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Heterogeneous Vertical Tax Externalities and Macroeconomic Effects of Federal Tax Changes: The Role of Fiscal Advantage*

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Abstract

How do state tax rates respond to federal tax shocks? This paper presents a novel mechanism of heterogeneous vertical tax externalities across state-levels of *fiscal advantage*, showing that tax increases can be expansionary – even without their reinvestment. States rich in natural resources have a fiscal advantage in the inter-state competition over production factors which allows them to respond better to increases in federal taxes and, consequently, attract capital from other parts of the nation. We add heterogeneity in fiscal advantage levels to an otherwise standard model of vertical tax externalities and horizontal tax competition. The model shows that, irrespective of federal redistribution, the contractionary effect of a federal tax increase can be overturned in fiscally advantaged states, through an increase in their tax base. Using the case of the U.S., and narrative-based measures of federal tax shocks a-la Romer and Romer (2010), we provide empirical evidence for the various aspects of this mechanism. Specifically, our baseline estimates indicate that, controlling for federal transfers, a 1% increase in the GDP share of capital-related federal taxes at the beginning of a year *increases* the growth rate of the per capita tax base by approximately 0.7% in high fiscal advantage states at the end of it.

JEL classifications: H77, Q32

Keywords: Federalism, natural resources, fiscal advantage, tax competition

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1 Introduction

How do state tax rates react to federal tax shocks? This question has been at the center of debates in the fiscal federalism literature, and is becoming increasingly important given the global trend to fiscally decentralize. Previous empirical and theoretical studies addressing this question have considered the reactions to such shocks by the average state.[1] However, major cross-state differences are observed in virtually all federations. This reflects on the potential heterogeneous reactions to changes in federal taxes. While such changes are uniform across the nation, their effects are not. We make a first attempt to investigate these potentially different reactions and their implications by focusing on one margin, namely natural riches that induce *fiscal advantage*, a term we define below. We show, theoretically and empirically, via the case of the U.S., that due to the fiscal advantage borne by their resources, natural resource rich states are able to respond more competitively to federal tax increases, and as a result benefit from capital inflows that may raise their tax base –even without reinvestment of the taxes levied– and thus increase fiscal inequality across the nation.

More generally, this paper presents a novel mechanism of heterogeneous vertical tax externalities across levels of fiscal advantage.[2] We define the latter to be the level of income that states receive from non-mobile sources. States rich in non-mobile factors have more flexibility in taxing mobile tax bases, giving them an advantage in the inter-state fiscal competition. A potentially major non-mobile income source is natural resources, which we use to proxy for fiscal advantage.[3] Natural resources are non-mobile given their inherent geographical characteristics. In addition, unlike other non-mobile income sources they represent a significant source of revenues for certain states, as depicted in Figure 1 for the case of U.S. states,[4] and their (persistent) abundance is based on plausibly exogenous geological features. Evidence for the fiscal advantage borne by natural resources is given, for example, by James (2015) and Raveh (2013) who find that the income from natural riches enables U.S. states to charge lower tax rates on mobile factors, and present a more competitive fiscal environment.[5] Similar patterns are also observed in Russian states (Cai and Treisman (2005)), and Chinese provinces (Yao and Zhang (2008)).[6]

[1] See Boadway and Shah (2009), Madies, Paty, and Rocaboy (2004), Wilson and Wildasin (2004) and references therein. Specifically, previous studies provide mixed results on states' fiscal reaction to federal tax shocks, focusing on the *average* state.

[2] Throughout the paper, the terms *vertical* and *horizontal* refer to state-federal and state-state perspectives, respectively.

[3] Specifically, our focus in this paper is on point-source resources; namely, oil, gas, and minerals.

[4] As the figure illustrates, the average share of state natural resource tax revenues in total state tax revenues can be higher than 15% in a number of a states, and can get up to about 40% (in the case of the Alaska). Other potential non-mobile, plausibly exogenous income sources are neither as prominent nor present sufficient cross-state variation.

[5] For instance, James (2015) estimates that a $1 increase in states' resource revenues results in a $0.25 fall in states' non-resource revenues. In the empirical part we provide further evidence for the robustness of these patterns.

[6] An additional, more specific, example is the case of the Canadian province of Alberta. Having the second largest

Our main hypothesis is that the vertical fiscal response to federal tax shocks is relatively more inelastic in fiscally advantageous states. To examine this conjecture, and its implications, we construct a model of heterogeneous vertical tax externalities. Motivated by Brulhart and Jametti (2006), we add heterogeneity in fiscal advantage levels to an otherwise standard model of vertical tax externalities and horizontal tax competition. The model captures the case of a closed, two-level, federation with complementary state and federal public good provision, where state governments compete for the nation's capital stock, focusing on capital taxation and movement – features that we substantiate in the empirical part. The analysis outlines how fiscal advantage affects the reaction of states' capital tax rates to federal tax shocks, and the patterns of cross-state capital reallocation that follow.

A central feature of the model is the existence of horizontal capital tax competition with varying levels of fiscal advantage. Under this framework, the natural resource rich states exploit the fiscal advantage borne by their resources to compete more aggressively in the inter-state competition over capital. Greater capital tax reductions allow them to attract capital from the other states, and end up with a larger per capita capital stock in equilibrium. An important vertical implication, under the assumption that state and federal public goods are complementary, is that high fiscal advantage states respond to a federal tax increase with smaller relative capital tax increases, which lead to further capital movement towards them.[7] The intuition is simple: having a larger per capita tax base, the high fiscal advantage states can maintain the same level of public good provision with smaller tax increases.

The analysis indicates that with sufficient capital inflows a federal tax increase may actually *raise* the capital tax base in fiscally advantaged states, and in turn also increase their output – irrespective of federal redistribution. This sheds new light on the standard result in the literature that, controlling for reinvestment of taxes levied, tax increases necessarily contract the tax base and output. Another implication of this is that some states may benefit from federal tax increases on the account of other states for which such increases are harmful, hence increasing fiscal inequality across the nation.

The empirical part of the paper tests the predictions of the theory, and provides evidence for

petroleum reserves in the world, Alberta exploits its resource wealth, which it fully owns through the Canadian Constitution and is only partially redistributed by the Canadian Federal Government, to be more lenient with taxes it levies on the mobile tax bases; indeed, this fiscal advantage enables it to present one of the most competitive tax environments in North America (Boadway (2006)).

[7]Notably, vertical tax reactions can be in either direction, depending on the underlying assumptions. In this case, the tax co-movement is driven by complementarities in the public goods supplied by the federal and state governments. This assumption, and its consequent positive tax relationship, are motivated by evidence provided in Perez-Sebastian and Raveh (2018); as will be evident, they also gain support by the findings of our empirical analysis. We consider further implications of this feature in the theoretical part.

some of its main features. We undertake an inter-state analysis of the U.S. economy using an annual-based panel covering the period 1963-2007. This analysis is based on two key variables: fiscal advantage and federal tax shocks. We measure fiscal advantage levels using the share of severance taxes in states' total tax revenues.[8] Figure 1 shows the distribution of this variable across U.S. states for our sample period (1963-2007). A significant cross-state heterogeneity is apparent, ranging from 0 (in Vermont and Rhode Island, for instance) to more than 0.4 (in Alaska). We exploit this variation in the empirical analysis.

Moving to the second key variable of our analysis, we use data on narrative-based measures of U.S. federal tax shocks from Romer and Romer (2010) (henceforth, RR), aggregated to an annual-level. RR employ narrative sources such as presidential speeches and federal reports, among others, to classify the motivation of major federal tax changes into endogenous and exogenous, and estimate their effect on federal tax revenue. Our focus is on those shocks that they classified as exogenous to address related endogeneity concerns;[9] this stands at the heart of our identification strategy. In addition, to motivate the emphasis on capital in the model, we divide these tax shocks to corporate-related and non-corporate-related based on the methodology set in Reingewertz (2018). We elaborate on these points in the empirical part.

We concentrate primarily on the interaction of the two to address a set of questions that follow the various stages of the model. We first ask whether natural resource rich states present a more competitive fiscal environment, and whether this translates into having larger per capita capital stocks. We provide supporting evidence, some based on previous work, that this is the case. Thereafter, we turn to the main analysis to examine the effects of federal tax shocks across levels of fiscal advantage. We begin this section with an event study analysis that examines the impacts on changes in state average tax rates, real capital stock per capita, population, and real output per capita in the three years prior and four years past a major corporate-related federal tax change across fiscally advantaged and non-fiscally advantaged state groups.[10] The results reveal a common-trend prior to an event, which changes thereafter; specifically, in the fiscally advantaged states tax rates do not change, and capital and output increase, whereas in the remaining states tax rates increase and capital and output drop, most notably in the two years past the event.

To examine this in more detail under the full variation of the tax shocks and fiscal advantage levels, we focus on a one-year lag, and estimate the heterogeneous effects of a federal tax shock under

[8] U.S. states levy severance taxes on the exploitation of natural resources.

[9] Albeit we also illustrate that similar patterns are observed under the endogenous shocks.

[10] A major corporate-related federal tax change is defined as a change higher than the mean by at least half a standard deviation. The fiscally advantaged state-group includes the 8 states with the highest average fiscal advantage level, as illustrated in Figure 1, namely AK, LA, MT, ND, NM, OK, TX, WY; the non-fiscally advantaged state-group includes the remaining states.

a panel fixed-effects framework in which the treatment is interacted with fiscal advantage. Our results support the various aspects of the mechanism. Specifically, controlling for the reinvestment of the taxes levied, we find that following a federal tax increase, high fiscal advantage states: a) do not change their tax rates, unlike the other states that increase them; b) benefit from capital inflows to the extent of increasing their pre-shock per capita capital stock; c) experience an increase in output. These patterns, which indicate that federal tax increases can be beneficial for fiscally advantaged states, are observed using different measures of tax rates, capital inflows, and resource abundance, as well as different specifications and time periods.

The model emphasizes capital tax competition and capital mobility as the instruments through which the mechanism works. To substantiate this, we divide the empirical analysis to capital and non-capital related factors, wherever possible, by making several disaggregations, in addition to that of the tax shocks. Specifically, we look into state corporate and non-corporate tax rates and revenues, and we distinguish between firm and labor movements across states. Results indicate that the various aspects of the mechanism are completely driven by the capital-related shocks and effects. Consistent with the model, it is the corporate-related federal shocks that affect capital tax rates, revenues, and movement, with no observed effects on the labor side. Our baseline estimates indicate that, controlling for federal transfers, a 1% increase in the GDP share of corporate-related federal taxes *increases* the per capita tax base growth rate by approximately 0.7% in high fiscal advantage states in the year that follows.

This paper contributes to various strands of literature. First is the literature on fiscal equalization and disparities. As discussed in Qiao (1999), inter-state fiscal disparities are considered a major concern in federations, creating equity and efficiency related challenges. Boadway (2004), Boadway and Shah (2009), and Martinez-Vazquez and Searle (2007) summarize these challenges and the measures taken by federal governments to address them, most notably through equalization schemes. Little attention, however, has been given to the role of federal tax policy in this. Albouy (2009) discusses the unequal burden of federal taxation across states, and then illustrates in Albouy (2012) that this may interact with fiscal inequality and equalization incentives. We contribute to this literature by showing that federal tax coordination can exacerbate fiscal disparities across the nation via the cross-state capital reallocation that follows, hence posing equalization-related challenges not considered previously.

