THE ROBUST RELATIONSHIP BETWEEN TAXES AND STATE ECONOMIC GROWTH[1]

by

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Abstract

I estimate the relationship between taxes and economic growth using data from 1970-1999 and the forty-eight continental U.S. states. I find that taxes used to fund general expenditures are associated with significant, negative effects on economic growth. This finding is generally robust across alternative variable specifications, alternative estimation procedures, alternative ways of dividing the data into "five-year" periods, and across different time periods and BEA regions, though state-specific estimates vary widely. I also provide an explanation for why previous research has had difficulty identifying this "robust" relationship.

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> "Bartik (1994a,b) has suggested that the interregional elasticity of economic activity with respect to taxes is between -0.1 and -0.6 ….[However] the results are not very reliable and change depending on which variables are included in the estimation equation, or which time period is analyzed."
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> -- Michael Wasylenko (1997, p. 38)

> "My conclusion…is that we are uncertain about the effects of economic development policies, including broad state fiscal policy, on economic growth. How does this conclusion translate into policy? My message to policy makers is that the effects of state and local tax policy are so uncertain that concern over this issue should not be a driving force in general policy decisions."
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> -- Therese McGuire (1992, p. 458)

I. INTRODUCTION

A long-standing research enterprise has been devoted to estimating the effect of taxes on economic growth in U.S. states. To the extent a consensus exists, it is that taxes used to fund transfer payments have small, negative effects on economic activity. When used to fund productive expenditures, the associated tax effects are often estimated to vanish, or even become positive (Helms, 1985; Bartik, 1991; Phillips and Goss, 1995; Wasylenko, 1997). However, even this modest conclusion is disputed, since estimated effects vary widely across studies (Bartik, 1991; McGuire, 1992; Wasylenko, 1997).

Given the scores of studies that have investigated this issue, it is surprising that many important estimation issues have not been addressed. My study takes up several of these, and re-estimates the relationship between taxes and economic growth. I find that taxes used to fund general expenditures are associated with significant, negative effects on economic growth. Further, I show that these effects are generally robust across estimation procedures, alternative specifications of the regression equation, different time divisions of the data, and across time periods and BEA regions. In contrast, state-specific estimates are highly variable. I also provide a possible explanation for why previous research has had difficulty identifying these effects.

My analysis addresses the following estimation issues. First, it uses economic theory to derive an estimable equation. With respect to specification of the regression equation, theory has consequences for the following: (i) the inclusion/exclusion of labor, capital, and population variables along with, or instead of, underlying parameters such as saving, depreciation, and population growth rates; (ii) the inclusion/exclusion of a lagged dependent variable; and (iii) whether to include other explanatory variables in level or differenced forms.

The Cobb-Douglas production function has now become a standard point of departure for models of economic growth. Studies that have analyzed U.S. state fiscal policy[1] within this framework include Merriman (1990); Garcia-Milá and McGuire (1992); Evans and Karras (1994); Holtz-Eakin (1994); Garcia-Milá, McGuire, and Porter (1996); Aschauer (2000); Yamarik (2000); and. Shioji (2001). My study follows suit by employing a general version of the Cobb-Douglas production that includes the textbook Solow model and the augmented, human capital model of Mankiw, Romer and Weil (1992) as special cases.

A second specification issue concerns the role of time. Much of the previous literature has restricted taxes to have only contemporaneous effects on economic activity. When dynamic effects are incorporated, it is usually done indirectly, through the

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[1] The subsequent discussion of previous research restricts itself to state-level analyses in which the dependent variable is income or income growth, where income is measured either by Personal Income or Gross State Product in either total or per capita terms.

inclusion of a lagged income variable (e.g., Helms, 1985). My regression specifications allow taxes to have both contemporaneous and lagged effects.[2]

A related issue concerns how to define the length of a time period for time series observations of states. Previous research on state-level taxes and growth has relied almost exclusively on either cross-sectional (e.g., Romans and Subrahmanyam, 1979; Mullen and Williams, 1994; Yamarik, 2000) or annual panel data (e.g., Helms, 1985; Crain and Lee, 1999).

Cross-sectional data is undesirable because it ignores time-varying behavior in the explanatory variables. This is particularly a problem for taxes: The average state tax burden in 1999 was very close to its level in 1970 (cf. Reed, 2006, Figure 1), despite large variation over time. Cross-sectional analyses also suffer from omitted variable bias due to uncontrolled fixed effects -- to the extent these are not picked up in initial income levels.

On the other hand, annual data is particularly vulnerable to measurement error bias. This is, again, of particular relevance for tax studies. Using two very different approaches, Reed and Rogers (2006, 2007) estimate that roughly half of the annual variation in tax burden is due to factors other than tax policy. This bias is exacerbated by the inclusion of state fixed effects. Further, annual state-level income data are characterized by substantial serial correlation (cf. Evans and Karras, 1994). The combination of serial correlation with a lagged dependent variable produces inconsistent estimates.

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[2] Tomljanovich (2004) also allows for dynamic tax effects, but his study only includes state taxes, not state and local. The practical implication of this is that it ignores property taxes, among others, and locally financed public expenditures. The empirical importance of these is demonstrated by Helms (1985).

Multi-year interval data also suffer from these problems, but to a lesser degree: Measurement errors are more likely to cancel out over longer time periods. Serial correlation is less severe when observations are distanced further in time. A few studies have analyzed the effects of fiscal policy using multiple-year interval data. These include Garcia-Milá, McGuire, and Porter (1996); Aschauer (2000), Shioji (2001), Chernick (1997), and Tomljanovich (2004), though only the latter two directly study taxes. My analysis estimates tax effects over thirty years using five-year interval data.

A third issue is the selection of "control variables." Growth theory is sufficiently general that many variables are potential determinants of growth. Despite this, many studies of tax effects include no, or only a few, non-fiscal variables other than initial/lagged income, time, and/or state-fixed effects (cf. Becsi, 1996; Tomljanovich, 2004; Yamarik, 2000). Helms (1985) includes variables for state wages, percent unionization, and population density. Mullen and Williams (1994) include variables for growth of the civilian labor force, and the growth rates of private and public capital. Only Chernick (1997) and, notably, Crain and Lee (1999) have a broad set of control variables. My study includes an extensive set of control variables to avoid problems of bias associated with omitted variables.

That being said, it is well known that coefficient estimates are often highly dependent upon the particular set of variables included in the regression equation (Leamer, 1985; Levine and Renelt, 1992; Crain and Lee, 1999; Sali-i-Martin, 2004). To address this problem, I employ model selection criteria to determine variable selection. Further, I investigate the robustness of my results to alternative specifications.

A fourth issue concerns the choice of estimation procedure. Panel data are potentially characterized by complex error structures. Most previous research on fiscal policy uses OLS (e.g., Garcia-Milá and McGuire, 1992; Chernick, 1997; Crain and Lee, 1999), or OLS with standard errors corrected for general heteroscedasticity (e.g., Aschauer, 2000; Tomljanovich, 2004) or serial correlation (Evans and Karras, 1994). A few studies employ feasible Generalized Least Squares (FGLS) to address random effects (Garcia-Milá, McGuire, and Porter, 1996; Helms, 1985; Holtz-Eakin, 1994), though this procedure is usually rejected in favor of OLS with fixed effects. Dynamic panel data (DPD) estimators have occasionally been used to obtain consistent estimates when the regression specification includes both a lagged dependent variable and fixed effects (Holtz-Eakin, 1994; Shioji, 1994). My analysis allows for a variety of serial correlation, heteroscedasticity, and cross-sectional correlation behaviors in the error term. It investigates the robustness of estimating tax effects using alternative OLS, FGLS, and DPD estimators.

