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Public Debt and Growth in U.S. States

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PUBLIC DEBT AND GROWTH IN U.S. STATES*

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Abstract

The relationship between public debt and economic growth is a highly contentious issue. This paper examines the relationship between public debt and medium-term economic growth by applying semi-parametric methods to a panel of U.S. states. Partially linear models demonstrate that the relationship between debt and growth is non-linear. Although some borrowing may be beneficial, higher levels of debt exert a negative impact on growth. The principal implication of these results is that public debt may be acting as a drag on growth for U.S. States. The presence of nonlinearities and a negative relationship between debt and growth at a sub-national level suggests that this relationship may also operate at a national level.

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I. Introduction

The relationship between public debt and economic growth is a highly contentious issue, especially in an environment where many countries simultaneously suffer from high levels of public debt and slow growth. Academic and policy debate on the impact of public debt became more intense after Reinhart and Rogoff (2010) argued that levels of public debt above a threshold of 90 per cent of GDP are associated with materially weaker real GDP growth. This has led to much further research and controversy, particularly due to a discovery by Herndon, Ash and Pollin (2013) of elements in Reinhart and Rogoff's analysis that affect the quality of their conclusions.

This recent research has informed political debate on sovereign debt and austerity measures in Europe, Japan, the U.S. and other countries. Policy makers frequently refer to Reinhart and Rogoff's debt threshold finding as justification for austerity measures. Those who oppose this view, such as Krugman (2013), argue that weak growth is a major cause of high levels of debt and therefore the policy priority should be on increasing growth rather than reducing debt. This has been particularly important in the aftermath of the 2008-09 financial crisis during which debt levels have increased and growth has slowed. Policy makers have had to choose between austerity measures to reduce sovereign debt or further spending to stimulate growth.

Theoretical literature identifies several channels through which government debt can influence growth. In a basic model that exhibits "Ricardian Equivalence" government debt has no impact on growth because private savings move to exactly offset changes in government saving (Barro, 1974). However, the imposition of distortionary taxes to repay debt can lower output (Barro, 1979). In models where short-run output is demand-driven, fiscal deficits have a positive short-run effect on disposable income, aggregate demand and output (Elmendorf and Mankiw, 1999). In the long-run, the decrease in public savings is unlikely to be fully compensated by an increase in private savings, leading to a decrease in national savings and a reduction in investment domestically or abroad, lowering national income (Elmendorf and Mankiw, 1999).

DeLong and Summers (2012) have a more optimistic view of the potential of fiscal policy and argue that expansionary fiscal policy may even have long-run benefits by avoiding 'hysteresis'. They further propose that in a low interest rate environment, expansionary fiscal policy can even be self-financing. Others have found that fiscal multipliers are greater during recessions (see Auerbach and Gorodnichenko (2010), Mittnik and Semmler (2012) and Fazzari, Morley, and Panovska (2013)). The impact of fiscal policy has also been found to depend on the fiscal outlook, the presence of planned spending cuts and whether monetary policy is at the zero lower bound. (Corsetti, Kuester, Meier, & Müller, 2010).

Others take a more pessimistic view of even the short-term impact of fiscal policy. Cochrane (2011) argues that government debt increases uncertainty or leads to expectations of future problems such as inflation and can therefore have a negative effect in the short run. The importance of financial market stress for the effectiveness of fiscal policy has been increasingly appreciated (Mittnik and Semmler (2013), Afonso, Baxa, and Slavik (2011) and Brunnermeier and Sannikov (2014)), as has monetary union membership (De Grauwe and Ji (2013) and Proaño, Schoder, and Semmler (2014)).

These conflicting theoretical arguments provide powerful reasons to pay close attention to empirical studies. The vast majority of empirical studies of the relationship between public debt and growth are at the national level, and employ a wide variety of econometric techniques and specifications. Many papers do find some evidence of a negative relationship between debt and growth: Kumar and Woo (2010), Cecchetti, Mohanty, and

Zampolli (2011), Baglan and Yoldas (2013). Pescatori, Sandri, and Simon (2014) also find a negative impact on growth but only over short horizons, raising the risk that causality ran from growth to debt.

Several papers directly confront this causality issue which may generate a negative bias for OLS estimates of the effect of debt on growth: Kumar and Woo (2010) and Checherita-Westphal and Rother (2012) both conclude that high debt levels retard growth; while Panizza and Presbitero (2014) and Lof and Malinen (2014) find no significant causal relationship. Ferreira (2014) uses a sample of EU countries between 2001 and 2012 to find that public debt contributes positively to growth.

Much of the empirical literature tests for non-linearities in the relationship between debt and growth, commencing with Reinhart and Rogoff's (2010) debt threshold finding. Kumar and Woo (2010) fit a spline regression and find evidence of nonlinearity, with debt levels above 90 per cent having a significant negative effect on growth. Cecchetti et al. (2011) test a range of possible thresholds and find a threshold debt-to-GDP ratio of 96 per cent. Checherita-Westphal and Rother (2012) include a quadratic term for the debt-to-GDP ratio and find a negative impact of debt once it reaches 90-100 per cent of GDP. Égert (2013) uses nonlinear threshold models to find that negative effects kick in at much lower levels of government debt (20 to 60 percent of GDP), but also finds that results are sensitive to time periods, country coverage, and data frequency. Baum, Checherita-Westphal, and Rother (2013) apply the dynamic threshold panel methodology of Caner and Hansen (2004) to 12 euro area countries for 1990-2010. They find a positive short-run impact of some debt on GDP growth, but additional debt beyond 95 per cent of GDP has a negative impact. Minea and Parent (2012) find more complex non-linearities, with high levels of debt eventually having a positive association with growth.

