Are efficient taxes responsible for big government? Evidence from tax withholding

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Abstract

The paper examines the claim that more efficient taxes lead to bigger government by studying the effects of income tax withholding, a particular technological shock to tax efficiency. We exploit the variation in the timing of the adoption of withholding by state governments in the United States during the 1940's through 1970's. Due to improved compliance and other factors, withholding immediately and permanently increased income tax collections by 24 percent at given tax rates. We find that this efficiency shock caused a large increase in income tax revenues, although much of the increase occurred through a shift in the composition of revenues towards a heavier reliance on the income tax. We also find that the revenue from other taxes increased when withholding was adopted, which we intepret as evidence that the adoption of withholding was motivated by higher demand for government spending. We use the theory to disentangle the causal effect from withholding to higher taxes and the reverse causality from higher demand to withholding. The causal effect accounts for at most one half of the 8 percent increase in total revenue. Contrary to claims that withholding was *the* thing that enabled the post-war explosion of income taxation, we conclude that it accounts for approximately 9 percent of the growth of state income taxes during the period in question.

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1 Introduction

Explaining the growth of government during the 20th century has been one of the vexing questions in economics.[1] Several authors (Kau and Rubin (1981), Becker and Mulligan (2003)), claim that governments became bigger mainly because they became more efficient in raising taxes. In fact, a large class of positive models of the size of government gives the same testable prediction that a reduction in the deadweight costs of taxes will increases the size of government. These include Becker and Mulligan's (2003) model of interest groups, Meltzer and Richard's (1981) median voter model of pure redistribution, Hettich and Winer's (1988) model of determination of tax structure under probabilistic voting, or Brennan and Buchanan's (1980) model of Leviathan government.

In this paper we present a direct test of a causal link between tax efficiency and the size of government. We study the impact of a particular "technological shock" that improved the efficiency of taxes: the

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[1] For recent surveys, see Mueller (1989) or Holsey and Borcherding (1997).

introduction of income tax withholding at the state level in the United States. As opposed to the original method of collecting income taxes (taxpayers "voluntarily" filing the tax returns at the end of the fiscal year), withholding made tax evasion more difficult by deducting the tax immediately from workers' paychecks and collecting it from employers. Therefore it effectively broadened the tax base and enabled to raise the same revenue at lower tax rates. In conventional models of optimal taxation, income taxes with relatively broader tax base and lower marginal tax rates are regarded as more efficient. The impact of withholding on tax efficiency is large, immediate, and discontinuous, which makes it a particularly attractive source of identification.

Income tax withholding was first adopted at the federal level in 1943 with the goal to raise more revenue to finance the war expenditures. Later, it has been blamed for enabling the post-war expansion of federal government. As Milton Friedman, who at that time worked for the U.S. Treasury and helped to implement the federal withholding, stated in his memoirs:

> *"[W]ithout the system of current tax collection, it would have been impossible to collect the amount of income taxes that we collected during the war. At the time, we concentrated single-mindedly on promoting the war effort. We gave next to no consideration to any longer-run consequences. It never occurred to me at the time that I was helping to develop machinery that would make possible a government that I would come to criticize severely as too large ..."* [2]

While the expansion of the federal income tax after 1943 is indisputable, it is difficult to infer whether it was due to withholding or some other factors. The adoption of withholding at the state level, however, provides a unique set-up for identifying the effect of changes in tax efficiency on the size of government. Withholding was adopted state-by-state, and the variation in the timing of adoption is substantial. It spreads from 1948 (Oregon) to 1987 (North Dakota). This allows to exploit the difference-in-differences estimator in a panel of state-level data. Since withholding affected the deadweight cost of only one tax but not other taxes (barring potential spillover effects, of which, however, we find no evidence) we are able to investigate the effect of a reduction in deadweight cost on both level and composition of tax revenues.

The claim that more efficient governments are bigger has so far been subject to only few empirical tests, all relying either on a single time series or cross-country regressions. Kau and Rubin (1981) argue that the costs of collecting taxes have declined because changes in the structure of the economy made tax collection easier. They find that factors such as the growth in female labor participation and decline in self employment explain virtually all the growth of government during 1929-70. Yet while the connection between female labor participation and size of government may be indisputable, it is arguable whether such a connection is due to lower costs of tax collection, or due to a higher demand for government induced by higher female labor participation. Summers, Gruber and Vergara (1995) show that labor taxes are less distortionary when labor supply decisions are made collectively by labor unions (a phenomenon they dub "corporatism"). In their empirical analysis of 17 developed countries, they find that countries with a larger degree of corporatism do indeed have higher labor taxes as a share of GDP, though they do not tax more heavily other sources of income. Becker and Mulligan (2003) find support for their interest group model by regressing the size of government on various measures of tax efficiency[3] in a cross section of countries. For most measures they find a positive correlation between tax efficiency and the size of government.

These studies contrast with the view that the growth of government has been driven mainly by rising demand for public spending.[4] If this were the case, big governments may still be more efficient, but the direction of causality is reversed: Bigger governments are more likely to adopt a more efficient

[2] *Friedman and Friedman, p. 123.*

[3] For example, the share of government revenue raised from relatively more efficient taxes, or the ratio of average to marginal income tax rate.

[4] Wallis (1999).

tax system since the benefits of doing so are increasing in the amount of revenue that needs to be raised. The difference between the "efficiency" and "demand" explanations of government growth is not as much about the underlying theory of government but rather about the relative importance of efficiency versus demand factors. Empirical framework of this paper allows to decompose how much of the post-withholding increase in revenues can be attributed to higher efficiency of taxes and how much to a higher demand for spending.

We generalize alternative positive models of government into a social planner model of the optimal size of government and composition of tax revenues. Withholding is modelled as an improvement in the technology of income tax collections. We also model the reverse causality and distinguish two stimuli for adoption: a "supply-driven" adoption, which occurs when the administrative costs of withholding fall, and "demand-driven" adoption, which occurs when the demand for spending reaches a critical level. The effect of withholding on tax revenues can be decomposed into three effects: substitution effect (a shift in composition of revenues towards the income tax and away from other taxes, holding total revenues constant), scale effect (an increase in total revenues due to a reduction in marginal deadweight costs) and the demand effect (an increase in total revenues due to an increase in demand for spending that stimulated the adoption of withholding). Only the first two effects represent a causal relationship from efficiency to taxes, while the third represents the reverse causality. The model predicts that taxes other than the income tax should decline when adoption is supply-driven, while they may increase if adoption is demand-driven. Similarly, the model predicts that the income tax rates should decline when adoption is supply-driven while they may increase if adoption is demand-driven.

The empirical results provide convincing evidence of a causal relationship from efficiency to taxes. First, our estimates confirm that withholding indeed made income taxes more efficient by immediately and permanently increasing the collections by 23.7 percent, holding the tax rates constant. This estimate is very robust to alternative specifications and always statistically significant. The improvement in tax collections translates into a 2.8 percent reduction in deadweight costs of state income taxes. Second, we find that the major response of state governments to this efficiency shock was a shift in the composition of revenue: the share of the income tax in total tax revenue increased by about 19%. Third, we find that the adoption of withholding was demand-driven, since the revenue from other taxes actually increased by 3.8 percent in response to withholding. We investigate the possibility that the increase in revenue from other taxes could be due to some technology spillover through which withholding could have reduced the deadweight cost of other taxes. However, we find no evidence of such a spillover, and we present some evidence that the increase in revenue from other taxes was due to an increase in tax rates.

We decompose the estimated changes in revenues into substitution, scale, and demand effect, and find that substitution effect increased income taxes by 21.7 percent and decreased other taxes by 3.45 percent. In the presence of demand-driven adoption, the model allows only to set an upper bound on the scale effect and a lower bound on the demand shock: The scale effect increased total tax revenues by at most 3.9 percent, while the demand shock increased revenues by at least 3.8 percent and at most 7.7 percent. Still, the sum of the substitution and scale effects implies that withholding caused an increase in income taxes by 21.7 to 25.8 percent, even though much of this causal link can be attributed to a shift in composition of revenues rather than an overall increase in taxation.

In a similar vein, withholding produced only a once-and-for-all change in levels of income tax revenues. We find no evidence that it induced increases in income tax rates. Contrary to Milton Friedman's claim, withholding can hardly be blamed for enabling the post-war expansion of income taxes, provided that qualitatively the same results apply to the federal income tax.

The rest of the paper is organized as follows. Section 2 provides institutional background on tax withholding at the state level. Section 3 develops a theoretical model and derives testable predictions. Section 4 explains our estimation strategy and section 5 describes the data. Empirical results are presented in section 6. Section 7 concludes.

2 Income tax withholding - institutional background[5]

Today, the individual income tax is (together with the general sales tax) the main source of revenue for state governments and represents 36 percent of states' total tax revenue.[6] However, state income taxes were relatively unimportant until the 1950's. During the 19th and in the early 20th century, states' efforts to tax income were frustrated by their inability to effectively collect the tax. In 1911 Wisconsin was the first state to enact a modern, broad-based income tax. State individual income taxes became widespread during the 1930's, when 18 states implemented them. Yet by 1944, they represented less than 9 percent of tax revenues in the states that were imposing them, and mere 6 percent in all states.

By introducing income tax withholding in 1943 the federal government made a major change in tax administration.[7] Until then, taxpayers paid their income taxes when they filed annual returns. Since then, employers have been required to withhold a certain fraction of their workers' paychecks and pay it directly to the government. At the end of the fiscal year, taxpayers file income tax returns in which they compute the assessed income tax. Any difference between the assessed tax and the amount withheld during the previous year is either refunded to the taxpayer (if negative) or has to be paid to the government (if positive).

Some limited forms of withholding had existed at the state level even before 1943.[8] In 1948, Oregon became the first state to require withholding on all wage and salary income in 1948. Nine states adopted withholding in the following 10 years, and 12 states adopted it at the turn of the 1950's and 1960's (see Table 1). With the exception of North Dakota, all 29 states that had a broad-based income tax at the end of the World War II implemented withholding by the early 1970's. There were also 10 states that imposed individual income tax during the 1960's and 1970's. All of these states chose to withhold from the outset. Withholding has become an "industry standard" in the tax collection business. No state has abolished it, or even considered to abolish it.