Second is the literature on tax changes, output, and the macroeconomy. This vast literature, surveyed by Gale and Orszag (2004), Hebous (2011), and Ramey (2011), studies the medium and long-run effects of fiscal shocks on the macroeconomy, including output and composition of GDP, emphasizing their contracting nature and role in crowding out investment. Additional re-

lated studies examine similar links between federal fiscal shocks and state-level effects, including Chodorow-Reich, Feiveson, Liscow, and Woolston (2012), Clemens and Miran (2012), Fishback and Kachanovskaya (2010), Hayo and Uhl (2015), Nakamura and Steinsson (2014), Owyang and Zubairy (2010), Shoag (2010), Serrato and Wingender (2014), Taylor and Yucel (1996), and Wilson (2012). In contrast to these studies our focus is on differential state-tax reactions to federal shocks, and the resulting implications. Our contribution to this literature is twofold. First, we show that tax increases can be expansionary in some states, both to the tax base as well as to output, even without the reinvestment of tax revenues. This, in turn, can help to explain the wide confidence bands that RR find on their estimates. Second, the horizontal channel we highlight, via factor reallocation across the nation, potentially sheds light on the national level outcomes in output and investment discussed in these previous studies.

Third is the literature on the effects of resource booms in fiscally decentralized, federalized economies, and the more general natural resource curse hypothesis. Van der Ploeg and Poelhekke (2016) provide a synthesis of the empirical literature on the local effects of resource shocks. Various studies look more specifically into the state-level fiscal effects of resource booms, including Boadway (2006), James (2015), and Raveh (2013). Notably, standard models of the resource curse, which provide the conceptual foundations for these studies, assume a single centralized system of public finance. Conversely, the current effort examines the implications of cross-state differences in resource abundance in a system of fiscal federalism. A similar perspective is adopted by Perez-Sebastian and Raveh (2016), who show that resource-driven asymmetric fiscal shocks in a federation may yield resource curse effects via inefficient factor reallocation across states. The current analysis, however, focuses on the roles of federal fiscal policy and vertical tax externalities in driving this mechanism.

Last is the theoretical literature on horizontal and vertical tax competition. Some studies look into a horizontal population-based asymmetric tax competition (Bucovetsky (1991), Kanbur and Keen (1993), and Wilson (1991)) or otherwise a horizontal asymmetry in natural resource wealth (Raveh (2013), and Perez-Sebastian and Raveh (2016)), while others look into vertical tax competition under symmetric settings (Dahlby and Wilson (2003), Hoyt (2001), and Keen (1998)). In this paper we study concurrent asymmetric vertical and horizontal tax competition, where the asymmetry is sourced at the horizontal level via cross-state differences in fiscal advantage. Through this, we highlight the role of the horizontal channel when considering vertical shocks.

The paper is structured as follows. Section 2 introduces the analytical framework. Section 3 presents the empirical analysis, providing evidence for the mechanism. Section 4 concludes.

2 The Model

We consider a federation composed of N states, competing over the nation's capital stock through fiscal means. Each state i (with $i = 1, ..., N$) is populated by a fixed mass of consumers of size one. Each individual owns a fixed amount of capital k that can be supplied to the production activity in any of the states. In return, state-i consumers obtain an interest rate r, and these proceeds net of taxes are allocated to the purchase of a private good c_i.

The framework makes several underlying assumptions that require some further comment. First, we take the simplifying route of operating in a closed economy setting; having an open economy would not affect the main results provided the cross-state systematic response patterns to the federal shock are maintained.[11] Second, we introduce the simplifying feature of having fixed populations. Essentially, what is required for the model results to hold is that labor is sufficiently less mobile than capital, especially when moving towards relatively-isolated natural resource rich areas; this is supported, for example, by evidence offered by Perez-Sebastian and Raveh (2016).[12] Third, we assume that an inter-state fiscal competition over production factors arises in a fiscally decentralized, or federalized, economy; several studies have shown this is the case in a vast array of economies such as the U.S., Russia, China, and others (see Wilson and Wildasin (2004) for a survey). Last, the general focus is on capital taxes rather than labor taxes; we provide empirical evidence supporting this assumption in the following section.

In the model, there are state governments and a federal authority. All of them tax capital, and employ those revenues to buy units of private firms' output that become an intermediate product in the supply of public goods to consumers. The federal tax rate equals τ, and the state one equals t_i. In turn, G and g_i represent the goods provided by the federal and state authorities, respectively. In addition, state governments receive income at the amount z_i from severance taxes levied on the exploitation of natural resources located in their territories; this feature denotes the fiscal advantage of natural resource rich states.[13]

[11] In addition, note that inflows from abroad have a relatively small impact on total input-stock changes (especially in big economies like the U.S., where the empirical section focuses later). Net capital flows across countries are relatively small compared to those within them — as observed through the Feldstein-Horioka puzzle (Feldstein and Horioka (1980)). Immigration flows are relatively small as well; for instance, EuroStat reports that the annual inflow of migrants in the European Union in recent years represents about 3 per 1000 inhabitants.

[12] Labor can be less mobile due to the non-pecuniary benefit that individuals derive from living in their home, a preference for a particular region for cultural or nationalistic reasons, or having access to the larger supply of amenities in more densely populated areas (e.g. Mansoorian and Myers (1993)). Implicit in the assumption is also the relatively high mobility of capital across regions within the same nation; evidence supporting this is provided, for example, by Kalemli-Ozcan, Reshef, Sorensen, and Yosha (2010) who illustrate the strong fit of neoclassical models when considering a within-U.S. framework.

[13] This setting implicitly assumes partial equalization by the federal government. This phenomenon stands at the heart of this mechanism, enabling the occurrence of an asymmetry across regions which, as was substantiated earlier,

Motivated by the general framework of Brulhart and Jametti (2006), Keen and Kotsogiannis (2002), and Zodrow and Mieszkowski (1986), we assume that each profit-maximizing firm in state i is owned by a consumer that resides in that state. Firms operate under perfect competition, and produce output (y_i) using capital (k_i) according to the following production function:

$$y_i = Ak_i^{\alpha}, \tag{1}$$

where $\alpha \in (0, 1)$, that is, the production function displays diminishing marginal returns over the capital input. Profits (π_i) from the firm's activity are given to the owner. Technology (1) delivers a pre-tax interest rate in state i equal to:

$$r_i = \alpha A k_i^{\alpha-1}. \tag{2}$$

In equilibrium, the return to capital net of taxes must be equalized across states, that is:

$$\alpha A k_i^{\alpha-1}(1 - t_i - \tau) = \alpha A k_j^{\alpha-1}(1 - t_j - \tau), \tag{3}$$

for all $j = 1, ..., N$. This equality implies that a state that charges a lower tax rate will attract capital, and will end up with a larger per capita stock in its production process.

Policy-makers are benevolent central planners.[14] In particular, state i chooses t_i to maximize the representative consumer's utility taking the behavior of firms and other governments as given.[15] Its problem can be written as:

$$\max_{\{t_i\}} U_i = \ln c_i + (g_i^{\sigma} + G^{\sigma})^{1/\sigma} \tag{4}$$

subject to

$$g_i = \phi(t_i r_i k_i + z_i) \tag{5}$$

$$c_i = \pi_i + r_i\,(1 - t_i - \tau)\,k. \tag{6}$$

The value of the elasticity parameter σ lies within the interval $(-\infty, 1]$. When σ equals $-\infty$, state and federal public goods are perfect complements; conversely, they are perfect substitutes when σ takes a value of 1. As will become evident, the substitution feature and its degree are central to

is observed in the vast majority, if not all, of federations.

[14] This is a simplifying feature. However, the government's objective within a tax competition context can be expressed in several forms. For example, other models consider a leviathan government (Brennan and Buchanan (1980)) or a semi self-interest one (Cai and Treisman (2005)). These other behavioral approaches should not affect our results so long as the fiscal advantage feature is maintained and states target the same objectives.

[15] This represents the main difference with models in the tradition of Zodrow and Mieszkowski (1986). In contrast to our setting, policymakers in those frameworks internalize the effect of local taxes on firms' demand for capital. Following such an approach would not affect the main insights of our analysis.

the analysis; we elaborate on this later in this section. In expression (5), the parameter $\phi \in (0,1)$ proxies for government inefficiency. The implication is that each unit collected in taxes, which is used as an intermediate good by the public sector, generates $\phi < 1$ units of public good.[16]

Regarding expression (6), rents obtained from firms are the profits left after paying for capital. In particular, given that capital taxes are only paid by consumers, a firm's profits in state i equal:

$$\pi_i = y_i - r_i k_i. \tag{7}$$

In addition, budget constraint (6) implicitly suggests a resident-based tax system, whereas equilibrium condition (3) implies source-based taxation. Notice however that both expressions are compatible in equilibrium.[17]

We assume for simplicity that the federal government provides the same amount of its public good in each state as follows:

$$G = \phi \tau r k, \tag{8}$$

where r is the average interest rate across the N states.[18] Notice that the parameter ϕ appears in this equality as well. Its role is generating a contractionary impact of a tax rate increase. If we measure GDP as $c_i + g_i + G$ (i.e., the sum of final goods), it is straightforward to note that GDP falls with taxes. This feature is motivated by previous studies indicating the contracting nature of tax increases (e.g. RR).

Finally, in order to close the model, we need the following market clearing conditions for capital and the good produced by private firms, respectively:

$$Nk = \sum_{i=}^{N} k_i, \tag{9}$$

$$\sum_{i=}^{N} y_i = \sum_{i=}^{N} \left(c_i + \frac{g_i}{\phi} \right) + \frac{G}{\phi}. \tag{10}$$

[16] We assume that ϕ, and any potential effects of g_i and G on state TFP, do not differentiate systematically across levels of z_i. Hence, for simplicity we consider ϕ to be the same across states, and assume that both g_i and G do not affect productivity in the state.

[17] We could instead write the budget constraint as: $c_i = \pi_i + k \sum_{j=1}^{N} \mu_j r_j (1 - t_j - \tau_k)$; where μ_j is the share of state i's capital invested in state j, and $\sum_{j=1}^{N} \mu_j = 1$. This expression would generate the same results as (6). The key point is that, in equilibrium, both the level of the net return $r_j(1 - t_j - \tau)$ and its change as a response to variations in any tax rate must be the same across states.

[18] Alternatively we could consider that, in per capita terms, the federal government spends more in richer states. For example, we could suppose that the amount supplied by the federal good in state i equals $G = \phi\tau[\lambda r_i k_i + (1-\lambda) r k]$. In this scenario, G has two components, one with weight $\lambda \in (0,1)$ that rises with k_i –and therefore with the state's GDP– and a second one, with weight $1 - \lambda$, that is common to all states. This modification would not affect the main results of the model.

These two conditions allow for trade in capital and the private good across states.

The FOCs to problem (4) with respect to the tax rate t_i yield:

$$\frac{r_i k}{\pi_i + r_i\left(1-\tau-t_i\right)k} = \phi r_i k_i \left[1+\left(\frac{\tau r k}{t_i r_i k_i + z_i}\right)^{\sigma}\right]^{\frac{1-\sigma}{\sigma}}. \tag{11}$$

The LHS represents the marginal utility of private good consumption (MUc), and the RHS gives the marginal utility of state public good consumption (MUg), both with respect to the tax rate. At the optimum the two sides are equalized. Notice that MUg depends on the elasticity of substitution between the two public goods. From (11) we can deduce that t_i decreases with z_i if $\sigma < 1$, that is, as long as public goods are not perfect substitutes; moreover, when z_i is sufficiently large, t_i can, in principle, decrease to zero. When $\sigma = 1$, however, the optimal value of t_i is independent of z_i. Note that under the former case states rich with natural resources will present relatively lower tax rates, attract capital from the other states as a result (given condition (3)), and have larger per capita capital stocks in equilibrium; we find support for this prediction in the empirical part.