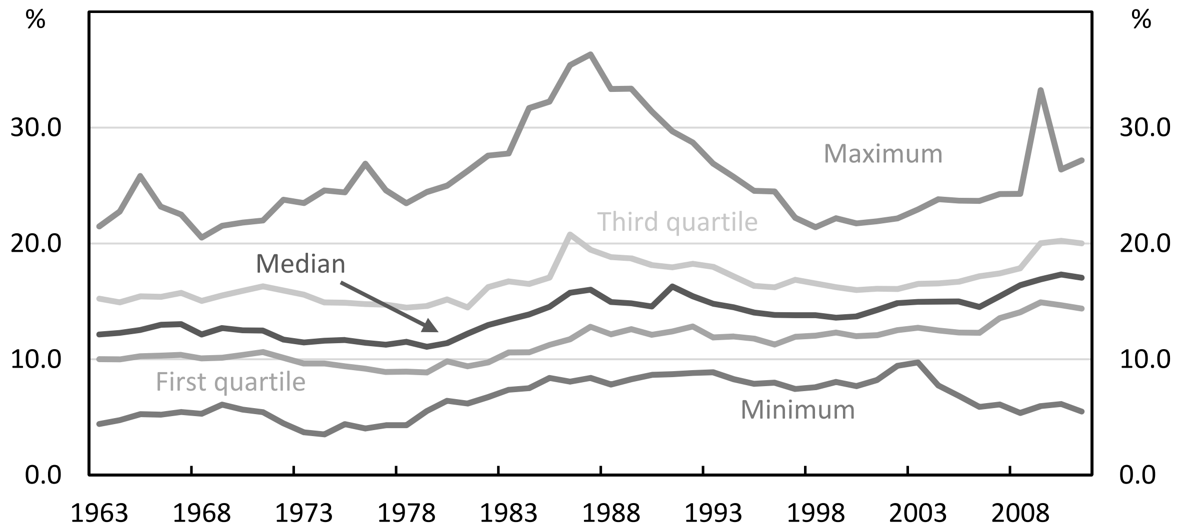
Heterogeneity of the impact of debt across time and countries is the focus of one strand of the empirical literature. Proaño, Schoder and Semmler (2014) argue that financial stress is a crucial source of non linearity between debt and economic activity and find that at high levels of financial stress, the debt-to-GDP ratio negatively affects growth regardless of the level of debt. Eberhardt and Presbitero (2013) find evidence of non-linear relationships between debt and long-run growth, but with much heterogeneity across countries and time. Kourtellos, Stengos, and Tan (2013) find lower thresholds in countries with low institutional quality.

Panizza and Presbitero (2013) propose that future research should focus on sources of heterogeneity across countries and time periods. Studying U.S. states is a means of removing a substantial amount of heterogeneity between the studied regions. In particular, there is greater consistency in economic conditions, including a common currency, no monetary policy tools, similar inflation rates, and less diversity in financial distress. Studying US states also alleviates substantial concerns about data construction. Dippelsman, Dziobek, and Mangas (2012) make the simple point that public debt statistics are not constructed according to internationally accepted methods, and find several examples where public debt-to-GDP ratios for a country range from 40 to over 100 per cent depending on the definition used. U.S. state debt data are measured consistently across states. Other advantages include a more transparent legal structure to enforce debt repayment, and significantly greater factor mobility between states that could hasten any effects of debt on growth.

These advantages have to be weighed against the disadvantages of studying the effects of public debt at a sub-national level. The key disadvantage is that U.S. states are not independent nations and although state-level results are valuable in their own right, we need to be cautious in extrapolating results to nations. The amount of debt that a state can incur with minimal growth penalty might be quite different than for a nation. But since some of the same underlying mechanisms are at work, evidence of a growth penalty at the state level provides strong evidence that there is also a growth penalty at the national level.

One concern with studying U.S. states is the impact of balanced budget requirements. Almost all states have them, but different stringency of the rules (Poterba and Rueben, 1999) enable many states to accumulate substantial debts. The variation in state debt-to-GDP ratios (including local government debt) over time is highlighted in Figure I. Between 1963 and 2011, state debt-to-GDP ratios have ranged between 3.5 per cent and 36.3 per cent with a mean of 14.2 per cent and a standard deviation of 4.4 per cent.

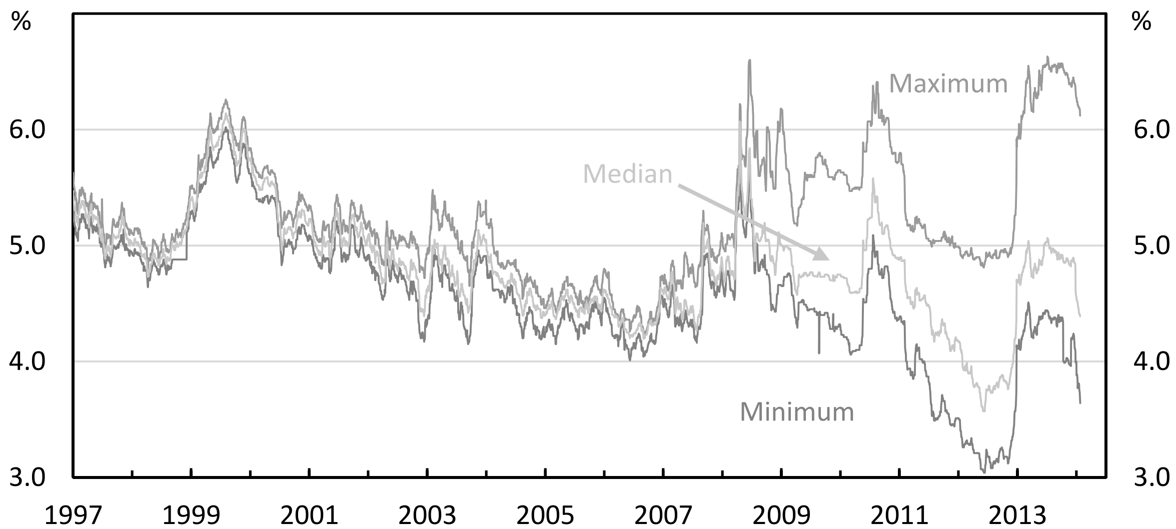
FIGURE I
STATE DEBT-TO-GDP RATIOS*



*Sources: US Census Bureau, BEA.

Debt levels can be sufficiently high for financial market participants to envisage a real risk of default, so that state borrowing rates can vary not just over time but also between states. Credit ratings have historically ranged from a high of AAA to a low of BBB (California in 2003 and Massachusetts in 1989-1991). Using limited 30-year yield data from 1997 for a sample of between 18 and 20 U.S. states, the variation in yields over time are shown in Figure II. Yields have ranged from a low of 3.04 per cent for Virginia in December 2012 to a high of 6.63 per cent for Pennsylvania in January 2014. On June 30 2014, yields ranged from a low of 4.00 per cent for Virginia to a high of 6.27 per cent for Pennsylvania. The variation in yields, both before and after the 2008-09 financial crisis, suggests that state yields do incorporate a positive risk premium. The substantial widening of risk premia that came with the crisis was a significant by-product of the decline in state finances and the general market-wide reduction in risk tolerance during the financial crisis. The implication of the variation in credit ratings and yields is that state debt is not perceived to be fully guaranteed by the federal government. Even if there were to be a federal government bail-out, it is likely that this would be associated with some loss to bondholders and/or future repayment requirement through higher taxes in the future. In other words, economic agents should be mindful of state debt.

