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CHRISTCHURCH, NEW ZEALAND

Taxes and Economic Growth in OECD Countries: A Meta-Analysis

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Nazila Alinaghi
W. Robert Reed

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Department of Economics and Finance
School of Business
University of Canterbury
Private Bag 4800, Christchurch
New Zealand

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Taxes and Economic Growth in OECD Countries: A Meta-Analysis

Nazila Alinaghi[1]
W. Robert Reed[2†]

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Abstract: This study performs a meta-analysis of the effect of taxes on economic growth in OECD countries. A challenge with synthesizing tax estimates is that they measure different things. This follows because studies differ in the government budget constraints implied by their regression specifications. To address this problem, we use a taxonomy from Gemmell, Kneller, and Sanz (2009) that predicts the growth effects from various tax-spending-deficit combinations. We apply this taxonomy to 979 estimates from 49 studies of tax effects in OECD countries. Our headline result is that a 10% increase in taxes is associated with a decrease in annual GDP growth of approximately -0.2% when bundled as part of a TaxNegative tax-spending-deficit combination. The same tax increase is associated with an increase in annual GDP growth of approximately 0.2% when part of a TaxPositive fiscal policy package. All of our data, output, and programming code is publicly available at https://osf.io/6bfgx/.

Keywords: Meta-analysis, Taxes, Economic growth, OECD

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

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[1] Victoria Business School, Victoria University of Wellington, NEW ZEALAND
[2] Department of Economics and Finance, University of Canterbury, NEW ZEALAND

†Corresponding author: W. Robert Reed, email: bob.reed@canterbury.ac.nz

I. INTRODUCTION

A multitude of studies have estimated the effect of taxes on economic growth. With so many studies working over a limited number of datasets, one would think that something resembling a consensus would have arisen. Not so. In their review of the literature, Kneller and Misch (2017, page 165) conclude "that at least the direction of the short-run and long-run growth effects can be predicted with a reasonable degree of certainty, but there is disagreement with respect to the magnitude." Interest in the relationship between taxes and economic growth continues. Since Kneller and Misch published their study, more studies have appeared (e.g., Baiardi et al., 2019; Luo, 2019; Ornmaechea and Morozumi, 2019; Yanikkaya and Turan, 2020). However, these have not brought us any closer to a consensus.

One approach to this state of affairs is to conclude that the existing literature is not sufficiently robust to provide reliable guidance to policymakers (Baiardi et al., 2019). Another approach is to focus on just one or a few studies. A problem with this approach is that the associated results may not be reliable (e.g., Reinhart and Rogoff, 2010). Relatedly, it ignores the role of publication bias. It is now well-known that many areas of empirical research are affected by the desire of researchers and journals to produce significant results and/or results that confirm theoretical or ideological beliefs (cf. Ioannidis, 2005; Doucouliagos and Stanley, 2009; Stanley and Doucouliagos, 2012; Franco, Malhotra, and Simonovits, 2014; Ioannidis, Stanley, and Doucouliagos, 2017). A published study that appears to be well-done may have results that are filtered by publication bias. A final problem with this approach is that the tax effects reported in a given study may not be applicable to the policymaker's situation. This arises because every tax estimate is conditioned on an underlying government budget constraint, either explicitly or implicitly. Depending on the budget constraint, the results may not be appropriate for the policymaker's circumstances. We elaborate on this below.

Our approach is to use meta-analysis to synthesize estimated tax effects in the growth literature. Meta-analysis is a statistical tool for averaging estimates from studies that measure the same or a similar thing (Stanley and Doucouliagos 2012). The underlying idea is that by pooling estimates across many studies we get a more reliable estimate than by relying on any single study.

Ours is not the first study to apply meta-analysis to the literature on taxes and economic growth. Phillips and Goss (1995) aggregated estimates of tax effects on economic growth for U.S. states. Later, Nijkamp and Poot (2004) studied the effects of fiscal policy more generally on economic growth across countries. However, these initial attempts did not incorporate modern procedures. More recently, Gechert (2015) used meta-analysis to study the literature on fiscal multipliers. However, his study was hampered by the failure of the original studies to report standard errors for the associated multiplier effects, which is a key variable in addressing publication bias.

Our meta-analysis has three goals. Most importantly, we want our analysis to produce estimates of the magnitude of tax effects on economic growth that can be useful to policymakers. Secondly, we want to investigate whether publication bias exists, and whether it constitutes a significant feature of the empirical tax literature. Finally, we want to create a database of estimated tax coefficients that can be used by other researchers.

We focus on estimated tax effects from national-level studies of OECD countries. Expanding the set of countries beyond the OECD raises concerns of noncomparability. Our final sample consists of 979 estimates from 49 studies. We divide the estimates into three fiscal policy categories based on their predicted impact on economic growth: *TaxNegative, TaxAmbiguous,* and *TaxPositive*. We find that there are significant differences in the growth effects of a tax increase depending on the associated fiscal policy category. Further, the estimates are economically important when benchmarked to average annual GDP growth for the countries in our sample. Finally, we find evidence of publication bias favoring negative tax coefficients. However, its economic impact is small.

Our analysis proceeds as follows. Section II reports how we collected our sample of estimates. Section III discusses the problem of interpreting tax estimates when the underlying regression equations assume different government budget constraints. Section IV performs a meta-analysis of the effects of taxes on economic growth. Section V provides a robustness check by investigating whether the results are sensitive to the addition of control variables. Section VI summarizes our findings and concludes. All the data and code necessary to replicate the results of this paper are publicly available at Open Science Framework.[1]

II. SELECTION OF STUDIES AND CONSTRUCTION OF DATASET

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

(1) $$growth = \alpha_0 + \alpha_1 tr + \boldsymbol{X\beta} + error,$$

where $growth$ is a measure of economic growth, tr is a measure of the tax rate, and $\boldsymbol{X}$ is a vector of control variables. 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 were substituted for each of the three categories.[2] These are reported in APPENDIX 1. Keyword combinations were searched using the following search engines: EconLit, Google

[1] https://osf.io/6bfgx/

[2] Note that the keywords employed to identify the relevant studies were combined by the use of 'Boolean' operators such as AND, OR, and NOT. This means that studies included 'economic growth' as the main keyword (and not 'tax') were also retrieved and proceeded to the next refinement step. However, most of such studies were excluded from the final pool of studies as a result of not fulfilling the imposed inclusion criteria. An example would be studies examined the effect of spending on economic growth. Such studies while seem relevant may well be excluded, since they employ the total revenue (sum of tax and non-tax revenues) and not tax revenues in their specifications.

Scholar, JSTOR, Web of Science, Scopus, RePEc, EBSCO, and ProQuest.[3] A total of 401 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. The dependent variable had to be a measure of GDP growth.[4] The growth equation had to include a tax variable that was measured in percentage points of income.[5,6] 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.[7] All estimated tax effects had to report a standard error or associated t-statistic. Finally, only studies written in English were included.[8]

Backwards and forwards citation searches supplemented the keyword search to locate additional studies. To supplement our own search, we contacted 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. This process produced a list of 67 studies, some of which were multiple versions of the same study.[9] It included journal articles, conference proceedings, studies from think tanks and research firms, theses and dissertations, working papers and other unpublished research. All the studies were then re-read carefully to make sure they satisfied our criteria for eligibility.

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[3] Note that the main keywords reported in APPENDIX 1 were not only searched in the keyword field of 'advanced searched' of these search engines but in the abstract field. Therefore, if a study mentioned these keywords anywhere in the title and/or in the abstract, it was retrieved.
[4] Alternatively, the dependent variable could be the level of income, as long as the explanatory variables included its lag.
[5] Studies where the "tax variable" consisted of all revenues, such as the ratio of total revenues to GDP, were not included.
[6] We did not include studies that estimate nonlinear tax effects, such as the "growth hills" of Milasi and Waldmann (2018).
[7] We eliminated single country studies because the combination of short data ranges with a large number of potential confounders makes estimates unreliable.
[8] We closed our search in January 2016, reopened it in June 2020, and closed it again in July 2020.
[9] When multiple versions of the same paper included different estimates, we pooled the estimates across versions.