Withholding reduces the deadweight cost of the income tax by increasing the revenue collected at given tax rates or, equivalently, by making it possible to raise a given amount of revenue at lower tax rates. In conventional models of public finance, lower marginal tax rates are associated with smaller distortions on the labor supply, effort, tax evasion, or any other margin that affects taxable income. Withholding generates more revenue primarily by an improvement in tax collections. It makes tax avoidance more difficult, since the tax authorities receive the tax liability immediately as the income is earned and do not need to rely on taxpayers' self-reporting of income. Second, withholding induces a time shift in tax collections. Initially, it causes a transitory increase in tax revenues as the government collects the tax liability twice during the adoption year. However, when taxes are progressive, withholding also generates a permanent increase in tax collections due to the so called "earlier realization of the growth in the tax base". As incomes are rising, more taxpayers move into higher brackets with higher marginal tax rates and the average tax rate rises. As withholding shifts the tax collection forward, the government receives the *growth* in average tax rate one year earlier than it would have under the traditional regime. Last, withholding effectively increases government revenue by overwithholding. Since both the state and federal systems are designed such that the average taxpayer receives a refund, the government obtains an interest-free loan from the taxpayers.

According to our estimates (section 6.1) withholding can be thought of as a revenue-neutral tax reform that reduced marginal tax rates of state income taxes by 23.7 percent. One can then calculate the reduction in deadweight costs due to withholding by using Feldstein's (1999) formula:

[5] The historical information in this section was taken from Murray (1964) and Penniman (1980).

[6] Source: Census of Governments.

[7] The United States were not the first country to implement withholding. Great Britain and Germany were withholding taxes before World War II.

[8] For example, a few states required withholding of the non-residents' income.

$$DWC = \frac{1}{2}\frac{\tau^2}{(1-\tau)}TI\ \epsilon \tag{1}$$

where τ is the marginal tax rate, TI is the taxable income, and ϵ is the elasticity of taxable income with respect to net-of-tax share. The percentage change in deadweight costs from a change in tax rate from τ_0 to τ_1 is then

$$\frac{dDWC}{DWC} = \frac{\tau_1^2}{\tau_0^2}\frac{(1-\tau_0)}{(1-\tau_1)} \tag{2}$$

Note that the percentage change does not depend on the elasticity of taxable income. In our calculation, τ_0 is measured as a sum of the federal and state average marginal tax rate in a state one year prior to the adoption of withholding. The average marginal tax rate for the federal tax is taken from Barro and Sahasakul (1983). The data for a state average marginal tax rate is not available for the period in question, therefore we assume that the ratio of the average marginal tax rate and the average tax rate for the state tax is the same as for the federal tax. The federal average tax rates are also reported in Barro and Sahasakul (1983), and we construct the state average tax rate as a ratio of state income tax revenue to state personal income from our own dataset. The state average marginal tax rate is then easily imputed. τ_1 is the revenue-neutral post-withholding average marginal tax rate - i.e., τ_0 reduced by 23.7 percent. The federal average marginal tax rate one year prior to the adoption of withholding is, on average, 22.9 percent, and the imputed state average marginal tax rate is, on average, 1.6 percent. The percentage reduction in deadweight cost due to withholding is computed for each state and it ranges from 0.08 (Mississippi) to 5.5 (Wisconsin). The percentage reduction is the greatest in the states that had a high average tax rate. On average, we find that withholding reduced the deadweight cost of state income taxes by 2.8 percent.

Withholding also affects the administrative cost of tax collection, although our data do not allow to assess by how much. The overall effect is ambiguous. On one hand, there is obviously more paperwork involved. On the other hand, the costs of collecting taxes from delinquent taxpayers, potential evaders, and non-residents are probably much lower under withholding. When the tax returns are due, most of the tax liabilities that would have remained unreported or owed under the traditional system are already in the government coffers. It is not surprising that before withholding was expanded to all payroll income, some states were requiring it for non-resident income, where the costs of chasing delinquent taxpayers are larger. Combining these two effects suggests that withholding probably increased the fixed but reduced the marginal administrative costs of tax collection. Administrative costs count as deadweight costs of taxes, and it is the marginal, not fixed deadweight cost that matters for the size of government.[9]

3 Theoretical model

There is no shortage of alternative positive models of the size of government that predict a link between deadweight costs and the size of government. They include Becker and Mulligan (1998) model of political competition among interest groups, Meltzer and Richard (1981) model of income redistribution under majority voting, Hettich and Winer (1988) model of public goods provision under probabilistic voting, Grossman and Helpman (1996) model that combines both interest groups and

[9] An alternative view of why withholding may increase the size of government should be mentioned here. A popular argument accuses withholding of reducing the visibility of the income tax. Allegedly, taxpayers do not perceive the tax as strongly as they did under the traditional method of collection, and they may be willing to accept higher taxes. However, despite the intuitive appeal, it seems difficult to accept the view that taxpayers can be fooled all the time, and that they do not know how much they pay in taxes just because they do not pay them at once. The fact that withholding makes paying the tax more comfortable does not necessarily imply that taxpayers are willing to accept higher taxes. Moreover, the empirical literature on other aspects of fiscal illusion has found evidence that is mixed at best (Oates 1991). In the remainder of the paper, the focus is entirely on the real effects of withholding.

voting, or Brennan and Buchanan (1980) of government as a Leviathan. Despite markedly different assumptions about the public choice mechanism, the political equilibrium in each of these models can be represented as a solution to the social planner's problem (Samuelson (1954)) of maximizing a weighted sum of agents' utilities. Alternative mechanisms of public choice give different groups of taxpayers and subsidy recipients different "political power", which is reflected in their weights in the social planner's problem.

As a consequence, these models yield qualitatively identical predictions on how the tax system responds to an improvement in the efficiency of a single tax source (the income tax in our case). The logic of the argument follows from the planner model, in which the marginal deadweight costs are equalized across tax sources and are equal to the social marginal benefit of public spending. A decline in the deadweight costs of the income tax implies that first there should be a *substitution effect*: for a given amount of total revenue, income tax revenue should increase and revenue from other taxes decrease in order to equalize marginal deadweight costs across tax sources. Since the deadweight costs of the entire tax system have declined, there should also be a *scale effect*: both the income tax revenue and revenue from other taxes should increase to equalize the marginal benefit with marginal deadweight cost.

Below we use the social planner framework to formally model the effect of withholding on the level and composition of tax revenues. The government provides G dollars of public spending, which creates a social benefit $\gamma B(G)$. The function $B(G)$ is increasing and concave. The parameter γ reflects both the value of public spending to its recipients as well as their weight in the planner's problem. The government revenue comes from two sources, the income tax R^I and other taxes R^O.

To collect the income tax, the government imposes a flat rate τ on income y. Since the government is an imperfect tax collector, the revenue actually collected is a fraction $a \in (0, 1)$ of the revenue that should be collected:

$$R^I = a\tau y \tag{3}$$

Equation 3 defines the technology of tax collection. The parameter a depends, for example, on a state's economic characteristics and the state's expenditures on tax enforcement. ay can be thought of as the taxable income - the fraction of income that is effectively being taxed. The deadweight costs increases linearly in taxable income and the elasticity of taxable income ϵ, and quadratically in the tax rate:

$$C(R^I) = \frac{1}{2}\tau^2(ay)\epsilon = \frac{1}{2}\frac{\epsilon}{ay}R^{I2} \tag{4}$$

where the last expression follows from the substitution of equation 3 and explicitly shows that the deadweight cost of the income tax falls when the government's ability to collect the tax improves.

The composition or collection technology of other taxes is not of particular interest; we merely assume that the deadweight costs of other taxes are independent of the deadweight costs of the income tax and increasing quadratically in revenue: $C(R) = \frac{1}{2}\delta R^{O2}$. The independence assumption is an important one, since if a reduction in deadweight cost of the income tax also reduced the deadweight cost of other taxes, revenue from both taxes would rise. However, since our estimates do not suggest the presence of such a technology spillover, we consider the independence assumption to be appropriate.

The government's problem is to choose R^I and R^O in order to maximize the social benefit of spending net of the deadweight costs of taxes:[10]

$$\max_{R^I, R^O} \gamma B(G) - \frac{1}{2}\frac{\epsilon}{ay}R^{I2} - \frac{1}{2}\delta R^{O2} \text{ s.t. } R^I + R^O = G \tag{5}$$

[10] For income taxes, the direct choice variable is the tax rate τ instead of revenue R^I. However, it is analytically much more convenient to solve the model for R^I; the tax rate then drops out according to $\tau = \frac{R^I}{ay}$.

The solution to the problem is best characterized in two stages: In the first stage, for any given G, the government chooses the composition of taxes $(R^{I*}(G), R^{O*}(G))$ that minimizes the deadweight costs. The solution to the first stage defines the deadweight costs of the tax system, $C(G) = C(R^{I*}(G)) + C(R^{O*}(G))$. In the second stage, the government chooses the optimal size of government that maximizes $\gamma B(G) - C(G)$.

The solution to the first stage gives the familiar result that the marginal deadweight costs must be equalized across both taxes. It is straightforward to verify that

$$\begin{aligned} C(G) &= \frac{1}{2}\frac{\delta\epsilon}{a\delta y + \epsilon}G^2 = \frac{1}{2}cG^2 && (6) \\ R^{I*}(G) &= \frac{a\delta y}{a\delta y + \epsilon}G = \frac{ay}{\epsilon}cG = s^I G && (7) \\ R^{O*}(G) &= \frac{\epsilon}{a\delta y + \epsilon}G = \frac{1}{\delta}cG = s^O G && (8) \\ \frac{R^{I*}}{R^{O*}} &= \frac{\delta}{\epsilon/ay} && (9) \end{aligned}$$

Both tax sources increase proportionally with total taxes and are inversely related to their deadweight cost parameters. The advantage of this formulation is that the terms $\frac{ay}{\epsilon}c$ and $\frac{1}{\delta}c$ denote the shares s^I and s^O of the income tax and other taxes, respectively, which are easily observable in the data.

The solution to the second stage is given by equalizing the marginal benefit of spending to marginal deadweight costs and implicitly defines the demand for government revenues as a function of γ and the deadweight cost parameter c:

$$\gamma B' = cG \tag{10}$$

Withholding enters this model as an increase in a. We cannot estimate a, but we do estimate da/a, the percentage increase in tax collections which we refer to as the "efficiency effect" of withholding. The comparative statics on a show the percentage changes in revenue due to withholding:

$$\begin{aligned} \frac{dG}{G} &= \left(\frac{y}{\epsilon}\frac{c^2}{c - \gamma B''}\right) da > 0 && (11) \\ \frac{dR^I}{R^I} &= \left(\frac{ds^I/da}{s^I} + \frac{dG/da}{G}\right) da = \frac{da}{a} + \frac{d\tau/da}{\tau}da = \left(1 + \frac{acy}{\epsilon}\frac{\gamma B''}{c - \gamma B''}\right)\frac{da}{a} > 0 && (12) \\ \frac{dR^O}{R^O} &= \left(\frac{ds^O/da}{s^O} + \frac{dG/da}{G}\right) da = \left(\frac{cy}{\epsilon}\frac{\gamma B''}{c - \gamma B''}\right) da < 0 && (13) \end{aligned}$$

Equation 11 shows that spending must increase, because it is cheaper to raise an additional dollar of revenue. Equation 12 decomposes the change in income tax revenue into substitution and scale effects. The substitution effect (the first term) is the change in the share of income tax in total revenue. The scale effect (the second term) reflects a higher demand for revenue induced by a reduction in marginal deadweight costs. For the income tax, the substitution and scale effects have the same sign.