A fifth issue addresses the role of influential observations. Point estimates may mask the fact that results can be driven by just a few time periods, or just a few states. This is of particular importance to policy-makers who are interested in extrapolating the results of empirical studies to their own states and time periods. With only a few exceptions, previous research on tax effects reports only average effects: Mullen and Williams (1994) and Chernick (1997) check for (i) robustness across different time periods and (ii) the effect of omitting some states from their samples. My analysis goes further by interacting tax variables with both time, region, and state dummy variables to check for robustness across these dimensions.

The paper proceeds as follows: Section II derives a model of economic growth that is general enough to encompass many of the models that have been used in previous research. Section III describes the data and discusses associated specification issues. Section IV presents the initial empirical results. Section V checks for robustness across (i) alternative variable specifications, (ii) alternative estimation procedures, (iii) different time divisions of the data, and (iv) different time periods, regions, and states. Section VI provides a possible explanation for why my study finds a robust relationship between taxes and economic growth while previous studies have not. Section VII concludes.

II. A MODEL OF ECONOMIC GROWTH

I assume that state income (Y_t) is determined by the following general version of the Cobb-Douglas production function,

$$(1) \qquad Y_t = A_t K_t^{\alpha} (L_t Q_t)^{\beta} = A_t Q_t^{\beta} K_t^{\alpha} L_t^{\beta},$$

where K_t and L_t are capital and employment, Q_t is the efficiency of labor, and A_t represents other factors that influence state incomes (e.g., human capital variables, factor neutral productivity determinants). The textbook Solow model and the augmented human capital model of Mankiw, Weil, and Romer (1992) are both special cases of Equation (1).[3]

Dividing both sides by N_t gives

$$(2) \qquad \frac{Y_t}{N_t} = A_t Q_t^{\beta} \left(\frac{K_t}{N_t}\right)^{\alpha} \left(\frac{L_t}{N_t}\right)^{\beta} N_t^{(\alpha+\beta-1)}.$$

This can be expressed in log form as

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[3] The textbook Solow model is $Y_t = K_t^{\alpha}\left(L_t Q_t\right)^{1-\alpha} = Q_t^{1-\alpha} K_t^{\alpha} L_t^{1-\alpha}$. Mankiw, Romer, and Weil's augmented version of the Solow model is $Y_t = K_t^{\alpha} H_t^{\beta}\left(L_t Q_t\right)^{1-\alpha-\beta} = H_t^{\beta} Q_t^{1-\alpha-\beta} K_t^{\alpha} L_t^{1-\alpha-\beta}$.

$$(3) \qquad ln\left(y_t\right) = \alpha\, ln\left(k_t\right) + \beta\, ln\left(\ell_t\right) + \left(\alpha + \beta - 1\right) ln\left(N_t\right) + ln\left(A_t\right) + \beta\, ln\left(Q_t\right)$$

where $y_t = \frac{Y_t}{N_t}$, $k_t = \frac{K_t}{N_t}$, and $\ell_t = \frac{L_t}{N_t}$.

Differentiating Equation (3) with respect to time yields

$$(4) \qquad \frac{\dot{y}_t}{y_t} = \alpha \frac{\dot{k}_t}{k_t} + \beta \frac{\dot{\ell}_t}{\ell_t} + \left(\alpha + \beta - 1\right)\frac{\dot{N}_t}{N_t} + \left(\frac{\dot{A}_t}{A_t} + \beta \frac{\dot{Q}_t}{Q_t}\right)$$

It follows that

$$(5) \qquad \begin{gathered} \ln(y_t) - \ln(y_{t\text{-}L}) \cong \alpha\left[\ln(k_t) - \ln(k_{t\text{-}L})\right] + \beta\left[\ln(l_t) - \ln(l_{t\text{-}L})\right] + \\ \left(\alpha + \beta - 1\right)\left[\ln(N_t) - \ln(N_{t\text{-}L})\right] + C_t \end{gathered} ,$$

where $C_t = \left[ln(A_t) - ln(A_{t\text{-}L})\right] + \beta\left[ln(Q_t) - ln(Q_{t\text{-}L})\right]$ and L = the length of the time period minus 1 (e.g., for a five-year period with t measuring calendar years, L = 4).[4,5,6]

Equation (5) identifies changes in capital, employment, and population as important determinants of economic growth. However, the last term, C_t, allows a role for other variables -- potentially many other variables -- to affect economic growth.

III. DATA AND ESTIMATION ISSUES

My data consist of observations on 48 U.S. states from 1970-1999.[7] I decided on this particular time period because a longer time frame would have required me to omit many variables of interest. The respective thirty years of data are grouped into 6, five-year

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[4] In the subsequent empirical work, the difference in log values is multiplied by 100.

[5] An alternative specification solves for the steady state value of *y* as a function of state parameters, and then introduces convergence through the inclusion of a lagged value of the dependent variable. The main cost of this approach is that it requires the imposition of additional restrictions.

[6] I also check for robustness when $L = 5$, so that the endpoints and startpoints of the respective five-year periods coincide.

[7] Alaska and Hawaii were omitted, as is usual in studies of U.S. state economic growth.

periods (1970-1974, 1975-1979, … , 1995-1999). Data for most of these variables were collected from original data sources.[8]

In addition to the previously cited benefits, five-year interval data[9] offer the following advantages over annual data: They (i) average out "business cycle effects" (Grier and Tullock, 1989); (ii) minimize errors from misspecifying lag effects; and (iii) reduce time-specification issues. Time-specification issues arise because data can have different start and end periods within a given calendar year. For example, state income data are defined over calendar years; state fiscal data are defined over fiscal years (which are different for different states); and other variables (e.g. employment, population data) may be measured at different points within the year (beginning/middle/end). In addition, a number of variables (e.g., variables based on decennial Census data) require interpolation in order to get a balanced panel.

Following Equation (5), the general specification for the empirical models is[10]:

$$DLNY_t = \begin{bmatrix} \beta_0 + \beta_1 DLNK_t + \beta_2 DLNL_t + \beta_3 DLNN_t \\ + state\ fixed\ effects + time\ fixed\ effects \end{bmatrix} + \sum_d \delta_d \left(X_{d,t} - X_{d,t-4} \right) + \sum_l \lambda_l X_{l,t-4} + \varepsilon_t , \tag{6}$$

where $t = 1974, 1979, 1984, 1989, 1994, 1999$; $DLNY_t$, $DLNK_t$, $DLNL_t$, and $DLNN_t$ are the respective difference quantities from Equation (5) multiplied by 100 (to give percent); $\left(X_{dt} - X_{d,t-4} \right)$ is the change in the explanatory variable over the five-year period ("differenced" form); and $X_{l,t-4}$ is the value of the explanatory variable at the beginning

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[8] The Appendix presents statistical descriptions of all the variables used in this study.

[9] The data are formatted in terms of five-year differences, not averages (cf. Equation [5]).

[10] I do not impose the restriction that $\beta_3 = \left(\beta_1 + \beta_2 - 1 \right)$ because population growth could also be related to C_t, in which case the restriction would be violated.

of the five-year period ("level" form). Note that the last two terms can also be thought of as capturing the "contemporaneous" and "lagged" effects of X.[11]

A comparison of Equations (5) and (6) reveals that the "differenced" and "level" forms of X are designed to proxy for $C_t = [ln(A_t) - ln(A_{t-L})] + \beta[ln(Q_t) - ln(Q_{t-L})]$. As this latter term is in differences, one may question why the level form of X is also included. Consider that C_t incorporates factors that affect the growth rate of productivity, which is related to the production of new ideas. The supply of new ideas is likely related to the size of the population. This argues for inclusion of the level form of population. Similar arguments can be made for other variables.[12]

As my measure of taxes, I use tax burden, defined as the ratio of state and local tax revenues to personal income. Tax burden is by far the most commonly employed measure of state taxation, and can be thought of as the "effective average tax rate" in a state (e.g., Helms, 1985; Mofidi and Stone, 1994; Mullen and Williams, 1994; Carroll and Wasylenko, 1994; Knight, 2000; Caplan, 2001; Yamarik, 2000, 2004; Alm and Rogers, 2005).

