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

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Abstract: The impact of fiscal policy, particularly tax policy, on economic performance has been a centre of attention for decades now. Despite a large body of research on the topic, no consensus exists within the academic community and therefore the empirical evidence has so far been mixed. Considering 641 comparable estimates of the effect of taxes on economic growth in OECD countries derived from 42 studies, this study aims to answer the following questions by applying a meta-regression analysis: (Q1) What is the overall, mean effect of taxes on economic growth? (Q2) Are some taxes (e.g., personal income taxes) more distortionary than others (e.g., value added taxes)? (Q3) Is there any empirical evidence to support the conventional wisdom that "distortionary taxes" used to fund "unproductive expenditures" are especially harmful for economic growth? (Q4) What are the factors causing researchers to encounter different or even contradictory results? Our results suggest that there is a publication bias towards negative estimates in the literature. Controlling for publication bias, we find that the overall effect of taxes on economic growth is statistically insignificant and negligibly small. An increase in unproductive expenditure funded by distortionary taxes has a significant negative effect on growth. We find weak evidence to support the idea that some taxes are more distortionary than others. Lastly, there are several factors that can explain discrepancies among the reported estimates.

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

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

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1.1. Introduction

The effect of taxes on economic activity is one of the highly contested research areas in macroeconomics. Many studies have examined the effects of taxes on economic performance such as 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). But against expectation, there is no consensus among economists on whether taxes have any influential effect on economic growth, and if they do, how large the effect might be. While theory may not provide enough guidance on the ultimate effect of taxes on growth, so that the issue becomes an empirical one, the empirical results have a number of complications that make it challenging to draw general conclusions.

There are many possible reasons for the existence of a lack of consensus. Let's first see why there is no clear a priori theoretical prediction about the effects of taxes on economic growth. In the neoclassical growth model introduced by Solow (1956), fiscal variables such as taxes and spending may have transitional effects on output levels but they have no impact on the rate of economic growth in the long run. The steady-state growth rate is driven by exogenous factors such as the rate of technical progress and population growth. However, the endogenous growth model introduced by Barro (1990) and King and Rebelo (1990) challenged the traditional neoclassical growth model and predicted that the long-run growth will be affected by productive expenditures and distortionary taxation. As taxes have no permanent effects on per capita GDP growth in the neoclassical model, most researchers assume that the endogenous model can better explain growth. Further, the reported growth effects of taxes depend not only on the type of taxes/expenditures considered (Barro, 1990; Barro and Sala-i- Martin, 1992; Futagami et al., 1993; and Deverajan et al., 1996) but the net effect of taxes on growth also depends on how public spending and deficits are financed (Kneller et al., 1999; Bleanet et al., 2001; Gemmell et al., 2009). For example, a distortionary tax such as a personal income tax used to fund unproductive expenditure such as transfer payments may have different growth effects than the situation in which the same distortionary taxes are used to fund productive expenditure on public infrastructure.

Like the theoretical literature, empirical studies provide ambiguous results on the growth effects of tax policy due mainly to the lack of a uniform frame of reference. The difficulty in finding robust evidence of the effect of taxes on growth may be explained by several methodological choices, such as what countries to include, how to measure taxes and economic performance, the problem of omitted variables, particularly the exclusion of different types of expenditures, differences in the inclusion of control variables, the selection of estimation methods, and the duration of estimated tax effects. For these and other reasons, it is hardly surprising that these conflicting results exist.

Since the literature lacks any visible patterns, conventional narrative reviews can be used to compare estimates across studies and therefore highlight the reasons for the heterogeneity observed. However, these reviews suffer from the following shortcomings: (i) they reflect the reviewers' points of view and can certainly vary from one reviewer to another; (ii) bias might be an inherent part of these kinds of reviews; (iii) no clear inclusion/exclusion criteria are typically reported and therefore they cannot be replicated by other scholars; (iv) there is no objective standard for how to weight alternative estimates, and (v) as a result, they cannot be relied upon to provide clear and concrete guidance to policy makers and other researchers concerning the relationship in the research question.

To overcome the above-mentioned shortcomings and in order to be able to provide a clear picture of the existing literature investigating the effects of taxes on economic growth in

OECD countries, I apply a meta-regression analysis (MRA). An MRA is a quantitative method for reviewing research of the existing literature in order to aggregate the empirical findings on a given research question. One of the main advantages of an MRA is that it allows one to disentangle various factors causing the conflicting results among researchers (Stanley, 2001). Meta-analysis has been traditionally used in the medical sciences to synthesize the results of clinical trials but it has been recently used in the social science, particularly in economics.

To do so, I collect the estimates from this literature and carefully track the factors that can cause heterogeneity across studies and then by the use of this technique, I am able to compare and synthesize the estimates across the different studies.

This study aims to answer the following questions by applying a meta-regression analysis: (Q1) What is the overall, mean effect of taxes on economic growth? (Q2) Are some taxes (e,g., personal income taxes) more distortionary than others (e.g., value added taxes)? (Q3) Is there any empirical evidence to support the conventional wisdom that "distortionary taxes" used to fund "unproductive expenditures" are especially harmful for economic growth? (Q4) What are the factors causing researchers to encounter different or even contradictory results? As part of this research, I check for publication bias, by which I mean some estimates are disproportionately reported either due to statistical insignificant or for reporting the "wrong-direction" according to the associated theory (Stanley and Doucouliagos, 2012; Havranek and Irsova, 2012). I calculate an "overall tax effect" after accommodating and correcting for publication bias. It is worth mentioning that any measure of the "overall tax effect" on growth is not informative enough mainly because it encompasses estimated effects as a result of various kinds of fiscal policies. Accordingly, I compare estimated tax effects from two types of policies: (i) tax effects that are theoretically predicted to have a negative impact on economic growth versus (ii) tax effects that are theoretically predicted to have a positive impact on economic growth. The differences between these two sets of estimated tax effects will provide a measure of the impact of tax policy on economic growth.

To answer these four questions, this study collects 713 comparable estimates of tax effects on economic growth in OECD countries derived from 42 primary studies. According to a final sample of 641 estimates, I find strong evidence that the empirical literature suffers from a negative publication bias. In other words, there is a tendency to over-report negative estimates. Once I control for this bias, I then calculate that the "overall effect" of taxes on economic growth is small and statistically insignificant. However, as mentioned earlier, this "overall tax effect" is not very informative because it includes estimated effects from different kinds of fiscal policies.

After accommodating and correcting for publication bias, once I turn to analysing different types of tax policies, I find evidence that the composition of fiscal policy matters. For example, increases in productive expenditures and/or government surpluses funded by non-distortionary taxes have a statistically significant, positive effect on economic growth. However, increases in unproductive expenditures funded by distortionary taxes and/or deficits have a statistically significant, negative effect on economic growth. These differences in the policy compositions may explain the heterogeneity reported among the literature. Further, I find weak evidence that taxes on personal income are more growth-retarding than other types of taxes. Evidence regarding other types of taxes is mixed.

The remainder of this paper is organized as follows. Section 1.2 explains how I collected the sample of estimates. Section 1.3 discusses some of the reasons why studies of tax effects can produce different estimates. Section 1.4 represents my empirical results, addressing the above-mentioned research questions. Section 1.5 summarizes the main findings of this research.

1.2. Selection of Studies and Construction of Dataset

This meta-regression analysis collects estimated tax effects derived from all the studies estimating the following specification:

$$g = \alpha_0 + \alpha_1 tr + error, \tag{1.1}$$

where g is a measure of economic growth, tr is a measure of the tax rate, and the data are taken from OECD countries. I conducted a comprehensive research strategy including both electronic and manual search procedures. It is worth noting that studies estimating interaction and/or non-linear transformation of tax effects, such as the "growth hills" of Bania, Grey and Stone (2007) and also studies estimating interactive terms, such as Deskins and Hill (2010) are not included in this MRA mainly because if there is an interactive term in the model, the total effect is an outcome of both the term and its interaction. Unfortunately, the meta-analyst rarely has the data necessary to calculate the marginal effects and their respective standard errors.