Our final sample consists of 49 studies. APPENDIX 2 lists the individual studies used in our analysis, and APPENDIX 3 provides a PRISMA flow chart summarizing our search process.[10]

Once studies were selected, we went through each equation/estimate within those studies and coded relevant data, estimation, and study characteristics. Each estimate was independently coded 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 (Havránek et al., 2020).

III. USING THE GOVERNMENT BUDGET CONSTRAINT TO INTERPRET ESTIMATED TAX EFFECTS

In order for tax estimates to be correctly interpreted, they need to be placed in the context of the government budget constraint. As noted by Kneller, Bleaney, and Gemmell (1999), no change in taxes takes place in isolation. It is accompanied by a change in one or more other fiscal categories: other revenues, expenditures, and/or the budget deficit. This gives rise to the following identity:

$$(2) \qquad 0 = tr + \left(\frac{OtherRevenues}{Income}\right) - \left(\frac{Expenditures}{Income}\right) + \left(\frac{Deficit}{Income}\right),$$

where tr here represents the effective tax rate, $tr = \left(\frac{Taxes}{Income}\right)$. To avoid perfect multicollinearity, one or more of these variables must be omitted from a regression specification. This has an important implication for empirical work.

The interpretation of the estimate of α_1 in Equation (1) will differ depending on which government budget constraint variables are omitted from the control variables in Equation (1). If $\left(\frac{Expenditures}{Income}\right)$ is omitted but other revenues and deficit is included, then α_1 measures the effect of increases in taxes “holding constant” other revenues and deficit. As a result, the

[10] PRISMA stands for “Preferred Reporting Items for Systematic Reviews and Meta-Analyses”. For more information, see the PRISMA website: http://prisma-statement.org/.

estimated tax effect incorporates the growth effects of associated increases in expenditures. Alternatively, if $\left(\frac{OtherRevenues}{Income}\right)$ is omitted and expenditures and deficits held constant, then the estimated tax effect picks up changes in the composition of revenues, mixing in the effects of a greater reliance on taxes accompanied by a lesser reliance on other revenue sources. Accordingly, estimates from two different studies using the exact same data could estimate very different tax effects, even opposite-signed estimates, depending on the specification of the regression equation.

In practice, specifications of fiscal policy regressions employ a variety of tax and spending categories, some of which are very detailed. For example it is common to divide taxes into "distortionary" and "non-distortionary" categories. Taxes on labor and capital are commonly classified as "distortionary", while taxes on consumption are considered relatively "non-distortionary". [11] Likewise with expenditures: expenditures on health and public infrastructure are generally regarded as relatively "productive", while income transfers such as welfare and social security are generally regarded as relatively "unproductive". Within the sub-categories of distortionary taxes and non-distortionary taxes, and productive expenditures and unproductive expenditures, are sub-sub-categories.

TABLE 1 gives a flavour of just how quickly the number of categories can grow. It lists eight categories of revenues (taxation on income and profit, social security contributions, taxation on payroll and manpower, etc.) and ten categories of expenditures (general public services, defence, education, etc.). Thus, even if there existed a perfectly conducted, bias-free

[11] Distortionary taxes are those that distort the private sector's allocation of resources. Proportional wage-income taxes are commonly viewed as being distortionary. A non-distortionary tax leaves the allocation of resources unchanged. A lump sum tax is commonly given as an example of a non-distortionary tax. In practice, no tax is truly non-distortionary, so the distinction hinges on the degree to which the allocation of resources is affected. In a similar fashion, government expenditures are divided into productive versus unproductive expenditures. A productive expenditure is one which increases private sector production. Investment in education and infrastructure are examples of productive expenditures. Welfare expenditures and other income transfers are commonly classified as unproductive (Kneller, Bleaney, and Gemmell, 1999). We note that if the economy is dynamically inefficient, distortive taxation could enhance growth.

study that estimated the effect of say, an increase in payroll taxes to fund an increase in social security benefits, the associated tax effect estimates would not be very useful for policymakers if they were considering an increase in, say, value-added taxes to fund investments in public infrastructure.

This is where meta-analysis can be helpful. By combining estimated tax effects from many different studies and controlling for the associated tax-spending-deficit specifications employed by those studies, it makes it possible for estimated tax effects to be more closely matched to actual fiscal policies. This could be done by estimating a meta-regression equation with the estimated tax effects as the dependent variable, and a series of dummy variables as explanatory variables identifying different tax-spending-deficit combinations. This would allow the policymaker to calculate a predicted tax effect for the specific policy being considered. The challenge is how best to do this.

As there is no standard specification of the government budget constraint in studies of taxes and economic growth, a great variety of tax-spending-deficit combinations have been employed. TABLE 2 illustrates this situation by presenting a sampling of tax-spending-deficit specifications used by five different studies. The studies cover similar time periods and countries and measure fiscal variables as effective rates, but they differ in the number and types of fiscal categories they include in their regression equations.

The Colombier (2009) study simply includes an average tax rate with nothing else. The Romero-Avila and Strauch (2008) study includes a complete set of tax and spending categories, so that the omitted fiscal variable is the budget deficit. The Bleaney et al. (2001) study also includes an exhaustive, though somewhat different, set of tax and spending categories, where the omitted fiscal variable is non-distortionary taxes. The Afonso and Fuceri (2010) and Muinelo-Gallo and Roca-Sagalés (2013) papers provide still two alternative specifications. Our argument is that all of these studies have useful information to provide to policy-makers. The challenge is how best to aggregate their findings.

It should be clear from TABLE 2 that there are too many different tax-spending-deficit specifications to represent each with a unique dummy variable. As a result, some degree of aggregation is required. What we need is a taxonomy that classifies tax-spending-deficit specifications with respect to their combined effect on economic growth. Such a taxonomy would need to be both applicable to empirical research; and exhaustive, so that it would cover the full range of tax-spending-deficit possibilities encountered in actual research. We are aware of only one such taxonomy, the classification presented in Gemmell, Kneller, and Sanz (2009), which draws from Barro (1990) and Kneller, Bleaney, and Gemmell (1999). We reproduce their taxonomy in FIGURE 1 and use it to define three types of fiscal policies in TABLE 3.

TaxNegative Fiscal Policies are policies where an increase in the tax rate is predicted to produce negative economic growth. Gemmell, Kneller, and Sanz, 2009 (henceforth, GKS) identify two corresponding tax-spending-deficit combinations. The first is an increase in distortionary taxes to fund unproductive expenditures. The second is an increase in distortionary taxes accompanied by a decrease in non-distortionary taxes.

According to GKS, there are three tax-spending-deficit combinations that are predicted to produce positive economic growth (*TaxPositive Fiscal Policies*): (1) An increase in non-distortionary taxes to fund productive expenditures. (2) An increase in non-distortionary taxes accompanied by a decrease in distortionary taxes. And (3) an increase in non-distortionary taxes to decrease the deficit. Every other combination of taxes-spending-deficits is predicted to have “ambiguous” (or zero) growth effects (*TaxAmbiguous Fiscal Policies*). GKS classify a fiscal policy as “ambiguous” when the individual components have conflicting effects and it is unclear which effect is stronger.