FIGURE II
30-YEAR STATE GOVERNMENT BOND YIELDS*



*Data are for a sample of 18-20 states for which yield data were available. Source: Bloomberg.

Applying semi-parametric methods allows for a more robust examination of the nonlinearities in the relationship between public debt and growth. While research on the relationship between public debt and economic growth informs us about factors that might cause debt to affect growth, there is no settled functional form for this relationship. If parametric specifications do not match the true functional form in the relationship between public debt and growth, they will suffer from misspecification bias. Semi-parametric approaches allow the data to direct the key relationships of interest, reducing the size of any misspecification bias, although at the expense of reduced efficiency. Although these methodologies impart few constraints on the relationship between public debt and growth, previous theoretical and empirical papers still inform the parametric component of the empirical specifications, including the growth regression framework and the selected control variables.

The most closely related paper is Gray and Stone (2012), who use a quadratic functional form to study the relationship between state debt and fiscal policy on growth. They find that growth in real per-capita personal income is positively related to debt for debt-to-personal-income ratios under 40 percent, but negatively related to additional debt.[1] This result needs to be interpreted with caution, as the maximum debt-to-personal income ratio in their data is only 42.7 percent, and the "negative" relationship for high debt levels may be an artifact of the quadratic specification or the omission of initial income per capita and population growth variables that are commonly included in growth regressions. A preliminary working paper by Wu (2014) also estimates a quadratic relationship using just three years of regional Chinese data. Wu reports a debt threshold of 35 percent of GDP, a figure exceeded by just one Chinese province.

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[1] This "40 percent" finding is reported in the working paper version available at http://mpra.ub.uni-muenchen.de/39731/. The online-journal version omits the finding and reports estimates too imprecisely to enable calculation. The interaction term involving debt and deficit may be the reason for the omission in the online journal.

Several papers study the relationship between other aspects of U.S. state public finance and growth and tend to indicate that public finance is an important determinant of growth: Reed (2008) and Goff, Lebedinsky, and Lile (2012) study taxation policies; Reed (2009) and Alm and Rogers (2011) study taxes and expenditures; Alesina and Bayoumi (1996) and Stone (2014) study the impact of balanced budget rules; and Horváth, Moore, and Rork (2014) examine the impact of federal aid to U.S. states.

There are no papers studying public debt and growth using partially linear models. Greiner and Fincke (2015) apply a non-parametric method using penalized splines to examine the relationship between public debt and growth in seven advanced economies. They find a negative, non-linear relationship but they do not incorporate control variables into the non-parametric analysis. Imbs and Ranciere (2005) apply Robinson's (1988) double-residual estimator to find an external debt overhang effect for developing countries.

The remainder of the paper is organized as follows: Section II describes the data and methodology; Section III presents and discusses the results; and Section IV concludes.

II. Methodology

Data Sources

We obtained data on state and local finances from the U.S. Census Bureau's Annual Survey of State and Local Government Finances and Census of Governments for 1957-2011. The series include total debt outstanding, total revenue, total taxation revenue, total expenditure, revenue from the federal government and total interest on debt. For each state we sum state and local government values. State government values are exact while local government values use survey data for non-census years (census years end with 2 or 7). Local finance data were not available for 2001 or 2003 and so these were linearly interpolated using the 2000, 2002 and 2004 values. We used total debt outstanding instead of net debt since sinking fund data were unavailable for 13 years throughout the dataset. There were no data on pension obligations.

State nominal GDP data are from the Bureau of Economic Analysis (BEA) for 1963-2013. There is a break in the data in 1997 when the BEA moved from the SIC industrial classification to NAICS. In 1997 the data are available under both classifications: we use the growth rates from the SIC series for 1963-1997 to extrapolate the NAICS estimates for 1997-2013. We also obtain annual state personal income and population data from the BEA for 1929-2013.

We construct state real GDP series by deflating state nominal GDP with the BEA's national GDP deflator. State-level deflators are only available from 1987. Reed (2008) and Alm and Rogers (2011) also use this approach and note that measurement error in the growth rate of real GDP will arise where relative purchasing power parity (PPP) does not hold between the states.

We report summary statistics for each included variable for the 48 contiguous states for five-year periods commencing 1963-2008 in Table I.

TABLE I
SUMMARY STATISTICS

	N	Mean	Std. dev.	Min	Max
5-year forward real per capita GDP growth rate (%)	2208	0.020	0.017	-0.076	0.110
State govt debt (% of GDP)	2208	0.140	0.044	0.035	0.363
State govt spending ex. Interest (% of GDP)	2208	0.157	0.028	0.086	0.264
State govt balance (% of GDP)	2208	0.008	0.013	-0.040	0.190
Log real GDP per capita	2208	10.276	0.339	9.276	11.298
Population growth (%)	2208	0.011	0.011	-0.060	0.128
State govt revenue from federal govt (% of GDP)	2208	0.030	0.011	0.007	0.106

Notes. All state finance variables are state and local government totals. Values marked as % are in decimal form.

Econometric Framework

We estimate a partially linear model of the following form:

$$g_{i,t+1,t+5} = F(DEBT_{i,t}) - \phi \ln(y_{i,t}) + \beta \mathbf{X}_{i,t} + \tau_t + \nu_i + \varepsilon_{i,t+1,t+5} \quad (1)$$

The regressand $g_{i,t+1,t+5}$ is the five-year average forward change in log state real GDP per capita $y_{i,t}$ calculated as $g_{i,t+1,t+5} = (y_{i,t+5} - y_{i,t})/5$; $F(DEBT_{i,t})$ is a general function of the ratio of state and local debt to state GDP; $\mathbf{X}_{i,t}$ is a set of control variables; τ_t is a full set of year fixed-effects; and ν_i is a full set of state fixed effects.

The parametric component follows several papers examining the relationship between public debt and growth at a national level, particularly Cecchetti et al. (2011), Checherita-Westphal and Rother (2012), and the baseline OLS regression of Panizza and Presbitero (2014). These are based on conditional convergence growth equations in the tradition of Barro (1991) with the addition of the debt-to-GDP ratio to determine whether debt has an impact on growth. Conditional convergence equations are derived from the neoclassical growth model of Solow in which real per capita income growth depends on the initial level of physical and human capital, converging to its steady state slowly over time.