Equation 12 also shows an alternative, and somewhat more intuitive decomposition of the increase in income tax revenue. First, the efficiency effect mechanically raises revenue by da/a percent. Second, since the current tax rate is no longer optimal, the government should respond to an increase in a by adjusting the tax rate. This effect, which we label the "political effect", will increase the revenue by $d\tau/\tau$ percent.

The political effect reflects the sensitivity of demand for public spending to deadweight costs. One special case is $d\tau/\tau = -da/a$, which would occur if the government reduced the tax rate such that it would exactly offset the efficiency effect. In this case, demand for income tax revenue would be insensitive to deadweight cost. Another special case is $d\tau/\tau = 0$, which means that the government would simply keep the extra revenue from withholding. Last, if demand for spending is sufficiently responsive to deadweight cost, the tax rate may increase and hence revenue grow "on top of" the efficiency effect, which is essentially Friedman's assessment of the post-war growth of the federal income tax. It is straightforward to verify, however, that our model predicts that $d\tau/\tau \in (-da/a, 0)$, i.e., the tax rate should fall and the overall change in tax revenue should be smaller than the efficiency effect.

Finally, equation 13 shows the response of other taxes. The substitution effect is negative and dominates over the scale effect, and hence the revenue from other taxes must decrease. [11]

The analysis has to be modified if the change in a is endogenous, which is in fact our case since the states adopted withholding voluntarily and for a reason. Naturally, withholding is adopted whenever the benefit exceeds the costs, broadly defined. The cost of withholding $F(da)$ includes the obvious administrative costs but may also capture the political costs, such as the unpopularity of withholding among some taxpayers. The benefit of withholding is the reduction in deadweight costs[12], $(\epsilon/a^2y)R^{I2}da$. Withholding is adopted when

$$F(da) < \frac{\epsilon}{a^2 y} R^{I2} da \tag{14}$$

Since a majority of states adopted withholding more than 15 years after the federal government, the costs of withholding must have been significant and initially made the adoption not worthwhile. Adoption may be driven either by a shift in the "supply" of withholding or "demand" for withholding. Supply-driven adoption occurs when the costs $F(da)$ fall below a critical level. An example of a decline in $F(da)$ at the state level may be the federal withholding, since it reduced the administrative costs of withholding for the states. Demand-driven adoption occurs when the income tax revenue R^I reaches a critical level so that the efficiency gain is large enough. This can occur either after a period of a steady growth in the demand parameter γ and a corresponding growth in income tax revenues, or after a large one-time positive shock to γ, as was clearly the case with federal withholding. Withholding is, after all, a technology that generates more revenue, so it is natural to expect adoption when governments need more revenue.

When adoption is driven by an increase in demand for government spending, the simultaneous increase in a and γ has significant implications for the *observed* changes in tax revenues after withholding. In addition to the substitution and scale effects, the revenues will also change in response to the demand shock, the right-most term in the equations below:[13]

$$\frac{dR^I}{R^I} = \frac{dR^I/da}{R^I}da + \frac{dR^I/d\gamma}{R^I}d\gamma = \left(\frac{ds^I/da}{s^I} + \frac{dG/da}{G}\right)da + \frac{dG/d\gamma}{G}d\gamma > 0 \tag{15}$$

$$\frac{dR^O}{R^O} = \frac{dR^O/da}{R^O}da + \frac{dR^O/d\gamma}{R^O}d\gamma = \left(\frac{ds^O/da}{s^O} + \frac{dG/da}{G}\right)da + \frac{dG/d\gamma}{G}d\gamma \lesseqgtr 0 \tag{16}$$

$$\text{where } \frac{dG/d\gamma}{G} = \frac{c}{\gamma(c-\gamma B'')} > 0 \tag{17}$$

[11] The substitution effect is greater than the scale effect because as total spending increases, the marginal benefit of spending decreases, which means that the marginal deadweight costs of both the income tax and other taxes must decrease. Since there is no change in the efficiency of other taxes, revenue from other taxes must be reduced in order to reduce the marginal deadweight costs.

[12] For discontinuous changes in a, the benefit of withholding also includes the incremental value of public goods, net of the incremental deadweight costs. For an infinitesimal change in a, this effect is zero by the envelope theorem.

[13] When adoption is supply-driven, the predictions of the model are the same as if da were exogenous.

Income taxes increase by more than what dR^I/da predicts, and it need no longer be true that the income tax rate should decline. Similarly, other taxes do not decrease by as much as dR^O/da predicts, and they may even rise. Only the substitution and scale effects represent the causal relationship from withholding to revenues, while the response to the demand shock, $\frac{dG/d\gamma}{G}d\gamma$ represents the reverse causality from higher spending to withholding. We are able to estimate the change in revenues after the introduction of withholding, but our estimates would have causal interpretation only if the adoption was supply driven, or if the demand shock was captured by observable variables. If the adoption of withholding was driven by an unobservable demand shock, the estimated changes in revenues would be augmented by that shock. Despite this, the model allows us to disentangle the causal effect of withholding from the reverse causality.

First, we are able to detect the substitution effect. Note in equations 15 and 16 that if there was no causal relationship from deadweight costs to revenues (i.e., if the substitution and scale effects were zero), the demand shock would increase both taxes by the same percentage. Next, if the scale effect is positive, it would also increase both taxes by the same percentage. Therefore, the estimates provide evidence of the substitution effect if the increase in income tax revenue exceeds the increase in revenue from other taxes.[14]

Second, we are able to detect the demand shock, provided it is sufficiently large. In the absence of demand shock, revenue from other taxes should decrease; therefore observing an increase in revenue from other taxes gives unambiguous evidence of a positive demand shock. Only if the demand shock is small such that the revenue from other taxes decreases we are unable to say whether the demand shock was present or not.

Third, the model allows to measure the substitution effect and to at least set bounds on the demand and scale effects. With the information on pre-withholding tax shares and post-withholding changes in revenue, we easily obtain the increase in total revenue due to the scale effect and the demand shock combined:

$$\dot{G} = \frac{dG/da}{G}da + \frac{dG/d\gamma}{G}d\gamma = s^I \dot{R}^I + s^O \dot{R}^O \tag{18}$$

where we simplify notation by $\dot{x} = dx/x$. By substituting equation 18 into equation 15 we pin down the substitution effect:

$$\dot{s}^I = \dot{R}^I - \dot{G} \tag{19}$$

and equivalently for other taxes. The upper bound on the demand shock is the increase in total revenue $\dot{G}$ since the two would be equal under the extreme assumption that the scale effect is zero and the entire increase in total revenue comes from the demand shock. The lower bound on the demand shock is the increase in other taxes, since the two would be equal under the opposite extreme assumption that the scale effect for other taxes exactly offsets the substitution effect. Hence

$$\frac{dG/d\gamma}{G}d\gamma \in \left[\dot{R}^O, \dot{G}\right] \tag{20}$$

Finally, the scale effect drops out as the difference between the increase in total revenue and the demand shock (eq.18). Therefor, under the extreme assumption for the lower bound on the demand shock we obtain an upper bound on the scale effect and vice versa. The upper bound on the scale effect is thus equal to the difference between the increase in total revenue and the increase in revenue from other taxes. The lower bound on the scale effect is; unfortunately, we are unable to rule out the extreme assumption that the increase in total revenue is solely due to the demand shock. Hence

$$\frac{dG/da}{G}da \in \left[0, \dot{G} - \dot{R}^O\right] \tag{21}$$

[14] Or, if the scale and demand effects are small enough, we should still observe an increase in income tax revenue and a decrease in revenue from other taxes.

To summarize, the model generates testable predictions for the changes in revenue in response to withholding, both under the favorable assumption that the adoption of withholding is exogenous or driven by supply factors, as well as under the less favorable assumption that the adoption was driven by an unobservable shock to the demand for public spending. If there is a causal relationship from a reduction in deadweight cost of one tax to the level and composition of tax revenue, we should observe an increase in income taxes and a decrease in other taxes under supply-driven adoption, and an increase in income taxes and a reduction or increase in other taxes under demand-driven adoption, but the increase in income taxes must exceed the increase in other taxes. If tax revenues do not respond to deadweight costs, we should observe no change in revenues under supply-driven adoption, and a proportional increase in revenue from both taxes under demand-driven adoption.

4 Empirical strategy

Below we derive an econometric model of the technology of tax collections and demand for tax revenues that directly reflects the structure of the theoretical model. For expositional clarity, the model abstracts from the complexities of the actual income tax schedules and assumes that all income y_{it} is taxed at a flat tax rate τ_{it}, without any exemptions, deductions, or loopholes. Estimation issues raised by relaxing this assumption will be discussed below. The subscripts i and t denote state and year, respectively. All financial variables (revenues and income) are in per capita terms.

The technology of tax collections is defined as follows:

$$R_{it}^T = (1 + \alpha D_{it}) r^T (X_{it}, y_{it}) \tau_{it} y_{it} e^{u_{it}^T} \tag{22}$$

The term $(1+\alpha D_{it})r^T(X_{it}, y_{it})$ is an empirical counterpart of a in equation 3. D_{it} is a dummy variable indicating whether a state has withholding. The coefficient on the withholding dummy, α,measures the efficiency effect - the percentage increase in tax collections holding the tax rate constant (that is, $\alpha = da/a$). The term $r^T(X_{it}, y_{it}) < 1$ denotes the fraction of income that the government is able to tax in the absence of withholding. It is assumed to be a function of socio-economic variables X_{it}, where the income per capita y_{it} is explicitly included among these variables. u_{it}^T is the error term.