In lieu of developing our own classification system, we use GKS's taxonomy to categorize tax-spending-deficit specifications. For each of the 979 estimated tax effects in our sample, we identify both the operative tax type and the omitted fiscal categories implied by the respective regression specification. Tax types and expenditures are classified as non-distortionary/distortionary, productive/unproductive, or other according to the taxonomy in TABLE 1. We then use TABLE 3 to code the respective tax-spending-deficit combinations as belonging to one of the three fiscal policy categories.[12]

To clarify how we do this, we provide a few concrete examples from the tax studies reported in TABLE 2. Colombier (2009) regresses *Real GDP per capita growth* on *Average tax rate*, where the omitted fiscal categories are *All expenditures* and *Deficit*. We categorize *Average tax rate* as a distortionary tax since most taxes are distortionary (TABLE 1); and *All expenditures* as a mix of productive and unproductive expenditures (TABLE 1). According to TABLE 3, this combination of fiscal policies is classified as *TaxAmbiguous.*

Romero-Ávila and Strauch (2008) estimate three tax effects for *Direct taxes, Indirect taxes*, and *Social contributions*. The omitted fiscal category is *Deficit*. TABLE 1 classifies *Direct taxes* and *Social contributions* as distortionary. According to TABLE 3, the combination of distortionary taxes and deficit/surplus place this fiscal policy pair in the *TaxAmbiguous* category. In contrast, *Indirect taxes* are non-distortionary (TABLE 1). Non-distortionary taxes in combination with deficit/surplus classify this as a *TaxPositive* fiscal policy (TABLE 3).

Bleaney et al. (2001) estimate the effect of *Distortionary taxes* on *Real GDP per capita growth*. The omitted fiscal category in their regression is *Non-distortionary taxes*. According to TABLE 3, the combination of an increase in *Distortionary taxes* holding everything constant but *Non-distortionary taxes* classifies this fiscal policy as *TaxNegative*. In this manner we go

12 The fiscal policy categories in TABLES 1 and 3 have been widely employed in the tax and growth literature. Examples include Angelopoulos et al. (2007), Arin (2004), Benos (2009), Bassanini et al. (2001), Blankenau et al. (2007), Bleaney et al. (2001), Gemmell et al. (2015), Kneller et al. (1999), Paparas et al. (2015), Gemmell et al. (2014), Muinelo-Gallo and Roca-Sagalés (2013), and Romero-Avila and Strauch (2008).

through the hundreds of estimated tax effects in our sample and categorize each one using the information in TABLES 1 and 3.

IV. EMPIRICAL ANALYSIS: Without Control Variables

A note on units of measurement. Any interpretation of estimated tax effects depends on the units of measurement employed for the $growth$ and tr variables (cf. Equation 1) in the original study. Each of these variables can be measured in percentage points (e.g., 2%) or in decimals (0.02). This will obviously affect the size of the tax coefficient, α_1. If a one-percentage point increase in the tax rate lowers growth by 0.1%, and if both $growth$ 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 $growth$ is measured in percentage points, and tr is measured in decimals, then the corresponding value of α_1 will be -10. And if $growth$ 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-percent increase in economic growth.[13]

The sample of estimated tax effects. Our literature search produced a dataset consisting of 979 estimated tax coefficients. FIGURE 2 and the accompanying descriptive statistics report estimated tax coefficients grouped by type of fiscal policy. The values represent the growth effects associated with a one-percentage point increase in the tax rate for a given fiscal policy. For example, the mean of estimated tax coefficients for the tax-spending-deficit combinations categorized as *TaxNegative* suggests that a one-percentage point increase in the tax rate for this type of fiscal policy — i.e., a one-percentage point increase in distortionary taxes accompanied by a one-percentage point increase in either unproductive spending or non-distortionary taxes

[13] Sometimes it was difficult to determine the units of measurement of the respective variables from the original study so as to properly interpret the coefficient. When this happened, 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.

(see TABLE 3) — would lower annual economic growth by -0.18 percentage points. Alternatively, a one-percentage point increase in taxes as part of a *TaxAmbiguous* fiscal package is associated with lower annual economic growth of -0.11 percent. If part of a *TaxPositive* fiscal package, the same tax increase is associated with a 0.02 percent increase in economic growth. As a point of comparison, the average, annual growth rate for OECD countries was approximately 2.50 per cent over the period 1970-2000[14], a period which roughly corresponds to the "average" sample period of the studies included in this meta-analysis.[15]

GKS's taxonomy suggests that fiscal policies can be ordered in terms of their effects on economic growth by *TaxNegative* ≤ *TaxAmbiguous* ≤ *TaxPositive*. This is reflected both in the histograms of the tax estimates, and in the respective mean and median values. However, it is important to note that the values reported in FIGURE 2 represent unconditional estimates of tax effects. They do not control for data, estimation and study characteristics that may be correlated with types of fiscal policies.

The estimation strategy. Our estimation strategy is built around the following specification:

(3) $$\hat{\alpha}_{1i} = \beta_0 + \beta_1 TaxNegative_i + \beta_2 TaxPositive_i + \sum_k \delta_k X_{ki} + \varepsilon_i,$$

where the dependent variable, $\hat{\alpha}_{1i}$, is the estimated tax effect from a regression in study *i*; $TaxNegative$ ($TaxPositive$) are dummy variables indicating that the estimated tax coefficient is part of a tax-spending-deficit specification where taxes are predicted to have a negative (positive) impact on economic growth; and the X_k are data, estimation, and study characteristics that may influence the sizes of the estimated tax effects.

[14] Growth rate is the average, annual rate over the period 1970-2000 for the 22 countries that belonged to the OECD in 1970.
[15] This is calculated by taking the average beginning and average ending dates for the sample ranges of the respective studies.

The coefficients β_1 and β_2 can be interpreted as the estimated growth effects of a one-percentage point increase in taxes associated with a *TaxNegative* and *TaxPositive* fiscal policy, compared to a one-percentage point increase in taxes associated with a *TaxAmbiguous* fiscal policy.

Four estimation procedures. Equation (3) can be estimated with Ordinary Least Squares (OLS). However, while the corresponding estimates will be unbiased and consistent, they will not be efficient. This is because the tax coefficients in our sample are estimated with different precisions, as reflected in their different standard errors.

Let $SE(\hat{\alpha}_i)$ be the standard error of the *i*th estimated tax coefficient. If all estimates come from a population with a single, true tax effect for each of the three categories, so that the only source of variation in ε_i is proportional to sampling error — i.e., $\text{var}(\varepsilon_i) = SE(\hat{\alpha}_i)^2\sigma^2$ — then Weighted Least Squares (WLS) estimation of Equation (3) will produce asymptotically unbiased, consistent, and efficient estimates with the appropriate weight being the inverse of $(SE_i)^2$.[16] This model is known in the meta-analysis literature as the inverse variance or "Fixed Effects" model (Borenstein et al. 2010), not to be confused with the panel data estimator of the same name.

The assumption that there exists a single, true tax effect within each fiscal policy category is obviously unrealistic, as tax effects can be expected to vary across time periods and economies. Let τ^2 represent the component of the variance of ε_i that is due to this heterogeneity in true tax effects. If we can assume that sampling error and variation in true effects are independent, and that the variance of ε_i is proportional to these two components, then $\text{var}(\varepsilon_i) = [SE(\hat{\alpha}_i)^2 + \tau^2]\sigma^2$.

This leads to an alternative version of WLS, known in the meta-analysis literature as the "Random Effects" model, with the appropriate weight now being the inverse of

[16] Strictly speaking, WLS will be unbiased only if the estimates of $\text{var}(\varepsilon_i)$ are equal to their population values.

$[SE(\hat{\alpha}_i)^2 + \tau^2]$ (Borenstein et al. 2010).[17] We thus have two WLS estimators that we can use, depending on whether the assumptions of the "Fixed Effects" or the "Random Effects" model are appropriate. While researchers generally agree that the "Random Effects" model most closely matches reality, there is some debate about which works best in practice (Doucouliagos and Paldam 2013; Reed 2015).[18] Accordingly, our analysis employs both "Fixed Effects" and "Random Effects".[19]

We acknowledge that the terms "Fixed Effects" and "Random Effects" are confusing given the association of these words with panel data estimation. Nevertheless, their use as descriptors of models with homogeneous and heterogeneous true effects is firmly entrenched in the meta-analysis literature. As a result, we retain that terminology here.