Panizza and Presbitero (2013) discuss the choice of the length of the growth episode and the interaction of these episodes over the sample. One-year growth maximizes the number of observations but can be driven too much by business cycle fluctuations. Therefore, five-year growth is the common choice. The model used in this paper uses five-year overlapping growth periods to maximize efficiency and to avoid arbitrarily selecting years with non-overlapping periods. Five-year non-overlapping periods are used as a robustness check.

The key technical innovation in this paper is the application of semi-parametric econometrics. This specification takes the form of a partially linear model where the non-debt control variables are included linearly and the debt term takes a non-parametric form.

$F(DEBT_{i,t})$ represents the potentially non-linear relationship between debt and growth. We enter other control variables parametrically to avoid the curse of dimensionality when estimating multiple non-parametric relationships and to focus on the relationship between debt and growth.

We apply four estimation methods to three sets of regressors. The first method is a commonly applied panel fixed-effects regression with debt entered linearly. This is equivalent to least squares dummy variable (LSDV) estimation. The second method applies Robinson's (1988) double-residual estimator to equation (1) with debt entered non-parametrically and with state and time fixed effects. For a textbook treatment of this method see Ahamada and Flachaire (2010). The third method utilizes first-differencing on the linear specification as a means of incorporating the state fixed-effects. The fourth method uses the panel fixed-effects estimator for a partially linear model from Baltagi and Li (2002) which also utilizes first-differencing. The sample for the first two estimation methods includes five-year periods starting 1963-2008, with sample size of 2208 where $N = 48$ and $T = 46$. With first differencing, the sample size is reduced to 2160 with $N = 48$ and $T = 45$.

When applied to static panel data models with fixed-effects, both LSDV estimation and first-differencing produce consistent estimates of the linear model. LSDV estimation tends to be more efficient when errors are serially uncorrelated while first-differencing tends to be more efficient when errors follow a random walk (Woolridge, 2002). Our overlapping growth periods are sure to induce a high level of serial correlation, so we apply both methods. All standard errors are clustered at the state level. Similar considerations apply to the semi-parametric methods. Both semi-parametric estimators use local polynomials of degree four, Epanechnikov kernels and a rule-of-thumb bandwidth estimator which minimizes the conditional weighted mean integrated squared error.

Using log real GDP per capita as a regressor makes our empirical specification a dynamic fixed-effects panel data model. LSDV estimates may be biased downwards even as *N* approaches infinity. However, the estimates are consistent in *T* with bias of order *O(1/T)*. Alternative estimators to achieve consistency require instrumental variable (IV) or generalized method of moments (GMM) estimation such as Arellano and Bond (1991) or Blundell and Bond (1998). Cecchetti et al. (2011) argue that these methods are not suited to macroeconomic panel data sets which have moderate *N* and *T* and are also subject to weak instrument problems. Panizza and Presbitero (2013) criticize the identification strategy in such methods where internal instruments, such as lags of debt or the debt of all other states, are applied. Given the lack of a suitable instrument for debt at a U.S. state level and our intention to focus on the application of semi-parametric methods to U.S. states, we do not address the downwards bias and simply note that we have a reasonably long time-series which substantially reduces the bias.

The conditional convergence framework and prior national-level studies inform our selection of regressors. The first set of regressors includes log real state GDP per capita as a proxy for initial capital; state population growth to measure potential labor force growth; revenue from the federal government received by state and local governments as a proportion of GDP to account for external revenue sources which are allocated by federal agencies; and the state debt-to-GDP ratio.

The second set of regressors also includes combined state and local government spending excluding interest payments as a proportion of GDP in addition to the variables in the first set of regressors. This variable accounts for automatic stabilizers and discretionary spending decisions made by state and local governments. Interest expenses are excluded because the interest burden is an important means through which debt can affect growth. Government spending is influenced by the business cycle and its coefficient should be interpreted with caution, but it is still useful to control for any short-run effects of government spending on growth when studying the effect of debt on growth. It is difficult to isolate the parts of government budget that are purely discretionary due to state budget balance rules.

The third set of regressors also includes combined state and local government budget balances as a proportion of GDP. Since government spending can be funded either by taxes or borrowing, the budget balance variable controls for the impact of marginal funding decisions on growth, holding government spending constant. It could also be thought of as a measure of the trajectory of debt. This set of regressors allows the examination of the extent to which the level of debt impacts on growth, holding constant government spending and the debt trajectory.

State and time fixed-effects have been incorporated into all specifications either directly or using first-differences. The state fixed-effects allow the model to capture systematic variation between states and to focus only on changes in debt within states over time rather than emphasizing differences between states where unobservable factors may be affecting debt or growth levels. The time fixed-effects capture systematic variation between years which is essential in order to account for changes in the rate of technological progress; changes federal U.S. debt; or other factors that affect growth in all states. Hausman specification tests suggest that random effects models are inappropriate.

We omitted several control variables used in previous national-level studies due to data availability; concern that debt may affect growth through these channels given that labor and capital is mobile between states; or limited variation of these factors across states. Gross state savings; educational attainment; population age structure; the inflation rate; and openness to trade are omitted.

We conduct Hardle and Mammen (1993) tests to assess the value of using our partially-linear model as opposed to estimating the relationship between debt and growth parametrically using a polynomial functional form. This test compares the non-parametric and parametric regression fits for a given polynomial using the squared deviations between them, obtaining critical values using a wild bootstrap simulation. This test is applied using both quadratic and cubic parametric estimators and using 500 simulations. Due to limitations in the statistical software, *Stata*, this test was only conducted for the double-residual estimator of Robinson (1988). An overview of *Stata* commands for the semi-parametric estimation and associated tests can be found in Verardi and Debarsy (2011) and Libois and Verardi (2013).

III. Results

We present results for each of the four estimation methods applied to each of the three sets of regressors in Tables II and III and Figure III. Figure III contains six graphs showing the non-parametric fit of the debt-to-GDP variable in the growth regression. The graphs plot each of the data points with the non-parametric fit shown as a solid line, bounded by shaded 95 per cent confidence bands. The difference between the mean predicted growth rates of the double-residual estimator and the first-difference estimator is simply due to the first-differences estimator not including the mean growth rate in the function $F\left(DEBT_{i,t}\right)$.