Equations 23 and 24 express, in a reduced form, the demand for income tax revenue, R_{it}^I, and the demand for revenue from other taxes, R_{it}^O. They are functions of the socio-economic parameters of the state and also of the efficiency effect of withholding:

$$\begin{aligned} R_{it}^I &= (1 + \beta^I \alpha D_{it}) r^I (y_{it}, X_{it}, Z_{it}) e^{u_{it}^I} && (23) \\ R_{it}^O &= (1 + \beta^O \alpha D_{it}) r^O (y_{it}, X_{it}, Z_{it}) e^{u_{it}^O} && (24) \end{aligned}$$

The parameters β^I and β^O denote the political effects, also our parameters of interest. Both β^I and β^O interact with α because, as the model predicts, the more revenue withholding brings in, the greater the political effect is in absolute terms. The products $\beta^I\alpha$ and $\beta^O\alpha$ have the interpretation of the "total effect" of withholding - the overall percentage change in revenue due to the efficiency and the political effects combined. The functions $r^I(\cdot)$ and $r^O(\cdot)$ are empirical counterparts of the parameter γ in equation 5. Z_{it} are variables that affect the demand but not the tax technology, and u_{it}^I and u_{it}^O are error terms.

Faced with the demand and the technology functions, the government selects the tax rate τ_{it} such that the income tax revenue demanded equals the revenue collected:

$$R_{it}^I = R_{it}^T \Leftrightarrow \tau_{it} = \frac{(1 + \beta^I \alpha D_{it}) r^I (y_{it}, X_{it}, Z_{it}) e^{u_{it}^I}}{y_{it} (1 + \alpha D_{it}) r^T (X_{it}, y_{it}) e^{u_{it}^T}} \tag{25}$$

We assume a log-linear functional form for r^T, r^I and r^O:

$$\begin{aligned}\log r^T &= a_X \log X + a_y \log y \\ \log r^I &= \gamma_X^I \log X + \gamma_y^I \log y + \gamma_Z^I \log Z \\ \log r^O &= \gamma_X^O \log X + \gamma_y^O \log y + \gamma_Z^O \log Z\end{aligned} \quad (26)$$

Taking the logs of equations 22, 24, and 25, and substituting 26 gives a system of estimating equations:

$$\log R_{it}^I = \log(1+\alpha)D_{it} + \log \tau_{it} + (1+a_X)\log X_{it} + (1+a_y)\log y_{it} + u_{it}^T \quad (27)$$

$$\begin{aligned}\log \tau_{it} &= \log(\frac{1+\beta^I\alpha}{1+\alpha})D_{it} + (\gamma_X^I - a_X)\log X_{it} + (\gamma_y^I - a_y - 1)\log y_{it} + \\ &\quad + \gamma_Z^I \log Z_{it} + u_{it}^I - u_{it}^T\end{aligned} \quad (28)$$

$$\log R_{it}^O = \log(1+\beta^O\alpha)D_{it} + \gamma_X^O \log X_{it} + \gamma_y^O \log y_{it} + \gamma_Z^O \log Z_{it} + u_{it}^O \quad (29)$$

The system can be estimated by three-stage least squares and α, β^I, and β^O can be identified. Identification requires variables, denoted Z, that affect the demand for revenue but not the government's ability to collect it. We have two variables for which we can be reasonably confident that this condition is satisfied: the percentage of Democrats in the state legislature, and federal grants. The percentage of Democrats obviously reflects the tastes of voters for specific government policies (including redistributive policies). Yet it is difficult to imagine how this variable could affect the tax collections, unless more Democratic states are more likely to use some unobservable methods of tax collections such as more frequent audits. The federal grants are correlated with the demand for revenue through the so called "flypaper effect", widely documented in the literature[15], and through matching grants, when a federal grant for a given project is conditional on the state's providing a certain fraction of funds from its own sources. To be a valid instrument, the grants cannot be awarded on the basis of the state's unobserved ability to raise revenue, as would occur if the federal government "compensated" the states with a poor record of tax collection by higher grants.

Several practical issues need to be addressed when estimating the equations 27-29. First, the actual tax systems are not characterized by a single flat tax rate, but by a (rather large) number of variables such as progressive tax rates, income brackets, exemptions, deductions, credits, etc. To obtain an estimate of α, we treat τ_{it} as a vector of tax variables, include all of them into the technology equation (27) and have a separate demand equation (28) for each variable. However, this procedure produces estimates of many $\beta' s$, one for each tax variable. These are not our ultimate parameters of interest, since changes in tax rates or brackets in actual tax systems do not translate one-for-one to changes in income tax revenues. To obtain a consistent estimate of β^I, we separately estimate the system of demand equations for all tax sources (23-24, in logs) by seemingly unrelated regressions to allow for the possible correlation of error terms across taxes. The coefficient on the withholding dummy in the income tax equation is the total effect of withholding, $\log(1+\alpha\beta^I)$, from which β^I is easily recovered by substituting the estimate of α from the technology equation, and its standard error is computed by the delta method. The disadvantage of this method is that since we have only two instruments for the tax rate, we can use only two tax variables in the technology equation. Naturally, we choose the lowest and the top tax rate.

As an alternative, we estimate the technology equation by OLS, and include all available tax variables in the technology equation. While OLS may produce a biased estimate of α due to the correlation between αD and τ, it enables us to include all available tax parameters in the regression, which should reduce the omitted variable bias. Fortunately, the estimates of α are insensitive to the particular estimation method.

[15]For a survey, see Hines and Thaler (1995).

In all regressions that follow, state and year dummies are included to capture unobservable fixed effects that are constant within a state over time, or across states within a year. The standard errors are computed by the robust standard error estimator (Kezdi (2004)), where the clustering is by state. It is likely that unobservable shocks u^I, u^O, and u^T in state i, time t, are correlated to the shocks in state i at other times, even after picking up the state fixed effect. It has been established that the failure to account for the within-unit autocorrelation between residuals leads to an underestimate of the standard error of the difference-in-differences estimator (Bertrand, Duflo and Mullainathan (2004)). The robust estimator eliminates this concern.

5 Data

The dataset is an annual panel of 48 states from 1944 till 1980. The data on state government tax revenues (by each tax source), general expenditures (broken down into six major categories), federal grants and debt were taken from "Compendium of State Government Finances", an annual printed publication by the Bureau of Census. Alaska and Hawaii are excluded because fiscal data for these states are available only since 1959 and by that time, both states already had withholding. The information on when each state implemented income tax withholding comes from Murray (1964) and Penniman (1980).

The Book of the States, a biennial publication by the U.S. Bureau of Census, provided some information on the design of state taxes. Since 1947, the publication reports the lowest statutory income tax rate, the end of the lowest income bracket, the top tax rate, and the beginning of the top income bracket, as well as some special provisions (temporary surtaxes, differential tax rates on dividend income etc.). It also reports the corporation income tax rates, general sales tax rates, and major excise tax rates (motor fuel, cigarettes, distilled spirits). The publication describes legislative changes occurring in each calendar year, which makes it possible to fill in the tax rates for those years that are not reported in biennial tables.

A variety of socio-economic control variables is used in the regressions. The data on state population, personal income, share of farm income[16], and the share of interest and dividend income in the state's personal income come from Bureau of Economic Analysis, Regional Accounts Data. The percentage of state population that is black, elderly (65+) and lives in urban areas was obtained from Census enumerations.[17] The data on the percentage of Democrats in the state legislature was provided by the National Council on State Legislatures.[18]. The personal income variables were converted into real 1982 dollars by the consumer price index. Government revenue and expenditure variables were converted into real 1982 dollars by the "state and local government expenditure deflator".[19]

Table 2 presents summary statistics for all variables used in the regressions.

6 Results

6.1 Income taxes and other taxes

Figure 1 provides a cursory exploration into the impact of withholding on income tax revenues. The vertical axis shows the ratio of income tax revenues to the state's personal income, averaged across the

[16]The farm income is very volatile and is negative for some states in some years. Since this variable is meant to capture the long-term agricultural vs. industrial character of the state rather than short-term shocks to agricultural incomes, I use three-year moving averages of farm income in the analysis.

[17]Since Census data are decennial, observation for the years between censuses were generated by simple linear extrapolation.

[18]We are indebted to Tim Storey of NCSL for sharing this data.

[19]Both indices are published in the Economic Report of the President.

29 states which had income tax in 1944. All state years on the horizontal axis are normalized so that year zero is the fiscal year in which a state implemented withholding. While the figures have to be read with caution since no other factors affecting tax revenues are controlled for, they strongly suggest that withholding had a sizeable impact on income tax revenues. Income tax revenues grow steadily before withholding until they reach 0.66 percent of personal income, then they discontinuously jump up to 1 percent immediately after withholding is adopted, and later continue to grow at a slightly higher rate.

In the same vein, Figure 2 shows the evolution of the sum of sales and corporation income taxes before and after withholding. We can see that these major revenue alternatives to the income tax fluctuate around 3 percent before, then they jump up somewhat once withholding is adopted, and then continue to grow to about 3.5 percent of personal income in eight years. This suggests that a demand shock motivated the adoption of withholding and manifested itself in the growth of other taxes, not just the income tax.

Table 3 presents estimates of the three-stage least squares model of tax technology with separate equations for the top and lowest tax rates. The coefficient on the withholding dummy in column 1 is the estimate of the efficiency effect. It confirms that withholding profoundly changed the tax collection technology by generating 23.7 percent more revenue, holding tax rates constant. The coefficient on the withholding dummy is significant at 1% significance level.

In the tax rate equations (column (2) and (3)), the coefficients on the withholding dummy are small in magnitude (0.033 and -0.026 for the top and lowest tax rates, respectively) and insignificant. This suggests that states did not adjust income tax rates in response to withholding, but merely "cashed in" the windfall of revenue from improved collection. Several socio-economic variables significantly affect the top tax rate. Namely, higher income per capita, share of black population, and share of urban population are associated with lower top tax rate. Higher share of Democrats in the state legislature is associated, as one might expect, with a higher top rate.

The estimates of the efficiency effect are very robust to alternative specifications. If we ignore the endogeneity of tax rates and estimate the technology equation by OLS (Table 4, column (1)), the coefficient on the withholding dummy is 0.27 and is also significant at 1%. Virtually the same coefficient is obtained if we include additional tax parameters (the lowest and highest tax brackets and their interactions with tax rates) in the regression (Table 4, column (2)).[20]

Table 5 estimates the system of demand equations for all taxes. The coefficient on the withholding dummy in the income tax equation (column (1)) is our estimate of the total effect (0.297). It is only marginally larger than the efficiency effect, which is consistent with the previous finding that the tax rates did not change significantly in response to withholding. This estimate, and the estimated efficiency effect from Table 3, are used to compute the estimate of β^I, reported in the bottom of Table 5. The estimated β^I of 1.279 is significantly greater than zero, but not significantly greater than one, hence we cannot reject the hypothesis that withholding did not induce a change in tax rates and all post-withholding increase in income tax revenue is accounted for solely by the efficiency effect.