The two WLS models can be easily related to Equation (3) by multiplying each term by the square root of the respective weight, $\frac{1}{\omega_i}$:

$$\text{(4.a)} \quad \frac{\hat{\alpha}_{1i}}{\omega_i} = \frac{\beta_0}{\omega_i} + \beta_1 \frac{TaxNegative}{\omega_i} + \beta_2 \frac{TaxPositive}{\omega_i} + \sum_k \delta_k \frac{X_{ki}}{\omega_i} + \frac{\varepsilon_i}{\omega_i}, \quad i = 1,2,\ldots,N,$$

where

$$\text{(4.b)} \quad \omega_i = \begin{cases} SE(\hat{\alpha}_i), & \textit{(FixedEffects1)} \\ \sqrt{SE(\hat{\alpha}_i)^2 + \tau^2} & \textit{(RandomEffects1)} \end{cases}.$$

OLS estimation of this transformed equation produces estimates equivalent to WLS. Additionally, when the meta-analysis sample consists of multiple estimates from the same

[17] Borenstein et al. (2010) discuss two main procedures for estimating τ^2: DerSimonian and Laird's method of moments, and restricted maximum likelihood. The Stata program that we employ ("metareg") allows both methods. The default is D&L and that is the method we use in our analysis.

[18] Our sample of estimated tax coefficients evidences a significant amount of variation beyond sampling error. Even with all the explanatory variables included in a meta-regression, the associated estimate of *I-squared*, a measure of effect heterogeneity based on τ^2, is 74.6%, which is quite substantial (Borenstein et al., 2010).

[19] APPENDIX 4 illustrates the difference in weighting for the "Fixed" and "Random" Effects models. The "Fixed Effects" model assigns a huge weight to a very small number of studies: Three studies receive approximately 95% of the weight. In contrast, the "Random Effects" model spreads the weights approximately uniformly across studies. Both models represent relatively extreme cases on either side of the weighting spectrum.

study, it is standard practice to correct for non-independence of the error terms by using cluster robust standard errors (Stanley and Doucouliagos, 2012).

A related issue concerns the weighting of estimates versus studies. The number of estimates per study can vary widely. In our sample, the number of estimates per study ranges from 2 to 128, with a median value of 34.[20] The WLS estimators discussed above implicitly give greater weight to studies with more estimates. Accordingly, we employ an alternative weighting scheme that, ceteris paribus, gives equal weight to studies rather than individual estimates:

$$(4.c) \quad \omega_i = \begin{cases} SE(\hat{\alpha}_i) \cdot \sqrt{n_{i \in S}} & \textit{(FixedEffects2)} \\ \sqrt{SE(\hat{\alpha}_i)^2 + \tau^2} \cdot \sqrt{n_{i \in S}}, & \textit{(RandomEffects2)} \end{cases}$$

where $n_{i\in S}$ is the number of estimates in study *S* from which estimate *i* was taken, and SE_i and τ^2 are defined as above. We estimate Equation (3) using all four estimation procedures as a way of checking for robustness.

<u>Estimating of Equation (3) with only a constant term</u>. If Equation (3) is stripped of all variables except the constant term, the estimated constant term, β_0, will be a simple weighted average of the estimated tax coefficients. Columns (1) through (4) of Panel A of TABLE 4 report the associated estimates using the four weights described above. The respective mean tax effects are all negative and significant at the 1-percent level. They range from -0.005 to -0.085. They suggest that a one-percentage point increase in the tax rate lowers annual economic growth between 0.005 and 0.085 percent on average. However, these estimates lump all tax estimates together, without regard to the fiscal policy packages they are associated with. As discussed in Section III, this impairs their usefulness as guides for tax policy.

[20] This is explained by the fact that studies often use multiple tax variables in the same regression, as well as estimating multiple regression equations.

Estimates of Equation (3) with tax category variables. Panel B of TABLE 4 adds the two fiscal policy dummy variables to the constant-only specification of Panel A. In this specification, the constant term represents the mean tax effect associated with *TaxAmbiguous* fiscal policies, with the two dummy variables indicating deviations from this mean. Consider first the estimates of β_1 in Columns (1)-(4). These imply that a one-percentage point increase in the tax rate when part of a *TaxNegative* fiscal package lowers annual economic growth between 0.034 and 0.083 percent on average, compared to when that same increase is part of a *TaxAmbiguous* fiscal package. In contrast, a one-percentage point increase in the tax rate when part of a *TaxPositive* fiscal package increases annual economic growth between 0.028 and 0.110 percent (cf. $\hat{\beta}_2$) compared to a *TaxAmbiguous* fiscal package. Note that all the signs for $\hat{\beta}_1$ and $\hat{\beta}_2$ are consistent with the growth effect ordering *TaxNegative* ≤ *TaxAmbiguous* ≤ *TaxPositive*, and ten of the twelve estimates are significant at the 1 percent level.

The last row of Panel B reports estimates of $\beta_2 - \beta_1$. This difference addresses the following question: If policy makers decided to raise taxes by one percentage point, what would be the difference in the estimated growth impact if the tax increase was adopted as part of a *TaxPositive* fiscal package rather than a *TaxNegative* fiscal package? The estimates indicate that packaging the tax increase as part of a *TaxPositive* fiscal policy would increase annual growth from 0.062 to 0.159 percent relative to a *TaxNegative* fiscal policy.

Correcting for publication bias. Publication bias arises when the estimates reported by researchers comprise a biased sample of the population of all estimates. This can happen when researchers/journals have preferences for estimates that are statistically significant and/or whose signs match theoretical expectations or personal beliefs (Christensen and Miguel, 2018). It can occur even in unpublished working papers if researchers only write up results that they think can get published.[21] Publication bias represents a serious challenge to the validity of meta-analysis. If the estimates in the literature are disproportionately large and significant, then averaging them will preserve this bias, producing a distorted estimate of the mean true effect.

The most common test for publication bias in the economics literature is the Funnel Asymmetry Test (FAT). The FAT is carried out by adding the standard error variable, $SE(\hat{\alpha}_i)$, to the specification of Equation (3) (Card and Krueger, 1995; Egger et al., 1997; Stanley, 2008). Evidence of publication bias is given by statistical significance of the *SE* variable. The addition of the *SE* variable to Equation (3) has a further benefit. It adjusts the estimates of the other variables for publication bias in much the same way that including an inverse Mills ratio adjusts for sample selection (Stanley and Doucouliagos, 2012, 2014).

Panel C of TABLE 4 reports our estimates of the tax effects correcting for publication bias. The first row presents the estimated coefficient on the publication bias term, *SE*. Across all four columns, we reject $H_0\colon \beta_{SE} = 0$ at the 1 percent level of significance, signifying the existence of publication bias. The negative sign of the estimate implies that the literature discriminates in favor of negative tax coefficients.

The next three rows report the "corrected" estimates of β_0, β_1 and β_2. These are not very different from the uncorrected estimates of Panel A. Thus, while the effect of publication bias is sufficiently large to be statistically significant, it is not large enough to be economically significant on average, though it may still be serious problem in individual studies.

Summarizing the results above, we find that our estimates of tax effects are generally statistically significant. To determine their economic significance, we can do some back-of-the-envelope calculations. We start by noting that tax burden in OECD countries typically

[21] Franco et al. (2014) report that the main source of publication bias is failure of researchers to write up results that are not significant or interesting.

ranges between 25-45%.[22] A 10% increase in the tax burden would amount to approximately a 3.5-percentage point increase in taxes.

Starting with the estimated tax effect associated with a *TaxNegative* fiscal policy in Column (1) of Panel C, a 3.5 percentage point increase in taxes would lower annual economic growth by -0.070 percent on average (= [-0.001-0.019] × 3.5). Repeating the exercise for the estimates in Columns (2)-(4) produce correspoinding tax effects of -0.112, -0.245 and -0.392 percent. On the other hand, a 3.5 percentage point increase in taxes as part of a *TaxPositive* fiscal policy is associated with increases in annual GDP growth of 0.136, 0.126, 0.325, and 0.150 percent, on average. Compared to an average annual growth rate of 2.50 percent, these tax effects are not insubstantial.