Parametric Regressions

For parametric regressions using the first set of regressors with neither government spending nor budget balance included (column (1) in *Tables II* and *III*), the estimated effect of debt on growth is negative and significant. In the fixed-effects parametric regression, the coefficient of -0.070 implies that a ten percentage point increase in the debt-to-GDP ratio is associated with an average decrease in annual real per capita GDP growth of 70 basis points.

In the first-differenced parametric regression, the coefficient is smaller, with the same change in debt being associated with an average 24 basis point reduction in annual growth. These values are economically meaningful and are larger than the linear relationships for national debt estimated in Kumar and Woo (2010) and Cecchetti et al. (2011) of 20 and 18 basis points respectively.

We report results for parametric regressions with the second set of regressors including government spending in column 3 in *Tables II* and *III*. For the fixed-effects method, the estimated effect of debt on growth is now not quite significant at the 5 percent level and slightly smaller in magnitude, with a 10 percentage point increase in the debt-to-GDP ratio lowering growth by 46 basis points. For the first-differencing method, the result is very similar to before, with a 10 percentage point increase in the debt-to-GDP ratio lowering growth by 20 basis points. Overall, debt is still negatively associated with growth even when government spending is held constant. Column 5 in Tables II and III contains results for parametric regressions with the full set of regressors including the government budget balance. The results are very similar to those in column 3 with debt exerting a negative effect on growth.

Semi-Parametric Regressions

The semi-parametric regressions suggest that there is a non-linear relationship between debt and growth. Figure III contains graphs of the estimated relationship between debt and growth – the relationship is similar in each of the six semi-parametric regressions. Debt appears to have a significant, positive relationship with growth up until a relatively low level of about eight per cent of GDP. States that are too reluctant to borrow appear to suffer a growth penalty. Beyond this, increases in debt are associated with decreases in growth. This effect moderates over time until a point is reached, between 20 and 25 per cent of GDP, where the standard errors are too large to make reliable inferences on the impact of further debt. The simple reason for the wide standard errors at higher debt levels is the paucity of observations. Moving from the fairly low debt ratio of 10 percent of GDP to the fairly high ratio of 20 percent of GDP detracts about 80 basis points from growth, with estimates ranging from 74 basis points for the double-residual estimator with the full set of control variables (column 6 in Table II and bottom-left panel of Figure III) to 99 basis points for the double-residual estimator with just the basic set of control variables (column 2 in Table II and top-left panel of Figure III).

The existence of nonlinearities in the relationship between debt and growth can be visually assessed using these graphs. If one can draw a straight line which stays within the marked confidence intervals, then one cannot reject that the relationship is linear. In none of the six graphs is it possible to draw such a line. It is difficult to visually assess whether a polynomial would have appropriately estimated the relationship parametrically, which is the rationale for the use of Hardle-Mammen tests. The p-values for the Hardle-Mammen tests, presented in Table II, are all less than 0.05. This implies that the hypothesis that a quadratic or cubic parametric specification would have been more appropriate than the semi-parametric regressions is rejected at a five per cent level of significance. This provides support for the application of semi-parametric regressions in this context and suggests that estimating polynomial specifications for the relationship between debt and growth could lead to misspecification bias.

As robustness checks, some variations on the semi-parametric regressions were conducted, with descriptions and results presented in the Appendix. Our results from these regressions show that the results are robust to using personal income in place of GDP, although the magnitude of the effect of debt on growth is smaller (Appendix Figure II). The results are also robust to using five-year non-overlapping growth periods rather than five-year overlapping periods (Appendix Figure III). Furthermore, they are robust to using different subsamples of years within the dataset (Appendix Figures IV and V). We studied alternative measures of the debt burden, and these regressions also supported the existence of a negative relationship between debt and growth beyond modest debt burdens (Appendix Figures VI, VII, and VIII).

Implications of Results

The partially linear model demonstrates the presence of a significant, non-linear relationship between public debt and growth for U.S. states that has important implications for U.S. state government policy. One interesting implication of the results is that states should not struggle too hard to ensure that they have no debt as very low debt levels are associated with inferior growth outcomes. This association deserves further study, but it may be that when states move to eliminate most debt they curtail productive investments. But this should not be interpreted as a license to accumulate large debts. Beyond quite modest debt ratios, further debt appears to cause slower growth.

These results have important implications for the relationship between public debt and economic growth at a national level. The presence of a negative relationship between public debt and growth at a U.S. state level (beyond a modest debt level) increases the likelihood of there being such a negative relationship at a national level. Since there are some differences in the channels through which debt can affect growth for U.S. states compared to nations, the turning point and magnitude of the relationship is likely to differ, but it is likely that there is a level of national debt beyond which further debt reduces growth. The nonlinearities may even be stronger at a national level if high debts take a toll on financial market confidence, because resulting high domestic interest rates or lending constraints would further reduce investment. Our results also suggest that national debt studies should apply flexible functional forms such as partially linear models, as simple parametric polynomial specifications could be subject to misspecification bias. Furthermore, partially linear models would likely reveal that the standard errors of predicted growth at very high levels of debt are extremely large, placing important constraints on the inferences that should be drawn.

These results assist in identifying some areas for future research on the relationship between public debt and growth. An ideal extension on this research at a U.S. state level would be to find a suitable instrument for state public debt and incorporate it into the semi-parametric analyses – the methods of utilizing an instrument are discussed in Ahamada and Flachaire (2010). Another strand of research at a U.S. state level could apply semi-parametric methods to examine other aspects of state finances such as government spending and taxation as well as the nonlinearities and interactions between these variables and debt. One could also examine whether the relationship between public debt and growth has varied over time as financial markets have developed, as well as during financial crises. This approach may become more practical as more data for the years following the 2008-09 financial crisis become available and as more state debt yield data become available. Finally, the partially linear models applied in this paper could be applied to national data.

