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**Working Paper**

## Do higher public debt levels reduce economic growth?

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## Working Paper 211 – Appendix

# Do Higher Public Debt Levels Reduce Economic Growth?

Philipp Heimberger





# Do Higher Public Debt Levels Reduce Economic Growth? - Online Appendix

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Data and code files to replicate the results reported in the paper are available here:  
<https://github.com/heimbergecon/pubdebt-growth>.

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## CONTENTS

Appendix A. Search strategy, data collection and standardisation for the meta-regression analysis as described in sections 3 and 4 .....	7
Appendix B. Primary studies included in the meta-analysis on the linear impact of public debt on growth in section 4 .....	10
Appendix C. Summary of variables included in the meta-regression analysis on the linear impact of public debt on growth in section 4 .....	13
Appendix D. Standardised coefficients vs. partial correlations .....	14
Appendix E. Further results on publication bias.....	16
Appendix F. Inclusion criteria for threshold estimates in section 5.....	17
Appendix G. Summary and descriptive statistics of all meta-regression variables on the threshold effects of public-debt-to-GDP on growth.....	18
Appendix H. Primary studies included in the threshold meta-analysis.....	19

## TABLES AND FIGURES

Table A1 / Studies included (n=33).....	10
Table A2 / Variables used in the meta-regression analysis in section 4.3.....	13
Table A3 / Non-linear tests of publication bias.....	16
Table A4 / Variables used in the meta-regression analysis in section 5.....	18
Table A5 / Studies included (n=22).....	19

Figure A1 / Flow of information through the different phases of the systematic review of the literature on the relationship between public debt and growth.....	8
Figure A2 / Consistent patterns of data for standardised coefficients and partial correlations .....	15

# Appendix A. Search strategy, data collection and standardisation for the meta-regression analysis as described in sections 3 and 4

## SEARCH STRATEGY AND DATA COLLECTION

We conducted a systematic search and review of the literature identifying all relevant primary studies concerning the impact of public debt on economic growth. In constructing the dataset, we took the following steps. To search for papers, we first used (i) Google Scholar and (ii) the EconLit database. We chose the following keywords in the search process: “Public debt + growth”; and “government debt + growth”. Furthermore, we used primary studies from the keyword search to screen their reference lists for further relevant papers. The criteria for inclusion in the meta-analytical dataset are as follows:

*Economic growth as the dependent variable and public-debt-to-GDP as an explanatory variable:* As a condition for being included in our dataset, papers used a measure of economic growth as the dependent variable and a measure of public-debt-to-GDP as an explanatory variable. Studies had to report results from some variant of the following generic econometric model (we ignore subscripts for brevity):

$$g = \alpha_0 + \alpha_1 D + \alpha_x Z_x + \varepsilon$$

where the dependent variable  $g$  is a measure of economic growth,  $D$  measures public debt-to-GDP,  $Z$  is a vector of other explanatory variables, and  $\varepsilon$  is the error term.

*Reported econometric estimates:* Only those empirical studies that presented regression results were considered. This restriction excludes papers that only present theoretical analysis, descriptive statistics or qualitative surveys concerning the literature on the link between public debt and growth.

*Time and language restriction:* We only included estimates published prior to May 2021 in English language.