An alternative way to judge economic importance looks at the difference, $\hat{\beta}_2 - \hat{\beta}_1$. For example, the estimate in Column (1) implies that a 3.5 percentage point increase in taxes as part of a *TaxPositive* fiscal policy is associated with 0.206 percent (= 0.059 × 3.5) greater annual growth than the same tax increase as part of a *TaxNegative* fiscal policy. The corresponding estimates from Columns (2) through (4) are 0.238, 0.570, and 0.524 percent. These estimates indicate that the kind of taxes raised, and the use these revenues are put to, can have economically important consequences.

V. EMPIRICAL ANALYSIS: With Control Variables

This section performs a robustness check by investigating if the tax effects of the previous section are sensitive to the inclusion of control variables. TABLE 5 describes various data, estimation, and study characteristics that we recorded for this purpose. The variables are grouped by categories such as Country Group, Economic Growth Measure, Tax Variable Measure, Duration of Tax Effect, among others.

[22] See https://stats.oecd.org/Index.aspx?DataSetCode=REV.

Country Group. While our meta-analysis focuses on tax effects in the OECD, different studies include different sets of OECD countries. The OECD includes a diverse set of countries (e.g., US, Germany, Turkey, Iceland, Mexico, Greece, and South Korea). Differences in economic, political, and regulatory characteristics among its members may influence how taxes affect economic growth. To control for these differences, we include dummy variables to indicate common country groupings in the literature. Estimates from G-7 countries account for 8.2% of our sample, and those from EU countries account for 10.3% (= 6.2% + 4.1%). The remainder (81.5%) study OECD countries not included in these categories.

Economic growth and tax measures. The literature has employed an assortment of variables to measure economic growth. Our sample only includes studies that estimate the tax effect on GDP. These fall into two categories: total GDP growth (19.1%) and per capita GDP growth (80.9%).[23] With respect to tax variable measures, most studies use average versus marginal rates (94.0% versus 6.0%); are specified in level rather than differenced form (80.5% versus 19.5%); and are effective rather than statutory tax rates (93.8% versus 6.2%). Depending on how a regression is specified, an estimated tax coefficient can measure a short-run (annual), medium-run, or long-run tax effect.[24] Most of the estimated tax effects in our sample measure the short-run effect of a tax change (71.8%), versus a medium- or long-run effect (4.8% and 23.4%).

Study type and data characteristics. As an alternative to controlling for publication bias with the *SE* variable, we included research that had not been peer-reviewed, such as working papers and Master and PhD theses. The rationale is that these outlets are less likely to be subject to publication bias (Stanley and Doucouliagos, 2012; Ringquist, 2013). While our sample is

[23] We don't make a distinction between real and nominal GDP because all of our studies take the log of growth and include annual time dummies.
[24] See APPENDIX 5 for how we determine which of these categories to classify a given tax estimate.

mostly comprised of estimates from peer-reviewed journals (71.1%), a substantial share come from other sources (28.9%).[25]

A finding from previous research is that effect sizes can change over time. Accordingly, we include year of publication or, if unpublished, year of most recent version. The studies in our sample date from 1993 to 2020, with a mean publication date of 2010. With respect to the data employed by the studies in our sample, almost all used panel data to estimate tax effects (99.0%). The average sample length in the studies was 31.6 years, and the average data mid-point was 1988.

Estimation and standard error type. About three-fourths of the estimated tax coefficients 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, 11.3% used GLS, and 14.2% attempted to correct for endogeneity using a procedure such as 2SLS or GMM.

Because the standard error plays such a significant role in meta-analysis, we categorized standard errors into three groups: *SEOLS* (54.5%); *SEHET* (33.6%), where standard errors were estimated using a heteroskedastic-robust estimator; and *SEHAC* (11.8%), 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 such as initial income (53.6%), a lagged dependent variable (22.2%), country fixed effects (67.2%), and measures of investment (67.3%), trade openness (14.4%), human capital (36.7%), population growth (25.5%), employment growth (44.9%), unemployment (8.2%), and inflation (11.1%).

[25] When alternative versions of a paper exist (e.g., published, working paper, conference paper), we use the published version. However, our sample also include any estimates from previous versions that did not appear in the published edition.

Estimates of Equation (3) with control variables. TABLE 6 reports the results of estimating Equation (3) with a full set of control variables using each of the four estimation methods. A total of 31 variables were included in each regression. Given the number of variables, we do not report all the results here, though the full set of results are available in an online supplement.[26] As before, we report estimates for the publication bias variable (*SE*) and the two tax dummies.

We also report estimates for the *Endogeneity* dummy variable because there is much concern in the literature about tax estimates suffering endogeneity bias. Two sources of endogeneity bias are commonly mentioned. First, countries may change tax rates in response to changes in economic growth. Second, progressive tax structures produce higher tax rates when national income increases. Of the studies that attempt to correct for endogeneity bias, 2SLS and GMM were applied in approximately equal measure. For the 2SLS studies, the most common instruments are lagged values of the respective tax measures. Of the remaining variables, none were statistically significant in more than two of the four regression equations.[27]

Even with the full set of control variables, the publication bias variable (*SE*) remains statistically significant at the 1-percent level. As before it is always negative, consistent with the existence of negative publication bias. One consequence of including control variables is that the constant term can no longer be interpreted as an overall mean tax effect associated with a *TaxAmbiguous* fiscal policy. Instead, its value is conditioned on the control variables taking zero values. As a result, we do not report its estimate. However, we can still interpret the

[26] See “Part2 Results” at https://osf.io/6bfgx/.

[27] A dummy variable indicating membership in G7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom and the United States) was statistically significant in all four regressions. However, only one of the 49 studies used this sample of countries (Arin, 2004), so we decided not to report the results in the table as it is essentially a study-specific dummy variable.

difference $\beta_2 - \beta_1$ as before. The estimates continue to be positive and statistically significant. They are slightly larger in size compared to their counterparts in Panel C of TABLE 4.

Across all four estimating procedures, the coefficient for *Endogeneity* is small in size and everywhere statistically insignificant. This may indicate that endogeneity bias is not practically important in studies of taxes and economic growth in OECD countries, perhaps because the different sources of endogeneity bias offset each other. Or it may indicate that the instruments that are commonly used, which typically consist of lagged values of the model's included variables, are not effective at correcting for endogeneity bias.

VI. CONCLUSION

Judging by the number of studies dedicated to the subject, there is much interest in identifying the effect of taxes on economic growth. Unfortunately, there is no consensus on the magnitude of this effect, as the literature has produced a wide range of effects. An underappreciated problem is that these studies are actually estimating different things, despite all claiming to provide estimates of "the effect" of taxes on growth. This follows from the fact that studies differ in the government budget constraints implied by their regression specifications. This greatly impacts the interpretation of the estimated tax coefficients.

We address this problem by categorizing estimated tax coefficients according to their implied government budget constraints. To do that, we use the taxonomy of fiscal policies presented in Gemmell, Kneller, and Sanz (2009), which in turn draws on Barro (1990) and Kneller, Bleaney, and Gemmell (1999).

Our headline results concern the size of tax effects on economic growth in OECD countries. We estimate that a 3.5 percentage point increase in taxes (roughly equivalent to a 10% increase) as part of a *TaxNegative* fiscal package is associated with decreased annual GDP growth of approximately -0.2%. The same increase in taxes as part of a *TaxPositive* fiscal package is associated with an increase in annual GDP growth of 0.2%. This compares with an average annual GDP growth rate of 2.5% for the countries in our sample. Stated differently, we estimate there is a 0.4% difference in annual GDP growth depending on whether the 3.5 percentage point increase in taxes is part of a *TaxNegative* or a *TaxPositive* fiscal package. These estimates suggest that taxes, and how taxes are raised and spent, have moderate impacts on economic growth.

With respect to the other goals of our study, we find strong evidence of publication bias. The results are consistent with researchers and journals discriminating in favor of negative estimated tax coefficients. While the bias is sufficiently large to be statistically significant, it is not large enough to be economically significant on average, though it may be important in individual studies.