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 into each of the three categories. All the potential alternatives are reported in Appendix 1.1. I searched several keyword combinations in various electronic search engines such as EconLit, Google Scholar, JSTOR, Web of Science, Scopus, RePEc, EBSCO, and ProQuest. The primary search yielded a total of 303 papers.

The abstracts and conclusions of these studies were then read carefully to eliminate any studies that did not meet the inclusion/exclusion criteria. To be included in this meta-analysis each study needs to: (i) report an estimate of a growth equation with a tax variable; (ii) focus on a full set or a subset of OECD countries (e.g., EU15, G7, EU members); and (iii) provide standard errors (or the statistics through which standard errors can be computed) associated with each regression coefficient. Backwards and forwards citation search strategies were then applied to identify any additional relevant original studies. This produced a list of 51 studies, some of which were multiple versions of the same study, and included peer-reviewed journal, conference proceedings, reports released by government agencies, think tanks and research firms, theses and dissertations, and working papers and other unpublished or grey literature. [1]

The list including all the studies collected until that period was emailed to 64 scholars who had written at least one research paper on the topic of taxes and economic growth in OECD countries. The researchers were asked to assist me in identifying any additional research papers of their own or Masters/PhD students who are working with them.[2] The responses I received from the researchers resulted in a revised list of 54 studies.[3]

Each study in the revised list was then read thoroughly to see whether they were eligible according to the inclusion criteria defined at the earlier stage. The dependent variable had to be a measure of GDP growth. Alternatively, the dependent variable could be the level of income, as long as the lagged dependent variable was included in the specification. The growth equation had to include at least one tax variable that was measured in units of percent of income. Studies in which the "tax variable" consisted of all revenues, such as the ratio of total revenues to GDP, were not included. This is because they lump together tax and non-

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[1] When reported estimates differ in multiple versions of the study, the peer-reviewed journal articles is considered as a benchmark. However, if there are additional estimates in previous versions of the study, I kept track of the outlet of the study, coded, and then pooled the estimates across versions.

[2] The letter along with the bibliography of the core studies emailed to the prominent authors in this research is available in Appendix 1.2and Appendix 1.3.

[3] I am grateful for helpful suggestion received from all the scholars.

tax revenues. The countries included in a given regression equation had to consist of a full set 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 studies that included only a single country were dropped from this meta-study. To be included, estimates had to include multiple countries. The reason being that it was felt that aggregating the growth experiences across multiple countries provide the greatest opportunity to generate externally valid results. They also offer more degrees of freedom which improves the efficiency of the economic estimates. All estimated tax effects had to report standard errors or associated t-statistics/p-values. Finally, only studies written in English were included. I closed my search on 13 January 2016. The final sample of 42 studies is listed in Appendix 1.4.

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

1.3. Factors that Cause Tax Estimates to Differ Across Studies

The government budget constraint. To estimate the precise effects of taxes on economic growth it is important to address a number of issues. The first and foremost is how to deal with the government budget constraint:

$$0 = Taxes + OtherRevenues - Expenditures - Surplus \quad (1.2)$$

The following specification is obtained by dividing both sides by $Income$:

$$0 = tr + \left(\frac{Other\ Revenues}{Income}\right) - \left(\frac{Expenditures}{Income}\right) - \left(\frac{Surplus}{Income}\right), \quad (1.3)$$

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

The regression coefficient can be misinterpreted easily if one ignores the role of the government budget constraint. The main argument is that the regression coefficient on α_1 in Equation (1.1) should be interpreted as the growth effect of tax financed by the omitted categories and it may differ depending on which category(ies) has been omitted from the regression. If $\left(\frac{\text{Expenditures}}{\text{Income}}\right)$ 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).

The interpretation becomes even more complicated once taxes and expenditures are decomposed into their parts: distortionary versus non-distortionary taxes; productive versus unproductive expenditures. This can be seen in the following specification:

$$0 = tr(Non-distortionary) + tr(Distortionary) + \left(\frac{Other\ Revenues}{Income}\right) - \left(\frac{Productive\ Expenditures}{Income}\right) - \left(\frac{Unproductive\ Expenditures}{Income}\right) - \left(\frac{Surplus}{Income}\right) \quad (1.4)$$

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 is being investigated, and depending on which other variables in the government budget constraint are omitted.

To address this issue, I 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 provided in Table 1.1, taken from Kneller, Bleaney, and Gemmell (1999).[4]

[4] I 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. Distortionary taxes are those distorting investment decisions (Barro, 1990).

Table 1.1: 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 1.2 summarizes the predicted effect of distortionary/non-distortionary taxes on economic growth given the omitted fiscal category. This is taken from Gemmell, Kneller, and Sanz (2009), however, it is adjusted to accommodate the totality of cases encountered in my sample. Accordingly, every estimated tax effect in my sample is assigned a predicted effect with respect to its impact on growth (negative, positive, or ambiguous/zero).

Table 1.2: 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 I combine the original categories of "zero" and "ambiguous" to "ambiguous".

There is another possible classification, in this case according to tax types. 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 presented in Table 1.3.

Table 1.3: 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)

Units of measurement. The second issue that deserves careful attention is the units of measurement for both economic growth (g) and tax rate (tr) variables. Each of these variables can be measured in percentage points (e.g., 10%) or in decimals (0.1). This will clearly 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 should be multiplied by 100 and therefore the corresponding effect will be -10. And if g is measured in decimals, and tr is measured in percentage points, then the value of α_1 should be divided by 100 and therefore the corresponding effect will be -

0.001. Accordingly, I 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. If the original study lacks summary/descriptive statistics or the proper interpretation of the estimated results, it would be then difficult to determine the measurement units. In these cases I contacted the author(s) to cross check the units. Those estimates were dropped from my analysis in the rare cases where I was unable to locate them, or they did not respond to my emails.

Countries. The third issue has to do with the specific countries included in a given study. While the countries considered as an OECD member are fairly homogenous, this grouping also involves developing countries such as Turkey. OECD membership is granted on the basis of both (i) economic performance and (ii) democratic and institutional development. Heterogeneities across OECD countries may yield systematically different results. Some of the studies available in the literature limit their sample to a sub-set of OECD countries including G-7, EU-15, and EU, with the idea that those subsets consist of more homogenous countries. Appendix 1.5 lists the 34 OECD countries, ordered by their year of admission to the OECD.[5] This meta-analysis controls for these different groupings to 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 in the original studies. If the time periods of Equation (1.1) 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,

[5] Latvia, the 35th member, was admitted to the OECD on July 1st, 2016.

while the latter reported annual growth rates. All things constant, one might expect α_1 to be larger in the former case. Accordingly, I adjust all growth measures to be (average) annual rates of growth.