TABLE II

OVERLAPPING REGRESSIONS OF FIVE-YEAR AVERAGE REAL STATE PER CAPITA GDP GROWTH WITH FIXED-EFFECTS

	(1) Parametric	(2) Semi-parametric	(3) Parametric	(4) Semi-parametric	(5) Parametric	(6) Semi-parametric
State govt debt (% of GDP)	-0.070**	non-parametric	-0.046*	non-parametric	-0.045*	non-parametric
	(0.027)		(0.024)		(0.025)	
State govt spending ex. Interest (% of GDP)			-0.299***	-0.301***	-0.277***	-0.277***
			(0.078)	(0.078)	(0.085)	(0.086)
State govt balance (% of GDP)					0.071	0.075
					(0.061)	(0.059)
Log real GDP per capita	-0.095***	-0.096***	-0.112***	-0.114***	-0.111***	-0.112***
	(0.014)	(0.014)	(0.016)	(0.016)	(0.017)	(0.017)
Population growth (%)	-0.030	-0.033	-0.097	-0.099	-0.100	-0.102
	(0.105)	(0.104)	(0.096)	(0.096)	(0.098)	(0.098)
State govt revenue from federal govt (% of GDP)	0.246*	0.247*	0.660***	0.662***	0.625***	0.625***
	(0.129)	(0.133)	(0.157)	(0.166)	(0.163)	(0.173)
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
State fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
First-differencing	No	No	No	No	No	No
N	2208	2208	2208	2208	2208	2208
R^2	0.493	0.520	0.515	0.541	0.516	0.542
Hardle-Mammen test p-value (quadratic)		0.036		0.018		0.034
Hardle-Mammen test p-value (cubic)		0.048		0.016		0.020

Notes. Dependent variable: State 5-year real per capita GDP growth. All state finance variables are state and local government totals. Values marked as % are in decimal form. Standard errors are clustered at a state level. The parametric regression is estimated using a fixed-effects panel regression. The semi-parametric regression is estimated using Robinson's double residual estimator with debt entered non-parametrically, with local polynomial estimation of degree four, an epanechnikov kernel and a rule-of-thumb bandwidth estimator. Hardle-Mammen tests are conducted to compare the semi-parametric fit to a parametric quadratic or cubic fit, using a wild bootstrap with 500 simulations. ***, ** and * refer to coefficients statistically different from 0 at the 1%, 5% and 10% confidence levels, respectively.

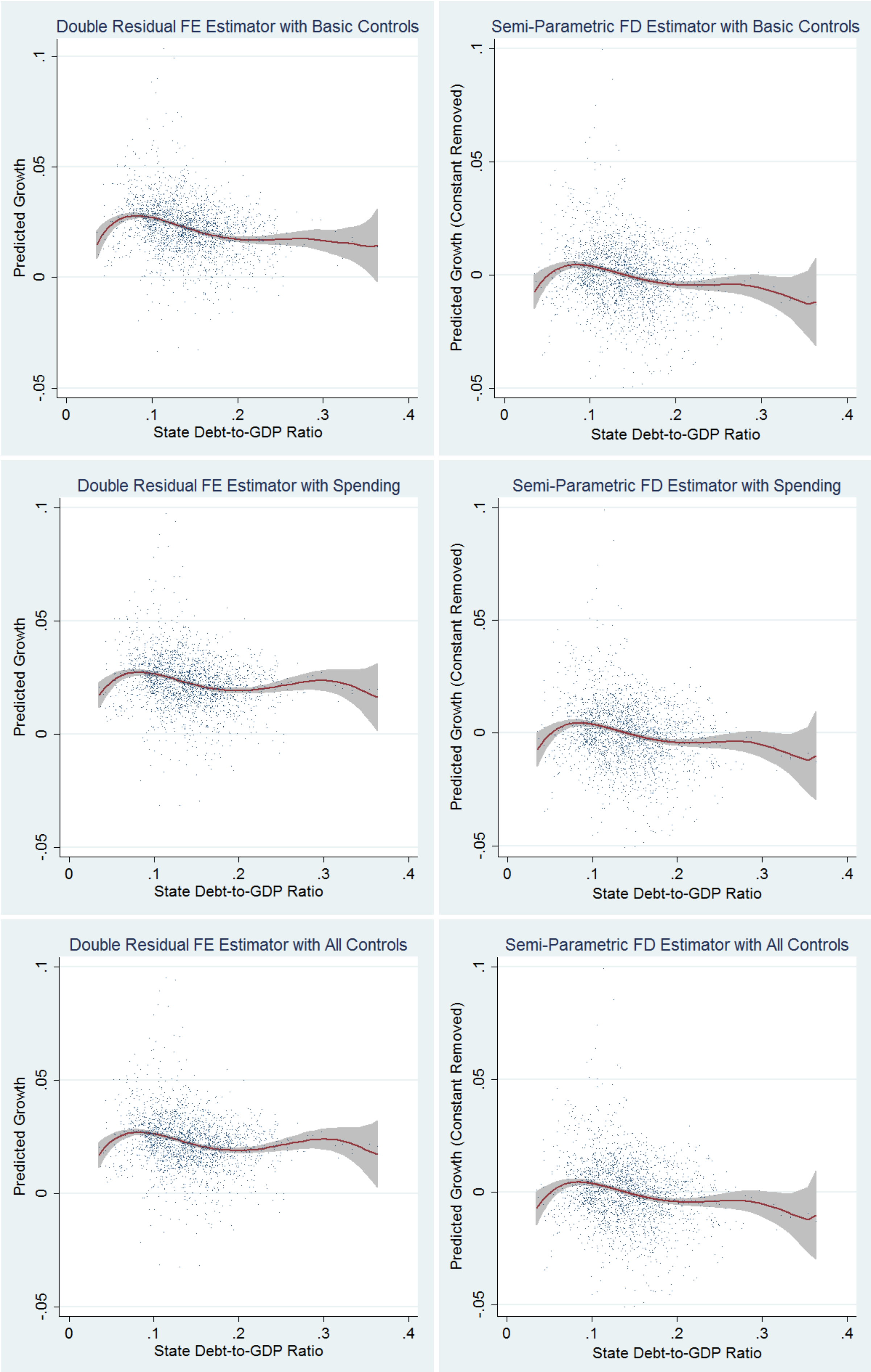
TABLE III

OVERLAPPING REGRESSIONS OF FIVE-YEAR AVERAGE REAL STATE PER CAPITA GDP GROWTH WITH FIRST-DIFFERENCING

	(1) Parametric	(2) Semi-parametric	(3) Parametric	(4) Semi-parametric	(5) Parametric	(6) Semi-parametric
State govt debt (% of GDP)	-0.024***	non-parametric	-0.020**	non-parametric	-0.020**	non-parametric
	(0.009)		(0.009)		(0.009)	
State govt spending ex. Interest (% of GDP)			-0.051*	-0.057**	-0.064**	-0.071**
			(0.027)	(0.024)	(0.029)	(0.027)
State govt balance (% of GDP)					-0.018	-0.019
					(0.011)	(0.012)
Log real GDP per capita	-0.205***	-0.203***	-0.211***	-0.210***	-0.212***	-0.212***
	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Population growth (%)	0.008	0.011	0.003	0.005	0.004	0.006
	(0.025)	(0.025)	(0.025)	(0.024)	(0.025)	(0.025)
State govt revenue from federal govt (% of GDP)	0.123	0.118	0.160	0.160	0.174	0.173
	(0.107)	(0.105)	(0.113)	(0.109)	(0.115)	(0.111)
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
State fixed-effects	No	No	No	No	No	No
First-differencing	Yes	Yes	Yes	Yes	Yes	Yes
N	2160	2160	2160	2160	2160	2160
R^2	0.694	0.696	0.695	0.697	0.695	0.697