A final contribution of our study is that we make all our data and code available at https://osf.io/6bfgx. In particular, our database of estimated tax coefficients, including the corresponding data, estimation, and study characteristics associated with those estimates, allows other researchers to further investigate the relationship between taxes and economic growth.

Limitations. A number of potential weaknesses of our study should be noted. The main area of concern is how we classified tax effects to the three categories of *TaxNegative, TaxAmbiguous,* and *TaxPositive* fiscal policies. Our choice of Gemmel, Kneller, and Bleaney (2009) was necessitated by the fact that it is the only taxonomy in the literature. However, researchers may disagree with this classification system. Even given this taxonomy, there remained subjectivity in how we assigned tax effects to the GKS categories, as not all regression specifications could be neatly matched to GKS. Other researchers might make different assignments. We note that "measurement error" in the assignment of tax effects to fiscal policy categories will bias estimates towards zero. By making our data and code available, we enable researchers to check whether different decisions might lead to different results. A further potential weakness concerns the correction for publication bias. While the FAT procedure that we employ is the predominant approach in economics, methods to correct publication bias remains an active research area. Hong and Reed (2020) demonstrate that current methods, including FAT, often are not effective at eliminating bias.

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AUTHOR BIOGRAPHIES

Nazila Alinaghi is a Research Fellow for the Chair in Public Finance at the Victoria University of Wellington. She completed a PhD in economics at the University of Canterbury. Since joining the CPF, Nazila has been working on several topics, including tax and transfer microsimulation modelling (minimum wage policy, designing direct tax reforms), estimating taxable income elasticities, and tax compliance.

W. Robert Reed is Professor of Economics, Department of Economics and Finance, University of Canterbury, New Zealand. He received his doctorate in economics from

Northwestern University. His main areas of research are replication, meta-analysis, and applied econometrics.

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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

SOURCE: Kneller, Bleaney, and Gemmell (1999).

TABLE 2
Different Tax-Spending-Deficit Specifications Used by Studies

Study	Colombier (2009)	Romero-Ávila & Strauch (2008)	Bleaney et al. (2001)	Afonso & Fuceri (2010)	Muinelo-Gallo and Roca-Sagalés (2013)
Regression	Table 1, Column 1	Table 5, Column 5	Table 1, Column 1	Table 5, Column 1	Table 3, Column 1
Dep. Variable	Real GDP per capita growth	Real GDP per capita growth	Real GDP per capita growth	Real GDP per capita growth	Real GDP per capita growth
Tax variable(s)	- Average tax rate	- Direct taxes - Indirect taxes - Social contributions	- Distortionary taxes	- Direct taxes - Indirect taxes - Social contributions	- Direct taxes - Indirect taxes
Other Fiscal Variable(s)	-None	- Govt. consumption - Govt. transfers - Govt. investment	- Other revenues - Other expenditures - Budget surplus - Productive expenditures - Non-productive expenditures	-None	- Non-distributive expenditures
Omitted Fiscal Categories	- All expenditures - Deficit	- Deficit	- Non-distortionary taxes	- All Expenditures - Deficit	- Distributive expenditures - Deficit
Countries	21 OECD countries	15 EU countries	22 OECD countries	28 OECD countries	21 OECD countries
Time Period	1970-2001	1960-2001	1970-1995	1970-2004	1972-2006

TABLE 3
Classification of Tax and Expenditure Combinations
By Their Predicted Growth Effects

TYPE OF TAX	*OMITTED FISCAL CATEGORY*	*PREDICTED EFFECT*
	A. TaxNegative Fiscal Policies	
Distortionary	Unproductive Expenditures	Negative
Distortionary	Non-distortionary Taxes	Negative
	B. TaxPositive Fiscal Policies	
Non-distortionary	Productive Expenditures	Positive
Non-distortionary	Distortionary Taxes	Positive
Non-distortionary	Deficit/Surplus	Positive
	C. TaxAmbiguous Fiscal Policies	
Distortionary	Productive Expenditures	Ambiguous
Distortionary	All Expenditures (Prod. & Unprod.)	Ambiguous
Distortionary	Other Expenditures	Ambiguous
Distortionary	Deficit/Surplus	Ambiguous
Distortionary	Other Revenue	Ambiguous
Distortionary	Distortionary Taxes	Ambiguous
Distortionary	Intergovernmental Revenue	Ambiguous
Distortionary	Net Utility Expenditures	Ambiguous
Non-distortionary	Unproductive Expenditures	Ambiguous
Non-distortionary	Productive & Unproductive Expenditures	Ambiguous
Non-distortionary	Other Expenditures	Ambiguous
Non-distortionary	Other Revenue	Ambiguous
Non-distortionary	Non-distortionary Taxes	Ambiguous
Non-distortionary	Intergovernmental Revenue	Ambiguous
Non-distortionary	Net Utility Expenditures	Ambiguous

SOURCE: Gemmell, Kneller, and Sanz (2009), where we combine the original categories of "zero" and "ambiguous" to "ambiguous" (see FIGURE 1 for the source table).

TABLE 4
Estimated Tax Effects without Control Variables

	Fixed Effects (Weight1) (1)	*Fixed Effects (Weight2) (2)*	*Random Effects (Weight1) (3)*	*Random Effects (Weight2) (4)*
A. CONSTANT ONLY				
$\boldsymbol{\beta_0}$	-0.005***	-0.006***	-0.085***	-0.070***
	(0.001)	*(0.002)*	*(0.019)*	*(0.015)*
B. CONSTANT + TAX CATEGORIES				
$\boldsymbol{\beta_0}$	-0.004***	-0.005***	-0.082***	-0.062***
	(0.001)	(0.002)	*(0.021)*	*(0.015)*
TaxNegative $(\boldsymbol{\beta_1})$	-0.034***	-0.047***	-0.037	-0.083
	(0.006)	*(0.016)*	*(0.057)*	(0.053)
TaxPositive $(\boldsymbol{\beta_2})$	0.028***	0.032***	0.110***	0.076***
	(0.008)	*(0.006)*	*(0.032)*	*(0.025)*
$\boldsymbol{\beta_2 - \beta_1}$	0.062***	0.078***	0.147**	0.159***
	(0.010)	*(0.017)*	*(0.061)*	*(0.055)*
C. CONSTANT + TAX CATEGORIES + CORRECTION FOR PUBLICATION BIAS				
SE	-1.447***	-1.246***	-0.957***	-0.581***
	(0.246)	*(0.237)*	*(0.310)*	(0.204)
$\boldsymbol{\beta_0}$	-0.001**	-0.002**	-0.031*	-0.036**
	(0.000)	*(0.001)*	*(0.016)*	*(0.014)*
TaxNegative $(\boldsymbol{\beta_1})$	-0.019***	-0.030***	-0.039	-0.076
	(0.004)	*(0.010)*	*(0.043)*	(0.048)
TaxPositive $(\boldsymbol{\beta_2})$	0.040***	0.038***	0.124***	0.079***
	(0.004)	*(0.004)*	*(0.041)*	(0.026)
$\boldsymbol{\beta_2 - \beta_1}$	0.059***	0.068***	0.163***	0.155***
	(0.006)	*(0.011)*	*(0.056)*	*(0.050)*
Observations	979	979	979	979

NOTE: The top value is the coefficient estimate, and the bottom value in parentheses is the associated cluster robust standard errors. *, **, and *** indicate statistical significance at the 10-, 5-, and 1-percent level, respectively. The four WLS estimators (*Fixed Effects-Weight1, Fixed Effects-Weight2, Random Effects-Weight1,* and *Random Effects-Weight2*) are described in Section IV in the text.