Duration of estimated tax effects. Since most growth models agree that tax-growth effects occur in the short-run, the distinction between short-, medium-, and long-run effects of tax may explain discrepancies observed in the literature. Thus, a fifth issue 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,

$$g_t = \alpha_0 + \alpha_1 tr_t + \alpha_2 tr_{t-1} + \varepsilon_t. \tag{1.5}$$

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:

$$g_t = \alpha_0 + \tau\, tr_t - \alpha_2 \Delta tr_t + \varepsilon_t, \tag{1.6}$$

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

$$g_t = \alpha_0 + \alpha_1 tr_t + \alpha_2 tr_{t-1} + \gamma g_{t-1} + \varepsilon_t. \tag{1.7}$$

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

$$\Delta g_t = \alpha_0 + \alpha_1 tr_t + \alpha_2 tr_{t-1} + (\gamma - 1) g_{t-1} + \varepsilon_t, \quad (1.8)$$

which can be rewritten in error correction form as:

$$\Delta g_t = \alpha_0 + \delta(g_{t-1} - \theta tr_t) - \alpha_2 \Delta tr_t + \varepsilon_t \ , \quad (1.9)$$

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 (1.9), 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.[6]

Specifications (1.5), (1.6), and (1.9) lead to three different measures of the effect of taxes on economic growth. My 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 to be addressed is how the primary studies define the tax rate and economic growth variables. While some studies use nominal GDP as a measure of economic growth, others use real GDP. I keep track of both measures, however, because as long as a given study applied the nominal GDP (in log form) and also included time dummies then there is no distinction between nominal and real GDP. Per capita GDP and total GDP are the other forms of measuring economic growth in the literature. One of the main challenges faced by empirical studies investigating the effects of tax is how to identify an accurate measure of tax rates (Mendoza et al., 1997). Since economic decisions depend on the marginal effective tax rate, this measure is more appropriate for examining the tax-growth effects. However, marginal effective tax rates are

[6] I have noticed that Equation (2.9) 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.

not observable and there is no obvious estimate of them. Therefore, several proxies have been proposed in the literature. The most commonly used proxy is "tax burden" defined as tax revenues over a given measure of income. But this specification creates a potential collinearity with government expenditures (Easterly and Rebelo, 1993). The other available alternatives are average effective tax rates and statutory tax rates - typically the top marginal rate. These are more sophisticated measures. The last two measures are believed to perform better as opposed to the former in capturing the complexity of the tax system. And some studies attempt to distinguish marginal from average tax rates. I use dummy variables to indicate the specific measures underlying a given estimate.

Control variables. In addition to the issues explained earlier, I code many other study characteristics. These include estimation methods, types of standard errors, whether the original study was published in a peer-reviewed journal, the publication date, the sample period length, the midyear of the sample period, and whether specific variables such as country fixed effects, human capital, trade openness, inflation, and others are included in the estimating equations. A full list of the variables used in this study is discussed in the next section.

1.4. Empirical Analysis

Preliminary analysis. My search strategy identified 42 comparable empirical studies that offer regression based estimates of tax-growth effects. By coding various characteristics discussed earlier I was able to produce a dataset including 713 estimated tax effects. Table 1.4 reports descriptive statistics for both these estimates and the associated *t*-statistics.[7] 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

[7] Excel spreadsheet that allows the user to replicate all the results of Table 2.4 through 2.10 can be downloaded from Dataverse: https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/KNQEYB.

economic growth. This should be compared to an average, annual growth rate for OECD countries of approximately 2.5 percent over the period 1970-2000, a period which roughly corresponds to the "average" sample period of the studies included in this meta-analysis.[8,9] The median *t*-statistic is -1.27.

Table 1.4 indicates that the estimated tax effects reported in primary studies range from a minimum of -3.52 to a maximum of 12.72. This seems unreasonable given the annual average growth rate of 2.5 percent. It suggests that a one percentage point increase in the tax rate is associated with over a 12 percentage point increase in annual growth rate, ceteris paribus. I cross check unreasonable estimates to avoid any potential coding errors. However, it seems there are outliers and potential leverage point in the literature. We know that the presence of outliers can lead to inflated error rates and substantial distortion of the coefficients and their associated statistical significance, so I delete the top and bottom 5 percent of estimates and as a result obtain a sample including 641 tax effects. Accordingly, the subsequent analysis works with a truncated sample of estimates (641 estimates) rather than initial full set (713 estimates).

The descriptive statistics for the truncated sample are also reported in Table 1.4. The range of estimated tax effects for this sample is from a minimum of -0.524 to a maximum of 0.166 which seems reasonable. The median t-statistic still indicates insignificance, while the sample of t-statistics ranges from a minimum of -14.50 to a maximum of 7.78, with a mean absolute value of 2.09.

[8] This is calculated by taking the average beginning and average ending dates for the sample ranges of the respective studies.
[9] 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 1.4: 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

Figure 1.1 plots the 641 estimated tax effects of the truncated sample. If tax effects were homogeneous across studies and sampling error is the only reason making the estimated effects differ, one would then expect a bell-shaped (standard) histogram. However, as can be clearly seen in Figure 1.1 this is not the case, implying that the distribution is skewed towards negative values. This histogram can also be used to identify if there is any publication selection in the literature. Lack of symmetry in this plot suggests that there might be publication selection bias towards negative estimates. The results from this simple visual test should also be confirmed using a more formal test (i.e. the Funnel Asymmetry Test).

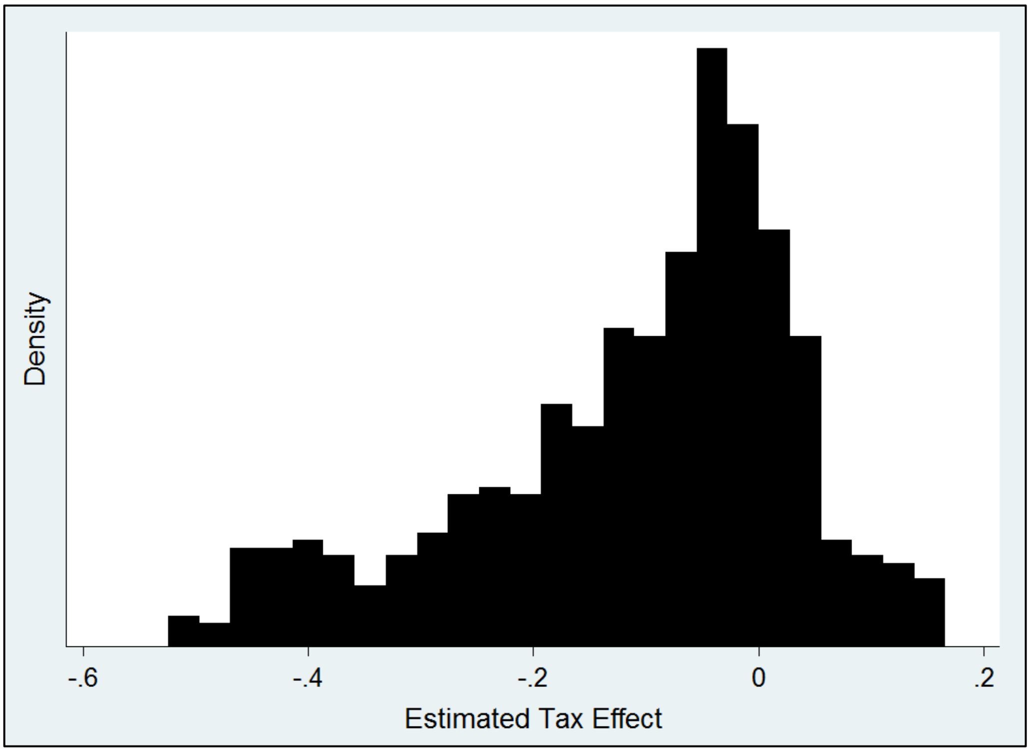

Figure 1.1: Histogram of Estimated Tax Effects (Truncated)

Figure 1.2 depicts a forest plot of the respective studies using a "Fixed Effects" weighting scheme. Note that the concept of both "Fixed Effects" and "Random Effects" in the meta-analysis context is quite different from the definitions used in the panel data literature (Reed, 2015). In the current context it simply means that the estimated tax effects are weighted by the inverse of their standard errors. For each study, a weighted average along with a 95 percent confidence interval is computed.