IV. INITIAL EMPIRICAL RESULTS

TABLE 1 summarizes the initial results. The first column (Equation [7]), reports the results of estimating a narrowly specified version of Equation (6). The only explanatory variable from the set of differenced variables, $\{(X_{d,t} - X_{d,t-4})\}_d$, is the change in tax

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[11] For an alternative derivation that arrives at a virtually identical specification, see Bassanini, Scarpetta, and Hemmings (2001).

[12] Previous studies of fiscal policy that specify income growth as the dependent variable have typically included either (i) level (cf. Helms, 1985; Chernick, 1997; Yamarick, 2000) or (ii) differenced forms of the explanatory variables (cf. Evans and Karras, 1994; Garcia-Milá, McGuire, and Porter, 1996; Crain and Lee, 1999), but not both. Romans and Subrahmanyam (1979) and Mullen and Williams (1994) are exceptions.

burden, *TaxBurden(D)*; and the only explanatory variable from the set of level variables, $\left\{X_{l,t-4}\right\}_l$, is the value of tax burden at the beginning of the period, *TaxBurden(L)*.

Both tax variables are negative and highly significant (the *t*-values are -4.38 and -2.25, respectively). This suggests that taxes have both an immediate and a persistent effect. The coefficient estimate for *TaxBurden(D)* indicates that a one percentage-point increase in tax burden over a five-year period is associated with lower real PCPI growth of 1.37 percent during that period. In addition, an increase in taxes raises the level of tax burden, which is associated with lower growth in future time periods. A state having a tax burden that is one percentage point higher than other states is estimated to have real PCPI growth that is lower by 0.90 percent in subsequent five-year periods.

Two points are worth noting. First, these effects represent the net effect of taxes and spending. Since expenditures variables are omitted from the specification, and since the relationship between U.S. state expenditures and revenues is generally one-to-one, the respective coefficients should be interpreted as an increase in taxes to fund general (unspecified) expenditures. Second, these estimated effects are sizeable. The mean value of the tax burden variable is 10.87, and the mean growth rate of real PCPI (*DLNY*) is 8.23 percent. Thus, tax variable coefficients in the range of -1.0 represent economically important relationships.

With respect to the rest of the equation, the results indicate that increases in a state's capital stock (*DLNK*), employed labor force (*DLNL*), and population (*DLNN*) are each associated with greater income growth. Overall, the equation has good explanatory power, though much of that comes from the state and time fixed effects.[13]

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[13] The R^2 value for the same specification without state and time fixed effects is 0.744.

The estimated tax effects of Equation (7) hold constant any effects that taxes might have on investment, employment and population growth. One might reasonably expect taxes to be related to these as well. Equations (8) through (10) investigate this by respectively regressing each of these on the two tax variables plus state and time fixed effects. Across all three equations, we see that higher taxes are associated with lower investment, lower employment growth, and lower population growth.

Notably, there are differences in the timing of the respective estimated effects. Equations (8) and (9) report that an increase in tax burden is associated with a statistically significant decrease in investment and employment growth during the same five-year period. Beyond that period, the tax effects are smaller and statistically insignificant. In contrast, Equation (10) indicates that an increase in tax burden is estimated to have a negligible contemporaneous effect on population growth. However, there is some evidence to indicate that higher taxes lower population growth in later time periods (the respective *p*-value is 0.19). These results are consistent with expectations about how taxes might affect each of these variables: investment and employment are more easily adjusted in the short-run, while migration decisions respond more slowly and require more time to be realized.

The preceding results suggest that taxes influence state economic growth via two general channels. The first channel is associated with the term, C_t, which collects changes in the efficiency of labor (Q_t) plus the effects of other time-varying factors related to productivity (A_t). The second channel is via the terms *DLNK, DLNL,* and *DLNN*, which incorporate the effects of taxes on investment, employment and population growth. Ideally, one could measure the combined effect of tax burden on economic growth by estimating a structural system of equations with *DLNY, DLNK, DLNL,* and *DLNN* all treated as endogenous. Unfortunately, a lack of good instruments makes this approach unfeasible.[14]

An alternative is to estimate a reduced form version of Equation (7), omitting the terms *DLNK, DLNL,* and *DLNN*. Equation (11) reports the results of this exercise. As expected, the combined effect of taxes is estimated to be substantially larger. A one percentage point increase in tax burden is associated with a contemporaneous, decrease of 2.59 percent in real PCPI growth. In addition, future five-year growth rates are estimated to be lower by 1.56 percent.

V. ROBUSTNESS CHECKS

Robustness with respect to alternative specifications. One concern with the previous set of results is that the estimated tax effects may suffer from omitted variable bias. It is thus important to control for the influence of other variables that may affect state economic growth. The subsequent analysis takes Equation (7) as its starting point, and appends this with theoretically appropriate control variables.

It is clear from Equation (5) that a large number of variables could be included as proxies for the unobserved term, C_t. Reed (2007) identifies thirty-two variables that have been used or suggested by previous studies. Eliminating the public sector variables (such as categories of public spending or taxes) -- since including these would change the nature of the tax variables -- leaves thirteen non-tax variables. These are identified in TABLE 2. Each of these can be argued to be included in differenced or level (initial

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[14] I estimated a model with lagged values of *DLNK*, *DLNL*, *DLNN*, and *TaxBurden(D)* as instruments, but rejected this approach because the first-stage estimates indicated weak correlations.

value) form. If one also allows the initial value of income to be included as a regressor[15], and recalls that the differenced form of the population variable (*DLNN*) is already included in the core specification, one obtains a total of twenty-six possible control variables.[16]

While it is likely that many of these variables do not really belong in the regression equation, it is not apparent a priori which ones should be excluded. Choosing one or a few sets of control variables is potentially a problem, since previous literature (e.g., Leamer, 1985; Levine and Renelt, 1992; Crain and Lee, 1999; Sali-i-Martin et al., 2004) has demonstrated that estimated coefficients are often fragile, sensitive to the particular composition of conditioning variables.

The problem is complicated by the fact that there are $2^{26} \cong 67$ million ways to combine twenty-six variables, each one a possible regression specification. I address the issue of variable specification in the following way. First, I estimate a complete specification that includes all twenty-six variables. Next, I identify and estimate the "best" specifications as determined by both SIC and AIC (corrected version) model selection criteria.[17] This produces three sets of regression results, each of which is reported in TABLE 3 (cf. Equation [12], [13] and [14]).

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[15] Note that the interpretation of this variable should not be associated with convergence, since the model is not specified in steady-state form. Rather, this variable should be interpreted as proxying for the effect of omitted, initial-value variables that affect productivity growth.

[16] The variable *DLNN* potentially affects economic growth through two channels: (i) directly (cf. Equation [5]), and (ii) indirectly, through C_t. If *DLNN* did not exert a separate effect via C_t, then its associated coefficient would be $(\beta_1 + \beta_2 - 1)$ (cf. Equations [5] and [6]). However, this hypothesis is consistently rejected in the subsequent empirical analyses. The upshot is that one cannot estimate an analogue of Equation (10), appended with control variables, since *DLNN* would appear as one of the control variables.

[17] This procedure, as well as the specific SAS program I use to implement it, is described in further detail in Reed (2007).

Of greatest interest are the first two rows of TABLE 3. These report the estimated coefficients of *TaxBurden(D)* and *TaxBurden(L)* after including alternative sets of control variables. Both tax coefficients are smaller in absolute value compared to Equation (7), where the estimated values are -1.37 and -0.90, respectively. Nevertheless, they remain negative across the expanded specifications of Equations (12) through (14). Further, they continue to be highly significant. In the "All Variables" specification of Equation (12), *TaxBurden(D)* and *TaxBurden(L)* have *t*-statistics(*p-values*) of, respectively, -2.58(*0.011*) and -2.87(*0.004*). The corresponding *t*-statistics are even higher in Equations (13) and (14). And while these latter two specifications are the product of sequential search, the *t*-statistics/*p*-values for the two tax variables can still be interpreted in the classical manner because the search procedure includes these two variables in every specification.