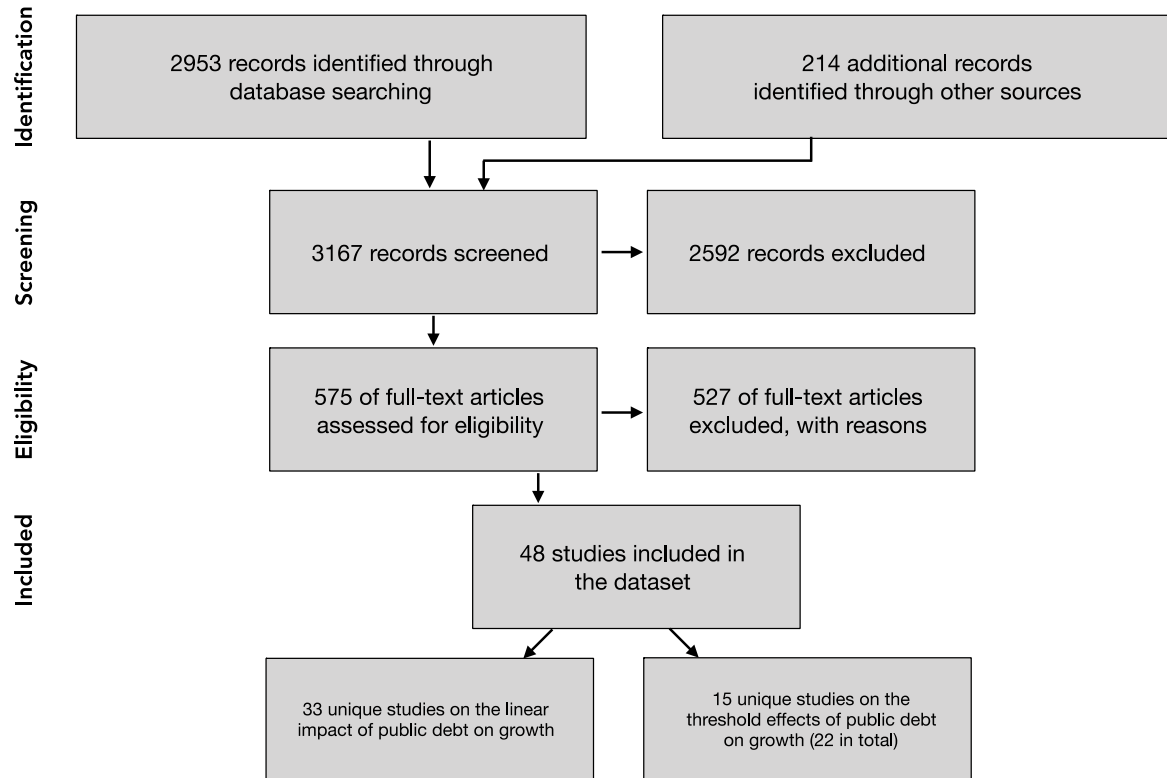
*Offered relevant statistics:* A paper had to meet certain reporting standards in order to be included in the dataset. The basic requirement was that the paper must have offered regression output (correlation coefficients and standard errors or t-statistics) from which standardised measures of the impact of public debt on growth could be computed.

Thirty-three papers were compatible with these criteria. We included all estimates from these papers that met the criteria of inclusion explained above, yielding a total of 566 estimates for the meta-study dataset. Appendix B lists the 33 primary studies that were included.

As a summary, Figure A1 presents the PRISMA flow chart for conducting the search and coding of the literature concerning the impact of corporate taxes on economic growth.



**Figure A1 / Flow of information through the different phases of the systematic review of the literature on the relationship between public debt and growth**



Source: own illustration.

To make the size of coefficients on the linear impact of public debt on growth comparable, we performed corrections and standardisations in two steps. First, our reference point for the dimension of the reported regression coefficient is that a one percentage point increase in the public-debt-to-GDP ratio is associated with an  $x$  percentage point change in the GDP growth rate (as in Cecchetti et al. 2011 or Woo and Kumar 2015). All divergent dimensions of regression coefficients were transformed into this structure by using the descriptive statistics reported in the underlying paper. Furthermore, when a study (e.g. Eberhardt and Presbitero 2015; Gomez-Puig and Sosvilla-Rivero 2018) calculates an effect of the public-debt-to-GDP ratio on the long-run level of GDP (instead of the growth rate), we transformed this value into a growth rate effect by assuming a conservative 10-year transition period to the new steady state, thus dividing the reported percentage change by a factor of 10.

The second step concerned addressing interaction terms or squared terms related to the public-debt-to-GDP variable in the underlying model specification. If such terms are included, we calculate the average marginal effect of public debt on growth and use the delta method to approximate the respective standard errors (e.g. Cazachevici et al. 2020, p. 3). This step increases comparability of studies that only consider a linear relationship between public debt and growth rates with studies that include a nonlinear relationship (by considering a squared term) or interactions of corporate tax rates with other factors.

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## Appendix B. Primary studies included in the meta-analysis on the linear impact of public debt on growth in section 4

**Table A1 / Studies included (n=33)**

Afonso and Jalles (2013)	Calderon and Rodrigo Fuentes (2013)	Kutivadze (2011)
Afonso and Alves (2015)	Cecchetti et al. (2011)	Megersa and Cassimon (2015)
Ahlborn and Schweickert (2018)	Ceh Casni et al. (2014)	Mencinger et al. (2014)
Akram (2011)	Eberhardt and Presbitero (2015)	Myatt and Liu (2015)
Akram (2015)	Fincke and Greiner (2015)	Ostry et al. (2015)
Ash et al. (2020)	Gomez-Puig and Sosvilla-Riveiro (2018)	Panizza and Presbitero (2014)
Baaziz et al. (2015)	Habimana (2017)	Sanusi et al. (2019)
Bal and Rath (2014)	Kourtellos et al. (2013)	Schclarek (2004)
Baum et al. (2013)	Kumar and Woo (2010)	Shah and Pervin (2012)
Bilan and Ihnatov (2015)	Kurecic et al. (2018)	Sosvilla-Riveiro and Gomez-Puig (2019)
Bonga et al. (2015)	Kurihara (2015)	Woo and Kumar (2015)

Notes: Studies published prior to May 2021 were included. Criteria of inclusion are described in the text.