Looking at Figure 1.2, there are a couple of points which deserve particular attention. First, most of the studies estimate small effects with tight confidence intervals, although, study 39 (Abd Hakim et al., 2013) is a notable exception with respect to the confidence intervals. Second, there is a large amount of heterogeneity across studies, given the large I^2 computed and represented at the bottom of this figure (Higgins and Thompson, 2002). As discussed earlier, there are several reasons that may explain why this is the case. These include different measures of tax rate and economic growth, how primary studies deal with government budget constraints (GBC), different time periods as well as different samples of countries, differences in estimation methods applied, whether the effect is short-, medium, or long-run and so on. The large value of I^2 suggests that the heterogeneity across studies is far beyond just sampling error.

Third, the last column calculates the percentage weight assigned to each study in calculating the overall weighted average. Study 26 (Hanson, 2010) is weighted substantially larger than all the other studies combined (81.39% versus 18.61%). The disproportionately large weight assigned to study number 26 is not a real concern as long as this study is truly more reliable. However, it might be a good reason to switch to the "Random Effects" weighting scheme.

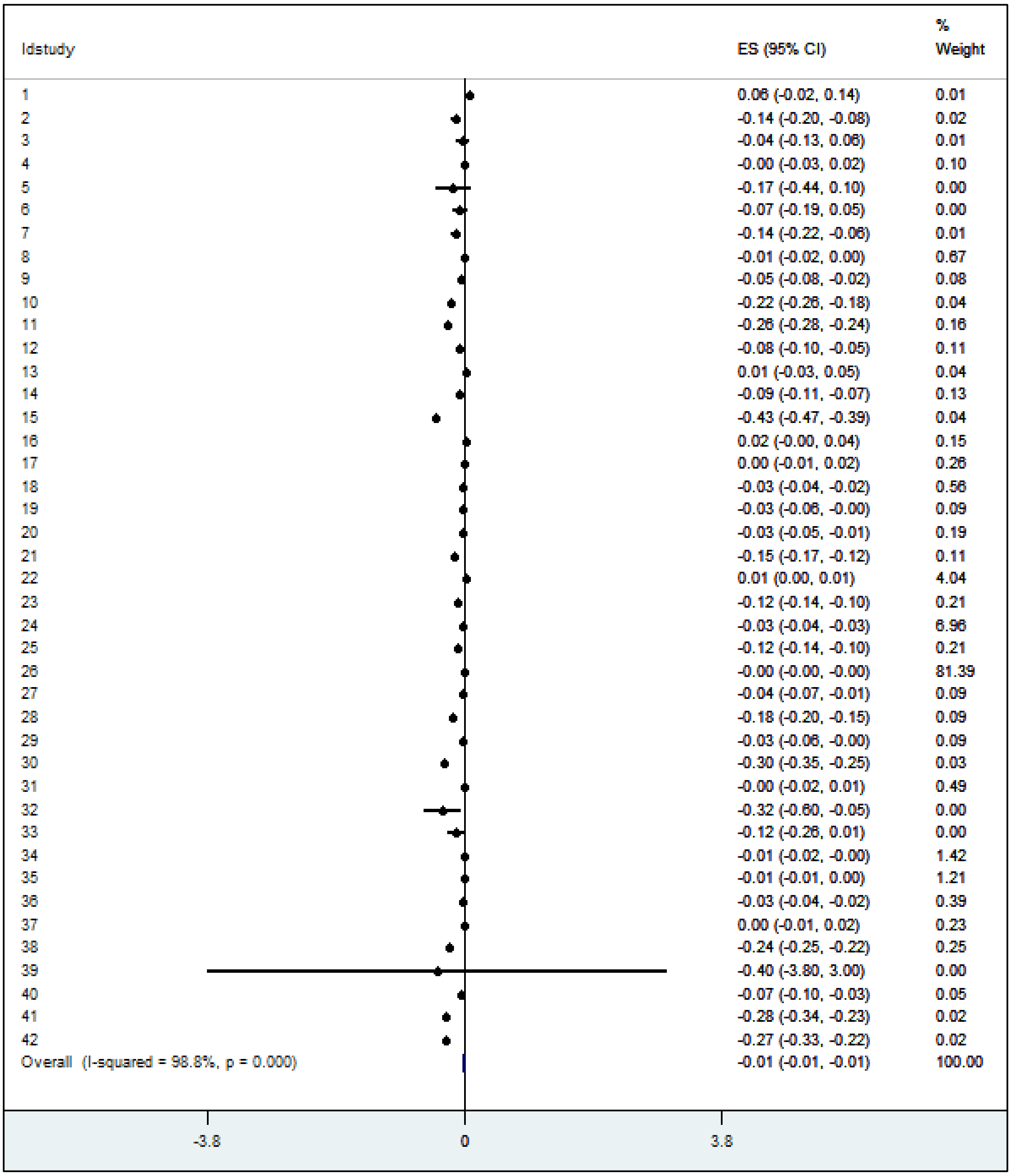

Figure 1.2: Forrest Plot of Studies (Fixed Effects)

The general assumption under the "Fixed Effects" framework is that there is an identical true effect size across all studies included in an MRA, and the only reason estimates differ is because of sampling error. Thus, it is not a concern if the estimates in the larger studies receive substantially more weight, because their "signal" is less distorted by "noise," since the estimates are more precise. In this framework, the optimal weight to assign each estimate is the inverse of its standard error.

In contrast, the general assumption under the "Random Effects" framework is that there is not just one true effect but a distribution of effects. This means that we cannot simply ignore a small study by assigning a smaller weight because these studies provide valuable information about the distribution of effects. Note that the weight implemented in the "Random Effects" model consists of two parts: (i) within-study variances (same as FE), and (ii) between-study variances (Borenstein et al., 2010).

Accordingly, the subsequent empirical work emphasizes the "Random Effects" estimates where tax effects are weighted by their standard error (within-study heterogeneity) plus another term that captures the between-study heterogeneity. This will have the effect of equalizing the weights given to individual studies because cross-study heterogeneity is so great. Appendix 1.6 displays the forest plot using "Random Effects". The study weights are much more balanced.

The distribution of the reported estimates is illustrated in Figure 1.3 and Figure 1.4 in a form of a funnel plot. The funnel plot is a scatter diagram of effect sizes (here regression coefficients) versus some measure of their precision, typically the inverse of the standard error $(1/SE_i)$. It can be used as a simple visual tool to identify if there is any publication selection bias available in the literature (Stanley and Doucouliagos, 2010). It also provides further insight into the distribution of estimated tax effects.