Condition (11) also implies that the tax rate t_i can go up or down with τ. This depends as well on the degree of complementarity between the public goods. Two forces lead to this result. On one hand, the force related to MUc: federal and state taxes reduce the individual's capacity to consume the private good in the same manner –notice $1-\tau-t_i$ in the LHS– and as a result, the two tax rates tend to go in opposite directions.[19] On the other hand, the force associated to MUg: the complementarity between federal and state goods implies that their tax rates –τ in the numerator and t_i in the denominator of the RHS– tend to move in the same direction. It is, for example, easy to show that if g_i and G are perfect substitutes ($\sigma = 1$) then the effect of τ on t_i is negative because the dominant force is the variation in MUc. Alternatively, when the public goods are sufficiently complementary (σ sufficiently negative), the effect coming from MUg dominates, and the impact is positive.

However, to fully understand this last effect when the goods are sufficiently complements, we need to do some additional algebra. First, notice that condition (11) implies that:

$$\frac{\tau r k}{t_i r_i k_i + z_i} = \left\{\left[\phi r_i k_i\left(\frac{\pi_i}{r_i k} + 1 - \tau - t_i\right)\right]^{\frac{\sigma}{\sigma-1}} - 1\right\}^{\frac{1}{\sigma}}. \tag{12}$$

The LHS of equality (12) gives the ratio of the federal public good to the state one, that is, G/g_i.

[19] In effect, the MUc represents the standard common-pool problem in vertical tax externalities (e.g. Berry (2008)): with overlapping governments taxing the same tax base, a federal tax increase erodes the states' tax base which in turn affects their fiscal reaction.

From (2) and (7), we can rewrite it as:

$$\frac{G}{g_i} = \left\{ (\phi A k_i^{\alpha})^{\frac{\sigma}{\sigma-1}} \left[(1-\alpha)\frac{k_i}{k} + \alpha(1-\tau-t_i) \right]^{\frac{\sigma}{\sigma-1}} - 1 \right\}^{\frac{1}{\sigma}}. \tag{13}$$

We can see that for any $\sigma < 1$ the relative weight of the federal public good falls with the natural resource rents because t_i decreases and, as a consequence, k_i rises with z_i. In addition, the ratio G/g_i converges to 1 as σ goes to minus infinity; that is, as g_i and G turn more complementary, their relative weights in total public goods supply become more equalized and less sensitive to changes in the federal tax rate. Finally, applying the implicit function theorem to expression (11), we obtain:

$$\frac{\partial t_i}{\partial \tau} = \frac{\frac{1}{\phi \tau r_i k_i} - \left[1 + \left(\frac{g_i}{G}\right)^{\sigma}\right] \left[1 + \left(\frac{G}{g_i}\right)^{\sigma}\right]^{\frac{1-\sigma}{\sigma}} / (1-\sigma)}{\frac{1}{\phi (t_i r k_i + z_i)} + \left[1 + \left(\frac{g_i}{G}\right)^{\sigma}\right] \left[1 + \left(\frac{G}{g_i}\right)^{\sigma}\right]^{\frac{1-\sigma}{\sigma}} / (1-\sigma)}. \tag{14}$$

Given that G/g_i converges to 1 as the two public goods become more complementary, expression (14) will converge to:

$$\frac{\partial t_i}{\partial \tau} \longrightarrow \frac{rk}{r_i k_i}, \tag{15}$$

as σ goes to minus infinity. Clearly, the limit value in expression (15) is strictly positive. In addition, its only difference across states will be due to the capital rents $r_i k_i$ included in the denominator. As noted above, given that better endowed states will charge lower capital tax rates, they will also enjoy higher levels of per capita stocks of capital, and then $r_i k_i$ –which equals $\alpha A k_i^{\alpha}$– will be larger. Therefore, the positive impact on the state tax rate of an increase in τ will be smaller in high fiscal advantage, natural resource richer, states so long as g_i and G are sufficiently complements. That will, in turn, trigger further capital movement towards those states from the resource poor ones (again, given condition (3)), increasing their per capita capital stock that may eventually increase their overall output, despite the negative federal shock.

For these results to hold, the theory requires sufficient complementarity, albeit not necessarily perfect, between public goods provided by state and federal governments.[20] Public economists, however, may consider state and federal spending to be rather substitutable, as argued for example by Hafer and Landa (2007), among others. For instance, federally provided health care spending, or income maintenance, may reduce the need to provide these at the state level. Nevertheless, the division of responsibility could as well be interpreted as pointing to some degree of specialization in

[20] The minimum degree of complementarity required depends on the parameter values chosen. Employing standard ones, numerical simulations suggest that the unitary elasticity of substitution represents a sufficient degree. Below we consider a simple variation of the model, presented in the Appendix, in which the threshold can be substantially lower, albeit remaining positive.

complementary items: if there is already a provider for a good, the best strategy may be to finance some other good, especially if both are complementary. This line of thought follows the fundamental allocative principle in fiscal federalism of *fiscal equivalence* (e.g. Inman and Rubinfeld (1997), and Olson (1969)), motivating the coexistence of multiple levels of jurisdictions; governments provide public goods based on correspondence between the geographical boundaries of the jurisdictions and those of the benefits derived from the supplied public goods.

As an example, a federal cross-state road calls for the development of, and carries little benefit without, local roads (and vice-versa), with the former (latter) being administered by a federal (state) government. Another prominent example is higher education, where the federal authority is usually responsible for the provision of student loans and research funding, and state governments finance personnel wages and capital structures of public universities. The different items –students, research, faculty, and buildings– targeted by the two levels of government are complementary inputs in the production of education. Notably, such complementarities can also be an outcome of cost-sharing motives, and exploitation of federal matching grants, which create co-movements in the expenditures of the two governments essentially by construction.[21]

Empirical evidence for the existence and relative importance of state-federal complementarities in vertical fiscal interactions is provided by Perez-Sebastian and Raveh (2018). Exploiting the design of the 1980 U.S. Crude Oil Windfall Act, they decompose the states' vertical fiscal reactions to this federal tax change to their common-pool and complementarity components, assuming the former is confined to the oil rich states. They conclude that g_i and G are, on average, complementary, with complementarity taking a significant role in the overall vertical tax externalities. Further evidence is contained in Appendix A. Using data from 2005 to 2012, we document strong co-movement between U.S. federal and state spending, controlling for business cycle and time effects, as well as for differences in income and intergovernmental transfers, hence illustrating that patterns are compatible with the complementarity assumption. In addition, Appendix B introduces more dominant common-pool tax effects into the model via the addition of state consumption tax, showing that dependency on the complementarity feature can be mitigated, albeit some complementarity is still required.

Nonetheless, the model considers one potential route to analyzing the effects of federal tax changes across levels of fiscal advantage. Alternative mechanisms, which do not rely on $g-G$ complementarities, may yield qualitatively similar outcomes. One example is the mechanism proposed

[21] In that respect, this notion of complementarity excludes co-movements related to unconditional grants transferred to the states by the federal government, as described in the literature on the so-called *Flypaper Effect* (e.g. Gramlich (1977), and Hines and Thaler (1995)), as these are a result of a windfall-based income effect rather than $g-G$ complementarities.

in Perez-Sebastian and Raveh (2019). An increase in τ may be expansionary in fiscally advantaged states if firms in the natural resource sector are immobile. Importantly, unlike them, we provide evidence that support the various aspects of the proposed mechanism, as discussed in the next section.

Before turning to the empirical part we sum up the main points of the analysis. The model showed that high fiscal advantage states have lower capital tax rates, and hence a larger per capita capital stock in equilibrium. With a federal tax increase, the latter enables those states to make smaller increases in their capital tax rates, thus attracting capital from the other states in amounts that may offset the negative effect of the federal shock and end up increasing output. The take away message is that a federal tax increase, despite the direct national contractionary hit, may in fact *increase* the per capita tax base and potentially increase overall output in some states through a nationwide capital reallocation, even without getting some of those levied taxes back in the form of federal transfers. In short, this simple mechanism emphasizes the potential horizontal effects of a vertical tax shock. Next, we take the model to the data.

3 Empirical Evidence

In this section we provide empirical evidence for the various aspects of the mechanism proposed. Consistent with the starting point of the model, we first look into systematic cross-state differences in tax rates and per capita capital stocks across levels of fiscal advantage. Following that, we address three inter-related questions; namely, following a federal tax increase, do high fiscal advantage states: 1) make relatively smaller increases in tax rates? 2) attract capital from other parts of the nation? 3) benefit from increased output regardless of federal redistribution? In addition, we provide support for our focus on capital movement and capital taxes, showing that results are rooted in the capital side.

We focus on the U.S. case, which presents several merits for the purposes of our analysis. First, its federal structure, high sub-federal fiscal autonomy levels, and lack of a fully equalizing transfers payment scheme closely follow our theoretical framework. Second, as previously established, it provides ample cross-state variation in fiscal advantage levels. Third, data availability at the state-level enables us to undertake the analysis over a relatively long period, using an annual-based panel of 50 U.S. states covering the years 1963-2007 (unless specified otherwise, in specific cases), and exploiting plausibly exogenous narrative-based measured federal tax shocks from approximately 50 act changes over the said period. These tax shocks form the basis of our identification strategy, as we further discuss below.

In the next sub-section we present the preliminary analysis, looking into cross-state differentials

in tax rates and per capita capital stocks. Sub-section 3.2 presents the main analysis, which starts with an event study analysis, and then continues to investigating heterogeneous vertical tax externalities, cross-state factor movements. differences in output effects, and robustness tests. Appendix C provides detailed description and sources of all variables. Table 1 presents descriptive statistics and a correlation matrix of the key variables.

3.1 Preliminary analysis: fiscal advantage, fiscal environment, and capital stocks

As noted, the proposed mechanism implies that natural resource rich states exploit the fiscal advantage borne by their resources to present a relatively more competitive business environment, which in turn attracts capital from other parts of the nation and allows having relatively greater per capita capital stocks. These points form the basis for the implications that follow, and so they make the starting point of our analysis. Therefore, the two main related questions that arise in this initial phase are the following. Do resource abundant states present a more competitive fiscal environment? Do they have greater capital stocks per capita?

Starting with the first question, previous studies showed that the fiscal environment is consistently and persistently more competitive in resource rich, high fiscal advantage U.S. states regardless of any shocks at the federal level. For example, using a panel for the period 1958-2008, James (2015) finds that tax rates are indeed lower and public good provision is higher in resource abundant U.S. states. Raveh (2013) in turn provides similar evidence under a cross-sectional framework, concluding that approximately 60% of resource-induced capital inflows are due to the business environment. As mentioned earlier, these patterns are also observed in additional fiscally decentralized economies, such as China and Russia. Next, we present some further evidence.

First, to better illustrate the specific case of corporate tax rates, in Figure 2 we plot the average GSP share of the mining sector in 2000-2005 against the average *Corporate Tax Climate Index* in 2006-2011 for the 50 U.S. states.[22] As can be seen, resource rich states have a more favorable tax environment ($\rho = 0.71$). Second, we plot states' average fiscal advantage level against their average tax rates (both described below) over 5-year interval bins, across our sample period. Figure 3 shows the case in levels, whereas Figure 4 illustrates the case in changes. Both cases reveal a negative correlation of -0.45 and -0.35, respectively, suggesting that fiscally advantaged states have lower tax rates. Third, we examine this association using our panel data under a conditional-correlations

[22]The *Corporate Tax Climate Index* is an index that ranks U.S. states by their 'tax-friendliness' to business. The index, published by the U.S. Tax Foundation, is calculated on a 1 to 10 scale, where 10 is friendliest. The earliest year for which this index is available is 2006.

framework; hence, we estimate variations of the following model, for state i at year t (1963-2007):

$$tax_{i,t} = \alpha + \beta(FA)_{i,t} + \gamma(y)_{i,t} + \zeta_t + \eta_i + \epsilon_{i,t}, \tag{16}$$

where tax is the non-severance average tax rate, FA is fiscal advantage, y is real per capita GSP, and ζ and η are state and year fixed effects, respectively, controlling for unobserved fixed variations across states and time.