Turning to the other variables, I find that the estimated coefficients are generally consistent with the predictions of growth theory, or at least not inconsistent. Focusing on the coefficients from Equation (13), we observe the following results (ignoring the distinction between initial levels and contemporaneous changes): higher educational attainment, a greater percentage of the population who are of working age, a greater percentage of the population that is nonwhite, a larger population, a greater reliance on agriculture, and a more unionized workforce are associated with higher economic growth. A larger female population, a larger mining sector, and greater industrial diversity are associated with lower economic growth. Lastly, ceteris paribus, states with a greater initial value of real PCPI grow slower than other states.

In conclusion, I find that the significant, negative tax effects reported in Equation (7) are robust to the inclusion of a wide variety of control variables. The next section investigates the robustness of the relationship between tax burden and state economic growth when alternative estimation procedures are employed.

Robustness with respect to alternative estimation procedures. The subsequent analysis selects Equation (13) as the best of the preceding specifications. This OLS equation displays good properties. It has a high R^2, the key explanatory variables all have large t-statistics, the Durbin-Watson statistic is close to 2, and a test of error normality fails to be rejected at the 5 percent level.[18]

However, there are at least two concerns. First, panel data are often characterized by complex error structures. Using the residuals from Equation (13), I tested for (i) first-order serial correlation, (ii) groupwise heteroscedasticity, and (iii) cross-sectional correlation. I found no evidence of significant serial correlation (the estimated value of the AR(1) parameter was -0.02). However, I reject the hypothesis of no groupwise heteroscedasticity[19] and find substantial evidence of cross-sectional correlation.[20] This raises worries about the inefficiency of the coefficient estimates and biasedness in the estimates of the standard errors.[21]

Unfortunately, while one can estimate an error variance-covariance matrix that allows for cross-sectional correlation, one cannot invert that matrix, since $N=48 > T=6$.

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[18] The Durbin-Watson statistic is 2.15; and the Jarque-Bera statistic is 5.07, with an associated p-value of 0.079.

[19] I use the modified Wald test for groupwise heteroscedasticity available in the STATA command **xttest3**. The corresponding sample Chi-square value is 798.30 with 48 degrees of freedom, and the associated p-value is 0.0000.

[20] I use Pesaran's test for cross-sectional dependence available in the STATA command **xtcsd**, which is distributed asymptotically standard normal. The corresponding CD statistic is -1.481 with a p-value of 0.1385. However, this test assumes that the cross-sectional correlations are all same-signed. It has low power when the cross-sectional correlations are not same-signed, which describes my data. The average, absolute value of the cross-sectional correlations is 0.375 even with the inclusion of time fixed effects. This is quite large. Accordingly, I correct some of my estimates for cross-sectional correlation even though I do not formally reject the null hypothesis of no cross-sectional dependence.

[21] Note that "White standard errors" are robust only to individual heteroscedasticity, and not cross-sectional correlation.

This precludes the use of Parks-type feasible Generalized Least Squares (FGLS). However, there are several alternatives. One approach is to continue to use OLS, but adjust the standard errors for cross-sectional correlation; either by using Beck and Katz's "panel-corrected standard error" procedure (Beck and Katz, 1995), or by using a more robust estimator of the error variance-covariance matrix. Another is to follow-up a suggestion by Greene (2003, pages 333f.) and use FGLS, weighting on groupwise heteroscedasticity while adjusting the standard errors for cross-sectional correlation. Accordingly, I check for robustness of the estimated tax effects across the following alternative estimation procedures:

i) OLS with panel-corrected standard errors

ii) OLS with robust estimation of the error variance-covariance matrix assuming cross-sectional correlation (i.e. "cluster" standard errors)

iii) FGLS (weighted on groupwise heteroscedasticity) with panel-corrected standard errors

iv) FGLS (weighted on groupwise heteroscedasticity) with panel-corrected standard errors

v) FGLS (weighted on groupwise heteroscedasticity) with "cluster" standard errors

There is an additional concern. Equation (13) includes both fixed effects and a lagged form of the dependent variable as explanatory variables. This generates correlation between the error term and the lagged form of the dependent variable, causing biased coefficient estimates (Nickell, 1981). To address this concern, I use two dynamic panel data (DPD) estimators: the Arellano-Bond (difference) one-step and two-step procedures.[22]

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[22] The DPD estimates were obtained using STATA's **xtabond2** procedure. Note that both the one-step and two-step procedures assume no cross-sectional correlation. I do not use the DPD(system) estimator because the key moment condition in the level equation requires that the "distance" between a state's initial

TABLE 4 reports the estimates from these alternative estimation procedures. For comparison's sake, the first row duplicates the tax burden estimates from Equation (13) in TABLE 3. There are two main findings from this analysis: Both FGLS and DPD confirm earlier results in that they produce negative coefficient estimates for each of the tax variables. The FGLS estimates are similar in size to the OLS estimates, while the DPD estimates are generally larger (in absolute value). In addition, the statistical significance of the tax effects is confirmed across all alternative estimation procedures. Of the sixteen *t*-statistics reported in TABLE 4, fourteen imply significance at the 1 percent level, with the remaining two significant at the 5 and 10 percent levels. Accordingly, I conclude that my main findings of negative, statistically significant tax effects are robust across alternative estimation procedures.

<u>Robustness across alternative cuts of the data</u>. The preceding analyses divide the thirty years of data from 1970-1999 into six periods of five-years each: 1970-1974, 1975-1979, … , 1995-1999. This section looks at two alternative ways of dividing the data. The first approach allows the endpoint of one five-year period to coincide with the beginning of the next five-year period. Following this approach, the data are divided as follows: 1970-1975, 1975-1980, 1980-1985, … , 1995-2000. A drawback of this approach is that it forces dependency between contiguous time periods. An alternative approach keeps the endpoints and beginning points of the periods separate, but shifts the data by a year: 1971-1975, 1976-1980, … , 1996-2000.

TABLE 5 reports the results. The first column of TABLE 5 uses FGLS (weighting on groupwise heteroscedasticity) with robust VCE for cross-sectional

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income and its "steady-state" value be uncorrelated with the state fixed effect (cf. Roodman, 2006, page 27). This is clearly violated in endogenous growth models and likely violated in exogenous growth models.

correlation to estimate the variable specification of Equation (13).[23] These results were previously reported in abbreviated form in TABLE 4. The subsequent two columns use the same estimation procedure and variable specification but employ different cuts of the data.

Alternative cuts of the data can make a difference. For example, the estimates for *Female(D)* change considerably, with the respective *t*-values ranging from -4.38 to -1.51. The coefficients for *Mining(D)* and *Diversity(L)* also show substantial variation, even switching signs. Indeed, the coefficient for *TaxBurden(L)* in Column (3) is less than half the size of the equivalent estimate in Column (1), with a correspondingly large change in the respective *t*-statistic.

Nevertheless, these estimates provide overall confirmation of the previous tax burden results. Across the alternative time divisions of the data, the coefficients of the two tax variables are uniformly negatively signed and statistically significant, always having a *t*-statistic larger than two in absolute value.

<u>Robustness across time periods, regions, and states</u>. A possible concern with previous estimates is that the results may be driven by a few time periods, regions, or states with particularly strong relationships between tax burden and economic growth; and that these may not be broadly representative for the majority of observations. Previous specifications assumed that the estimated tax effects were the same for all observations. In this section, I use interaction terms to estimate individual time period, region, and state effects.

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[23] I chose this estimation procedure given that testing of the residuals produced evidence of groupwise heteroscedasticity and cross-sectional correlation.