Figure 1.3 displays individual estimates. In Figure 1.4 each study is represented by a single point relating its mean estimate to its mean standard error.[10]

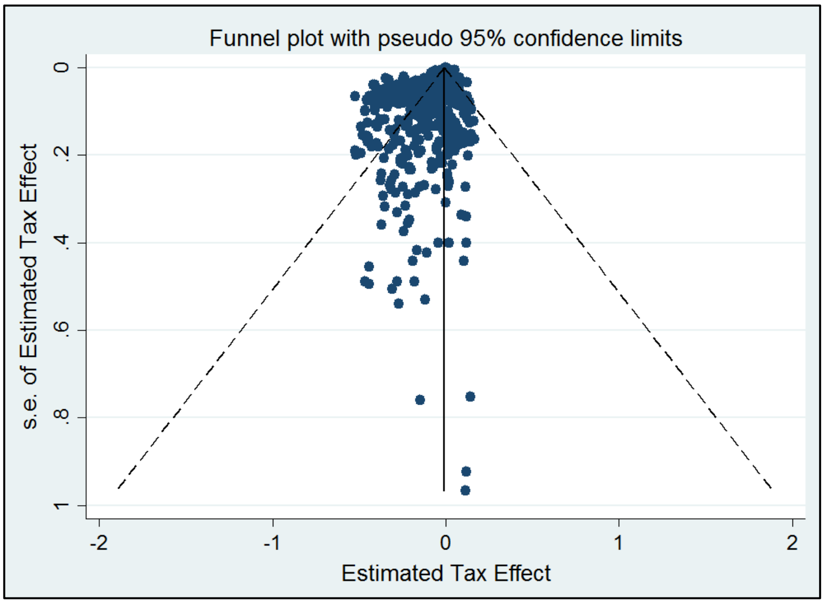

Figure 1.3: Funnel Plot (All Estimates)

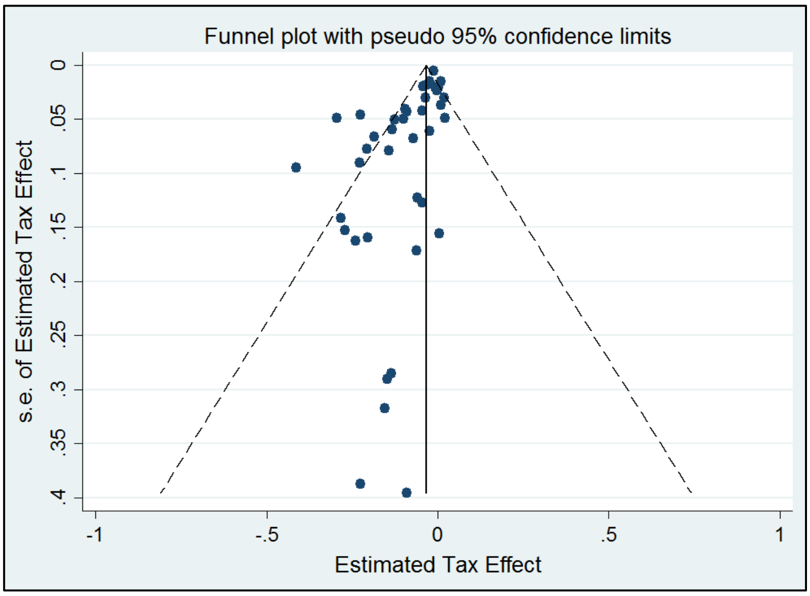

Figure 1.4: Funnel Plot (Mean of Study Estimates)

[10] Both funnel plots omit observations where the standard error is greater than 1. This allows one to better observe the pattern of points at the top of the funnel.

The solid line in both plots indicates the mean of estimated tax effects, and the dash lines that fan out from the top of the funnel shows 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 suggest there is publication bias in favour of negative estimates. Further, the wide dispersion at the top of the funnel is consistent with substantial heterogeneity previously shown by the I^2 value.

FAT/PET tests. Table 1.5 reports the results of two tests: the Funnel Asymmetry Test (FAT) which is a conventional way to detect whether the literature suffers from publication selection bias (Egger et al., 1997; Stanley, 2008), and the Precision Effect Test (PET), which tests for the significance of the overall effect (Stanley and Doucoulliagos,2012; Shemilt et al., 2011). Both tests are obtained from estimating the following specification using weighted least squares (WLS),

$$\hat{\alpha}_{1,ij} = \beta_0 + \beta_1 SE_{ij}, \tag{1.10}$$

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 $H_0\!: \beta_1 = 0$ and $H_0\!: \beta_0 = 0$, respectively.

My analysis uses four different weights to estimate Equation (1.10). The "Fixed Effects" and "Random Effects" 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 ignores the fact that some studies report more estimates compared to others. As a result, a study including 10 estimates would be weighted 10 times more than a study including one single estimate, ceteris paribus. To address this issue, I multiply both sets of weights by the inverse of the number of estimates reported per study, $\left(\frac{1}{N_i}\right)$. Doing so, I assign each given study approximately the same weight as others even though the number of reported estimates differs from one study to another. Thus, "Weight 1" refers to the standard weighting scheme in which the number of reported estimates matter and studies with higher number of estimates receive the higher weight. However, by using "Weight 2" I assign each study the same importance.

Table 1.5: 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 (1.10) 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.

Heteroskedasticity is always an issue for meta-regression analysis, because the original estimates, which are the dependent variable, come from very different datasets with different sample sizes and different estimation techniques. Thus, some variation of weighted least squares (WLS) should always be employed. Furthermore, authors in this literature typically report multiple estimates and therefore estimates within the study cannot be assumed independent. To account for these data complexities, the first four columns of Table 1.5 report the results of estimating Equation (1.10) using WLS with respect to the four different weighting schemes described above, and calculating cluster robust standard errors, with clustering by study. 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 imply that there is a selection bias in favour of negative estimated tax effects, perhaps due to researchers choosing to disproportionately report negative estimates, or reviewers in peer-reviewed journals discriminating against positive results. These results are consistent with earlier visual inspection of the estimated effects histogram and also the visual evidence of publication bias from the funnel plots represented in Figure 1.3.

The first four columns of the second row of Table 1.5 report the PET. All four estimators show that the overall tax effect, controlling for publication bias, is statistically insignificant and relatively small in economic terms. According to the "Random Effects (Weight1)", a 10-percentage point increase in the tax rate is associated with a 0.01 percentage point decrease in annual GDP growth, ceteris paribus.

The last two columns report random effects estimates of Equation (1.10) 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 (compared to previous results), and statistically significant at the 1 percent level. According to the "Random Effects (Weight1) in Column (5), a 10-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 influenced by negative publication bias. Once one controls for that, the estimated tax-growth effect is substantially smaller and statistically insignificant. As a result, I want to be sure that my subsequent analysis corrects for this.

This section has addressed one of the main objectives of this research, to obtain an "overall estimate" of the effect of taxes on economic growth in OECD countries. I find that once I correct and accommodate for publication-bias then the overall effect on taxes is statistically insignificant and negligibly small in economic terms. However, my 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 intervention can be estimated as a positive or negative tax effect depending on the omitted fiscal categories from the primary 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 2.3 identified factors that may cause heterogeneity in the reported estimates. In this section I compare tax effects associated with fiscal policies that are predicted to have negative growth effects with those predicted to have positive effects. I also investigate whether some types of taxes are more growth-retarding than others. To do that, it will be necessary to control for the factors that may influence estimates of tax effects.

Table 1.6 reports the variables used in the subsequent meta-regression analysis. The first sets 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 in the table, I 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. Approximately 34.5 percent of tax effects are of this type. However, many studies disaggregate tax effects into separate types. For example, 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) and 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 types of taxes.

Other variables are grouped according to the following 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 rather than marginal rates (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 my 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.

I categorized standard errors into three groupings because the standard error plays such a significant role in meta-analysis: *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%).

Table 1.6: 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.

In my investigation of tax effects I adopt the following empirical procedure. First I 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*. I 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. I then combine the two sets of tax variables to check for robustness.

For each set of regressions I also include two sets of control variables. The top panel of each of the following tables 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.[11] Since the tax variables are locked into each regression, the use of the stepwise procedure does not invalidate testing for their significance. All regressions also include the publication bias variable, *SE*, and thus control for publication bias.

The results of this analysis are given in Table 1.7 through Table 1.9. Table 1.7 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, I 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 predictions of growth theory.