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## Appendix C. Summary of variables included in the meta-regression analysis on the linear impact of public debt on growth in section 4

The table below presents a summary of the meta-regression variables included in the meta-regression analysis of the linear impact of the public-debt-to-GDP ratio on economic growth in section 4.3.

**Table A2 / Variables used in the meta-regression analysis in section 4.3**

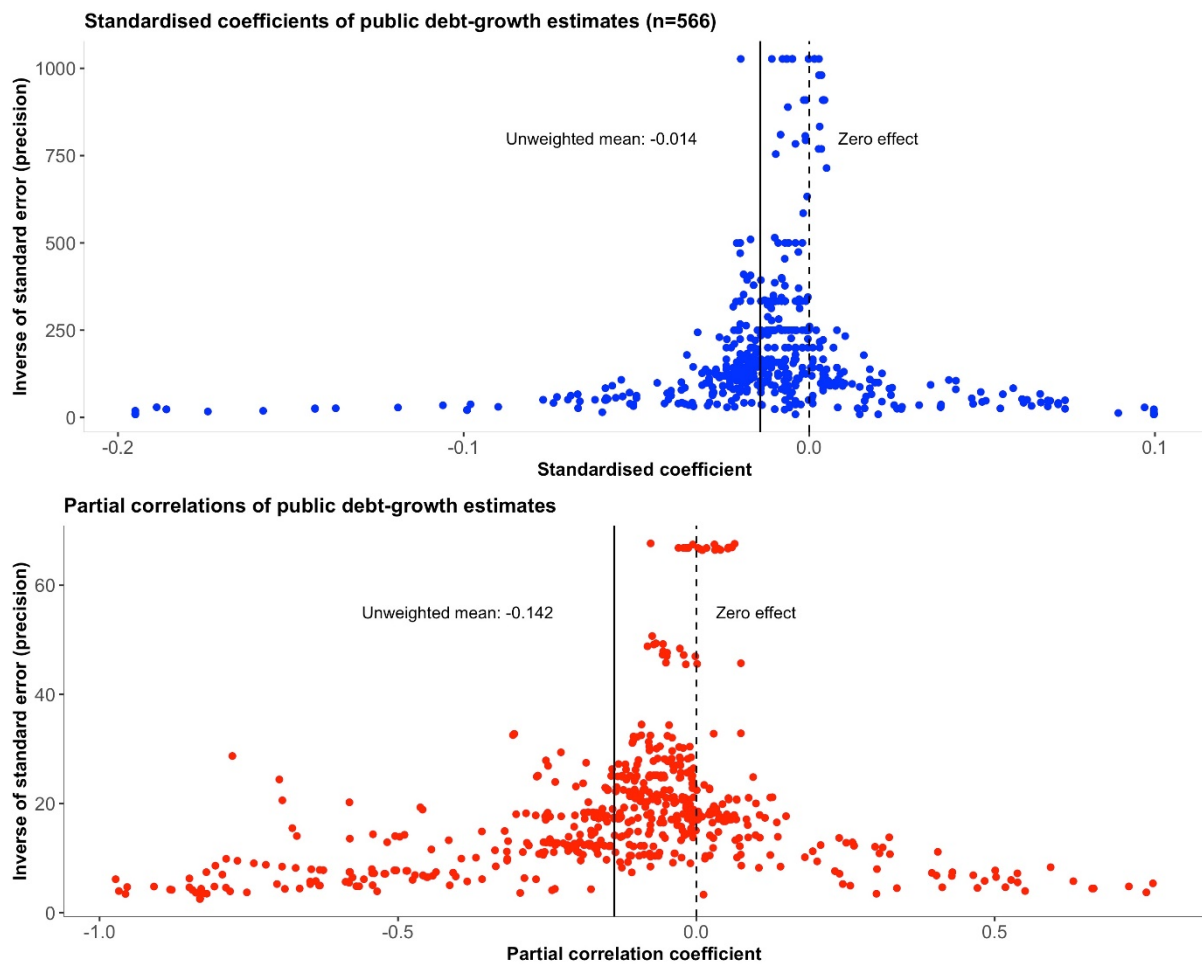
Variable name	Variable description	(N=566)	
		Mean	S.D.
SC	Standardised coefficient based on taking the steps explained in section 3; interpretation: a 1 percentage point increase in public-debt-to-GDP is associated with an x percentage point change in economic growth	-0.014	0.046
PCC	Partial correlation coefficient of economic growth with public-debt-to-GDP	-0.142	0.293
StandardErrorCorrected	Standard error of SC	0.015	0.021
StandardErrorPCC	Standard error of PCC	0.086	0.068
<b>Country composition</b>			
AdvancedCountries (reference)	BD=1: Only advanced countries included in the data	0.535	0.499
DevelopingCountries	BD=1: Only developing countries included in the data	0.150	0.358
MixofCountries	BD=1: Mix of advanced and developing countries included in the data	0.314	0.465
<b>Data and estimation details</b>			
LongRunExplicit	BD=1: Estimate explicitly looks at long-run effects of public debt on growth. E.g. via ECM/PMG models or multi-year averages	0.290	0.454
ShortRunExplicit	BD=1: Estimate explicitly looks at short-run effects of public debt on growth. E.g. via ECM or ARDL models	0.138	0.345
HorizonOther (reference)	BD=1: Study does not clearly state the horizon of the underlying estimate or horizon remains ambiguous	0.572	0.495
CrossSection	BD=1: Cross sectional data used	0.035	0.185
GrowthPerCapita	BD=1: Dependent variable (economic growth) defined in per capita terms	0.730	0.444
LaggedPublicDebt	BD=1: Explanatory variable (public debt) introduced as a lag to address reverse causality	0.286	0.452
TacklingEndogeneity	BD=1: Econometric approach addresses endogeneity between public debt and growth by using instrumental variables	0.292	0.455
<b>Publication characteristics</b>			
MeanYearData	The mean year of the underlying data sample minus the mean year over all studies	-4.82e <sup>-14</sup>	13.370
JournallmpactFactor	Journal impact factor normalised to a range between 0 and 1	0.267	0.361
Citations	Natural logarithm of the number of citations	4.437	2.101
<b>Additional control variables</b>			
Investment	BD=1: Investment included as control	0.376	0.485
Inflation	BD=1: Inflation included as control	0.420	0.494