TABLE 5
Summary Statistics of Study Characteristics

Variable	***Description***	***Mean***	***Min***	***Max***
	COUNTRY GROUP			
G7	=1, if G7 countries	0.082	0	1
EU15	=1, if EU15 countries	0.062	0	1
EU	=1, if EU countries but not EU-15	0.041	0	1
*OECD**	=1, if OECD countries but not G7, EU-15, or EU	0.815	0	1
	ECONOMIC GROWTH MEASURE			
GDP	=1, if dependent variable is GDP growth	0.191	0	1
*PCGDP**	=1, if dependent variable is per capita GDP growth	0.809	0	1
	TAX VARIABLE MEASURE			
Marginal	=1, if marginal tax rate (as opposed to average tax rate)	0.060	0	1
Differenced	=1, if change in tax rate (as opposed to level of tax rate)	0.195	0	1
ETR	=1, if effective tax rate (as opposed to statutory tax rate)	0.938	0	1
	DURATION OF TAX EFFECT			
*ShortRun**	=1, if tax variable measures immediate/short-run effect	0.718	0	1
MediumRun	=1, if tax variable measures cumulative/medium-run effect	0.048	0	1
LongRun	=1, if tax variable measures long-run, steady-state effect	0.234	0	1
	STUDY TYPE			
PeerReviewed	=1, if study published in peer-reviewed journal	0.711	0	1
PublicationYear	Year in which the last version of study was "published."	2010	1993	2020
	DATA CHARACTERISTICS			
CrossSection	=1, if data are cross-sectional.	0.010	0	1
*Panel**	=1, if data are panel	0.990	0	1
Length	Length of sample time period	31.6	5	47
MidYear	Midpoint of the sample time period	1988	1970.5	2008

Variable	***Description***	***Mean***	***Min***	***Max***
	ESTIMATION TYPE			
*OLS**	=1, if OLS estimator is used.	0.745	0	1
GLS	=1, if Generalized Least Squares estimator is used.	0.113	0	1
Endogeneity	=1, if estimator corrects for endogeneity, e.g. 2SLS, 3SLS, or GMM.	0.142	0	1
	STANDARD ERROR TYPE			
*SEOLS**	=1, if OLS standard error is considered.	0.545	0	1
SEHET	=1, if heteroskedasticity standard error is considered.	0.336	0	1
SEHAC	=1, if both heteroskedasticity and autocorrelation standard error are considered.	0.118	0	1
	INCLUDED VARIABLES			
InitialIncome	=1, if initial level of income included	0.536	0	1
LaggedDV	=1, if lagged dependent variable included	0.222	0	1
CountryFE	=1, if the country fixed effects are included	0.672	0	1
Investment	=1, if investment included	0.673	0	1
TradeOpenness	=1, if trade openness included	0.144	0	1
HumanCapital	=1, if human capital included	0.367	0	1
PopulationGrowth	=1, if population growth included	0.255	0	1
EmploymentGrowth	=1, if employment growth included	0.449	0	1
Unemployment	=1, if unemployment rate included	0.082	0	1
Inflation	=1, if inflation rate included	0.111	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 6
Robustness Check: Estimating Tax Effects with Control Variables (Selected Results)

	Fixed Effects (Weight1) (1)	***Fixed Effects (Weight2) (2)***	***Random Effects (Weight1) (3)***	***Random Effects (Weight2) (4)***
SE	-1.324*** *(0.275)*	-1.036*** *(0.244)*	-0.975*** *(0.350)*	-0.606*** *(0.214)*
TaxNegative $(\boldsymbol{\beta_1})$	-0.021 *(0.015)*	-0.039** *(0.017)*	-0.094** *(0.039)*	-0.132*** *(0.045)*
TaxPositive $(\boldsymbol{\beta_2})$	0.050*** *(0.009)*	0.045*** *(0.006)*	0.112*** *(0.036)*	0.082** *(0.031)*
Endogeneity	-0.001 *(0.001)*	-0.000 *(0.001)*	0.011 *(0.022)*	0.025 *(0.022)*
$\boldsymbol{\beta_2 - \beta_1}$	0.070*** *(0.017)*	0.085*** *(0.018)*	0.206*** *(0.054)*	0.215*** *(0.052)*
Observations	979	979	979	979

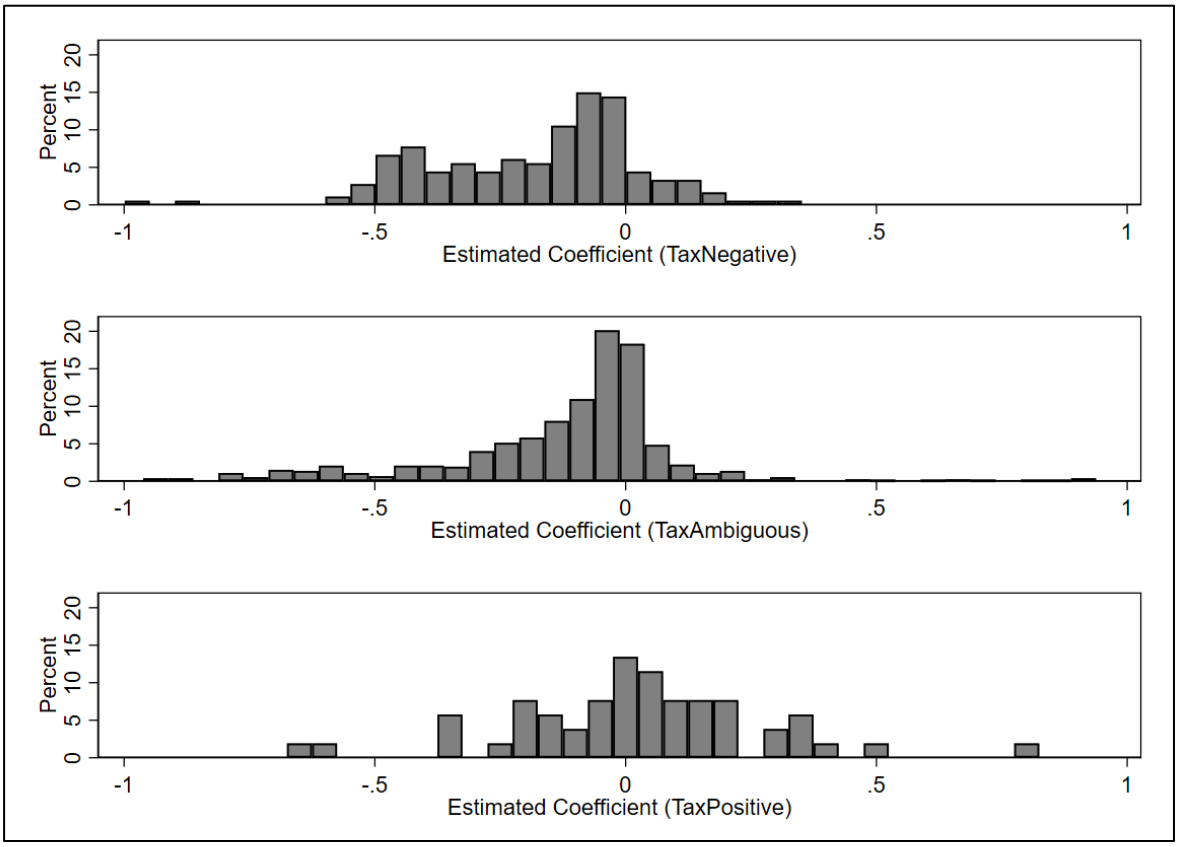
NOTE: The top value in each cell is the coefficient estimate, and the bottom value in parentheses is the associated cluster robust standard errors. *, **, and *** indicate statistical significance at the 10-, 5-, and 1-percent level, respectively. The four WLS estimators (*Fixed Effects-Weight1*, *Fixed Effects-Weight2, Random Effects-Weight1,* and *Random Effects-Weight2*) are described in Section IV of the text.

FIGURE 1
Gemmell, Kneller, and Sanz (2009)'s Classification of the Growth Effects of Various Fiscal Polices Combinations

Financed by:		Public Spending: Productive	Public Spending: Unproductive	Budget Surpluses
Taxes:	Distortionary	*positive/negative* (at *low/high* gov. size)	*negative*	*ambiguous*
	Non-distortionary	*positive*	*zero*	*positive*
Budget Deficits		*ambiguous*	*negative*	-

SOURCE: Gemmell, Kneller, and Sanz (2009), Table 1, page 19.