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

Table 1.7: 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 (2.10) 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 1.8: 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***	-1.144***	-0.725***	-0.612**
	(-4.18)	*(-5.14)*	*(-3.96)*	*(-2.64)*
Labour-Tax	-0.037***	-0.027***	-0.064***	-0.047**
	(-3.38)	*(-3.13)*	*(-2.73)*	*(-2.03)*
Capital-Tax	-0.021**	-0.017**	-0.009	-0.005
	(-2.44)	*(-2.23)*	*(-0.49)*	*(-0.19)*
Other-Tax	0.345**	0.356***	0.151	0.109
	(2.60)	*(2.82)*	*(1.36)*	*(0.81)*
Mixed-Tax	-0.049***	-0.045***	-0.099***	-0.070*
	(-6.77)	*(-8.47)*	*(-3.49)*	*(-1.92)*
Overall-Tax	-0.034	-0.039**	-0.005	-0.003
	(-1.63)	*(-2.36)*	*(-1.05)*	*(-0.88)*
Control Variables Selected Via Backwards Stepwise Regression				
SE	-1.147***	-1.219***	-0.651***	-0.528***
	(-4.19)	*(-4.80)*	*(-4.95)*	*(-3.45)*
Labour-Tax	-0.040***	-0.028***	-0.057**	-0.038*
	(-5.28)	*(-3.45)*	*(-2.32)*	*(-1.74)*
Capital-Tax	-0.023***	-0.018**	-0.005	-0.001
	(-2.86)	*(-2.58)*	*(-0.24)*	*(-0.07)*
Other-Tax	0.414**	0.434**	0.135	0.126
	(2.43)	*(2.64)*	*(1.23)*	*(0.87)*
Mixed-Tax	-0.051***	-0.046***	-0.085***	-0.052***
	(-6.91)	*(-8.86)*	*(-2.81)*	*(-3.09)*
Overall-Tax	-0.046***	-0.051***	-0.002	0.000
	(-3.88)	*(-4.07)*	*(-0.53)*	*(0.18)*

Note: The top panel reports the results of estimating Equation (1.10) 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 1.9: 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***	-1.024***	-0.647***	-0.525**
	(-4.02)	*(-4.70)*	*(-4.22)*	*(-2.48)*
Prediction-Negative	-0.045**	-0.038**	-0.085**	-0.108***
	(-2.44)	*(-2.31)*	*(-2.25)*	*(-2.91)*
Prediction-Positive	-0.001	0.005	0.062**	0.060**
	(-0.11)	*(0.43)*	*(2.07)*	*(2.03)*
Labour-Tax	-0.031**	-0.020	-0.023	-0.011
	(-2.42)	*(-1.48)*	*(-0.82)*	*(-0.43)*
Capital-Tax	-0.015	-0.009	0.026	0.027
	(-0.97)	*(-0.62)*	*(1.16)*	*(1.07)*
Other-Tax	0.285**	0.313**	0.154	0.111
	(2.21)	*(2.48)*	*(1.39)*	*(0.87)*
Mixed-Tax	-0.045***	-0.038***	-0.062*	-0.035
	(-3.13)	*(-2.82)*	*(-2.20)*	*(-0.99)*
Overall-Tax	-0.031	-0.031	-0.000	0.001
	(-1.21)	*(-1.52)*	*(-0.02)*	*(0.18)*
	Control Variables Selected Via Backwards Stepwise Regression			
SE	-0.925***	-0.997***	-0.623***	-0.402***
	(-3.89)	*(-4.28)*	*(-5.03)*	*(-2.94)*
Prediction-Negative	-0.039***	-0.040***	-0.089**	-0.112***
	(-6.56)	*(-3.29)*	*(-2.60)*	*(-5.61)*
Prediction-Positive	-0.012	0.007	0.063**	0.070***
	(-1.29)	*(0.53)*	*(2.08)*	*(3.55)*
Labour-Tax	-0.041***	-0.021	-0.023	0.010
	(-4.57)	*(-1.47)*	*(-0.78)*	*(0.48)*
Capital-Tax	-0.022**	-0.008	0.021	0.046***
	(-2.48)	*(-0.59)*	*(0.89)*	*(3.02)*
Other-Tax	0.316*	0.368**	0.145	0.075
	(2.00)	*(2.38)*	*(1.33)*	*(0.60)*
Mixed-Tax	-0.055***	-0.037***	-0.050*	-0.017
	(-6.26)	*(-2.97)*	*(-1.79)*	*(-0.95)*
Overall-Tax	-0.048***	-0.026**	0.001	0.005***
	(-4.03)	*(-2.07)*	*(0.33)*	*(4.42)*

The results are only slightly less supportive of growth theory when the tax type variables are added to the specification. Table 1.9 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, I consider the random effects estimator to be more reliable, so that the results from Table 1.9 are generally consistent with those from Table 2.7.

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 1.9, Bottom panel, Column 1) to a maximum of 0.194 (Table 1.7, Bottom panel, Column 4), with a midpoint value of approximately 0.11.

Let me 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, my 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 1.1, Labour and Capital taxes are commonly classified as distortionary, while Consumption taxes are classified as non-distortionary.

Table 1.8Table 1.8 estimates a meta-regression with the tax type variables but with prediction variables omitted, while Table 1.9 includes both. As the omitted category is Consumption taxes, I 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 1.8 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 1.9), 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 1.8, Top panel, Column 3) to 0.010 (Table 1.9, 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, my 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 1.8 regressions, they are insignificant in the preferred *Random Effects* estimations. When the prediction variables are added, the respective coefficients are generally insignificant (cf. Table 1.9). One of the regressions even produces a significant positive coefficient (bottom panel, *Random Effects-Weight2*). As a result, I conclude that the evidence that Capital taxes are more distortionary than Consumption taxes is mixed.

Bayesian model averaging of control variables. In order to address one of the main objectives of this study I now turn to an analysis of the control variables. The problem is that other than the two sets of tax variables, there are 28 control variables and it is not clear which ones should be included. In other words, multicollinearity is an issue with the inclusion of so many variables. 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 1.9, only 5 of the 28 control variables are statistically significant at the 5 percent level. In contrast, when a general-to-specific (G-to-S) approach is used -- in this case, backwards selection -- only 9 of the 28 control variables are significant (cf. bottom panel of Table 1.9). Further, one of the variables that is significant in the top panel is not significant in the bottom panel's specification. Thus, variable selection matters when trying to determine the effect of various control variables on estimated tax effects.

To tackle the problem of specification uncertainty, I use a technique called Bayesian Model Averaging, or BMA (Zeugner, 2011). BMA is not specifically designed for meta-regression studies. But because model uncertainty is an issue in these studies, it is an appropropriate method to apply. BMA runs a vast number of regressions with different subsets of the explanatory variables, and then constructs a weighted average over the set of estimated coefficients.

Table 1.10 reports the results of an analysis where I 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 with respect to the estimation procedure used. However, they are more consistent across analyses than would be the case, say, if I reported the results from specifications that included all variables and those that employed stepwise regression. I report results for both the "Fixed Effects (Weight 1)" and "Random Effects (Weight 2)" 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.

I report three summary measures. For each variable I compute a Posterior Inclusion Probability (*PIP*), which is the sum of posterior model probabilities of the regressions in which the variable is included. It can capture how well the model is designed and may be compared to the adjusted R^2, or to information criteria. With 28 control variables, there are 2^{28} potential regressions with various 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 values rather than the estimated coefficient in constructing a weighted average.

Table 1.10 uses yellow to highlight 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 1.4 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.

I find that studies that measure economic growth using total GDP (*GDP*) rather than per capita 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 are 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 as to how standard errors are calculated, 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, I 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, I again emphasize that the sizes of the associated effects are small.