Notes: BD means binary dummy, which takes the value of 1 if the condition is fulfilled and zero otherwise.

## Appendix D. Standardised coefficients vs. partial correlations

This section reports the distribution of reported results for our alternative standardised effect size, the partial correlation coefficient, and the corresponding precision estimates, where the latter are calculated as the inverse of the standard errors of the partial correlations. Section 3.2 presents information on how the partial correlation can be calculated based on the information reported in primary studies, and why it does not offer a clear-cut interpretation concerning the economic relevance of the size of the partial correlations.

Figure A2 shows consistent patterns of the data for standardised coefficients and partial correlations. For both effect measures, we find that more imprecise estimates are located on the left side of the plot where results on a negative impact of public debt on growth are to be found. The unweighted mean of the partial correlation is -0.142, indicating a small-to-moderate negative impact of public debt on growth (Doucouliagos 2011). However, the weighted mean of the partial correlation coefficient of -0.055 is significantly smaller than the unweighted mean since the most precise estimates are closer to zero. According to the interpretation guidelines in Doucouliagos (2011), a partial correlation of -0.055 very small and difficult to distinguish from zero, which is consistent with our other findings.

**Figure A2 / Consistent patterns of data for standardised coefficients and partial correlations**

Note: The upper panel is a replication of Figure 2, showing the standardised coefficients against the inverse of the corresponding standard error (n=566). The lower panel provides the same analysis for the partial correlations. The solid vertical lines in both panels show the unweighted mean of the standardised coefficient; the dotted vertical lines indicate the zero effect lines.

Source: Own calculations.

## REFERENCE

Doucoulagos, H. (2011): How large is large? Preliminary and relative guidelines for interpreting partial correlations in economics, Deakin University Working Paper SWP 2011/5.



## Appendix E. Further results on publication bias

This table reports results based on two non-linear tests for publication bias.

**Table A3 / Non-linear tests of publication bias**

	(1)	(2)	(3)
	<b>Unw. avg</b>	<b>Ioannidis et al. (2017)</b>	<b>Furukawa (2019)</b>
Mean beyond bias	0.014**	-0.002	0.002
Publication bias	(0.005)	(0.001)	(0.001)

Note: The table reports the resulting mean beyond bias of two non-linear approaches to detecting publication bias. The dependent variable is the standardised coefficient of the effect of public-debt-to-GDP ratios on economic growth rates. Column (1) serves as a comparison and shows the unweighted average (Unw. Avg) of the standardised coefficient, tested against zero. Column (2) focuses on the top 10% of observations with the smallest standard error as suggested by Ioannidis et al. (2017). Column (3) employs the “stem” method proposed in Furukawa (2019). Standard errors clustered at the study level are in parentheses. \*\* refers to statistical significance at the 5% level.