The tax rate, tax, is measured as non-severance state tax revenues divided by GSP. Our proxy for fiscal advantage, FA, in this exercise and the following ones is the share of severance tax revenues in total state tax revenues. Severance taxes are incurred on the extraction of non-renewable natural resources, such as oil and natural gas. They provide a potentially significant –and non-mobile– source of income to the states in which they are located, hence relieving their fiscal constraints, and allowing them to be more flexible with taxes levied on the mobile tax bases. Importantly, these rents are net of the amount that the federal government levies for redistribution. Income from severance taxes, measured as a share from total tax income, thus provides a direct measure for states' fiscal advantage level.[23] The variable y controls for cross-state heterogeneity, which we assume (here and throughout the various exercises to follow) is largely captured by income differences, given the relatively homogenous inter-state environment. Data are retrieved from the U.S. Census Bureau and Bureau of Economic Analysis. Standard errors are clustered by state. Our focus is on β, which indicates the association between fiscal advantage levels and average tax rates.

Results appear in Regressions 1-3 of Table 2. Specifically, Regression 1 excludes y, Regression 2 follows the specification outlined in Equation (16), and Regression 3 examines a version of Equation (16) in which tax and FA are in changes. In all three cases the estimated β is negative and precise; indicating that the negative association between fiscal advantage and tax rates is also a feature of our data.

Moving to the second question, we undertake a similar descriptive exercise to examine cross-state differences in per capita capital stocks. Hence, we estimate the following variation of Equation (16):

$$k_{i,t} = \alpha + \beta(FA)_{i,t} + \gamma(y)_{i,t} + \zeta_t + \eta_i + \epsilon_{i,t}, \tag{17}$$

where k denotes real capital stock per capita. Data on capital stocks are retrieved from Garofalo and Yamarik (2002). Our focus is once again on β, which this time indicates the association between fiscal advantage levels and per capita capital stocks. According to the model, this association is expected to be positive.

[23] In a later section we also consider different variations of this measure (such as its per capita form or share in GSP) for robustness.

In Regressions 4 and 5 of Table 2, we estimate Equation (17) with the exclusion and inclusion of y, respectively. Both cases yield positive and statistically significant βs, as expected. In the third case, presented in Regressions 6-7 of the same table, we take an instrumental variable approach, via 2SLS estimation. The adoption of this approach addresses two points. First, the extent of fiscal advantage may be endogenous to the degree of capital intensity, as more capital may suggest, for instance, further exploration efforts. The suggested approach may mitigate concerns related to this potential endogeneity bias. Second, the initial estimations followed a reduced form setting; via the proposed method we can point more clearly at the role of tax rates in connecting between fiscal advantage and the capital stock.

We adopt the instrumental variable used in James (2015). This measure is based on the interaction of two plausibly exogenous variables. The first is the cross-sectional difference in geologically-based recoverable stocks of crude oil and natural gas. This data is derived from the U.S. Geological Survey at a province level, which James (2015) aggregates to the state level.[24] The second is the international prices of crude oil and natural gas. Their interaction provides the (weighted) average state resource endowment, which is then normalized by state personal income, averaged over 1958-2008. This measure on one hand provides plausibly exogenous variation in resource windfalls across states as well as within them, and yet on the other is highly correlated with oil production, as illustrated by James (2015), and hence with fiscal advantage. This, in turn, suggests that this measure is expected to be strongly associated with the endogenous variable (average tax rates).

In addition, we assume that in the short run this measure affects the state capital stock only via its effect on state tax rates, and thus follows the exclusion restriction under the specification of Equation (17). This assumption is based on the conjecture that potential direct impacts of exogenous changes to the value of natural endowments on the productivity of capital may take longer to sink in this case due to the geologically-based nature of the endowments, which require the decision to recover the underground resources before they may affect the demand for capital.

Regression 6 presents the first-stage results. The coefficient on the instrument is negative and precise, mimicking the association of fiscal advantage. In addition, the F-Statistic is 49. This points at a strong first-stage. The second stage results, in Regression 7 indicate that the instrumented average tax rates have a negative and significant effect on the capital stock, further supporting the link between fiscal advantage and capital via the tax-rates channel.

These results, in conjunction with the evidence discussed above, provide some indication that tax rates (capital stocks per capita) are indeed lower (higher) in resource abundant, fiscally advantaged states, consistent with the starting point of the model. Next, we test the implications of this.

[24]This measure excludes AK and HI. This restricts the (main) empirical analysis to the 48 contiguous states.

3.2 Main analysis: federal tax shocks, and fiscal advantage

The preliminary analysis indicated that fiscally advantaged states have a more competitive fiscal environment, and as a result a higher per capita capital stock in equilibrium, consistent with the starting point of the theoretical analysis. In this section we move to the main analysis in which we examine the heterogeneous impacts of federal tax shocks. We start with describing the data on these shocks, and then move to analyzing it, first via an event study and then through panel estimations that exploit the full variation of the shocks.

3.2.1 Federal tax shocks

One of the main variables in the analysis is our proxy for the plausibly exogenous changes in federal tax rates. As mentioned earlier, we use a narrative-based measure based on data from RR. In their work, RR decompose all major post-WWII federal tax changes (approximately 50) to their endogenous and exogenous parts. They do so by using narrative sources, including presidential speeches and budgetary reports among others, to classify each tax change into one of four main motivations: spending driven, countercyclical action driven, inherited deficit driven, and long run growth driven; they regard the former (latter) two as being endogenous (exogenous) given their relative short (long) term based view. In addition, they also use the same sources to approximate the magnitude of the change on federal tax revenues, reporting it at the quarter in which tax liabilities actually changed; thus, if a tax law changed taxes in steps, they report its series of revenue effects.[25] Out of the 50 tax changes they examine, 27 are categorized as exogenous and incur tax liabilities that are within our sample period; Table A2 outlines these tax changes.

We use their data, yet aggregate their quarterly-based estimations to be at an annual level.[26] Our identification strategy is primarily based on the examination of the shocks that RR regarded as exogenous as they represent federal policy changes that are based on long-term motives, and hence are less susceptible to endogeneity biases that are driven by contemporaneous economic trends. To observe the distribution of these plausibly exogenous federal tax shocks across the sample period, Figure 5 plots the annual non-normalized federal revenue changes during 1963-2007. As the graph indicates, there are multiple years with an increase, decrease, and no change, hence providing sufficient variation to exploit.

In addition, to motivate the emphasis on capital tax rates in the model, and examine their role in the analysis, we disaggregate the federal tax shocks into corporate-related and non-corporate-

[25] Some tax changes had retroactive components for which RR constructed a separate measure, which introduces some complications, as they describe. Hence, we follow their benchmark measure that excludes this feature.

[26] The aggregation is done due to state-level data limitations, given that the latter is provided at an annual level.

related following RR's documentation. RR record the aim of each tax bill and the type of tax affected. Using this, we classify each tax change as corporate or non-corporate related. Tax changes that only affect federal non-corporate taxes are included in the latter group; the balance is then relegated to the former group.[27] In effect, we follow the methodology adopted in Reingewertz (2018). Table A2 outlines the classification of each tax change; 10 and 17 tax changes are included in the corporate-related and non-corporate-related groups, respectively. With this classification we then assign the tax shocks (of each tax change) to each group, accordingly. As the correlation matrix of Table 1 notes, the tax shocks of the two groups have virtually zero correlation; hence, shocks in either group appear to be independent.

3.2.2 Event study analysis

As a first step, we analyze the impacts of federal tax shocks within an event study analysis framework. Such a framework enables focusing on the major shocks, and examining carefully the differential effects on the fiscally advantaged and non-advantaged state-groups over time. To do so, we follow a methodology reminiscent of the one adopted in Serrato and Zidar (2018), and estimate the following model using our panel of U.S. states:

$$O^{g}_{i,\Delta(t-1,t)} = \alpha + \beta(O)_{i,t-1} + \sum_{k\in(-3,-2,-1,0,1,2,3,4)}^{s\in(NRR,NRP)} \gamma^{s}_{k}(D^{k}_{t}) + \delta(Year) + \theta(Commodity)_{t-1} + \eta_i + \epsilon_{i,t}. \quad (18)$$

In terms of notation, $O^{g}_{i,\Delta(t-1,t)}$ is one of our four outcome variables of interest, namely tax rates, capital, population, and output, in changes between periods $t-1$ and t. O is also added in levels in $t-1$ to control for convergence. Tax rates and capital are measured via the *tax* and k variables outlined previously, respectively. D is an indicator for an event. We define an event to be a corporate-related tax change that is at least half a standard deviation higher than the mean.[28] This definition yields 5 events throughout our sample period.[29] NRR denotes the fiscally advantaged (natural resource rich) state-group, defined as the 8 states with the highest average fiscal advantage level during our sample period, as illustrated in Figure 1.[30] NRP denotes the non-

[27] Hence, the tax changes included in the corporate-related group may also have a component related to non-corporate taxation. For instance, the Social Security Amendments of 1967 raised marginal tax rates on low and middle income taxpayers; having no direct effect on corporate-related taxation, it is included in the non-corporate-related group. Conversely, the Revenue Act of 1978 reduced both personal and corporate tax rates, and hence is included in the corporate-related group.

[28] We focus on corporate-related tax changes in the event study analysis because these are the tax changes that drive the key patterns, as we illustrate in the baseline panel estimations to follow.

[29] Since the shocks are annualized figures of a series of revenue effects, these events are not matched with specific tax reforms.

[30] These include AK, LA, MT, ND, NM, OK, TX, and WY. In effect, the threshold for being included in the NRR group is an average fiscal advantage level of 10% over our sample period. Indeed, the remaining states have

fiscally advantaged (natural resource poor) state-group, which includes the remaining states. Given that the differences are calculated over a prolonged period, and hence are persistent, in conjunction with the geographic roots of natural resource wealth, we consider this division to be plausibly exogenous. In addition, η_i is a state fixed-effect that controls for unobserved fixed heterogeneity at the state level, $Year$ is a time trend,[31] and $Commodity$ is a vector of price measures that includes the average international prices of crude oil, coal and natural gas which control for price-driven differential effects. Last, given that our treatment is at the national level we follow (in this case, as well as in the following analyses) a two-way clustering approach, where standard errors are clustered by state and year.

Our focus is on the γs, which give an estimate for the impacts on changes in state average tax rates, real capital stock per capita, population, and real output per capita in the three years prior and four years past a major corporate-related federal tax change across fiscally advantaged and non-fiscally advantaged state groups. The results, together with their 95% confidence intervals, appear in Figure 6. The observed patterns point at a common-trend prior to the event in all cases, which changes in the year after the event takes place. Specifically, the NRR-states do not change their tax rates in response to an event, while their capital stock and output increase; conversely, the NRP-states increase their tax rates, and experience a decrease in their capital and output. In both cases population is not responsive. Notably, the effects on tax rates, capital, and output are most prominent in the first two years past the event. These patterns are consistent with those highlighted by the model, including the emphasis on the capital shocks and reaction. Motivated by these results, we next examine these impacts within a panel fixed-effects framework that exploits the full variation in the federal tax shocks and states' fiscal advantage levels, and focuses on the short term effect, one year past the shock.

3.2.3 Heterogeneous vertical tax externalities

Let us test the model's prediction concerning the heterogeneous state reactions to federal tax shocks across levels of fiscal advantage. As the model suggests, having a larger tax base in per capita terms, and more generally a steady and significant non-mobile source of income, is expected to lead to better absorption of federal tax changes, and consequently to relatively inelastic vertical tax reactions. The results in the initial event study analysis were consistent with these patterns.

substantially lower average fiscal advantage levels, as illustrated in Figure 1, hence motivating this division.