Table 1.10: 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
Mid-Year	0.93	-0.003	0.00	1.00	-0.006	0.00

Variable	Fixed Effects(Weight1)			Random Effects(Weight2)		
	PIP	Post. Mean	Cond. Pos. Sign	PIP	Post. Mean	Cond. Pos. Sign
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 1.5 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.[12] 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 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 1.10 the figure also indicates the variable specifications of the top models. These closely match the *PIP* values in Table 1.10. The corresponding figure for the *Random Effects(Weight2)* estimator is quite similar and is reproduced in Appendix 1.7.

[12] 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*.

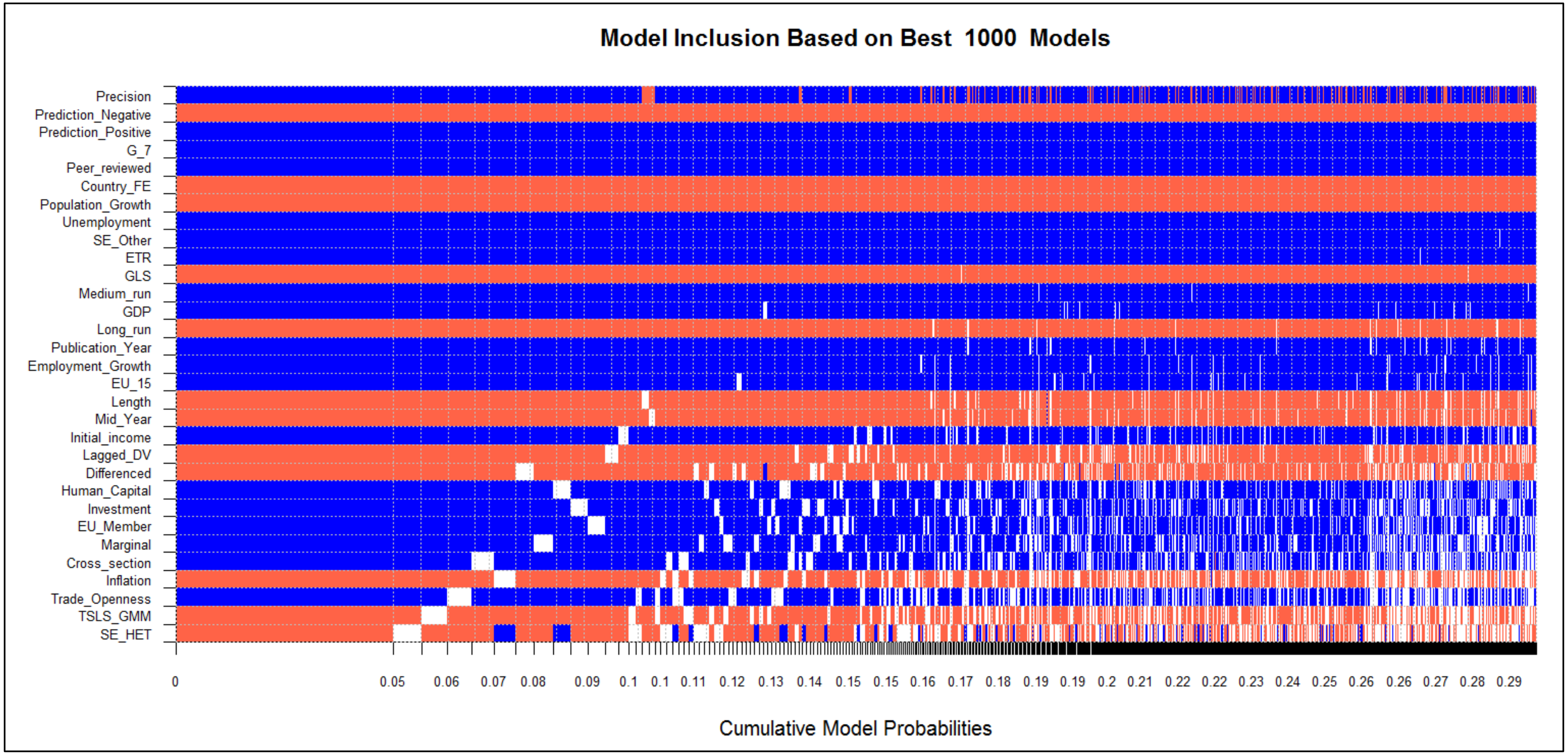

Figure 1.5: Visual Representation of BMA Analysis (Fixed Effects-Weight1)

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. A further detail about this plot is given in Zeugner (2011).

1.5. Conclusion

The effect of taxation on economic growth has been an enduring question. Despite the large body of research devoted to taxes and economic growth in OECD countries, the general picture that emerged from the empirical evidence is inconclusive. 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 fiscal 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 of 713 estimates from 42 studies, all of which attempt to estimate the effect of taxes on economic growth in OECD countries. I drop outlier estimates from both top and bottom of the sample range, and apply meta-analysis to analyse a final sample of 641 estimates. First, there is statistical evidence to support that estimates in the literature suffer from negative publication bias. Second, by accommodating and correcting 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 lumps together different tax policies.

Third, to provide a clear picture of the scope of tax policy to effect economic growth, I categorize tax policies by their predicted effects on economic growth according to the findings in public finance. Once I control for publication bias, increases in unproductive expenditures funded by distortionary taxes and/or deficits have a statistically significant, negative effect on economic growth. On the contrary, 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 my meta-regression analysis, I 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.

Fourth, with respect to particular types of taxes, I 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, I 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 great advantages of meta-analysis compared to the original studies and also narrative reviews is that it can avoid some of the problems associated with publication bias and selective reporting of results. Further, it can control for differences across studies that might otherwise mask significant effects. It can also add new information relevant to the literature (Stanley and Doucouliagos, 2013). This is particularly of interest when estimating the effects of tax policy. The results of this study indicate that once 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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1.7. Appendices

Appendix 1.1: 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 1.2: Letter to the Authors (OECD)

Dear Sir/Madam,

I am a Professor of economics at the University of Canterbury in New Zealand. We have a research team here undertaking a "meta-analysis" of the relationship between taxes and economic growth in the OECD countries.

A thorough meta-analysis involves collecting as many papers as possible on a subject, including unpublished research. The latter is known as "grey literature", and includes conference proceedings, reports from research firms or think thanks, theses and dissertations, etc. The unpublished literature is particularly important for addressing publication bias.

In this context, I am asking for your help.

Attached to this email is a listing of research on the topic of taxes and economic growth in the OECD countries. To be included, the research had to (i) include data from OECD countries (ii) have a dependent variable that was the growth of per capita personal income (PCPI) or GDP, and (iii) include one or more measures of taxes.

I am contacting you because you have researched in this area in the past.

Would you please look over this list and see if there are any notable omissions? I have broken the list down to the following categories: (i) journal articles, (ii) conference proceedings, (iii) studies from think tanks and research firms, (iv) theses/dissertations, and (v) working papers and unpublished research.

The last two categories are especially difficult to get information on. I would be greatly appreciative if you could identify any research we may have omitted.

Finally, if you are aware of any researchers who are currently researching in this area, it would be great if you could reply back with their names, and I will follow up with them directly.

I am sure you would agree that the subject of taxes and economic growth in OECD countries is very important. There is now a substantial enough literature that a careful meta-analysis can help to organize an empirical consensus of the existing literature.

Thank you so much for any help you can provide.