Notes. Dependent variable: State 5-year real per capita GDP growth. All state finance variables are state and local government totals. Values marked as % are in decimal form. Standard errors are clustered at a state level. The parametric regression is estimated using a first-differenced panel regression. The semi-parametric regression is estimated using Baltagi and Li's panel fixed-effects estimator which utilizes first-differencing with debt entered non-parametrically, with local polynomial estimation of degree four, an epanechnikov kernel and a rule-of-thumb bandwidth estimator. ***, ** and * refer to coefficients statistically different from 0 at the 1%, 5% and 10% confidence levels, respectively.

FIGURE III – SEMI-PARAMETRIC REGRESSIONS OF PUBLIC DEBT ON REAL PER CAPITA GDP GROWTH



IV. Conclusion

This paper examined the relationship between public debt and medium-term economic growth by applying semi-parametric methods to a panel of U.S. states. The results demonstrate that the relationship between debt and growth is non-linear and that although some debt may be beneficial, there is a level beyond which debt begins to have a negative impact on medium-term growth. One implication is that states may achieve higher medium-term growth by seeking lower levels of public debt, on average, over the course of the business cycle. The results may also have important implications at the national level. While the exact nature and magnitude of the relationship between public debt and growth will differ between states and countries, our results provide general support for the existence of a negative relationship between public debt and medium-term growth beyond some level of debt.

Studying the nature of the relationship between debt and growth remains an important area of research. More detailed data collected on a consistent basis for U.S. states offers hope of learning more about some of the mechanisms through which debt affects growth. State level data also offer the hope of finding plausible instruments for debt to better identify causal relationships between debt and growth. Finally, the partially linear model is itself useful. It reduces the risk of misspecification bias, and also makes it extremely obvious if there is far too little data near any debt level to draw reliable inferences about the relationship between debt and growth. Given how much of the debate on national debt levels turns on a fairly small number of very high-debt episodes, it would be useful if the reliability of such inferences was made crystal clear.

V. Appendix: Robustness Checks

Appendix Figures I through VIII present graphs for semi-parametric regressions using seven alternative specifications, together with two graphs from our primary regressions for comparison. All control variables are used in these regressions. Appendix Figure I contains results from our primary regressions, which are the bottom two panels of Figure III in the main part of the paper. In Appendix Figure II we use personal income in place of GDP and real per capita personal income growth in place of real per capita GDP growth. Several U.S. state-level studies of the effects of aspects of state public finances such as Reed (2008) focus on personal income instead of GDP. The plotted relationship appears to be similar, although the magnitude of the effect is smaller compared to the original results. This implies that some of the effect of debt on growth comes from other components of state GDP such as the operating surplus of enterprises. We next report results using non-overlapping five-year growth periods in place of overlapping five-year growth periods in Appendix Figure III. Again, the plotted relationship appears to be similar to our primary results. Appendix Figure IV contains results when we restrict the sample to exclude the most recent ten years of data, while Appendix Figure V contains results when we exclude the first ten years of data. The results are qualitatively similar in both of these reduced sample periods, one of which omits the recent financial crisis while the other omits almost all years prior to the first oil shock.

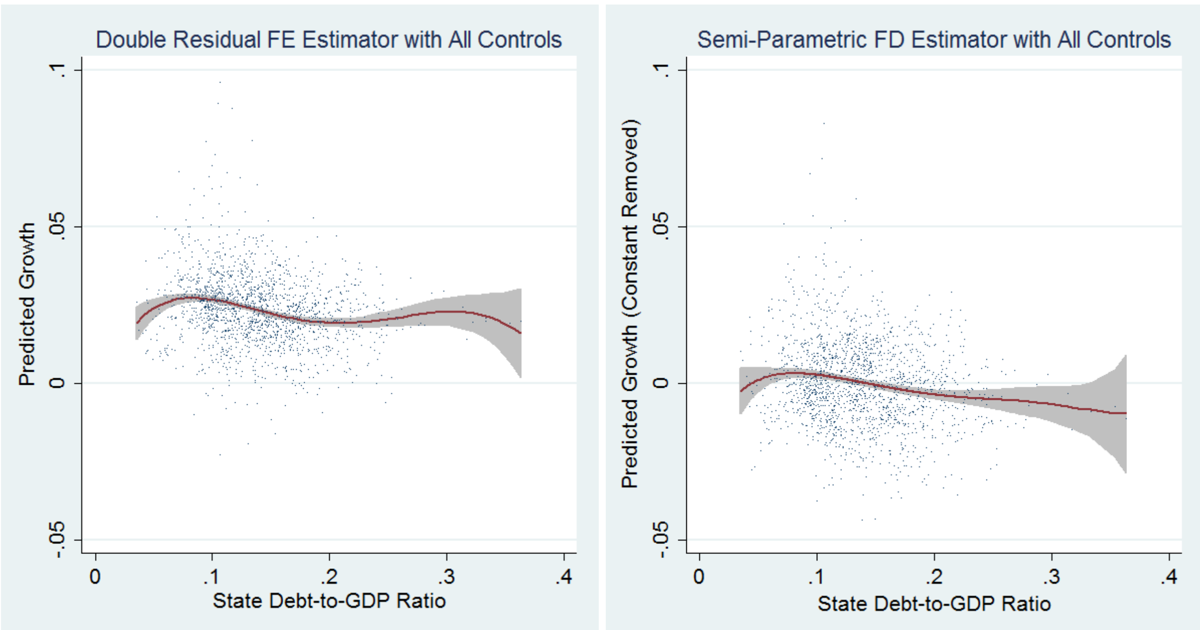
We next examine three alternative measures of the debt burden: the debt-to-revenue ratio, the interest-to-revenue ratio and the interest-to-GDP ratio. Measures of debt burden generally include a variable such as debt or interest as a numerator with a debt carrying capacity measure as the denominator, such as state government revenue or GDP. We report the graphs from the semi-parametric regressions in Appendix Figures VI through VIII with the debt burden measured by: state debt to government revenue; state interest payments to government revenue; and state interest payments to GDP. The results mostly support the proposition that above a modest debt burden, further debt has a negative impact on growth.