How did other taxes respond? According to Table 5, the corporation income taxes and sales taxes increased by 8.1 and 6.4 percent, respectively. Both estimates are statistically significant. The only tax category that declined was "miscellaneous taxes" , which include property, license, death and gift, poll, and other miscellaneous taxes, although the estimated decline is not statistically significant and much smaller in magnitude (3 percent). Note that the percentage increase in the other taxes is much lower than the increase in income taxes. This holds also in absolute levels: One year before withholding, the sales and corporation income tax revenues were, on average, $207 and $25 per capita, respectively. The estimated percentage increases represent an absolute increase by 13.2 and 2 dollars, respectively. On the other hand, the income taxes were $58 one year before adoption, so the 29.4

[20] As another robustness test, we re-estimated the models in a linear form, and always obtained positive and significant estimates of the efficiency effect. They implied an increase in tax revenue per capita by 11-14 dollars, depending on specification.

percentage increase implies an absolute increase by 17 dollars.

These results are clearly consistent with the predictions of the model in the presence of demand-driven adoption. The fact that an increase in income taxes significantly exceeds the increase in other taxes provides a strong evidence of a substitution effect. Governments do respond to changes in tax efficiency - at the very least they shift the composition of tax revenues and start relying more heavily on the tax that becomes more efficient. However, was the scale effect of withholding also important? Or were the observed increases in all taxes solely due to the demand shock?

We decompose the estimated increases in revenues into substitution, scale and demand effects using the estimates of the total effects from Table 5 and equations 18 through 21. The shares of income, corporation income, sales, and miscellaneous taxes one year before withholding are 15.2, 6.4, 54.3, and 24 percent on average. The increase in total revenue is 7.7%.[21], which is also an upper bound on the demand shock. The lower bound on the demand shock is the increase in other taxes, 3.8%. As a consequence, the scale effect of withholding could not exceed the difference between the total increase in revenue and the lower bound on the demand shock: $7.7 - 3.8 = 3.9\%$. The results thus show that the response to the efficiency shock increased total taxes by 0 to 3.9 percent, while the demand shock accompanying withholding increased taxes by 3.8 to 7.7 percent. As explained in section 3, we are unable to rule out the possibility that the entire increase in taxes was due to the demand shock. However, since the model's prediction about the substitution effect is clearly supported, we can reasonably expect that the scale effect is not zero either. Nevertheless, the bounds tell us that the demand effects was at least as important as the scale effects, since demand effect and the upper bound on the scale effect are equal.

Finally, the substitution effects are computed according to equation 19. The percentage changes in the share of each tax in total revenue is 21.7% for the income tax and −3.9% for other taxes. Translated into percentage points, the substitution effect implies that the share of income taxes increased and the share of other taxes decreased by 3.3 percentage points.[22]

We were concerned with the possibility that pre-existing unobservable trends are biasing the results. If, for example, an unobservable factor that is positively correlated with the demand for tax revenue was operating several years before a state adopted withholding, then the coefficient on a withholding dummy variable would be capturing the effect of such unobservable factor rather than an actual response to withholding. To check for possible unobservable trends, and to obtain additional insights about the speed of response of tax revenues to withholding, we estimate the same systems of equations as in Tables 4 and 6, but replace the withholding dummy with dummy variables each of them representing the year of adoption, the 1st, 2nd, etc. up to 8th year after adoption, and a dummy variable equal to 1 for 9 and more years after adoption. We also include dummy variables for the 1st, 2nd, etc. up to 9 and more years before withholding. The dummy variable representing the last year before adoption is taken out of the regression so that this year serves as the baseline. For expositional clarity, only the coefficients on the dummy variables from selected equations and their 95% confidence intervals are plotted against the time axis in figures 3 through 5.[23]

Figure 3 plots the estimated efficiency effects from the three-stage model. It shows that there was no unobservable trend before the adoption and that the efficiency effect of withholding was immediate: Holding the tax rates constant, income tax revenues rose by 31.9 percent in the adoption year. The efficiency effect then declines until it reaches 18.7 percent 3 years after adoption. The reason for this decline is that the increase in the adoption year is represented in large part by the a one-time forward shift in payments of taxes. This effect appears not only in the adoption year, but also in the following year, because in many states withholding came into force on January 1, while in almost all states the fiscal year begins on July 1. Hence the forward shift in tax collections that occurs in the first 12 months after adoption is accounted for in two fiscal years. After the 3rd year, the technological

[21] Since $0.294 \times 0.152 + 0.081 \times 0.064 + 0.064 \times 0.543 - 0.031 \times 0.24 = 7.7\%$

[22] The model imposes a restriction that $(\partial s^I/\partial a)da = (\partial s^O/\partial a)da$.

[23] Complete results from the regressions are available upon request.

effect rebounds back to 33 percent during the next five years. This is somewhat puzzling, since we would expect withholding to be a once-and-for-all improvement in tax collection technology. One possible explanation for this growth is that the states learned over time how to use the withholding system and gradually improved collections. We can speculate that after appreciating the benefits of withholding, the states expanded its use to the sources of income not initially covered (small firms, the self-employed), although we do not have a direct evidence of that.

Figure 4 shows the total effect of withholding on income tax revenues by plotting the coefficients from the demand equation. It does suggest that there was an unobservable upward trend in the demand before adoption, although rather small in magnitude. The "pre-effect" of withholding grows steadily from -0.1 to zero during the eight years preceding the adoption. Once withholding is adopted, income tax revenues immediately rise by 32 percent, decline somewhat (due to overlapping) in the next two years and then steadily grow again to 38 percent above the pre-withholding level over the next six years. The average value of coefficients on the dummy variables representing years before the adoption of withholding is -0.046, which can be interpreted as the magnitude of the upward bias of the "static" estimate of the total effect (Table 5, column (1)). Deducting the pre-withholding trend would reduce the estimate from 0.294 to 0.248. The estimated total and efficiency effects are virtually identical in all years following the adoption. In the language of the model, the political effect β^I is indistinguishable from one, which confirms that all post-withholding growth in income tax revenues can be accounted for by the improvement in tax collection and that withholding did not induce states to increase tax rates.

The ultimate test of the model comes from the response of other taxes. The coefficients on the pre- and post-withholding dummy variables for the (sum of) sales and corporation income taxes are plotted in Figure 5. One can see that, after controlling for other determinants, the other taxes were actually on a downward trend before withholding. The trend reverses exactly when withholding is adopted - other taxes jump up by 6.2 percent and then they continue to grow at a slower rate. The coefficients on the post-withholding dummies in the income tax equation are statistically different (at a 5% significance level) from the corresponding coefficients in the other taxes equation in all years, which provides an alternative measure of a significant substitution effect. The switch in the trend for other taxes[24], and especially their discrete jump in the adoption year provide strong evidence for the demand-driven adoption.

While we interpret the estimated increases in corporation income and sales taxes due to withholding as an evidence of the demand shock that stimulated the adoption of withholding, there is an alternative explanation that withholding may have also improved the efficiency of other taxes. In the presence of such a "technology spillover", all taxes may rise even if there is no demand shock, and the entire increase in income as well as other taxes could be interpreted as the causal effect of more efficient taxes. However, we do not find any evidence of such spillover. In Table 4, we estimate the technology of tax collection for corporation income, general sales, and excise taxes, by regressing the revenue per capita against the respective tax rates, withholding dummy, income, and other variables that potentially affect collections. The results show no effect of withholding on the revenue from the other taxes, once tax rates are controlled for.[25]

In the absence of technology spillovers, the increase in other taxes should be explained by higher tax rates. Partial evidence of that is presented in Table 6, which presents the 3SLS estimates of the tax collection technology with endogenous tax rates (equations 27 and 28) for the corporation income tax and the general sales tax. The results show that the corporation income tax rate increased by 11.2 percent, but show only a statistically insignificant 2.5% increase of the general sales tax rate.

[24] As a statistical check, we regressed the coefficients for the 8 years before withholding and 8 years after withholding against a time trend. The coefficient on the time trend is -0.0045 before withholding and 0.0084 after withholding, and the coefficients are statistically significant from each other. Hence withholding appears to have reversed the unobservable trend in corportation income and sales taxes.

[25] Ideally, the technology equations should be estimated by seemingly unrelated regressions, since unobservable shocks to collection are likely to be correlated across taxes. This way, however, we would lose many observations, since less than half of the states simultaneously impose individual income, corporation income, general sales, and excise taxes.

6.2 Timing of adoption

Since the data are consistent with the prediction of the model only under demand-driven adoption, we use the standard techniques of duration analysis to explore directly whether the adoption was influenced by demand or supply factors. This way, we also exploit a different source of identification since we are investigating whether the likelihood of adoption depends on observable demand variables, while in the preceding regressions the demand-driven adoption was detected from unobservable demand shocks correlated with withholding.

Equation 14 gives a very general adoption condition: the state should adopt withholding when the costs of withholding $F(da)$ fall below the efficiency gain, which is increasing in the revenue collected and in the deadweight cost parameter of the income tax (ϵ/ay). A fall in $F(da)$ or an increase in ϵ/ay leads to a supply-driven adoption. An increase in income tax revenue (after a steady growth or a sudden demand shock) leads to a demand-driven adoption. The model thus predicts, first of all, that states with higher income taxes should adopt withholding earlier. There are several variables which could potentially stimulate adoption through their effect on the demand for tax revenue: percent black and the elderly, Democrats in state legislature, federal grants and debt/revenue ratio (low federal grants or high debts imply that the states "need" more tax revenue).

Second, the model predicts that states with an inefficient income tax (low a or high ϵ) are more likely to adopt. The share of farm income and the share of dividend income are potential proxies for a relative inefficiency of a state's income tax, and should have a positive effect on the likelihood of adoption. However, these variables could also be positively related to the costs of implementing withholding, which would have an opposite effect on the likelihood of adoption. Unfortunately, we do not have variables that directly measure the administrative costs of withholding. The effect of population should be positive if, as seems plausible, the total deadweight costs of an income tax are increasing linearly in population while the costs of implementing withholding per capita are decreasing in population due to scale economies in tax administration. An effect of these variables would indicate a supply-driven adoption.