[31] Notably, the inclusion of time fixed effects would have absorbed the effect of the event and its decomposition.

To put this prediction under more careful analysis, we estimate models of the following type:

$$tax_{i,t} = \alpha + \beta(FED)_{t-1} + \gamma(FA)_{i,t-1} + \delta(FED * FA)_{i,t-1} + \mu(\mathbf{X})_{i,t-1} + \lambda(Year) + \theta(Commodity)_{t-1} + \eta_i + \epsilon_{i,t}; \quad (19)$$

in addition to the notation described previously, FED represents federal tax shocks normalized by GDP, and $\mathbf{X}$ is a vector of controls. Based on the results in the event analysis, we look into the effects of shocks that occurred at the beginning of the period $(t-1)$ on the outcome at the end of it (t). We maintain this general framework in later estimations as well.

Following Taylor and Yucel (1996), $\mathbf{X}$ includes real GSP per capita to deal with income differences, and a spatially-oriented GSP measure to control for potential spatial effects; in particular, we include the average real per capita GSP of all states excluding that of the state inspected. In addition, $\mathbf{X}$ includes a *deductions* dummy that controls for whether the state deducts federal income and/or corporate taxes. This dummy can either take a value of 0 (no deductions), 1 (either corporate or income deductions) or 2 (deductions for both cases). Last, $\mathbf{X}$ also includes real per capita transfers from the federal government. In the context of the current exercise its inclusion is motivated by Smart (1998) who shows that it affects state fiscal behavior. However, federal redistribution takes additional essential roles in the analysis. First, it controls for differences in federal aid, through which it helps our fiscal advantage proxy to make a cleaner measure of that advantage. Second, it enables us to capture the effects of tax increases that are net of their reinvestment, highlighting a key distinction between our analysis and previous studies that examine the macro-level effects of tax shocks (e.g. RR).

We focus on δ, the coefficient on our interaction term of interest. Results appear in Table 3. In the benchmark cases, Regressions 1-6, *tax* denotes non-severance average state tax rates. Given that federal shocks are uniform across states by definition, year fixed effects absorb them; thus, to see their direct effect, Regression 1 includes a time trend and commodity prices instead. In the second regression, we add year fixed effects (and hence drop the federal shock, as well as the time trend and commodity prices), and in the third case, we test a dynamic setting that includes in addition a lagged dependent variable. As can be seen, the estimated δ is negative and significant in all cases; moreover, in the specification that includes the federal shock, β is precisely estimated with a positive sign. Therefore, increases in federal tax rates raise state tax rates for the average state, yet the increase is lower in fiscally advantaged states.

These results imply that fiscally advantaged states may actually decrease their tax rates in response to increases in federal ones, unlike the model's prediction of co-movement under sufficient

g_i and G complementarity. To show more clearly that the result on the interaction term indicates that the latter states simply make a weaker response, similar to the observed patterns in the event study analysis, we examine the reaction coming from the NRR and NRP state-groups concurrently, by estimating the following variation of Equation (19):

$$tax_{i,t} = \alpha + \beta(FED * NRR)_{t-1} + \gamma(FED * NRP)_{i,t-1} + \mu(\mathbf{X})_{i,t-1} + \lambda(Year) + \theta(Commodity)_{t-1} + \eta_i + \epsilon_{i,t}; \quad (20)$$

the state fixed effects absorb the separate effects of NRR and NRP, but the concurrent inclusion of their interaction with FED, together with the exclusion of FED, enables decomposing the average effect of the federal tax shocks to those that come from NRR and NRP separately.

We estimate three versions of this model. In the first, FED is the total federal tax shocks; in the second, FED denotes the corporate-related shocks, and in the third it represents the non-corporate-related shocks. The results on β and γ appear in Regressions 4-6, respectively. In the first case (Regression 4) we see that the positive impact of the federal tax shocks on states' tax rates originates in NRP states, as γ is positive, large, and precise, whereas β is very close to zero and non-significant. The following two cases (Regressions 5 and 6) indicate that these patterns are a feature of the corporate-related federal tax shocks. The results in Regression 5 are reminiscent of those observed in Regression 4 only with a significantly larger magnitude of γ, whereas Regression 6 does not yield differential impacts. To interpret the magnitude on the baseline results (Regression 5), a 1% increase in the GDP share of corporate-related federal tax revenues increases the average tax rate in NRP (low fiscal advantage) states by about one tenth of that.

Next, we examine the impact on different types of tax rates. So far, we employed the ratio of average tax rates to GSP as the dependent variable. However, albeit being a commonly used benchmark measure of tax rates, it does not represent a direct measure of tax rates per se. In addition, despite controlling for GSP in the regression, an increase in this tax measure could be a result of other indirect channels that affect the denominator. Hence, we look into various types of statutory tax rates, that represent both the labor and capital sides. To better examine the role of the corporate-related and non-corporate-related federal tax shocks in driving the changes in the various types of states' tax rates, we estimate the following version of Equation (19):

$$tax_{i,t} = \alpha + \beta(CORP * FA)_{t-1} + \gamma(NCORP * FA)_{i,t-1} + \mu(\mathbf{X})_{i,t-1} + \nu_t + \eta_i + \epsilon_{i,t}, \quad (21)$$

in which FED is disaggregated to its two types, namely $CORP$ (corporate-related) and $NCORP$

(non-corporate-related) shocks, and year fixed effects (ν_t) are included.[32]

We estimate five separate cases of this model; in each case *tax* denotes a different statutory tax rate, namely state individual income, top income, top corporate, sales-apportioned corporate, and capital gains tax rates.[33] Results appear in Regressions 7-11, respectively. In the first two, labor-related state tax rates, we see that neither of the federal tax shocks bear an effect. This changes in the following three, capital-related types of state tax rates, in which we notice that similar to the baseline result in Regression 2, β is negative and significant; corporate-related federal tax shocks induce a relatively smaller impact on state capital tax rates when FA is higher. These results are consistent with the theoretical setting, and provide further support for our focus on capital. We will, however, continue to dig deeper into this distinction as the analysis progresses, maintaining this corporate/non-corporate division in federal shocks in the following sections.

3.2.4 Cross-state capital movements

A second prediction of the model is that, following a federal tax increase, the more moderate fiscal response of the fiscally advantageous states leads to capital inflows from other parts of the nation. In this sub-section we test this prediction. We look directly into changes in states' real per capita capital stocks. In the Appendix, we present complementary analyses which examine changes in tax revenues, firm movements, population, and inter-state migration.

In all cases we estimate variations of the following model:

$$x^{g}_{i,\Delta(t-1,t)} = \alpha + \beta(x)_{i,t-1} + \gamma(FED)_{t-1} + \delta(FA)_{i,t-1} + \varphi(FED * FA)_{i,t-1} + \mu(\mathbf{X})_{i,t-1} + \lambda(Year) + \theta(Commodity)_{t-1} + \eta_i + \epsilon_{i,t}, \quad (22)$$

where $x^{g}_{i,\Delta(t-1,t)}$ denotes the change between $t-1$ and t in one of the factors noted, with its level version added in $t-1$ to address convergence. This framework enables examining factor movements.[34] The remaining controls follow the previous definitions. Based on the results of the previous sub-section and the fit with our theoretical framework, we continue to adopt the corporate/non-corporate division to better understand the difference. Therefore, unless otherwise specified, in all upcoming cases FED represents either the corporate-related or non-corporate-related fiscal shocks. Our main focus is on the coefficient on our interaction term of interest,

[32] In these cases year fixed effects (which, once again, absorb the average effects) are included, as we are interested in the effects of the interaction terms.

[33] The sample coverage, in terms of states and years, differs across cases, depending on data availability. See Appendix C for further details on sources and availability. Top income and corporate tax rates denote the top bracket tax rates. Sale-apportioned corporate tax rates represent states' corporate tax rate adjusted for states' sales-apportionment weight. See Serrato and Zidar (2019) for further details.

[34] Nonetheless, we also consider an alternative levels-based framework, as outlined below.

namely φ.

Capital stocks We first look at the real per capita capital stock, k, as our outcome variable x in expression (22). In this exercise, we seek to realize whether the rate of change in states' k is systematically different across levels of fiscal advantage following a federal tax shock. Controlling for the initial capital stock level and assuming similar depreciation rates across the nation,[35] such systematic differences can be informative about the direction and magnitude of capital reallocation across the nation.[36]

Results appear in Table 4. Regressions 1-2 replicate Regressions 1-2 of Table 3 in terms of the specification followed, but with a different dependent variable and a focus on the corporate-related federal shocks. Regression 3 provides estimation results employing non-corporate-related federal shocks. Regression 4 includes both the corporate and non-corporate related shocks. When a time trend and commodity prices are included (Regression 1), the coefficient γ is estimated to be negative and significant: a corporate-related federal tax increase decreases the capital tax base for the average state. However, in both the initial corporate-related cases (1-2), δ is positive and significant; hence, the contractionary effect on the capital tax base is strongly mitigated to the extent that federal fiscal shocks become expansionary in fiscally advantageous states. Regressions 3 and 4 confirm that effects are completely driven by the corporate-side, as we observe no differential effect following a non-corporate-related shock, while the corporate-related shock maintains its effect.

To better understand the distinct behavior of high and low fiscal advantage states under the corporate-related scenarios, we estimate a model reminiscent of (20), with the difference of employing x in changes, and its lagged value. In effect, we interact FED with NRR and NRP, while excluding the average effect and year fixed effects. The opposite results on the coefficients on the two interaction terms highlight the distinction. Unlike the tax rates' analysis, here the results do not indicate weaker response in the high fiscal advantage states, but rather a completely opposite one. While a corporate-related federal shock decreases the capital tax base in low fiscal advantage states as would be expected, it actually increases it in the high fiscal advantage ones. In addition, the magnitude shows that this is economically meaningful; in the 8 fiscally advantageous states, a 1% increase in the GDP share of corporate-related federal tax revenues raises the growth rate of real per capita capital stock by approximately 0.7 percentage points on average, controlling for redistribution.

[35] An assumption corroborated by Garofalo and Yamarik (2002), who find roughly equal capital depreciation rates across U.S. states.

[36] Nonetheless, one limitation of this measure is that it does not allow separating between the sources of capital formation. We address that by examining additional proxies of capital movement in the following sub-sections.

In addition, we test three additional specifications. First, we examine the case where the dependent variable (real capital stock per capita) is in levels, for robustness. Second, we consider a case in which the dependent variable is the share of state capital stock in the national capital stock. This specification may offer further consistence with the model which considers a similar measure. Third, given that the dependent variable is in changes, we test a specification in which the treatment is in changes as well, hence instead of $FED * FA$ we include $FED^{g}_{i,\Delta(t-1,t)} * FA$ in which FED is in changes between $t-1$ and t. Since we are interested in the results on the interaction terms, these three cases include year fixed effects in lieu of the time trend and commodity prices. Results appear in Regressions 6-8. All cases indicate that the coefficient on our interaction term of interest remains positive and significant, supporting the robustness of this result.

Tax Revenues, firms, and labor To shed further light on the factor reallocation process, we test the same hypothesis from additional angles, and look into differences in tax revenues, and movement of firms and labor. The analyses are relegated to the Appendix. The results are qualitatively similar to those obtained under the baseline case, using capital stocks, and provide further support to the dominant role of the corporate side in this. Specifically, we observe that corporate-related federal tax hikes induce relative increases in the growth of corporate tax revenues and the number of firms of fiscally advantaged states, while yielding no differential response over changes in state population and inter-state migration.