I first check for robustness across time periods. There are a total of 6 five-year periods: (1970-1974, 1975-1979, 1980-1984, 1985-1989, 1990-1994, 1995-1999). I respecify Equation (13) and include time-interaction effects to capture changes in the tax burden/economic growth relationship over time. Following the previous results on estimation procedures, all coefficients are estimated using FGLS (with weighting for groupwise heteroscedasticity), with a White robust estimator for cross-sectional correlation used to calculate standard errors. I first estimate time-specific coefficients for the variable *TaxBurden(D)*. I then repeat the robustness check by estimating time-specification coefficients for the variable *TaxBurden(L)*.

TABLE 6 summarizes the results. Notably, each of the twelve time-specific coefficients is negative. Ten of the twelve are individually significant. While the pattern isn't perfect, smaller estimated coefficients for *TaxBurden(D)* are generally accompanied by larger coefficients for *TaxBurden(L)*, and vice versa.[24] A similar pattern is observed when I estimate region- and state-specific interaction terms. An interpretation consistent with these results is that changes in tax burden take longer to register their effects for some time periods, regions, and states. That being said, the main finding from TABLE 6 is that the estimated relationships between economic growth, and both the differenced and level forms of tax burden are negative for every time period.

TABLE 7 reports the results of a similar analysis checking for robustness across the eight BEA regions and states. The top part of the table reports the results of the regional analysis: Fifteen of the sixteen estimated tax effects are negative; ten are significant at the 10 percent level. The bottom part of the table reports a summary

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[24] The smaller estimated coefficients for *TaxBurden(D)* during the 1980's is consistent with the findings of Carroll and Wasylenko (1994), though their study focused on state employment.

analysis for the states: Of the forty-eight, state-specific coefficients for *TaxBurden(D)*, 72.9 percent are negative. Of these, fifteen are statistically significant at the 10 percent level, and thirteen of these are negative (86.7 percent). The corresponding numbers for the *TaxBurden(L)* coefficients are 64.5 and 69.2 percent, respectively. Only two states (Montana and Virginia) have positive coefficients for both *TaxBurden(D)* and *TaxBurden(L)*, and none of the associated coefficients are significant at the 10 percent level. In contrast, twenty states have negative coefficients for both tax variables. In eleven of these cases, at least one of the tax coefficients is significant at the 10 percent level.

The results of TABLE 7 are not as robust as those of TABLE 6. In general, I find that as the data are cut into finer slices, the results become less consistent. By the time I get to the state level, there are only 6 observations per estimated coefficient (compared to 48 observations for the time-period analyses).[25] Nevertheless, it is clear that the finding of negative and statistically significant tax effects applies widely across time periods, regions, and states; and is not driven by a few observations exerting a disproportionately strong influence.

<u>Robustness across alternative specifications of government finances</u>. As Helms (1985) points out, the government budget constraint should always be kept in mind when interpreting the coefficients of fiscal variables:

> *(Tax Revenues + Non-Tax Revenues) – (Welfare Expenditures + "Productive Expenditures") + Deficit = 0 ,*

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[25] An alternative approach that estimates individual state effects without a great sacrifice in degrees of freedom is to include squared terms for both tax variables. This allows taxes to exert either positive or negative effects on economic growth, depending on the value of the respective tax variable. The respective coefficients can be used to solve for the threshold level at which the effect of taxes switches signs. When I did this, I found that all states had estimated negative tax effects for both of the tax variables. I thank a referee for suggesting this approach.

where I define "Productive Expenditures" as all state and local Direct General Expenditures other than Public Welfare. Thus, an increase in taxes must be accompanied by some combination of (i) a decrease in Non-Tax Revenues (e.g., fees and federal aid), (ii) an increase in Welfare Expenditures or Productive Expenditures, and (iii) a decrease in the Deficit. Previous specifications did not attempt to distinguish these alternatives.

TABLE 8 reports the results of including variables for both differences and levels of Non-Tax Revenues and Welfare, appropriately divided by state Personal Income. In Column (2), the coefficients on the tax variables should now be interpreted as estimating the effect of an increase in taxes matched by a corresponding increase in general expenditures (as a practical matter, we can ignore deficits as they are usually negligibly small compared to overall revenues and expenditures.) The tax coefficients remain negative and statistically significant.

Column (3) adds welfare variables to the specification. The tax coefficients in this specification should be interpreted as estimating the effect of an increase in taxes matched by a corresponding increase in Productive Expenditures. Again, the estimated coefficients remain negative and statistically significant. Column (4) removes the Non-Tax Revenue variables from the specification, with no change in the overall finding of negative and statistically significant tax effects.

It is interesting to note that the negative tax effects are close in size to the corresponding negative effects associated with Non-Tax Revenues.[26] This is consistent

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[26] However, we cannot reject the null hypothesis that the coefficients associated with the difference and level forms of the two kinds of revenues are the same. The associated *p*-values for the specifications of Columns (2) and (3) are *0.51* and *0.47*.

with an interpretation that both variables are measuring negative effects associated with a larger public sector; and that the added, distortionary effects of taxes are negligible.

On the other hand, the positive and statistically significant coefficients for the welfare variables are puzzling. A possible explanation is that transfer payments are almost exclusively received by state residents, and hence contribute directly to state income.[27] In contrast, other government expenditures can be diverted outside the state's economy (e.g., as payments to out-of-state suppliers of government services or supplies), so that the corresponding stimulative spending effects may not contribute to economic growth within the state.

VI. WHY HAVE PREVIOUS STUDIES FOUND IT DIFFICULT TO ESTIMATE ROBUST TAX EFFECTS?

In this section I show that annual data produces substantially different estimates of tax effects compared to five-year interval data. This may provide an explanation for why previous studies have found it difficult to estimate robust tax effects.

Column (1) of TABLE 9 uses OLS to estimate an annual analogue to Equation (13). The data cover 1970-1999 and include the log of capital, employment, and population, along with state and annual time fixed effects and a number of other control variables. The dependent variable is the log of real PCPI. I begin by following the conventional practice of only including contemporaneous values of the explanatory variables.

In contrast to the prior results, I now estimate a positive relationship between tax burden and state incomes. A one-percentage point increase in tax burden is estimated to

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[27] State Personal Income as measured by the BEA includes transfer payments.

increase real state PCPI by 0.16 percent. Further, the coefficient is significant well below the 5 percent level, with a *t*-value just over three.

To check the sensitivity of this result, I drop various sets of variables from the specification of Column (1). Column (2) drops the capital, employment, population, and lagged income variables. Column (3) drops these, plus the control variables. Column (4) drops these, plus all fixed effects. While the tax coefficient remains positive throughout, its size and statistical significance is unstable across specifications.

A somewhat different picture emerges when the specification is broadened to allow lagged effects. Column (5) reports the results of adding lagged values of the tax burden variable to the specification of Column (1). While the contemporaneous relationship between tax burden and economic growth remains positive, lagged values of tax burden are estimated to be negatively associated with state income.

This suggests that previous studies may have failed to identify a negative relationship between taxes and economic growth because they relied on specifications that used annual data and did not allow for lagged tax effects. My analysis suggests that tax policies take time to work their full effects on the economy. When the specification is sufficiently general to pick up these effects, a negative relationship between taxes and economic growth emerges.

The use of annual data may also have contributed to previous findings of coefficient instability. Annual data are more vulnerable to measurement error bias than five-year interval data. Fixed effects exacerbate the influence of measurement errors. As demonstrated by Reed and Rogers (2006, 2007), tax burden substantially mismeasures state tax policy. Consequently, it would not be surprising if estimates of tax effects based on annual data were prone to instability depending on the particular distribution of measurement errors in the sample. This may be an additional reason why previous studies have had difficulty identifying robust tax effects.

VII. CONCLUSION

Using five-year data from 1970-1999 and the forty-eight continental states, I find that both (i) contemporaneous changes and (ii) lagged levels of taxes are negatively and significantly related to economic growth. The estimated effects vary depending on variable specification; estimation procedure; time period, region, and state; and the manner in which the data are organized into five-year intervals. Nevertheless, the finding of negative and statistically significant tax effects is generally robust across all of these dimensions, with one exception: State-specific estimates of tax effects vary widely. This latter result may be explained by the narrow parsing of the data. At this level of analysis there are only six observations per state-specific tax coefficient.