Sincerely,

Appendix 1.3: Bibliography (Attachment to the Above Letter)

Bibliography

(i) Journal Articles

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(ii) Conference Proceedings

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(iii) Studies from Think Thanks and Research Firms

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(iv) Theses/ Dissertations

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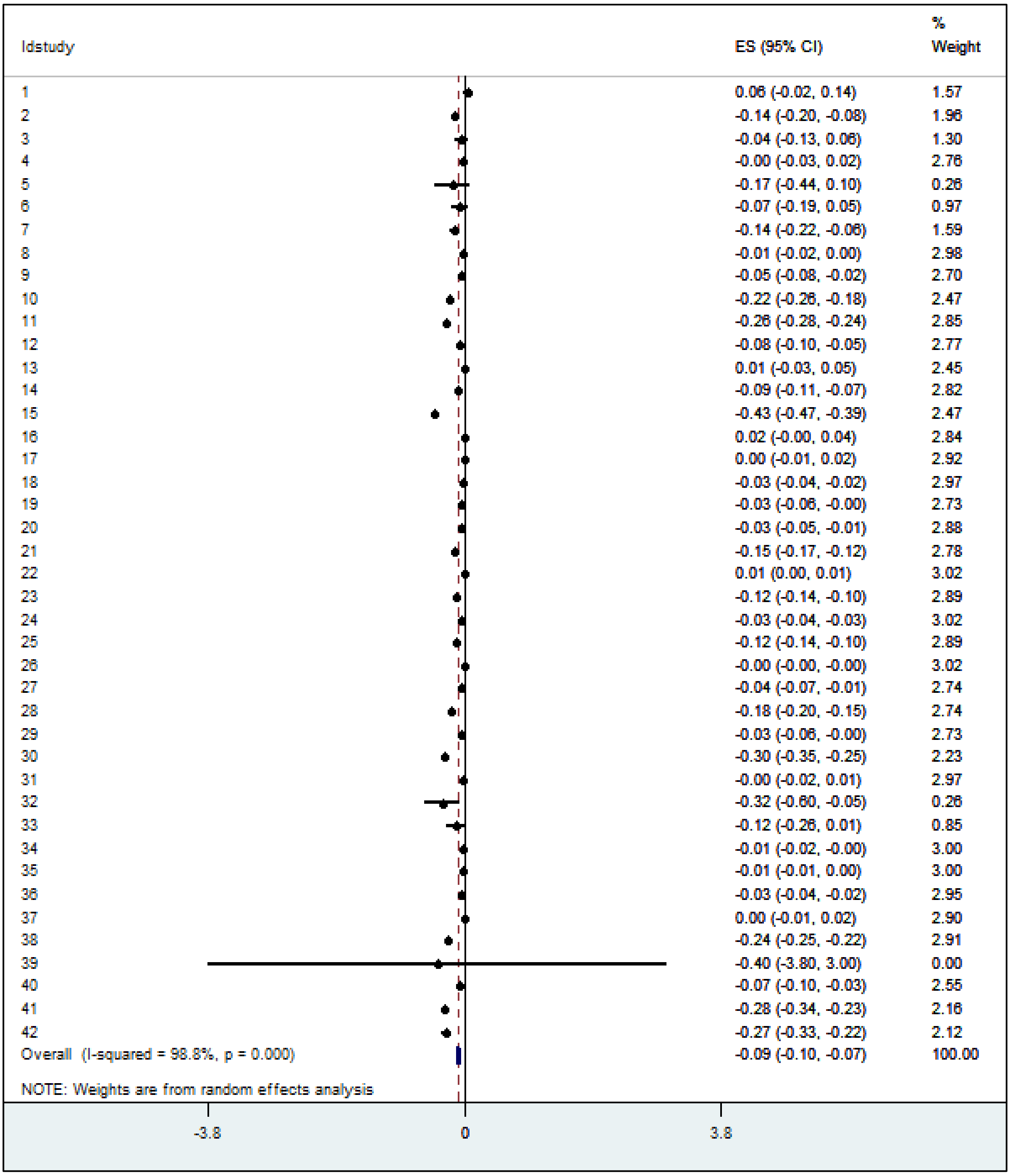
Appendix 1.4: Final Sample of Studies

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

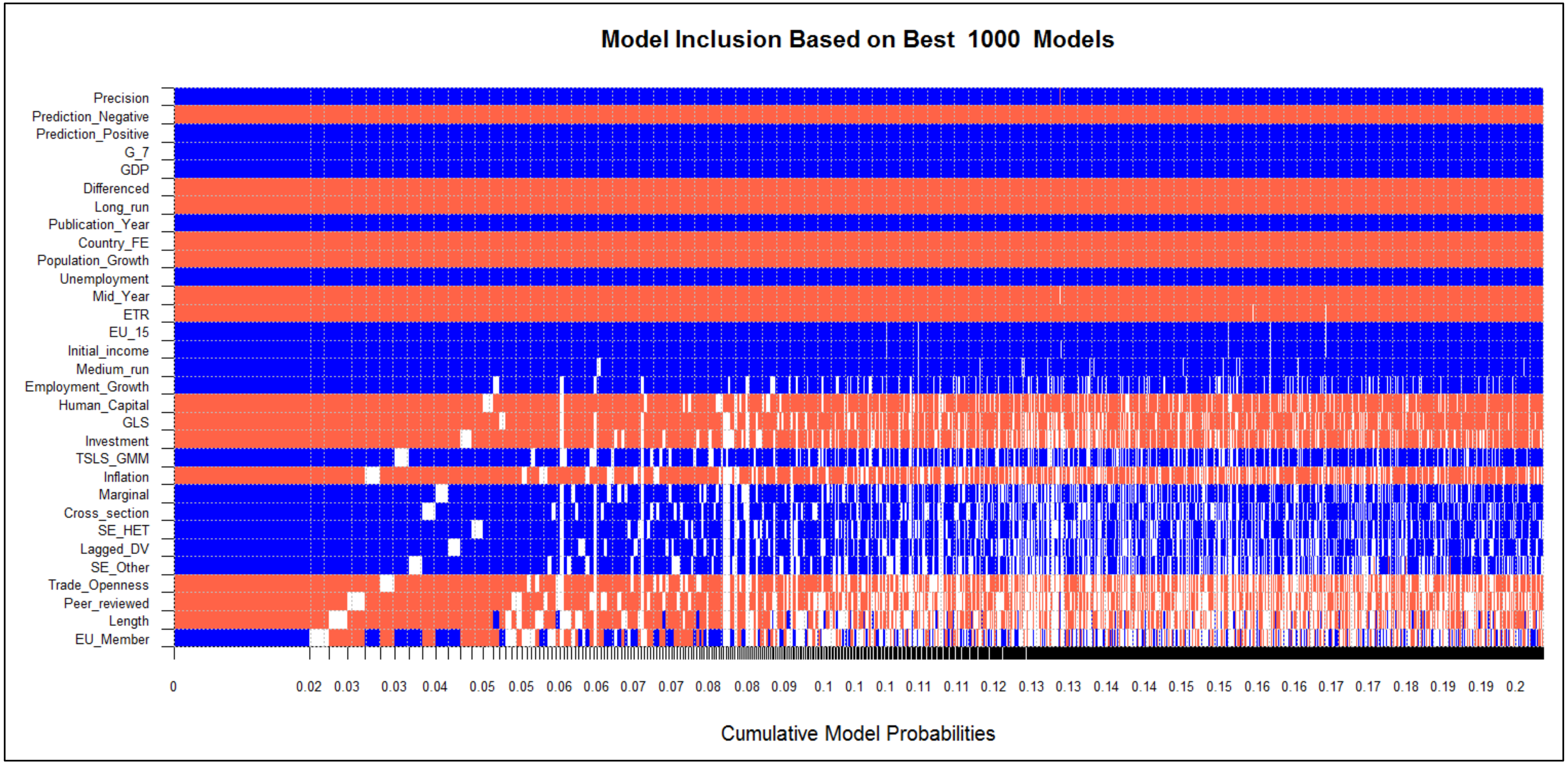
Appendix 1.5: List of Countries with Groupings

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 1.6: Forrest Plot of Studies (Random Effects)



Appendix 1.7: 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).