3.2.5 Federal tax shocks and state output

To this point we provided evidence for the various aspects of the proposed mechanism. In particular, we observed that fiscally advantageous states have a better absorption of federal tax increases and that as a consequence they are able to attract capital from other parts of the nation, and hence increase their tax base. The question that naturally follows is whether this translates to having systematic differences in output.

In order to address this key issue, we next estimate variations of the following model:

$$y^{g}_{i,\Delta(t-1,t)} = \alpha + \beta(y)_{i,t-1} + \gamma(FED)_{t-1} + \delta(FA)_{i,t-1} + \varphi(FED * FA)_{i,t-1} + \mu(\mathbf{X})_{i,t-1} + \lambda(Year) + \theta(Commodity)_{t-1} + \eta_i + \epsilon_{i,t}; \quad (23)$$

this is the same model employed before with the difference of having the real per capita GSP (y) as the outcome variable. Hence, this is a cross-state growth regression, where the focus is on the differential effect of a federal tax shock across levels of fiscal advantage. Given that, we follow Mankiw, Romer, and Weil (1992) and also include population growth in $\mathbf{X}$ in all specifications. Consistent

with the model and the previous evidence, we hypothesize that the standard contractionary effect documented, for instance, in RR would be mitigated in fiscally advantageous states to the extent of becoming expansionary, despite controlling for federal redistribution.

We test this in Table 5. This time we start initially with total federal shocks and the non-corporate-related ones. These are presented in Regressions 1 and 2, respectively. The first case, using the total federal shocks, shows through γ that our estimates are consistent with RR's: an increase in federal tax rates is contractionary for the average state. The result on the interaction term, however, confirms our hypothesis: the contractionary effect is mitigated in high fiscal advantage states, to the extent of being expansionary. We discuss this latter option in more detail below. Then, Regression 2 shows once again that the effect observed for the total shocks is not driven by non-corporate-related changes, as we get a non-significant outcome, as before.

We move to the corporate-related cases in Regressions 3-5. These replicate Regressions 2-3 and 5 of the previous table, respectively, only focusing on output; meaning, the first case has a time trend and commodity prices, the second one has year fixed effects and excludes the federal shock, and the third also includes year fixed effects yet with both the corporate and non-corporate-related shocks included. The first estimation points at the average state's contractionary effect through the negative and significant γ. All three cases, however, show that the main result holds through the positive and significant φ. Interestingly, its magnitude is approximately four times that estimated under the total shock. Moreover, it is as well significantly higher than γ in absolute terms. This, therefore, suggests that a federal tax shock can be potentially expansionary.

Next, we decompose the average effect to its NRR and NRP origins, by including their interactions with FED while excluding the latter. In effect, we follow the specification outlined in Equation (20), for the case of changes in output. Results appear in Regression 6. The estimated β and γ show the distinction: in the high (low) fiscal advantage states a corporate-related federal tax increase is expansionary (contractionary). In terms of magnitudes, a 1% increase in the GDP share of corporate-related federal revenues increases the growth rate in output by approximately 0.1 percentage points in the 8 fiscally advantageous states. These findings, hence, illustrate that tax increases do not necessarily lead to a contraction when controlling for government expenditure (reinvestment) as observed in previous studies (e.g. Blanchard and Perotti (2002)).

Robustness tests We undertake a number of tests to examine the robustness of the differential GSP growth effects across states, including examinations of different specifications, sample restrictions, time frames, fiscal advantage measures, federal tax shocks, and additional controls.[37] We

[37] As the distinct stages analyzed in sub-sections 3.1 to 3.2 eventually lead to the effect on output, we concentrate on robustness tests related to GSP growth. Nonetheless, this is merely a representation of the other stages; we note

relegate the analysis and discussion to the Appendix. Notably, the results of this analysis indicate that the main effect is robust to these additional tests.

4 Conclusion

The question of how state tax rates react to federal tax changes is of first order importance. Albeit being especially relevant for federations, it gains further general interest given the global trend to fiscally decentralize. In this paper, we offered a new mechanism of heterogeneous vertical tax externalities where states' reaction is based on their level of fiscal advantage; namely, the level of income coming from non-mobile sources, which we measured using the level of natural resource abundance.

The theory builds on the notion that natural rich states have a fiscal advantage in the inter-state competition which they exploit to attract capital from other parts of the nation through fiscal means. When federal tax rates increase, higher fiscal advantage states raise tax rates by less, due to their larger capital tax base. This enables them to benefit from additional inflows of capital that mitigate the contractionary impact of the federal policy action, to the extent of making it expansionary.

In the empirical part, we provided evidence for the various aspects of this mechanism using a panel of 50 U.S. states, over the period 1963-2007. We first observed that high fiscal advantage, resource rich, states have a more competitive fiscal environment, and a greater per capita capital stock. Then, examining narrative-based measured federal tax shocks a-la RR, we found that following a plausibly exogenous federal tax increase fiscally advantageous states: a) do not change their tax rates, unlike other states that increase them; b) attract capital from other parts of the nation to the extent of increasing their pre-shock stock; c) experience an increase in output, even without reinvestment of the taxes levied. Importantly, we have shown that these patterns are entirely driven by corporate-related federal tax shocks that affect states' capital either through corporate tax rates and revenues, capital stocks, or the number of firms.

The paper carries various policy implications for federalized and fiscally decentralized economies, especially in terms of better understanding the role of cross-state inequality when considering changes in federal tax rates. The mechanism put forward suggests that there is room to account for possible cross-state heterogeneity in the horizontal channel when coordinating vertical taxes. This is potentially important to avoid an exacerbation of fiscal inequality, and the possibly inefficient cross-national factor reallocation process that can follow a federal tax shock. Given that we have

that the various tests undertaken hold as well in each of the intermediate steps.

limited our analysis to the U.S. economy as well as to natural resources, future research may consider other federations or examine other forms of non-mobile regional differences.

Appendix

A Federal and State Expenditures

Given that the theoretical framework presented in Section 2 rationalizes our empirical findings as a response to the degree of complementarity of federal and state government spending, in this Appendix we further examine the relationship between these two variables. The definitions of the different data series employed are located in Section A.2.

A.1 Searching for complementarity through correlation

If complementarity between federal and state expenditures exists, we should observe that the two variables move together. Our next task is looking at whether this prediction is supported by the data. Obviously, complementarity is not the only reason why two variables can move together. For example, federal and state level spending can do so due to business cycle and time trend effects. In order to address these points, our data set also includes the cross sectional dimension of U.S. states' expenditures; hence, we present both panel and cross-sectional results. Another possible driver of the positive correlation can be intergovernmental transfers, like Medicaid grants that can help boost state level health spending; we will control for these effects as well. A third alternative that will be addressed later in this section is that government spending can be determined by states' income levels.[38]

We study data for the period 2005 to 2012 across 50 U.S. states. Data on federal spending are obtained from the PEW Charitable Trusts (PCT), whereas the figures at the state and local government levels come directly from the U.S. Census Bureau (USCB). We compute numbers in per capita terms –population comes from USCB– and deflate them using the nationwide consumer price index obtained from the Bureau of Labor Statistics.

PCT combines publicly available data sources (USCB mainly) to show the state-by-state distribution of federal spending divided into five major expenditure categories: *retirement benefits*, such as federal pension, disability, and social security; *nonretirement benefits*, which include programs such as Medicare, unemployment insurance, and food stamps; *grants*, related to funding, given to state and local governments, of health care, transportation, education, and housing programs; *contracts*, intended for purchases of goods and services mainly related to national defense; and *salaries and wages*.

In order to match these categories with state and local level expenditures reported by the census, we do the following.[39] We consider that the counterpart to federal retirement benefits are given by item codes $X11$ and $X12$ at the state and local levels; these pension codes cover the public employees' retirement system, and are part of social insurance trust expenditures in USCB. Nonretirement benefits at the state and local levels are captured by item codes $Y05$, $Y06$, $Y14$, $Y53$ –which include unemployment benefits, compensations to injured beneficiaries, and disaster reimbursement– and category J –education aid, public welfare payments, and bonuses to veterans.

Federal grants, in turn, are matched at lower government levels with current operations expenditures minus wages and salaries. Current operations (category E) include: compensations of own officers and employees; purchase of supplies, materials and contractual services, except any amounts for capital outlays, repair, and maintenance services. These expenditures finance a large

[38] Given the general trend to decentralize, federal spending will tend to grow more slowly than its state and local counterparts. The cross-sectional analysis and controlling for states' output levels can help mitigate this effect.

[39] All the item codes and categories belong to the 2006 edition of the U.S. Census Bureau's Government Finance and Employment Classification Manual.

variety of public goods and services provided by the public sector, such as air transportation, education, health, highways, judicial and legal services and parks, among others. Wages and salaries are provided by exhibit code $Z00$.

Finally, federal contracts are proxied at the state and local levels by capital outlays, categories F, G and K. Capital outlays represent contracts to pay personal services or other objects used in the construction of buildings and other improvements, and the purchase of land, equipment, and existing structures.

As mentioned before, a spurious positive correlation can be a consequence of intergovernmental transactions, which measure money transfers between governments to perform specific public functions or to provide for general financial support; an example is federal grants. For this reason, we will also include them in our analysis. As it is not straight forward to assign the different sub-categories of intergovernmental transfers to particular major expenditure groups, we choose to employ in our analysis a compound measure of net intergovernmental inflows calculated as the difference between intergovernmental revenues and expenditures.[40]

Table A1 shows the weights of the major expenditure categories, and of selected combinations of them in total spending for different levels of government. We consider three levels: federal, state, and state-and-local governments. The table also presents the correlations between administrative levels of each category.

For the federal government, the most important expenditures are retirement and nonretirement benefits, both together account for 56.7% of total spending. Those categories, however, are the less important ones at lower layers. In particular, their combined weight for the state and for the state-and-local governments is, on average, 21.0% and 11.4%, respectively. For these lower levels of government, current operation spending (matched with federal grants, wages and salaries) are the largest component, accounting for 69.6% (state) and 77.4% (state and local).

We can see as well in Table A1 that intergovernmental revenues and expenditures are important. For state governments, on average, intergovernmental revenues finance 38.4% of total spending. Nevertheless, these intergovernmental inflows in states are almost offset by their expenditure counterpart, which shows a weight of 37.2%. This is not the case when we group together state and local administrative units. For this last aggregation, intergovernmental expenditures are relatively small, just 0.2% of total expenditure, whereas intergovernmental revenues represent 19.5%. These calculations suggest that the greatest beneficiaries of intergovernmental transfers are local governments.

In terms of correlations, all the categories in Table A1 show a positive correlation between federal and lower levels of governments in the panel of U.S. states. The exception is retirement benefits that gives a correlation of -0.124 between the federal and the state governments, and one of -0.184 between the federal and the state-and-local levels. The positive relationship for the contracts category (proxied at state and local levels by capital outlays) is relatively modest and equals 0.130 and 0.066. Nonretirement benefits, on the other hand, show a large positive correlation of about 0.53 in both cases.

The current-operations expenditure categories (grants plus salaries and wages at the federal level) also show a large correlation. In particular, categories (2) and (4) together show a correlation of 0.752 between the federal and state governments, and of 0.566 between federal and state-and-local.[41] This is important to support our analysis, because as we said earlier current operations

[40] An example of this difficulty is item code $B79$, Public Welfare. It includes, among other things, federal programs such as temporary assistance for needy families, Medicaid, food stamps, child welfare services, and work incentives. Note that while Medicaid would need to be assigned to the *grants* category, the rest would need to be part of the *nonretirement benefits* category; unfortunately, to our best knowledge, USCB data does not enable undertaking such divisions.