Source: Own calculations.

## Appendix F. Inclusion criteria for threshold estimates in section 5

As a condition for being included in the dataset on threshold effects of the public-debt-to-GDP ratio on growth, papers had to report a single public-debt-to-GDP threshold which growth is reduced (i.e. multiple threshold models are excluded). There are two main econometric approaches for doing so. The first is to include a squared public-debt-term in the regression specification and estimate the debt turning point based on this (e.g. Cecchetti et al. 2011; Checherita and Westphal 2012). The second approach is to estimate an endogenous (panel) threshold model (e.g. Baum et al. 2013; Proaño et al. 2014; Egert 2015). Since almost all primary studies providing estimates on public-debt-to-GDP thresholds do not report standard errors around the threshold point estimates or corresponding t-values, we use the square root of the sample as a proxy for precision (e.g. Stanley and Doucouliagos 2012; Gechert 2015). Therefore, a main criterion for inclusion in the dataset was that studies had to report at least one public-debt-to-GDP threshold estimate and the underlying sample size. All the other criteria for inclusion are the same as those explained in Appendix A.

Twenty-two papers were included in the dataset on thresholds, yielding a total of 260 estimates. Appendix H lists the 22 primary studies that were included.

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## Appendix G. Summary and descriptive statistics of all meta-regression variables on the threshold effects of public-debt-to-GDP on growth

The table below presents a summary of the meta-regression variables included in the meta-regression analysis of threshold effects of the public-debt-to-GDP ratio on economic growth in section 5.

**Table A4 / Variables used in the meta-regression analysis in section 5**

Variable name	Variable description	(N=260)	
		Mean	S.D.
Threshold	Threshold in the public-debt-to-GDP ratio beyond which growth is estimated to slow (in % of GDP)	59.790	33.061
SEProxy	Inverse of the square root of the sample size	0.073	0.035
<b>Country composition</b>			
AdvancedCountries (reference)	BD=1: Only advanced countries included in the data	0.704	0.457
DevelopingCountries	BD=1: Only developing countries included in the data	0.046	0.210
MixofCountries	BD=1: Mix of advanced and developing countries included in the data	0.25	0.434
<b>Data and estimation details</b>			
SquaredTerm	BD=1: Threshold estimates by including a squared public debt term	0.354	0.479
GrowthPerCapita	BD=1: Dependent variable (economic growth) defined in per capita terms	0.411	0.493
LaggedPublicDebt	BD=1: Explanatory variable (public debt) introduced as a lag to address reverse causality	0.092	0.290
TacklingEndogeneity	BD=1: Econometric approach addresses endogeneity between public debt and growth by using instrumental variables	0.235	0.425
<b>Publication characteristics</b>			
MeanYearData	The mean year of the underlying data sample minus the mean year over all studies	0.096e <sup>-14</sup>	31.769
JournalImpactFactor	Journal impact factor normalised to a range between 0 and 1	0.364	0.364
Citations	Natural logarithm of the number of citations	1.781	1.781
<b>Additional control variables</b>			
Investment	BD=1: Investment included as control	0.358	0.480
Inflation	BD=1: Inflation included as control	0.419	0.494

Notes: BD means binary dummy, which takes the value of 1 if the condition is fulfilled and zero otherwise.

## Appendix H. Primary studies included in the threshold meta-analysis

**Table A5 / Studies included (n=22)**

Afonso and Alves (2015)	Caner et al. (2010)	Mencinger et al. (2014)
Arcabic et al. (2018)	Cecchetti et al. (2011)	Mupunga and le Roux (2015)
Baaziz et al. (2015)	Checherita-Westphal and Rother (2012)	Padoan et al. (2012)
Baglan and Yoldas (2013)	Chiu and Lee (2017)	Proaño et al. (2014)
Baum et al. (2013)	Egert (2015a)	Vranceanu and Besancenot (2013)
Bentour (2021)	Egert (2015b)	Yang and Su (2018)
Bilan and Ihnatov (2015)	Kutivadze (2011)	
Butkus and Seputienne (2018)	Lee et al. (2017)	

Notes: Studies published prior to May 2021 were included. Criteria of inclusion are described in the text.

Note that 7 of these 22 primary studies were already included in the meta-dataset on the linear impact of public debt on economic growth (see Appendix B). The other 15 primary studies are unique.

### REFERENCES (THE PRIMARY STUDIES INCLUDED IN THE THRESHOLD META-ANALYSIS)

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