APPENDIX FIGURE I – ORIGINAL SEMI-PARAMETRIC REGRESSIONS (FOR COMPARISON)

APPENDIX FIGURE II – SEMI-PARAMETRIC REGRESSIONS REPLACING GDP WITH PERSONAL INCOME

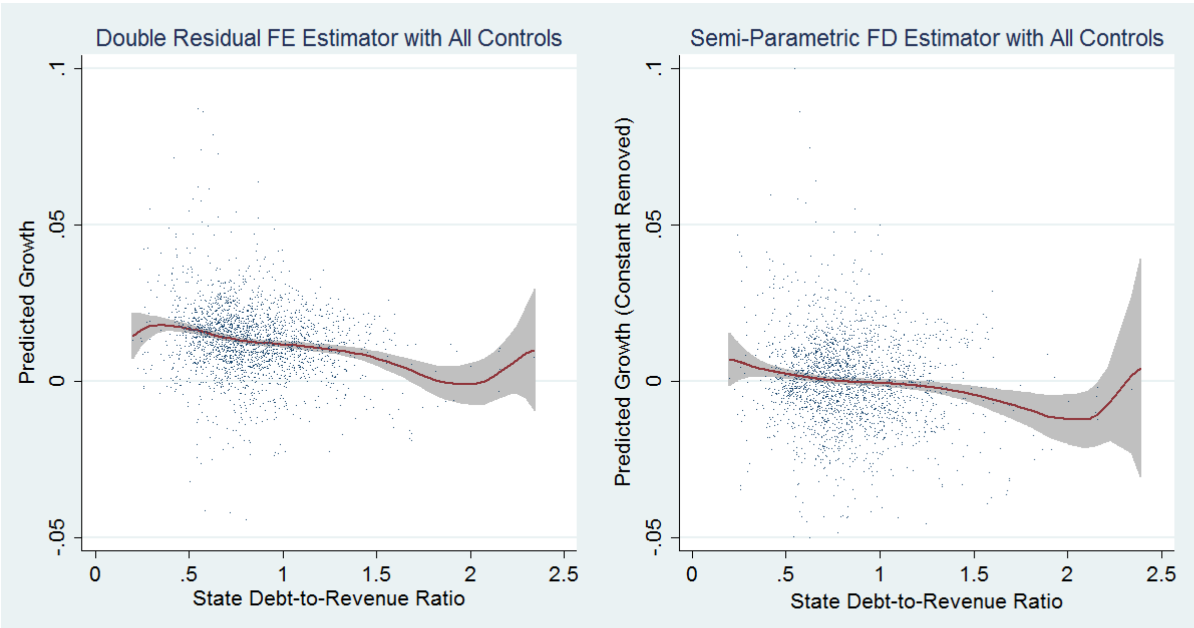
APPENDIX FIGURE III – SEMI-PARAMETRIC REGRESSIONS WITH NON-OVERLAPPING FIVE-YEAR GROWTH PERIODS

APPENDIX FIGURE IV – SEMI-PARAMETRIC REGRESSIONS FOR PERIODS BEGINNING 1963-1998

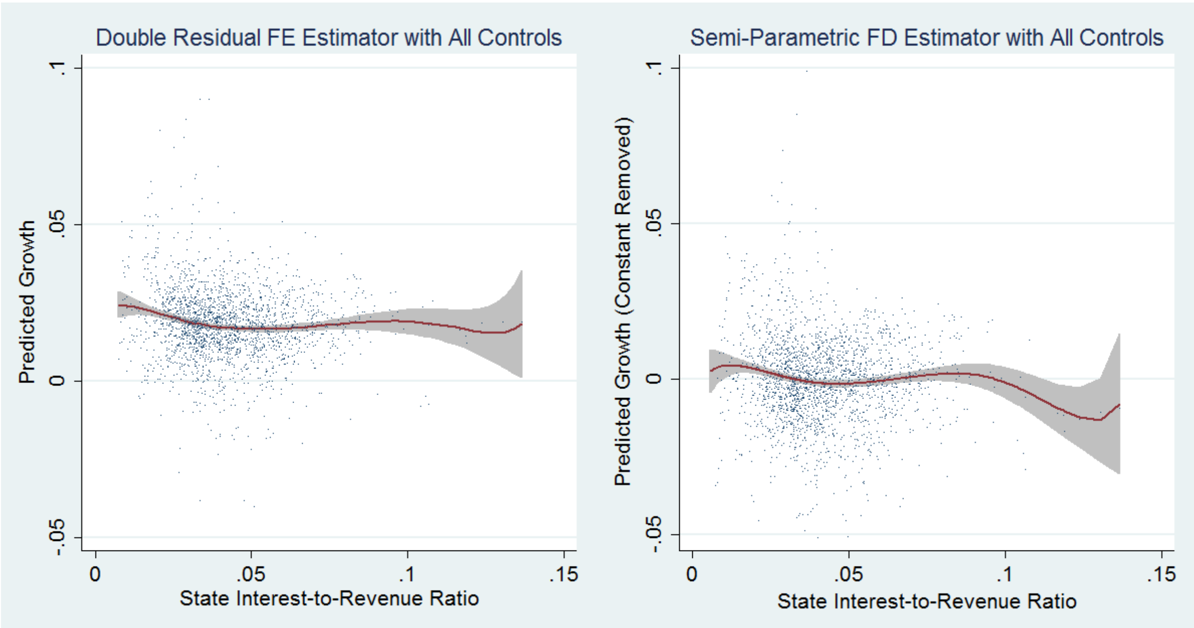


APPENDIX FIGURE V – SEMI-PARAMETRIC REGRESSIONS FOR PERIODS BEGINNING 1973-2008

APPENDIX FIGURE VI – SEMI-PARAMETRIC REGRESSIONS FOR STATE DEBT-TO-REVENUE RATIO



APPENDIX FIGURE VII – SEMI-PARAMETRIC REGRESSIONS FOR STATE INTEREST-TO-REVENUE RATIO



APPENDIX FIGURE VIII – SEMI-PARAMETRIC REGRESSIONS FOR STATE INTEREST-TO-GDP RATIO

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