[41] Given that federal grants are a form of intergovernmental transfers, we can choose to subtract the latter from current operation expenditures. If we do that, the correlations between this last category and federal grants plus wages and salaries become 0.586 at the state level, and 0.395 at the state and local level. We do not follow this

represent 77% of total spending at the state and local levels, and are the closest to the direct provision of public goods.

Next, we take into account that some expenditures are a consequence of inflows received from or allocated to other administrative layers. Therefore, we should consider these movements of money to calculate the relationships. As mentioned previously, it is not straight forward to assign the different intergovernmental-transfer item codes to our spending categories. Fortunately, we do know that retirement payments by the state and local governments (item codes $X11$ and $X12$) exclude payments to retirement plans administered by another government, such as federal social security and local payments to state-administered retirement systems. Therefore, federal intergovernmental revenues do not finance state and local retirement payments. We write "fortunately" because retirement payments do not represent a public good per se.

As a consequence, we compute total spending minus retirement benefits net of intergovernmental transfers, for each of the government layers (and their corresponding categories). Results from this exercise are contained in the last row of Table A1. The new spending aggregate accounts for a large share of total spending: 70.1%, 86.7%, and 73.8% in the federal, state, and state-and-local cases, respectively. Interestingly, the correlations are positive and relatively large, equal to 0.478 between the federal and state governments, and 0.354 between the federal and state-and-local levels. To get an idea of the effect of intergovernmental movements, we can compare these results to the ones contained in the row before last. The elimination of net intergovernmental inflows has reduced the correlations by about 0.07, making a relatively low difference.

Let us now plot the expenditures focusing on two broad categories: current-operations expenditures (state, and state-and-local governments), and total spending minus retirement benefits net of intergovernmental transfers (federal government). The former is our preferred measure for the direct provision of public goods, and the latter eliminates the effects of intergovernmental transfers. In this graphical exercise, we also take into account that federal, state, and local governments spend more in those categories in richer states on average. Then, in order to isolate spending from the effect of income, we regress real public expenditures per capita on real GSP per capita, and plot the residuals (federal against state levels).[42]

Figures A1 and A2 show the results for the panel of U.S. states and for the cross section given by the mean values per state in the LHS and RHS. Figure A1 shows federal versus state spending; whereas Figure A2 depicts federal versus state and local expenditures. We can see that the positive relationship is stronger for current operations spending (charts A, B, E and F) than for the net total spending measure (charts C, D, G and H). Nevertheless, in all cases, the fitted econometric lines give a positive and significant slope coefficient. This significance is always strong at the state government level (charts A to D), and also for the state-and-local level with the exception of chart H where the significance is weak.[43]

We could summarize the main results obtained in this Appendix as follows. We have shown in a panel of U.S. states that, in per capita terms, states' current-operations expenditures are highly positively correlated with grants plus salaries and wages paid by the federal government. Importantly, these expenditure categories account for about 77% of the state and local governments' budget, and are directly related to the provision of goods and services by the public sector. We have also shown that the effect of intergovernmental transfers in our results is relatively small. These findings have been obtained controlling for business cycle, inflation, time-trend, and income level effects. As a consequence, even though the proposed matching between different layers of government is not perfect, we believe that the evidence provided suggests there is complementarity in the supply of goods and services at the federal and state levels.

approach because intergovernmental transactions are larger concept than federal grants.

[42]Results without this correction are qualitatively the same.

[43]Following the discussion in footnote 41, if we subtracted intergovernmental transfers from current operation expenditures in charts A, B, E and F, the fitted lines would again show strongly significant positive slopes. The only difference would be a larger dispersion in the cloud of points.

A.2 Definitions of the different categories

The PEW Charitable Trusts (see its publication "Federal Spending in the States, 2005 to 2014" March 2016) defines the different series as follows:

1. *Retirement benefits*: payments to individuals, which include social security retirement, survivor, and disability payments, veterans' benefits, and other federal retirement and disability payments. Social security accounts for about four-fifths of these payments.

2. *Nonretirement benefits*: payments to individuals that include Medicare benefits, food assistance, unemployment insurance payments, student financial aid, and other assistance payments. Medicare accounts for nearly two-thirds of these payments.

3. *Grants*: include funding to state and local governments for a variety of program areas such as health care, transportation, education, and housing, as well as funding for individuals and other nonfederal entities, such as research grants. Medicaid grants to states account for about half of all federal grants.

4. *Contracts*: cover the purchase of goods and services, from military and medical equipment to information technology and catering services. Defense purchases account for two-thirds of federal contracts.

5. *Salaries and wages* for federal employees. Roughly two-thirds of this spending is for civilians, and one-third is for military personnel.

At the state and local government level, we approach federal categories 1. to 5. with the following items provided by the U.S. Census Bureau, respectively (The definitions of the variables reported below are extracted from https://www.census.gov/govs/definitions/):

1. Item codes $X11$ (Total Benefit Payments) and $X12$ (Withdrawals). These codes measure the distribution of cash benefits to, or withdrawals by, eligible persons under government-administered employee retirement systems covering public employees. They are part of Insurance Trust Expenditures.

    - *Insurance Trust Expenditures* are defined as cash payments to beneficiaries (including withdrawals of retirement contributions) of employee retirement, unemployment compensation, workers' compensation, and disability benefit social insurance programs. Excludes cost of administering insurance trust activities, state contributions of programs administered by the state or by the federal government, intergovernmental expenditure for support of locally administered employee-retirement systems, and noncontributory gratuities paid to former employees.

2. Item codes $Y05$ (regular unemployment benefits), $Y06$ (extended and special unemployment benefits), $Y14$ (workers' compensations for disability), $Y53$ (other cash benefits and withdrawals under social insurance programs) and category J.

    - Category J is part of *Assistance and Subsidies*, and includes direct cash assistance to foreign governments, private individuals, and nongovernmental organizations neither in return for goods and services nor in repayment of debt and other claims against the government. Except for the Federal Government, this category is limited to education grants, including scholarships to individuals and aid to private schools or colleges; public welfare cash assistance payments; and bonuses to veterans.

3. Category E (Current Operation Expenditures) minus exhibit code $Z00$ (Total Salaries and Wages).

    - *Current operations expenditures* are defined as direct expenditure for compensation of own officers and employees and for supplies, materials, and contractual services except amounts for capital outlays.
    - *Total Salaries and Wages* represent total expenditure during fiscal year for salaries and wages, covering all functions and activities of the government and its dependent agencies. Includes the general government, liquor stores, and utilities sectors.

4. Capital outlays categories F (Construction), G (Purchase of Land and Existing Structures) and K (Purchase of Equipment).

    - *Capital Outlays* represent direct expenditure for contract or force account construction of buildings, grounds, and other improvements, and purchase of equipment, land, and existing structures. Includes amounts for additions, replacements, and major alterations to fixed works and structures. However, expenditure for repairs to such works and structures is classified as current operation expenditure.

5. Exhibit code $Z00$ (Wages and Salaries).

Another important category employed in the analysis is *Intergovernmental Transactions*. They are defined by USCB as monies paid to or received from other governments for performing specific governmental functions or for general financial support, whether the activity is undertaken on behalf of the paying government or whether such funds are regarded as assistance for the support of activities of the receiving government. They are classified in the general government sector no matter their purpose (including utilities). Examples include the reimbursement of one government by another for tuition costs, hospital care, boarding prisoners, construction of public improvements, etc.; grants in aid; payments-in-lieu-of-taxes, and the like.

B The Model with State Consumption Tax Rate

To illustrate that the dependency on the complementarity feature can be mitigated, we introduce a more direct version of the *tragedy-of-the-commons,* common-pool, problem into our model by considering a consumption tax. If for example the federal authority raises the tax rate on capital, individuals will be able to spend less in consumption, and then the state government will see its tax revenues fall. This per se might give local governments an incentive to raise tax rates.

Suppose that consumption is taxed at rate t_c in all states. The state government then solves the following problem:

$$\max_{\{t_i\}} U_i = \ln c_i + (g_i^\sigma + G^\sigma)^{1/\sigma} \tag{24}$$

subject to

$$g_i = \phi(t_i r_i k_i + z_i + t_c c_i) \tag{25}$$

$$c_i = \frac{1}{1+t_c}\left[\pi_i + r_i\left(1 - t_i - \tau\right)k\right]. \tag{26}$$

$$G = \phi \tau r k, \tag{27}$$

Then (26) into (25) obtains

$$g_i = \phi \left\{ t_i r_i \left(k_i - \frac{t_c}{1+t_c} k \right) + z_i + \frac{t_c}{1+t_c} \left[\pi_i + r_i \left(1 - \tau \right) k \right] \right\}.$$

That is, with a $t_c > 0$, an increase in τ implies less local tax collection and, then, less g_i. Similarly, a rise in t_i allows for larger spending in public goods, but less than when $t_c = 0$ because t_c also affects c_i negatively.

With the new definitions, the FOC becomes

$$\begin{aligned} \frac{r_i k}{\pi_i + r_i \left(1 - \tau - t_i \right) k} &= \phi r_i \left(k_i - \frac{t_c}{1+t_c} k \right) * \\ & \left\{ 1 + \left[\frac{\tau r k}{t_i r_i k_i + z_i + \frac{t_c}{1+t_c} \left[\pi_i + r_i \left(1 - t_i - \tau \right) k \right]} \right]^{\sigma} \right\}^{\frac{1-\sigma}{\sigma}}. \end{aligned} \tag{28}$$

Condition (28) implies that the reaction of G/g_i (the ratio inside square brackets) to an increase in the federal tax rate τ rises with t_c. Notice that this helps t_i react in the same direction as τ as long as $\sigma < 1$. The implication is that a larger t_c reduces the degree of complementarity required to get the qualitative results that we have in the paper. Nevertheless, because the LHS pushes the local tax rate to move in the opposite direction than the federal one, we still need some degree of complementarity between G and g_i.

Albeit analyzing $\partial t_i / \partial \tau$ is now less straight forward, focusing on the extreme cases we can say that if federal and state public goods are perfect substitutes: $\sigma = 1$ and then $\partial t_i / \partial \tau = -1$; that is, as in Section 2, we do not get co-movements in the tax rates. Whereas if they are perfect complements: $\sigma = -\infty$ and then $G = t_i$; thus meaning that

$$\frac{\partial t_i}{\partial \tau} = \frac{rk + \frac{t_c}{1+t_c} r_i k}{r_i k_i - \frac{t_c}{1+t_c} r_i k}. \tag{29}$$

Expression (29) is positive because it can be safely assumed that $\frac{t_c}{1+t_c}$ is relatively small.[44] The difference with what we had before in expression (15) is the additional term that depends on t_c and appears with positive sign in the numerator and with negative sign in the denominator of equality (29). Notice that this additional term is smaller in the resource rich region because r_i is lower. As a consequence, it can be easily shown that the derivative is smaller in resource richer states.

The conclusion is that the introduction of more dominant common-pool effects reduce the level of complementarity required to obtain our main results. However, some degree of complementarity between G and g_i is still needed to get them.

C Data

We use an annual-based panel that covers the 50 U.S. states over the period of 1963-2007 (with the exception of specific cases, where specified so). Unless otherwise specified, variables are based on data from the U.S. Bureau of Economic Analysis and the U.S. Census Bureau. Descriptive statistics and a correlation matrix of the key variables are presented in Table 1.

[44] Turning to the data, the average k across U.S. states over our sample period is $\$26,000$, and the lowest k_i is $\$12,000$. Examining expression (29), this suggests that only a t_c higher than 0.85 would result in a negative $\frac{\partial t_i}{\partial \tau}$; however, t_c is substantially lower in all states.