These results are surprising given that previous studies have had difficulty identifying a robust relationship between state taxes and incomes. My analysis suggests that this may be because previous studies of state income growth have tended to use annual data, have differed in their variable specifications, and have not allowed for lagged tax effects. When I use annual data and restrict the analysis to contemporaneous tax effects, I estimate positive tax effects, but the sizes and significances of the tax coefficient vary greatly depending on variable specification. When I include lagged values of the tax variable, a negative relationship between taxes and growth emerges. This lack of robustness is not apparent in the five-year interval data. This may be because the variables interact over time in complex ways that are difficult to model. It may also be that the data -- for definitional and measurement reasons -- are not well-suited to relating to each other at the annual level.

Much work remains to be done before reliable estimates of tax effects can be obtained.[28] However, this study establishes that there is an important empirical relationship between taxes and U. S. state economic growth. Obtaining a better understanding of the nature and cause of that relationship is a potentially fruitful avenue for future research. It is hoped that this study will stimulate efforts towards that end.

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[28] A key remaining issue is the problem of endogeneity between tax policy and economic conditions. Policy makers frequently raise taxes during economic downturns, and lower taxes during times of economic prosperity (Poterba, 1994). This generates a negative bias to estimates of contemporaneous tax effects. While this cannot explain why I find a negative, lagged effect for tax burden (cf. the coefficient for *TaxBurden[L]*), it may contribute to the estimated, negative effect for contemporaneous changes in the tax burden variable (cf. the coefficient for *TaxBurden[D]*).

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TABLE 1
Estimation of the Relationship Between Tax Burden and Economic Growth: Initial Results

	Equation (7) ***Dep. Variable = DLNY***	***Equation (8)*** ***Dep. Variable = DLNK***	***Equation (9)*** ***Dep. Variable = DLNL***	***Equation (10)*** ***Dep. Variable = DLNN***	***Equation (11)*** ***Dep. Variable = DLNY***
DLNK	0.3304 (7.26)	----	----	----	----
DLNL	0.4258 (6.70)	----	----	----	----
DLNN	0.4241 (5.02)	----	----	----	----
TaxBurden(D)	-1.3660 (-4.38)	-2.5881 (-2.43)	-0.8380 (-2.71)	-0.0346 (-0.13)	-2.5925 (-4.31)
TaxBurden(L)	-0.8979 (-2.25)	-0.8318 (-0.88)	-0.3143 (-0.85)	-0.5907 (-1.31)	-1.5571 (-2.15)
R^2	0.850	0.345	0.629	0.766	0.528
SIC	729.84	----	----	----	1043.76
AICc	815.28	----	----	----	1156.85
Observations	288	288	288	288	288
Hypothesis Tests					
State effects = 0	χ^2 = 120.46 (p-value = 0.000)	χ^2 = 91.67 (p-value = 0.000)	χ^2 = 46.67 (p-value = 0.486)	χ^2 = 787.22 (p-value = 0.000)	χ^2 = 60.99 (p-value = 0.083)
Time effects = 0	χ^2 = 86.76 (p-value = 0.000)	χ^2 = 90.93 (p-value = 0.000)	χ^2 = 301.00 (p-value = 0.000)	χ^2 = 54.68 (p-value = 0.000)	χ^2 = 194.79 (p-value = 0.000)

NOTE: Coefficients are estimated using OLS. t-statistics are reported in parentheses and are calculated using White heteroscedasticity-robust standard errors. All equations include state and time fixed effects. AICc denotes the "corrected" version of the AIC. Summary statistics for each of the variables are reported in the Appendix.

TABLE 2
List of Potential Control Variables for the Core Specification of Equation (7)[29]

VARIABLE	*DESCRIPTION (ALL VARIABLES CALCULATED AS 5-YEAR AVERAGES)*	*SELECTED STUDIES WHICH HAVE USED THIS OR A RELATED VARIABLE*
Education	Percent of population (aged 25 and up) who have completed college (SOURCE: Census)	Wasylenko and McGuire (1985); Garcia-Milà and McGuire (1992); Crown and Wheat (1995); Phillips and Goss (1995); Dalenberg and Partridge (1995); Partridge and Rickman (1996); Clark and Murphy (1996); Ciccone and Barro (1996); Crain and Lee (1999)
Working Population	Percent of population between 20 and 64 years of age (SOURCE: Census)	Wasylenko and McGuire (1985); Mofidi and Stone (1990); Dalenberg and Partridge (1995); Crain and Lee (1999)
Nonwhite	Percent of population that is nonwhite (SOURCE: Census)	Mofidi and Stone (1990); Partridge and Rickman (1996); Crain and Lee (1999)
Female	Percent of population that is female (SOURCE: Census)	Mofidi and Stone (1990); Partridge and Rickman (1996); Clark and Murphy (1996)
Population	Log of total population (SOURCE: Census)	Ciccone and Hall (1996); Alm and Rogers (2005)
Population Density	Population density (SOURCE: Census)	Wasylenko and McGuire (1985); Carroll and Wasyenko (1994); Clark and Murphy (1996); Ciccone and Hall (1996); Crain and Lee (1999)
Urban	Percent of population living in urban areas (SOURCE: Census)	Holtz-Eakin (1993); Partridge and Rickman (1996); Crain and Lee (1999)

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[29] This table is excerpted from Reed (2007).

VARIABLE	***DESCRIPTION (ALL VARIABLES CALCULATED AS 5-YEAR AVERAGES)***	***SELECTED STUDIES WHICH HAVE USED THIS OR A RELATED VARIABLE***
Agriculture	Share of total earnings earned in "Farm" and "Other Agriculture" industries (SOURCE: BEA)	Crown and Wheat (1995); Caselli and Coleman (2001)
Manufacturing	Share of total earnings earned in "Manufacturing" industries (SOURCE: BEA)	Crown and Wheat (1995); Crain and Lee (1999); Caselli and Coleman (2001); Stansel (2005)
Service	Share of total earnings earned in "Service" industries (SOURCE: BEA)	Clark and Murphy (1996)
Mining	Share of total earnings earned in "Mining" industries (SOURCE: BEA)	Holtz-Eakin (1993); Crown and Wheat (1995); Clark and Murphy (1996); Mitchener and McLean (2003)
Union	Percent of nonagricultural wage and salary employees who are union members (SOURCE: Hirsch, McPherson, and Vroman, 2001)	Plaut and Pluta (1983); Mofidi and Stone (1990); Dalenberg and Partridge (1995); Phillips and Goss (1995); Partridge and Rickman (1996); Clark and Murphy (1996)
Diversity	A measure of industrial diversity, $Diversity = \sum_i \left(\frac{Earnings\ in\ Industry_i}{Total\ Earnings} \right)^2$ (SOURCE: BEA)	Mofidi and Stone (1990); Garcia-Milà and McGuire (1992); Partridge and Rickman (1996); Crain and Lee (1999)

TABLE 3
Robustness Check Across Alternative Specifications

Variable Name[30]	***D/L***	***Equation (12)*** ***All Variables***	***Equation (13)*** ***Best SIC Specification***	***Equation (14)*** ***Best AICc Specification***
Tax Burden	***D***	-0.4240 (-2.58)	-0.5470 (-3.59)	-0.5368 (-3.36)
	L	-0.5838 (-2.87)	-0.6905 (-3.20)	-0.7045 (-3.39)
Education	***D***	1.2504 (1.99)	1.4766 (2.44)	1.1673 (2.00)
	L	1.2759 (6.84)	1.1221 (8.65)	1.2004 (7.06)
Working Population	***D***	1.3235 (3.51)	1.6503 (4.75)	1.3508 (4.21)
	L	0.9789 (4.42)	1.1264 (5.66)	1.0405 (4.89)
Nonwhite	***D***	1.1447 (2.27)	1.2900 (2.87)	1.0064 (2.20)
	L	-0.2699 (-1.77)	----	-0.3633 (-2.83)
Female	***D***	-2.7097 (-1.97)	-3.4947 (-2.92)	-3.4630 (-2.92)
	L	0.3608 (0.46)	----	----
Population	***L***	2.8954 (1.50)	4.0213 (3.19)	----
Population Density	***D***	0.0300 (0.74)	----	----
	L	0.0217 (1.64)	----	0.0269 (2.39)
Urban	***D***	-0.1486 (-1.32)	----	----
	L	-0.0674 (-0.94)	----	----

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[30] Summary statistics for each of the variables is reported in the Appendix.

