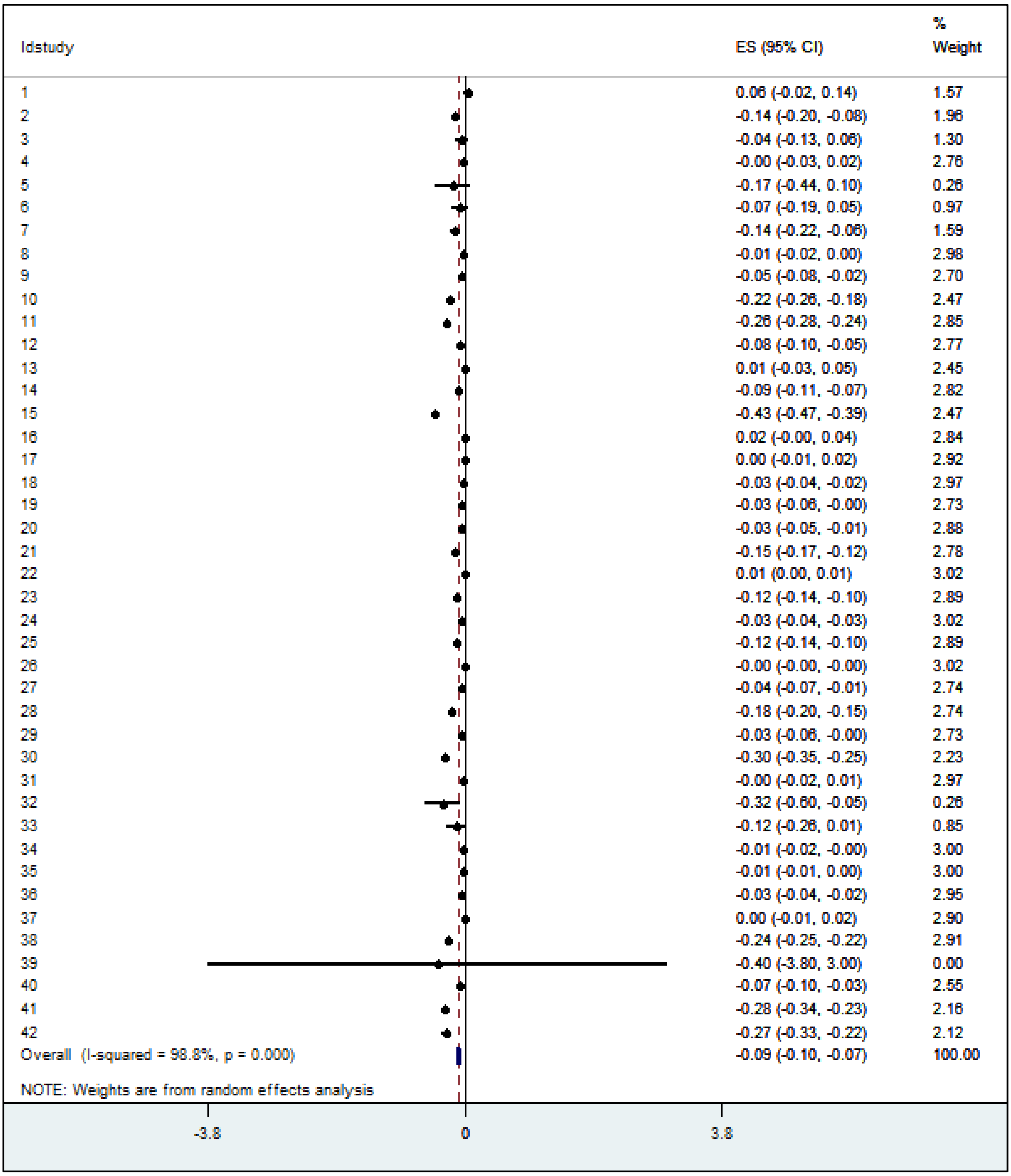
APPENDIX 2
Studies

ID	Study	Publication Status	Number of estimates
1	Afonso and Alegre (2008, 2011)	Working Paper + Journal	12
2	Afonso and Furceri (2010)	Journal	6
3	Afonso and Jalles (2013, 2014)	Working Paper + Journal	21
4	Agell et al. (1997)	Journal	3
5	Agell et al. (1999)	Journal	4
6	Agell et al. (2006)	Journal	4
7	Alesina and Ardagna (2010)	Journal	26
8	Angelopoulos et al. (2007)	Journal	36
9	Arin (2004)	Working Paper	80
10	Arnold et al. (2011)	Journal	5
11	Arnold (2008)	Working Paper	18
12	Baskaran and Feld (2013)	Journal	12
13	Bergh and Karlsson (2010)	Journal	3
14	Bergh and Ohrn (2011)	Working Paper	10
15	Bleaney et al. (2001)	Journal	19
16	Colombier (2009)	Journal	13
17	Daveri et al. (1997, 2000)	Working Paper + Journal	6
18	De La Fuente (1997)	Discussion Paper	15
19	Folster and Henkerson (2001)	Journal	7
20	Folster and Henkerson (1999)	Journal	7
21	Furceri and Karras (2009)	Working Paper	43
22	Gemmell et al. (2015)	Journal	10
23	Gemmell et al. (2008)	Working Paper	18
24	Gemmell et al. (2014)	Journal	53
25	Gemmell et al. (2011)	Journal	19
26	Hansson (2010)	Journal	23
27	Heitger (1993)	Journal	2
28	Karras and Furceri (2009)	Journal	32
29	Karras (1999)	Journal	28
30	Kneller et al. (1999)	Journal	35
31	Mendoza et al. (1997)	Journal	11
32	Miller and Russek (1997)	Journal	12
33	Muinelo-Gallo and Roca-Sagales (2013)	Journal	6
34	Padovano and Galli (2001)	Journal	2
35	Romero-Avila and Strauch (2008)	Journal	15
36	Volkerink et al. (2002)	Journal	26
37	Widmalm (2001)	Journal	6
38	Xing (2011)	Working Paper	34
39	Abd Hakim et al. (2013)	Conference Paper	2
40	Arin et al. (2015)	Working Paper	6
41	Paparas et al. (2015)	Journal	16
42	Xing (2012)	Journal	7