FIGURE 2
Estimated Tax Coefficients by Fiscal Policy Categories



NOTE: Histograms are truncated to lie between -1 and 1 to facilitate comparison.

	Mean	*Median*	*Observations*
TaxNegative	-0.18	-0.13	180
TaxAmbiguous	-0.11	-0.06	747
TaxPositive	0.02	0.03	52

APPENDIX 1
List of Terms Used in Electronic Search by Category

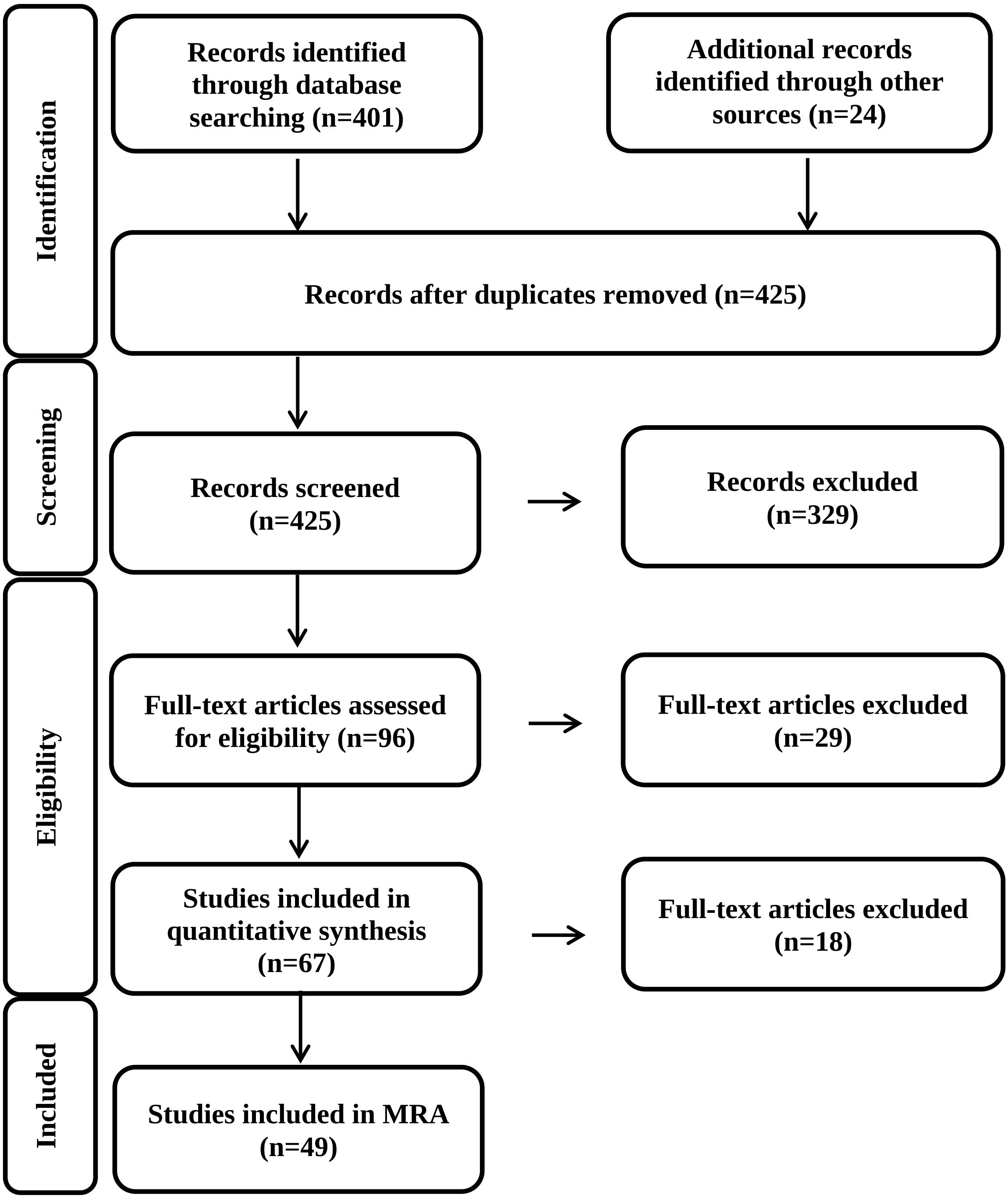
TAX	ECONOMIC GROWTH	OECD
Tax(es) /Tax rate(s)/Taxation	Economic growth	OECD countries
Tax policy(policies)	Growth	EU countries
Tax ratios	Economic indicators	G-7 countries
Tax changes	Long-term growth	High income OECD countries
Tax rate change	Long-run growth	Industrial countries
Fiscal policy(policies)		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	Fölster and Henrekson (2001)	Journal	7
20	Fölster and Henrekson (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	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

ID	Study	Publication Status	Number of estimates
43	Andrašić et al. (2018)	Journal	10
44	Baiardi et al. (2019)	Journal	60
45	Elshani and Ahmeti (2017)	Journal	14
46	Jaimovich and Rebelo (2017)	Journal	10
47	Luo (2019)	Journal	128
48	Ormaechea and Morozumi (2019)	Working Paper	38
49	Yanikkaya and Turan (2020)	Journal	6

APPENDIX 3
PRISMA Flow Diagram



APPENDIX 4
Study Weights

	Fixed Effects	*Random Effects*
Mean	2.04%	2.04%
Median	0.03%	2.18%
5%	0.0005%	0.87%
10%	0.0013%	1.47%
90%	1.2%	2.41%
95%	2.1%	2.43%
Maximum	67.9%	2.43%
Top 3	94.5%	7.3%
Top 10	98.8%	23.9%
Studies	49	49

NOTE: Study weights were calculated by $w_i / \sum w_i$, where $w_i = 1/(SE_i)^2$ or $w_i = 1/[(SE_i)^2 + \tau^2]$ depending on whether Fixed Effects or Random Effects were being used (cf. Ringquist, 2013, page 128).

APPENDIX 5
Classification of Tax Coefficients into Short-, Medium, and Long-Run Effects

Let the estimated relationship between $growth$ and the tax rate variable, *tr*, be given by the finite distributed lag model,

(A1) $growth_t = \alpha_0 + \alpha_1 tr_t + \alpha_2 tr_{t-1} + \boldsymbol{X\beta} + \varepsilon_t$.

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:

(A2) $growth_t = \alpha_0 + \tau\, tr_t - \alpha_2 \Delta tr_t + \boldsymbol{X\beta} + \varepsilon_t$,

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 (A1) is the auto-regressive, distributed lag model,

(A3) $growth_t = \alpha_0 + \alpha_1 tr_t + \alpha_2 tr_{t-1} + \gamma growth_{t-1} + \boldsymbol{X\beta} + \varepsilon_t$.

Subtracting $growth_{t-1}$ from both sides gives:

(A4) $\Delta growth_t = \alpha_0 + \alpha_1 tr_t + \alpha_2 tr_{t-1} + (\gamma - 1) g_{t-1} + \boldsymbol{X\beta} + \varepsilon_t$,

which can be rewritten in error correction form as:

(A5) $\Delta growth_t = \alpha_0 + \delta(growth_{t-1} - \theta tr_t) - \alpha_2 \Delta tr_t + \boldsymbol{X\beta} + \varepsilon_t$,

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 (A5), 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.[28]

Specifications (A1), (A2), and (A5) 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-, Medium-, or Long-run.

[28] We note that Equation (A5) is sometimes estimated using an equivalent, alternative specification: $\Delta growth_t = \alpha_0 + \delta(growth_{t-1} - \theta tr_{t-1}) + \alpha_1 \Delta tr_t + \boldsymbol{X\beta} + \varepsilon_t$, where δ and θ are defined as above.