Variable Name[30]	***D/L***	***<u>Equation (12)</u> All Variables***	***<u>Equation (13)</u> Best SIC Specification***	***<u>Equation (14)</u> Best AICc Specification***
Agriculture	***D***	0.5333 (4.19)	0.5365 (5.82)	0.5272 (5.08)
	L	0.3413 (3.03)	0.3881 (5.54)	0.4084 (6.03)
Manufacturing	***D***	-0.0218 (-0.13)	----	----
	L	-0.0304 (-0.25)	----	----
Service	***D***	0.0397 (0.16)	----	----
	L	-0.3083 (-1.90)	----	-0.2956 (-2.57)
Mining	***D***	-0.6314 (-2.72)	-0.5724 (-2.95)	-0.5032 (-2.50)
	L	-0.3006 (-1.58)	----	----
Union	***D***	0.1240 (1.86)	0.1143 (2.10)	0.1251 (2.37)
	L	0.0182 (0.27)	----	----
Diversity	***D***	0.2591 (1.00)	----	0.3241 (1.57)
	L	-0.2144 (-1.02)	-0.3495 (-2.26)	----
LNY_1		-41.857 (-8.37)	-39.783 (-9.72)	-44.085 (-9.96)
Number of observations		288	288	288
R^2		0.938	0.933	0.935
SIC		624.70	572.52	573.91
AICc		675.36	647.78	645.00

<u>NOTE</u>: The regression equation follows the general specification of Equation (6) in the text. "D" and "L" stand for differenced and level forms of the variables. In addition to the variables listed above, the model includes the variables DLNK, DLNL, DLNN, and state and time fixed effects. t-statistics are listed in parenthesis below each estimated coefficient.

TABLE 4
Robustness Check Using Alternative Estimation Procedures

Procedure	***TaxBurden(D)***	***TaxBurden(L)***
OLS	***-0.5470***	***-0.6905***
with robust VCE for individual heteroscedasticity	(-3.59)	(-3.20)
with panel-corrected standard errors	(-2.88)	(-3.35)
with robust VCE for cross-sectional correlation	(-5.43)	(-6.57)
FGLS (weighted on groupwise heteroscedasticity)	***-0.5086***	***-0.6494***
with robust VCE for individual heteroscedasticity	(-3.83)	(-3.89)
with panel-corrected standard errors	(-3.52)	(-4.43)
with robust VCE for cross-sectional correlation	(-3.54)	(-8.00)
DPD (difference)	***-0.6834***	***-0.8547***
Arellano-Bond one-step procedure	(-3.65)	(-3.67)
DPD (difference)	***-0.5341***	***-0.7684***
Arellano-Bond two-step procedure	(-1.74)	(-2.16)

NOTE: Coefficient estimates are boldface and italicized; t-statistics are reported in parentheses. Each estimation procedure estimates the same variable specification as Equation (13) in TABLE 3. The first set of OLS results repeats those results for comparison's sake. The respective estimation procedures are described in greater detail in Section IV.

TABLE 5
Robustness Check Using Alternative Cuts of the Data

Variable Name	*D/L*	***5-YEAR DATA*** *1970-1974, 1975-1979, …, 1995-1999*	***5-YEAR DATA*** *1970-1975, 1975-1980, …, 1995-2000*	***5-YEAR DATA*** *1971-1975, 1976-1980, …, 1996-2000*
Tax Burden	***D***	-0.5086 (-3.54)	-0.5616 (-3.91)	-0.4545 (-3.47)
	L	-0.6494 (-8.00)	-0.4179 (-3.00)	-0.3096 (-2.01)
Education	***D***	1.6935 (4.81)	1.4690 (5.33)	1.7034 (6.12)
	L	1.0819 (5.69)	1.3104 (5.94)	1.0290 (5.03)
Working Population	***D***	1.7580 (4.90)	0.8836 (4.06)	0.5753 (1.97)
	L	1.2660 (13.50)	1.3152 (13.92)	1.0980 (10.50)
Nonwhite	***D***	1.3004 (4.84)	0.9542 (4.08)	0.5168 (3.06)
Female	***D***	-3.2024 (-4.38)	-1.1457 (-1.51)	-0.8878 (-2.12)
Population	***L***	4.1887 (6.63)	5.5797 (3.75)	4.6138 (2.88)
Agriculture	***D***	0.5061 (5.66)	0.5657 (5.44)	0.3047 (2.24)
	L	0.3592 (5.79)	0.4739 (6.47)	0.5536 (6.00)
Mining	***D***	-0.4663 (-2.48)	0.0357 (0.23)	0.0780 (0.57)

Variable Name	***D/L***	***<u>5-YEAR DATA</u>*** ***1970-1974, 1975-1979, …, 1995-1999***	***<u>5-YEAR DATA</u>*** ***1970-1975, 1975-1980, …, 1995-2000***	***<u>5-YEAR DATA</u>*** ***1971-1975, 1976-1980, …, 1996-2000***
Union	***D***	0.1045 (3.07)	0.0776 (1.73)	0.0843 (4.96)
Diversity	***L***	-0.2312 (-1.86)	-0.2516 (-1.81)	0.0764 (0.94)
LNY_1		-39.042 (-12.67)	-43.288 (-12.85)	-34.17 (-11.61)
Number of observations		288	288	288

<u>NOTE</u>: Each of the three sets of regression results employs FGLS (weighting on groupwise heteroscedasticity) with robust VCE for cross-sectional correlation. t-statistics are reported in parentheses below the respective coefficient estimates. The first column reproduces previous results for comparison's sake (cf. third row from bottom in TABLE 4). The next two columns show the effects of using different cuts of the data.

TABLE 6
Robustness Check Across Time Periods

Time Period	***TIME-SPECIFIC COEFFICIENTS***			
	TaxBurden(D)		***TaxBurden(L)***	
	Coefficient	***t-statistic***	***Coefficient***	***t-statistic***
1970-1974	-1.1551	*-9.83*	-0.3062	*-5.18*
1975-1979	-0.7518	*-4.58*	-0.6710	*-7.32*
1980-1984	-0.0615	*-0.24*	-0.6455	*-7.18*
1985-1989	-0.1642	*-0.71*	-0.9044	*-6.61*
1990-1994	-0.6450	*-2.97*	-1.0086	*-8.20*
1995-1999	-1.1014	*-5.17*	-0.5286	*-4.98*

NOTE: Estimation results are generated by estimating the core variable specification of Equation (13), supplemented with the respective time-interaction dummy variables (cf. the text for further details). The estimation procedure is FGLS (weighting on groupwise heteroscedasticity) with robust VCE for cross-sectional correlation.