We estimate two alternative duration models. The first is the logit discrete-time hazard model with time-varying covariates (Allison (1984)) used, among others, by Fischback and Kantor (1998) to analyze the adoption of workers' compensation laws:

$$\log[P(t|X)/(1 - P(t|X))] = A + bX + e$$

where $P(t|X)$ is the conditional probability of adoption in a discrete point in time t given that adoption did not occur prior to t and given the vector of covariates X. A and b are parameters of the model and e is the error term. Dummy variables representing distinct five-year intervals are included among the covariates to capture the baseline hazard.[26] The second model is the Weibull proportional hazard model with time-varying covariates. We chose 1943, the year when withholding was "discovered" by the federal government, as the origin of the time scale because since then the states had the technology available for copying. A secular growth in most of the explanatory variables presents a potential concern: A government with an 8 percent ratio of general revenue to personal income, adopting withholding in 1960, would be considered relatively large in that year, while equally big government adopting withholding in 1970 would be considered relatively small. Therefore we estimate each model with the current values of regressors and also with their detrended values.[27]

[26] The use of year dummies would be inappropriate since there are many years when no state adopts withholding. In such years the year dummies would fully "explain" non-adoption. Clustering into five year intervals smoothes out these implausible jumps in the estimated baseline hazard.

[27] The detrending is done as follows: For every fiscal variable X, we regress that variable on the withholding dummy, state and year dummies, and socio-economic controls. Then we compute the detrended value of $\widehat{X}_{it} = X_{it} - \hat{\lambda}_t$, where $\hat{\lambda}_t$ is the estimate of the year fixed effect. This method removes the common time component from X_{it}. In the same way we detrended the socio economic variables, the only difference being that they were regressed only on state and year dummies since we have no good predictors of these variables.

Results are reported in Table 7. For logit estimates, the table reports the marginal effects of regressors on the hazard rate. For Weibull estimates, the table reports the hazard ratios. The results are fairly robust to the use of current versus detrended values of regressors and to model specification. The key finding is that higher income tax revenues significantly increase the hazard rate, and they are the only variable that has a significant effect on adoption in all specifications. The only other regressor that is significant in more than one specification is population, which has a negative effect on the hazard rate.[28] The estimated marginal effect of income tax revenues is quite substantial: A 10-percent increase in income taxes per capita (which, in pre-withholding years, would represent $4.5 per capita on average) increases the hazard rate by 0.0905. Since the average hazard rate in the sample is 0.055, this represents a 17-percent increase in the hazard rate.

The finding of a positive effect of income taxes on the likelihood of adoption is consistent with the demand-driven explanation for adoption - states adopted withholding once the income tax revenue was high enough so that it paid off to adopt a superior collection technology. None of the variables that could be associated with supply-driven adoption has a significant effect on adoption.

The last question we ask is: Where did the demand shock that actually triggered the adoption of withholding come from? Since total revenue increased by almost 8 percent due to a combination of scale and demand effects, what did the state governments do with the money? We estimated the response of six expenditure categories[29] to withholding but did not find a significant effect in any of the categories.[30] We did find, however, that the state debt is the likely source of the demand shock. Figure 6 plots the evolution of the ratio of state debt to general revenue before and after withholding, averaged across states. Debt grew steadily several years prior to withholding, it jumped up sharply from 45 percent of revenue to 53 percent in the year preceding the adoption, and levelled off after the adoption. Our interpretation of Figure 6 is that the states' demand for public spending was running short of revenue, and they closed the budget deficit by implementing withholding and raising other taxes at the same time. This finding also help explain why we did not detect an increase in any category of expenditures - the positive shocks to demand for public spending occurred already before the adoption.

7 Conclusions

While theories of the size of government have been unanimous in the prediction that more efficient taxes lead to a bigger government, the empirical literature has so far provided scant evidence and has been inconclusive in assessing whether the growth of government should be attributed primarily to improvements in the efficiency of taxes or to demand for government. This paper uses the historical experience with income tax withholding at the state level to investigate a causal link between deadweight costs and the level and composition of tax revenues. We found a large causal effect of withholding on income tax revenues, although much of the increase in revenues occurred through a shift in the composition of revenue away from other taxes and towards the income tax. This result resonates with the view that the political process favors efficient methods of redistribution (Becker (1983), Wittman (1985)). As for the empirical importance of demand versus efficiency factors, we found that withholding had a rather small effect on total revenue, and that the reverse causality from higher demand for spending towards withholding accounts for more than one-half, and possibly all, of the post-withholding increases in taxes. Despite popular beliefs withholding produced only a one-time

[28] This finding is somewhat puzzling since it contradicts the expected effect. The effect of population is, however, largely driven by California, which is a large state but adopts withholding as late as 1971. If California is taken out of the regression, the estimated marginal effect of population in the logit model has the same magnitude but is not significant.

[29] Namely, education, health and hospitals, public welfare, highways, natural resources and public safety. Results of the regressions are available upon request.

[30] We regressed the expenditure per capita on a withholding dummy, socio-economic variables, and state and year dummies for each of the expenditure categories. In an alternative specification, we replaced the withholding dummy variable with a full set of dummy variables representing each year before and after the adoption.

shift in the level of income taxes, but did not accelerate their growth. Our findings thus dispute Friedman's (1998) claim that withholding provided a major stimulus for the post-war growth in income taxation, with the caveat that our findings on state income taxes may not apply to the federal tax.

In conclusion, we would like to assess the contribution of withholding to the overall growth of state governments. Table 5 shows that income taxes increased by 29.4 percent, of which 21.7 percent was due to the substitution effect, at most 3.9 to the scale effect, and at least 3.8 to the demand shock. Hence the causal relationship from improved efficiency to higher income taxes can be blamed for increasing income taxes by 21.7 percent at least and 25.6 percent at most. Since the ratio of income tax revenues to personal income was, on average, 0.67 percent one year before adoption, the response to withholding added 0.14-0.17 percentage points. During the sample period, the ratio of income taxes to personal income increased from 0.31 percent to 1.93 percent. Therefore withholding accounts for about 8.6 to 10.5 percent of the overall growth of income tax revenues. And this was most likely the single biggest improvement in the tax collection technology during the period we are studying. In terms of empirical relevance, growth in demand for spending seems to be a far more important reason behind the growth of income taxes than improvements in tax efficiency.

Because income taxes represented 15.2 percent of total tax revenues prior to adoption, withholding contributed an accordingly smaller amount to the overall growth of total tax revenues - namely, a 2.1–2.6 percent increase. Over the sample period, the ratio of state tax revenues to personal income has increased from 3.7 percent to 6.4, a 73-percent increase, therefore the increases in income tax revenues caused by withholding account for about 3 percent of the growth of state government during the 1944-1980 period.

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Figure 1:

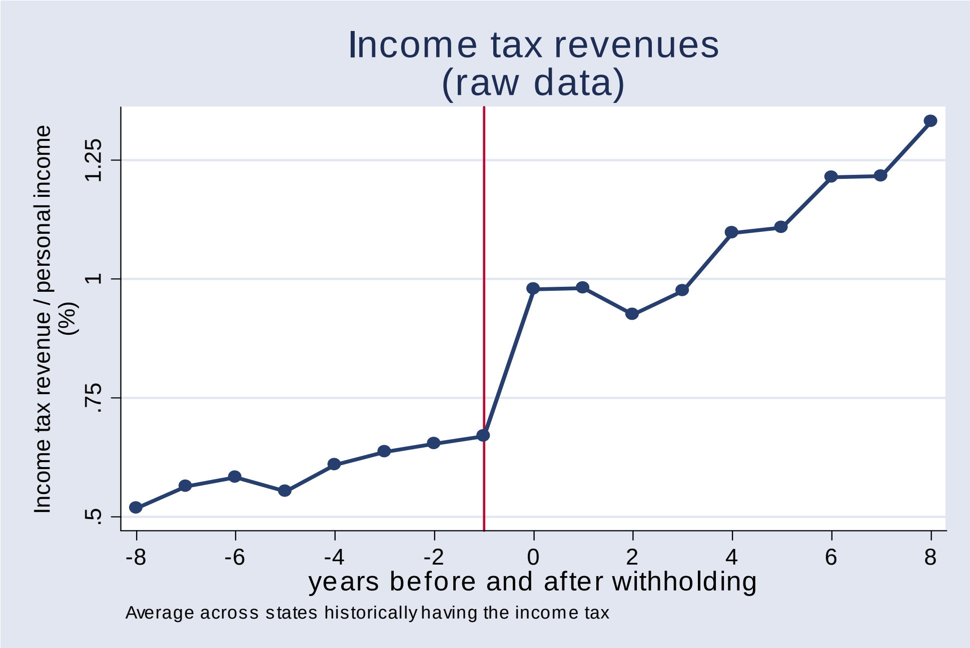


Figure 2:

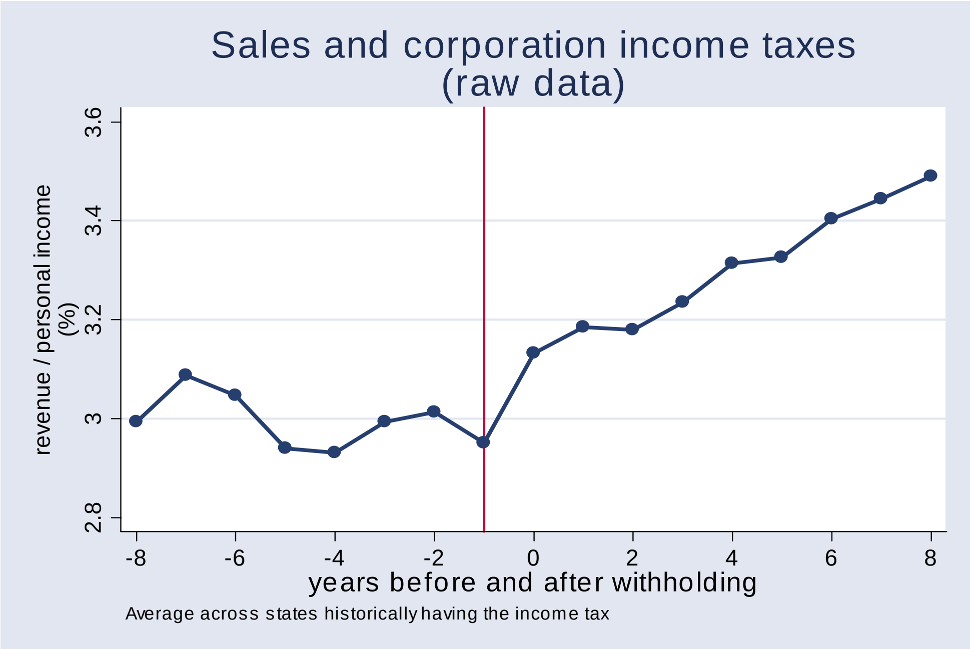


Figure 3:

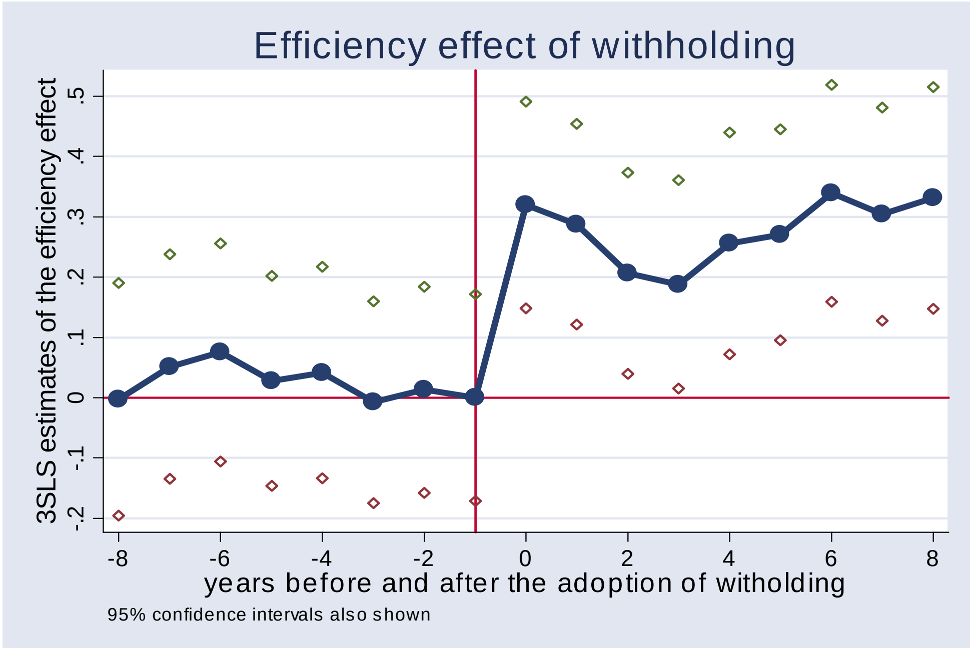


Figure 4:

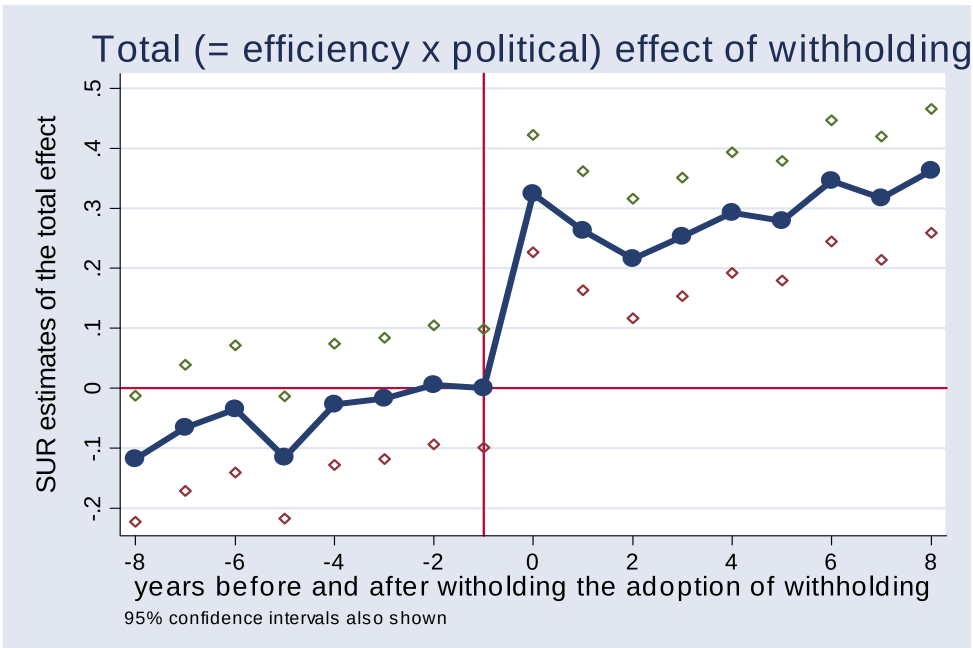
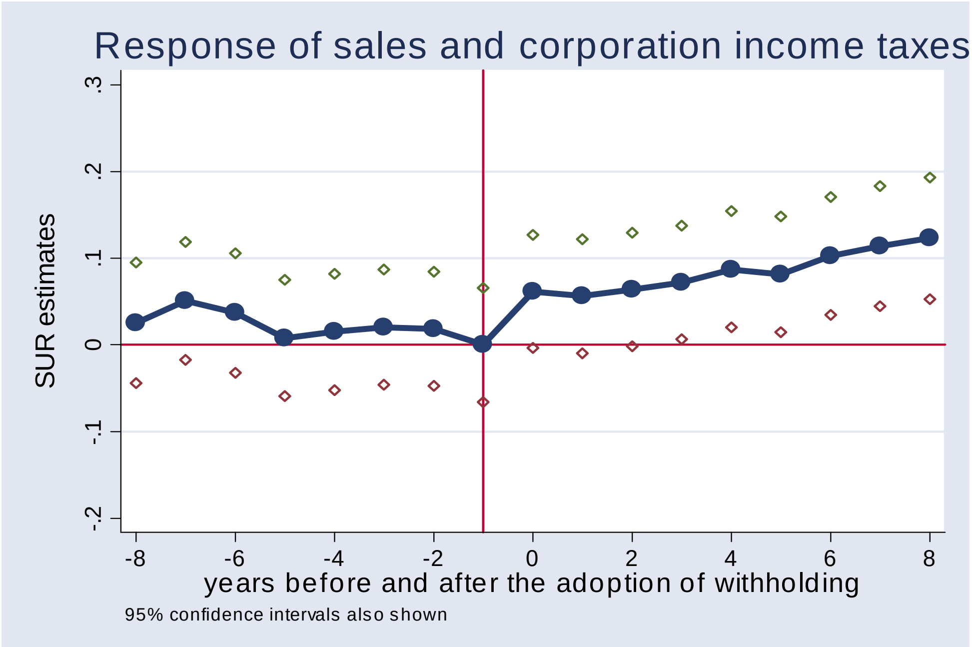


Figure 5:



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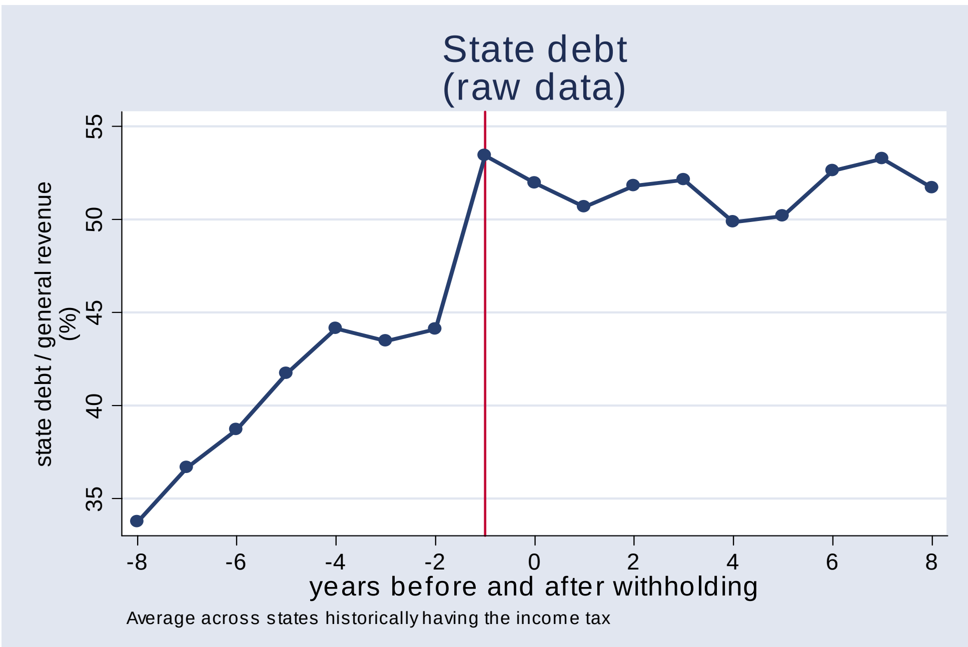

Table 1
Adoption of income tax withholding

Year	States adopting withholding
1948	Oregon
1949	Delaware
1951	Vermont
1954	Arizona
	Colorado
	Kentucky
1955	Idaho
	Maryland
	Montana
1956	Alabama
1959	Massachusetts
	North Carolina
	New York
	South Carolina
	Utah
1960	Georgia
1961	Louisiana
	Minnesota
	Missouri
	New Mexico
	Oklahoma
	West Virginia**
1962	Wisconsin
1963	Indiana**
	Virginia
1966	Arkansas
	Iowa
	Kansas
1967	Michigan**
	Nebraska**
1968	Mississippi
1969	Illinois**
	Maine**
1971	California
	Ohio**
	Pennsylvania**
	Rhode Island**
1976	New Jersey**
1987	North Dakota

* Source: Penniman (1980)
** States that adopted withholding with the introduction of the income tax. The states not reported in the table did not have a broad-based income tax between 1944-1980.

Table 2
Summary statistics

Variable	obs	mean	std. dev	min	max
Withholding dummy	1073	0.56	0.50	0.00	1.00
Income tax revenue / personal income	1073	1.06	0.78	0.10	3.77
Share of income tax in tax revenue	1073	19.14	11.82	1.90	59.64
Corporation income taxes / personal income	1073	0.39	0.21	0.00	1.22
Sales taxes / personal income	1073	2.81	1.11	0.64	6.30
Misc. taxes / personal income	1073	1.16	0.57	0.24	3.61
Federal grants / personal income	1073	2.26	1.23	0.22	6.28
Lowest income tax rate	985	1.75	0.86	0.50	5.74
Top income tax rate	985	7.12	3.23	1.70	20.13
Corporation income tax rate	986	4.25	2.66	0.00	12.00
General sales tax rate	986	2.17	1.48	0.00	5.00
Motor fuel tax rate (cents per gallon)	986	6.55	1.33	2.00	11.00
Cigarette tax rate (cents per pack)	986	6.42	4.55	0.00	21.00
Destilled spirits tax rate ($ per gallon)	986	1.32	1.17	0.00	4.53
Population (1000s)	1073	3,443	3,928	285	23,700
Income per capita	1073	7,684	2,459	2,859	14,417
Percent black	1073	11.0	12.2	0.0	47.6
Percent elderly	1073	9.0	1.9	4.5	13.7
Percent urban	1073	58.6	15.6	23.0	91.3
Farm income / personal income	1073	8.0	7.6	0.2	58.5
Interest and divident income / total income	1073	12.5	2.8	5.0	24.0
Share of Democrats in state legislature	1073	63.1	27.0	1.2	100.0

Sample: States that had a broad-based income tax in 1944, years 1944-1980

Table 3

3SLS estimates of the income tax revenue technology

Dependent variable:	(1) Income tax revenue (technology)	(2) Top rate	(3) Lowest rate
Withholding dummy	**0.237**	**0.033**	**-0.026**
	[0.091]**	***[0.022]***	***[0.027]***
Top tax rate	0.982		
	[0.603]		
Lowest tax rate	-0.829		
	[3.842]		
Income per capita	2.038	-1.07	-0.077
	*[0.937]**	*[0.123]***	*[0.147]*
Share of farm income	0.012	0.082	0
	[0.064]	*[0.034]**	*[0.040]*
Share of capital income	0.305	-0.053	0.319
	[1.191]	*[0.076]*	*[0.091]***
Population	0.377	0.187	0.318
	[1.347]	*[0.077]**	*[0.092]***
Percent elderly	-1.088	0.04	-0.526
	[1.964]	*[0.128]*	*[0.152]***
Percent black	0.276	-0.224	0.178
	[0.557]	*[0.032]***	*[0.038]***
Percent urban	1.57	-1.685	-0.52
	[2.923]	*[0.138]***	*[0.165]***
Share of Democrats		0.002	-0.001
in state legislature		*[0.001]**	*[0.001]*
Federal grants per capita		0.159	-0.014
		*[0.035]***	*[0.042]*
Observations	985	985	985
"R-squared"	0.90	0.84	0.80

Standard errors in brackets

* significant at 5%; ** significant at 1%

Year and state dummies included (coefficients not shown).