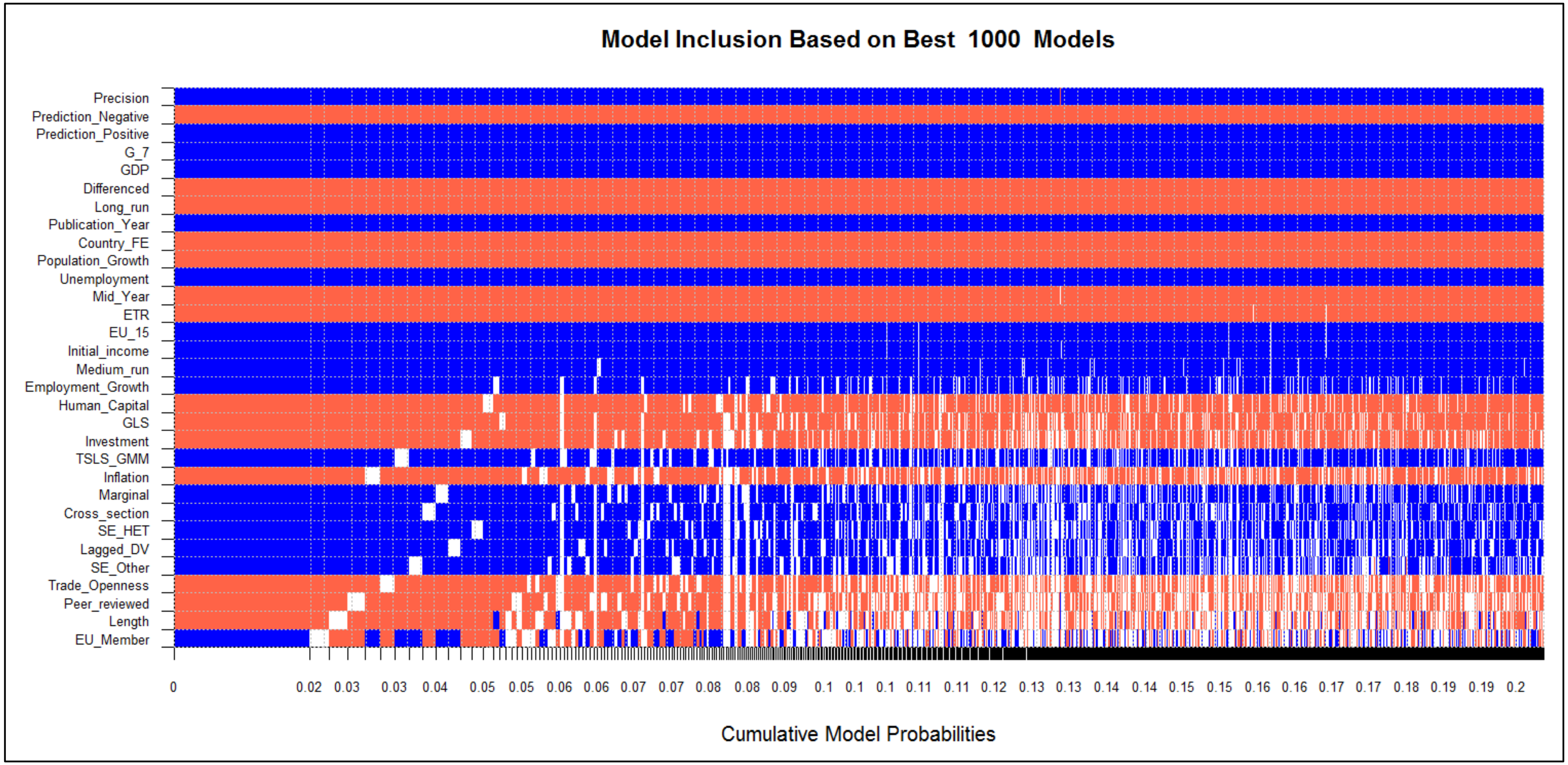
APPENDIX 3
List of Countries with Groupings

Year	*OECD*	*EU*	*EU-15*	*G-7*
1961	Austria	Austria	Austria	
1961	Belgium	Belgium	Belgium	
1961	Canada			Canada
1961	Denmark	Denmark	Denmark	
1961	France	France	France	France
1961	Germany	Germany	Germany	Germany
1961	Greece	Greece	Greece	
1961	Iceland			
1961	Ireland	Ireland	Ireland	
1961	Luxembourg	Luxembourg	Luxembourg	
1961	Netherlands	Netherlands	Netherlands	
1961	Norway			
1961	Portugal	Portugal	Portugal	
1961	Spain	Spain	Spain	
1961	Sweden	Sweden	Sweden	
1961	Switzerland			
1961	Turkey			
1961	United Kingdom	UK	UK	UK
1961	United States			USA
1962	Italy	Italy	Italy	Italy
1964	Japan			Japan
1969	Finland	Finland	Finland	
1971	Australia			
1973	New Zealand			
1994	Mexico			
1995	Czech Republic	Czech Republic		
1996	Hungary	Hungry		
1996	Korea			
1996	Poland	Poland		
2000	Slovak Republic	Slovak Republic		
2010	Chile			
2010	Estonia	Estonia		
2010	Israel			
2010	Slovenia	Slovenia		

APPENDIX 4
Forrest Plot of Studies (Random Effects)



APPENDIX 5
Visual Representation of BMA Analysis (*Random Effects-Weight2*)



NOTE: Each column represents a single model. Variables are listed in descending order of posterior inclusion probability (PIP) and have all been weighted according to the *Fixed Effects – Weight 1* case. Blue indicates that the variable is included in that model and estimated to be positive. Red indicates the variable is included and estimated to be negative. No colour indicates the variable is not included in that model. Further details about this plot is given in Zeugner (2011).

About the Authors

Nazila Alinaghi is a Research Fellow in Public Finance at Victoria University of Wellington, New Zealand.
Email: nazila.alinaghi@vuw.ac.nz

W. Robert Reed is Professor of Economics at the University of Canterbury, New Zealand
Email: bob.reed@canterbury.ac.nz