TABLE 7
Robustness Check Across BEA Regions and States

	TaxBurden(D)		TaxBurden(L)	
	Coefficient	**t-statistic**	**Coefficient**	**t-statistic**
REGION-SPECIFIC COEFFICIENTS:				
Great Lakes	-0.2226	*-0.36*	-0.5268	*-1.79*
Mid-Atlantic	-0.6228	*-1.97*	-0.4599	*-1.90*
New England	-0.5956	*-1.58*	-0.7789	*-2.13*
Plains	-0.7237	*-2.15*	-0.2635	*-2.16*
Rocky Mountain	-0.3329	*-2.22*	-1.1408	*-3.39*
South	-0.5232	*-2.29*	-0.4521	*-1.28*
Southwest	-1.2132	*-1.68*	0.4150	*0.87*
West	-0.7435	*-2.49*	-0.0570	*-0.10*
STATE-SPECIFIC COEFFICIENTS:				
Total Number of Coefficients / Number Negative *(Percent Negative)*	48 / 35 *(72.9)*		48 / 31 *(64.5)*	
Total Number of Significant Coefficients / Number Negative *(Percent Negative)*	15 / 13 *(86.7)*		13 / 9 *(69.2)*	

NOTE: Estimation results are generated by estimating the core variable specification of Equation (13), supplemented with the respective interaction dummy variables (cf. the text for further details). The estimation procedure is FGLS (weighting on groupwise heteroscedasticity) with robust VCE for cross-sectional correlation. For the last row, statistical significance is defined at the 10 percent level.

TABLE 8
Robustness Across Alternative Specifications of Government Finances

	Only taxes	*Taxes + Non-Tax Revenues*	*Taxes + Non-Tax Revenues + Welfare Expenditures*	*Taxes + Welfare Expenditures*
TaxBurden(D)	-0.5086 (-3.54)	-0.4020 (-2.82)	-0.4654 (-2.58)	-0.5622 (-3.45)
TaxBurden(L)	-0.6494 (-8.00)	-0.4866 (-7.63)	-0.5913 (-7.38)	-0.7277 (-8.13)
NonTaxRevenues(D)	----	-0.3763 (-2.98)	-0.4306 (-3.36)	----
NonTaxRevenues(L)	----	-0.3784 (-3.39)	-0.4375 (-2.94)	----
Welfare(D)	----	----	0.6157 (3.49)	0.5131 (3.14)
Welfare(L)	----	----	0.5749 (1.84)	0.3482 (1.29)

NOTE: Coefficients are estimated using FGLS (weighting on groupwise heteroscedasticity) with robust VCE for cross-sectional correlation. t-statistics are reported in parenthesis below the respective coefficient estimates. The first column reproduces previous results for comparison's sake (cf. the next to last row of TABLE 4). "Non-Tax Revenues" are defined as General Revenues minus Total Taxes divided by income. "Welfare" is defined as Direct General Expenditures on Public Welfare divided by income. Source for the government finance data is U.S. Census Bureau.

TABLE 9
Estimation of the Relationship Between Tax Burden and Economic Growth Using Annual Data

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
TaxBurden	0.0016 (3.06)	0.0017 (1.11)	0.0174 (8.77)	0.0040 (1.16)	0.0064 (6.27)
TaxBurden(-1)	----	----	----	----	-0.0025 (-1.96)
TaxBurden(-2)	----	----	----	----	-0.0020 (-1.62)
TaxBurden(-3)	----	----	----	----	-0.0001 (-0.11)
TaxBurden(-4)	----	----	----	----	-0.0025 (-2.63)
LNK	0.0754 (8.84)	----	----	----	0.0936 (9.97)
LNL	0.1073 (8.19)	----	----	----	0.1330 (9.79)
LNN	0.0064 (5.91)	----	----	----	0.0034 (3.29)
LNY_1	0.7466 (65.25)	----	----	----	0.7180 (55.54)
Education	0.0034 (10.38)	0.0174 (20.17)	----	----	0.0038 (10.62)
Working Population	0.0056 (11.85)	0.0288 (25.28)	----	----	0.0055 (11.19)
Nonwhite	-0.0004 (-2.84)	-0.0008 (-2.38)	----	----	-0.0001 (-1.09)
Female	0.0112 (8.33)	-0.0014 (-0.37)	----	----	0.0127 (8.95)
Agriculture	0.0028 (12.11)	0.0057 (11.53)	----	----	0.0015 (5.11)
Mining	-0.0005 (-1.16)	0.0029 (4.80)	----	----	-0.0011 (-2.74)

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
Union	0.0008 (5.31)	0.0049 (15.24)	----	----	0.0013 (8.45)
Diversity	0.0032 (7.06)	0.0039 (3.17)	----	----	0.0017 (3.10)
Other variables	state fixed effects, year fixed effects	state fixed effects, year fixed effects	state fixed effects, year fixed effects	----	state fixed effects, year fixed effects
Number of observations	1440	1440	1440	1440	1248
R^2	0.994	0.944	0.843	0.448	0.993

NOTE: The dependent variable is the log of real Per Capita Personal Income (1984 dollars). All equations are estimated using OLS. t-statistics are reported in parenthesis.

APPENDIX
Statistical Summary of Data

Variable		*Mean*	*Std. Deviation*	*Minimum*	*Maximum*
DLNY[1]		8.23	5.20	-9.38	40.45
DLNK[2]		7.42	7.81	-26.92	55.43
DLNL[3]		4.66	3.99	-7.22	14.97
DLNN[4]		4.63	4.48	-8.63	21.45
Tax Burden[5]	D	0.13	0.88	-5.52	5.91
	L	10.87	1.37	7.92	19.27
Education[6]	D	1.77	0.55	0.34	3.21
	L	16.41	4.92	6.66	30.21
Working Population[6]	D	0.97	0.93	-1.22	2.93
	L	55.84	3.18	47.54	62.26
Nonwhite[6]	D	0.56	0.51	-0.98	2.42
	L	11.75	8.76	0.36	37.35
Female[6]	D	-0.02	0.15	-0.57	0.75
	L	51.23	0.77	48.77	52.76
Population[6]	L	14.93	1.00	12.72	17.27
Population Density[6]	D	4.93	6.68	-8.44	37.26
	L	162.25	230.78	3.44	1089.83
Urban[6]	D	0.75	1.13	-1.97	3.96
	L	67.18	14.43	32.16	93.54
Agriculture[6]	D	-0.06	2.46	-16.72	18.85
	L	3.28	3.98	-8.92	29.06
Manufacturing[6]	D	-0.81	1.68	-6.09	3.37
	L	20.93	8.42	3.73	40.49
Service[6]	D	1.47	1.25	-3.22	6.40
	L	19.51	5.65	10.93	41.55
Mining[6]	D	-0.19	0.76	-3.29	4.27
	L	2.15	3.53	0.02	24.98

Variable		***Mean***	***Std. Deviation***	***Minimum***	***Maximum***
Union[6]	D	-1.47	2.36	-10.6	5.0
	L	18.48	8.12	3.3	41.7
Diversity[6]	D	-0.06	0.77	-5.42	4.66
	L	17.36	2.05	13.84	23.56
LNY_1[7]		2.53	0.20	1.96	3.06
NonTaxRevenues[8]	D	0.33	0.93	-2.13	6.26
	L	8.16	2.29	3.44	20.13
Welfare[9]	D	0.19	0.52	-1.70	2.88
	L	2.15	0.83	0.75	5.30

Variable Descriptions

[1] *DLNY is the percent change in real Per Capita Personal Income (1984 dollars).*

[2] *DLNK is the percent change in net private Capital Stock created through 1-digit SIC industries (measured in millions of chained 1996 dollars). These data were provided by Steve Yamarik (cf. Garofalo and Yamarik[2002]).*

[3] *DLNL is the percent change in total employment (source: BEA).*

[4] *DLNN is the percent change in total population (source: Census).*

[5] *Tax Burden is the ratio of total state and local tax revenues over total state personal income.*

[6] *These variables are described in TABLE 2. "D" denotes the five-year difference in the variable over the period (t-4,t). "L" denotes the value of the variable at the beginning of the five-year period.*

[7] *LNY_1 is the value of the log of real Per Capita Personal Income (1984 dollars) at the beginning of the five-year period.*

[8] *"NonTaxRevenues" is defined as General Revenues (state+local) minus Total Taxes (state+local) divided by Personal Income at the start of the fiscal year (source: Census).*

[9] *"Welfare" is defined as Direct General Expenditure of State and Local Governments on Public Welfare divided by Personal Income at the start of the fiscal year (source: Census).*