Fiscal and socio-economic variables are in logs. Fiscal variables are in per-capita terms.

Table 4
OLS estimates of the tax technology, by tax source

Dependent variable:	(1) Income tax revenue	(2) Income tax revenue	(3) Corporation income tax revenue	(4) General sales tax revenue	(5) Excise taxes revenue
Withholding dummy	**0.270**	**0.240**	**0.020**	**-0.026**	**-0.015**
	[0.062]**	***[0.055]*****	***[0.046]***	***[0.037]***	***[0.019]***
Top tax rate	0.436	1.534			
	*[0.094]***	*[0.345]***			
Lowest tax rate	0.038	-0.585			
	[0.064]	*[0.549]*			
Corp. income tax rate			0.767		
			*[0.122]***		
General sales tax rate				0.663	
				*[0.108]***	
Motor fuel tax rate					0.444
					*[0.068]***
Cigarette tax rate					0.113
					*[0.046]**
Distilled spirits tax rate					0.015
					[0.033]
Income per capita	1.535	1.637	1.385	0.791	0.192
	*[0.248]***	*[0.213]***	*[0.477]***	*[0.239]***	*[0.132]*
Share of farm income	0.042	0.022	0.048	-0.052	-0.014
	[0.062]	*[0.063]*	*[0.209]*	*[0.035]*	*[0.030]*
Share of capital income	-0.037	0.058	0.146	0.076	0.001
	[0.180]	*[0.194]*	*[0.278]*	*[0.190]*	*[0.047]*
Population	0.107	-0.01	-0.733	-0.121	-0.264
	[0.167]	*[0.156]*	*[0.298]**	*[0.095]*	*[0.088]***
Percent elderly	-0.596	-0.753	-0.306	0.402	-0.147
	[0.338]	*[0.336]**	*[0.581]*	*[0.406]*	*[0.164]*
Percent black	0.025	0.049	0.092	-0.051	-0.042
	[0.070]	*[0.080]*	*[0.109]*	*[0.095]*	*[0.034]*
Percent urban	0.939	0.74	0.386	-0.026	0.169
	*[0.408]**	*[0.446]*	*[0.409]*	*[0.571]*	*[0.131]*
Lowest tax bracket		-0.059			
		[0.074]			
Top tax bracket		0.11			
		[0.083]			
Lowest bracket * lowest rate		0.086			
		[0.074]			
Top bracket * top rate		-0.102			
		*[0.035]***			
Observations	985	984	759	719	588
Adjusted R-squared	0.95	0.95	0.85	0.86	0.89

Robust standard errors in brackets
* significant at 5%; ** significant at 1%
Year and state dummies included (coefficients not shown).
Fiscal and socio-economic variables are in logs. Fiscal variables are in per-capita terms.

Table 5
SUR estimates of the demand for tax revenue, by tax source

Dependent variable:	(1) Income taxes	(2) Corporate income taxes	(3) Sales taxes	(4) Miscellaneous taxes
Withholding dummy	**0.294**	**0.081**	**0.064**	**-0.031**
	[0.024]**	**[0.040]***	**[0.018]****	**[0.023]**
Income per capita	1.13	0.366	0.922	-0.365
	[0.133]**	[0.227]	[0.098]**	[0.127]**
Share of farm income	0.068	0.032	-0.023	0.009
	[0.035]*	[0.059]	[0.026]	[0.033]
Share of interest and dividend income	0.128	0.021	0.163	0.128
	[0.088]	[0.150]	[0.065]*	[0.084]
Population	0.1	-1.079	-0.156	-0.205
	[0.081]	[0.138]**	[0.060]**	[0.078]**
Percent elderly	-0.204	-0.532	0.397	0.618
	[0.136]	[0.232]*	[0.101]**	[0.130]**
Percent black	-0.073	-0.043	0.182	-0.135
	[0.034]*	[0.058]	[0.025]**	[0.033]**
Percent urban	-0.206	0.077	-0.746	0.547
	[0.148]	[0.252]	[0.109]**	[0.142]**
Federal grants	-0.002	-0.339	0.372	-0.05
	[0.039]	[0.066]**	[0.029]**	[0.037]
Share of Democrats in state legislature	0.001	0.003	-0.003	0.001
	[0.001]	[0.001]*	[0.001]**	[0.001]
Observations	941	941	941	941
"R-squared"	0.96	0.81	0.89	0.87
Alpha	**0.268**			
	[0.115]*			
Beta	**1.279**			
	[0.562]*			

Breusch-Pagan test of independence: chi2(6) = 75.416
Standard errors in brackets
* significant at 5%; ** significant at 1%
Fiscal and socio-economic variables are in logs. Fiscal variables are in per-capita terms.

Table 6

3SLS estimates of the tax technology, other taxes

	(1)	(2)	(3)	(4)
Dependent variable:	Corporation income tax revenue (technology)	Corporation income tax rate	General sales tax revenue (technology)	General sales tax rate
Withholding dummy	**-0.225**	**0.112**	**-0.043**	**0.025**
	[0.271]	***[0.026]*****	***[0.034]***	***[0.021]***
Corporation income tax rate	2.921			
	[2.305]			
General sales tax rate			1.763	
			*[0.225]***	
Income per capita	3.661	-1.053	1.641	-0.737
	[2.472]	*[0.170]***	*[0.274]***	*[0.132]***
Share of farm income	-0.378	0.184	-0.082	0.06
	[0.477]	*[0.056]***	*[0.045]*	*[0.028]**
Share of capital income	0.695	-0.266	0.68	-0.442
	[0.657]	*[0.116]**	*[0.189]***	*[0.091]***
Population	-0.687	-0.026	-0.112	0.022
	*[0.279]**	*[0.111]*	*[0.090]*	*[0.059]*
Percent elderly	0.582	-0.386	0.215	0.033
	[1.066]	*[0.192]**	*[0.198]*	*[0.123]*
Percent black	0.569	-0.23	-0.034	0.002
	[0.519]	*[0.041]***	*[0.054]*	*[0.034]*
Percent urban	1.324	-0.453	-0.821	0.685
	[1.094]	*[0.175]***	*[0.326]**	*[0.178]***
Share of Democrats in state legislature		0.001		-0.001
		[0.001]		*[0.001]**
Federal grants		-0.055		0.233
		[0.036]		*[0.032]***
Observations	759	759	719	719
"R-squared"	0.52	0.72	0.75	0.81

Standard errors in brackets

* significant at 5%; ** significant at 1%

Year and state dummies included (coefficients not shown).

Fiscal and socio-economic variables are in logs. Fiscal variables are in per-capita terms.

Table 7

Impact of explanatory variables on the probability of the adoption of withholding

Model:	Logit current-valued regressors	Logit detrended regressors	Weibull current-valued regressors	Weibull detrended regressors
Explanatory variables:				
Population (millions)	-0.0121	-0.0122	0.888	0.844
	[0.0035]**	[0.0039]**	[0.058]	[0.0724]*
Percent elderly	0.0080	0.0116	1.056	1.214
	[0.0068]	[0.0106]	[0.164]	[0.1699]
Percent black	-0.0003	0.0014	0.988	1.025
	[0.0017]	[0.0019]	[0.028]	[0.0399]
Percent urban	-0.0023	-0.0032	1.003	0.984
	[0.0023]	[0.0041]	[0.045]	[0.0558]
Income per capita	0.0000	0.0000	0.999	1.000
	[0.0000]	[0.0000]	[0.000]	[0.0004]
Share of farm income	-0.0080	-0.0099	0.901	0.857
	[0.0051]	[0.0084]	[0.106]	[0.1110]
Share of dividend	-0.0032	-0.0002	1.026	0.862
and interest income	[0.0056]	[0.0106]	[0.205]	[0.1481]
Share of democrats	0.0006	0.0011	1.010	1.017
in state legislature	[0.0007]	[0.0010]	[0.018]	[0.0215]
Income tax revenue	0.0021	0.0013	1.028	1.018
per capita	[0.0005]**	[0.0003]**	[0.007]**	[0.0031]**
All other taxes	0.0002	-0.0001	1.003	0.995
per capita	[0.0002]	[0.0002]	[0.003]	[0.0049]
Federal grants	0.0003	0.0006	1.001	1.011
per capita	[0.0003]	[0.0003]*	[0.006]	[0.0056]
Debt / general revenue	0.0003	0.0001	1.006	1.003
	[0.0003]	[0.0002]	[0.005]	[0.0042]
Dummy for 1944-48	0.0195	-0.3023		
	[0.1113]	[0.1259]*		
Dummy for 1949-53	0.0106	-0.1821		
	[0.1078]	[0.0679]**		
Dummy for 1954-58	0.0433	-0.0964		
	[0.0972]	[0.0524]*		
Dummy for 1959-63	0.0656	-0.0443		
	[0.0888]	[0.0534]		
Dummy for 1964-68	0.0523	-0.0126		
	[0.0671]	[0.0439]		
estmate of p			2.79	3.74
			[1.192]	[0.639]

Robust standard errors in brackets
* significant at 5%; ** significant at 1%
Marginal effects are reported for the logit estimates.
Hazard ratios are reported for the Weibull estimates.