Variable definitions

Federal tax shocks: Narrative-based federal tax shocks (Source: Romer and Romer (2010)). Based on narrative sources, RR decompose changes in federal tax rates to endogenous and exogenous, and translate these to changes in federal tax revenues (in Billions of real US$). We investigate the shocks they classified as exogenous, normalized by GDP. Table A2 outlines these tax changes. For further information on the endogenous/exogenous decomposition and the construction of the size and timing of the tax shocks, see RR.

Federal tax shocks, corporate / non-corporate related: Based on RR's documentation, we decompose the federal tax shocks to those that are corporate-related and those that are not. We classify an exogenous tax shock to be non-corporate-related if within the description of the bill it is specifically mentioned to be related only to non-corporate-related taxes, with the balance being classified as corporate-related. The tax shocks related to these tax changes are then classified accordingly. Table A2 outlines the classification of each tax change in the sample.

GSP per capita: Real Gross State Product divided by state population.

GSP per capita, other states: Average real GSP per capita over all states, with the exclusion of the state inspected.

Fiscal advantage: Share of severance tax revenues in total tax revenues.

Severance tax per capita: Severance tax income divided by state population.

Mining share: GSP share of the mining sector.

Price measure: The GSP share of the mining sector in 1963 multiplied by the international real price of crude oil in each year (Source: World Bank Development Indicators).

Capital stock per capita: State-level measure of capital stock, divided by state population, in constant prices (Source: Garofalo and Yamarik (2002) and its extension, available at the second author's homepage).

Average tax rates: Non-severance tax revenues normalized by GSP.

Top corporate tax rates: Top state tax corporate tax rates; 1963-2002 (Source: World Tax Database, University of Michigan).

Top income tax rates: Top state tax income tax rates; 1963-2003; VT excluded for most years (Source: World Tax Database, University of Michigan).

Individual income tax rates: State individual income tax rates; 1979-2007 (Source: Serrato and Zidar (2019)).

Sales-apportioned corporate tax rates: State corporate tax rates adjusted by the state-specific sales-apportionment weight; 1978-2007 (Source: Serrato and Zidar (2019)).

Capital gains tax rates: State capital gains tax rates; 1979-1990 (Source: Bogart and Gentry (1995)).

Deduction dummy: Dummy variable for whether the state deducts federal income and/or corporate taxes; takes value of 0 (no deductions), 1 (either corporate or income deductions) or 2 (deductions for both cases).

Transfers: Real per capita transfers from central government.

Number of firms: Number of firms per capita within the state, divided to those with 1-4 employees, and those with 5 or more; 1977-2007.

Inter-state migration: Number of migrations per capita coming from other states; 2001-2007 (Source: U.S. Internal Revenue Service).

Tax base rules: Franchise tax (an indicator for whether or not a Franchise tax is levied on corporations in a given state-year); federal income tax deductibility (an indicator for whether or not federal income tax is deductible in a given state-year); federal income as state tax base (an indicator for whether or not federal income is used as the state tax base in a given state-year); sales apportionment weight (the share of national profits of multi-state firms that are allocated to sales (for tax purposes) in a given state); 1980-2007 (Source: Serrato and Zidar (2018)).

Commodity prices: the average price of crude oil ($/bbl), coal ($/mt), and natural gas ($/mmbtu) (Source: The World Bank).

Corporate taxes per capita: The state's corporate tax revenues per capita in real terms.
Non-*corporate taxes per capita*: The state's non-corporate tax revenues per capita in real terms.
Population growth: The annual rate of change in state population.
Reserves of oil and gas: Recoverable state stocks of oil and natural gas (cross-sectional) interacted with the international price of crude oil and natural gas at time t, and normalized by the average state income (averaged over 1958-2008). AK and HI are excluded (Source: James (2015)).
Governor's party affiliation: An indicator for whether the Governor is affiliated with the Democratic or Republican parties.

D Tax Revenues, Firms, and Labor

In this section we provide additional results related to the analysis presented in Sub-section 3.2.4. Namely, we examine the noted cross-state capital movements hypothesis via changes in tax revenues, as well as in firm and labor movement.

D.1 Tax revenues

We test the hypothesis presented in Sub-section 3.2.4 from an additional angle, looking into differences in tax revenues. Systematic cross-state differences in per capita tax revenues following a federal shock can shed further light on the factor reallocation process. Adopting Equation (22), let us now consider x to be real per capita state tax revenues. Results appear in Table A3.

Regression 1 follows the specification of Regression 1 of Table 4. The estimated φ is qualitatively similar to that estimated in the case of capital stocks. Regression 2 follows the same specification, however it in addition includes controls for tax base rules. Serrato and Zidar (2018) find that tax base rules related to sales apportionment weight, franchise tax, federal income tax deductibility, and federal income as state tax base have the relatively strongest impact on corporate tax revenues. Hence, to address that we add controls for each of these rules;[45] the results in Regression 2 indicate that the main patterns are robust to this inclusion. Thereafter, Regressions 3-5 follow the specifications of Regressions 2-4 of Table 4, respectively. The qualitative results remain similar to the capital stocks cases; specifically, the coefficient on $CORP * FA$ is positive and significant, whereas that on $NCORP * FA$ is close to zero and imprecise; corporate-related federal tax shocks are those that drive the patterns observed.

Interpreting the magnitude using the estimates in Regression 3, having a 15% fiscal advantage level, a 1% increase in the GDP share of corporate-related federal tax revenues increases the growth in per capita corporate tax revenues by approximately 0.2%. Despite this relatively small increase, it is nevertheless surprising that an increase in a federal tax rate that directly pertains to a specific tax base increases the states' income collected from that tax base.[46] This, in conjunction with the observation that corporate tax rates are generally lower in high fiscal advantage states, suggests that the corporate tax base increased in those states through capital inflows.[47]

To show that things are, once again, rooted at the corporate side, Regression 6 looks into the effect on per capita non-corporate tax revenues under the specification of Regression 3. The

[45] See Appendix C for descriptions and sources of these controls.

[46] Notably, in our framework the response of states' tax revenues to changes in federal taxation is via horizontal tax competition that yields a multi-state equilibrium outcome. It is, therefore, an outcome of strategic behavior among states. Hence, the patterns observed do not imply the location of states across the Laffer Curve (Fullerton (2008)).

[47] Given the tendency of U.S. corporations to incorporate in Delaware –a resource poor state– it might be suspected that we underestimate the effect. We note, however, that when Delaware is dropped from the sample, the coefficients of interest remain largely stable. Hence this state does not seem to play a key role in the results.

estimated φ shows no clear patterns for the non-corporate tax revenues. The conclusion is that neither non-corporate shocks make a clear effect nor non-corporate revenues are significantly affected. These results provide further support for our general focus on capital.

D.2 Firms and labor

The final perspective that we take to assess whether capital is the main input that moves across states as a consequence of federal tax shocks is through a direct examination of the movement of firms and labor. Results appear in Table A4. In this case we focus on the 48 contiguous states in order to minimize differences in mobility costs. We start with the firms' analysis using state-level data covering the period of 1977-2007, derived from the U.S. Census Bureau. Adopting Equation (22), the variable that now takes the role of x in our empirical equation is the number of firms per capita. Realizing that mobility may change across levels of firm size, such that for instance smaller firms may be less willing to move given a stronger local attachment, we test two separate size groups; the first includes the firms that have up to 4 employees, and the second covers the remaining ones, having 5 or more. Each group comprises approximately half of the total number of firms.

Results appear in Regressions 1-5. Regression 1 looks into firms with up to 4 employees and replicates the specification of Regression 2 of Table 4. Regressions 2-5 examine firms with 5 or more employees and follow specifications of Regressions 1-4 of Table 4, in the same respective order. Regressions 2-3 test the corporate case, Regression 4 the non-corporate case, and Regression 5 includes both. As before, we focus on the estimation of the interaction term.

As can be seen, the case of having up to 4 employees does not provide clear patterns; smaller firms appear to be less responsive to federal shocks. This, however, changes with larger firms. The relevant outcome in Regressions 2-5 points at the patterns observed in previous tables. Following a corporate-related federal tax increase, the number of firms with 5 or more employees increases in states with high fiscal advantage;[48] specifically, a 1% increase in the GDP share of corporate-related federal tax revenues increases the growth rate of the per capita number of firms with 5 or more employees in states with a 15% fiscal advantage level by approximately one fifth of that. The data does not provide direct indication on firm movement; however, assuming marginal differences in cross-state firms' entry and exit rates, alongside our framework's key assumptions, this result suggests that there is firm movement towards the fiscally advantageous states. Regressions 4 and 5 then illustrate once again that these patterns are entirely driven by corporate-related shocks.

To further examine the distinction between capital and labor aspects, we next look into inter-state migration. Labor data is retrieved from surveys of the Internal Revenue Service which indicate individuals' place of residence in the precedent year. The period covered is 2001-2007. Results appear in Regression 6, which replicates Regression 1 with the exception of x now being per capita migration inflows from other states. Unlike firms, labor does not appear to induce a differential response, having an imprecisely estimated interaction term.[49] To exploit the full sample, Regression 7 replicates its former only considering the annual change in population as the labor movement proxy, in lieu of x; the outcome remains qualitatively similar. These results further strengthen our focus on capital, as we observe movements are restricted to firms and corporate-related shocks.

Last, we test the role of tax rates in driving these factor movements. To do so, we take a two-stage estimation approach. In the first stage, we take the predicted values from Regression 1 of Table 2, in which the non-severance average tax rates are explained by our proxy for fiscal advantage, together with state and year fixed effects. These values measure the portion of states'

[48] As in the tax revenue case, here the results are also stable when Delaware is dropped, so that the tendency of firms to incorporate there does not appear to underestimate the effect.

[49] Note that non-corporate-related shocks were not tested in this case given that they present no variation in the corresponding period of post-2001 years.

average tax rates explained by their fiscal advantage. In the second stage, we take the change in these predicted values, between $t-1$ and t, and interact them with the corporate-related federal tax shocks. In effect, we estimate the specification of Regression 3 in which the change in the predicted values from the first stage enter in lieu of FA.

Results appear in Regressions 8 and 9 for the cases of firms (5 or more employees) and inter-state migration, respectively. The estimated coefficients on the interaction terms point at similar patterns as in the baseline cases, in which firms exhibit a differential response, whereas labor does not (note that in this case the coefficient is negative, due to the usage of tax rates). These results highlight the role of changes in tax rates in driving the main observed patterns. In addition, in this case we also report the average effect of the change in the predicted values of the tax rates, to examine the elasticity of capital and labor movements. Interestingly, the estimates point at a short run corporate tax elasticity of approximately -0.51 in firm movement, with no clear effect on inter-state migration. These results are within the range of those reported in the empirical literature on tax elasticities (see, e.g., Giroud and Rauh (2019) and references therein), as well as with studies that point at the relatively inelastic response of migration in the short run (Mansoorian and Myers (1993), and Perez-Sebastian and Raveh (2016), among others).[50]

E Additional Tests

We undertake a number of tests to examine the robustness of the findings presented in Sub-section 3.2.5. All results are presented in Table A5. The general specification in all cases follows Equation (23) in its strictest form; namely, with year fixed effects and the federal shocks excluded. As before, the focus is on the interaction between the corporate-related federal shocks and a fiscal advantage proxy.

First, we test two additional level-based specifications. In the first, we use a standard level regression, following the abovementioned specification but with $y_{i,t}$ on the LHS. Results appear in Regression 1. In the second, we estimate the same level version using the Arellano-Bond procedure (Arellano and Bond (1991)), examining first differences while instrumenting variables using their lagged values; results appear in Regression 2. Our main findings hold in both cases, as the positive and significant estimated φ indicates.

Second, we test whether results are driven by post-2000 effects. As Figure 5 illustrates, post-2000 federal shocks are relatively stronger, thus potentially being the dominant sub-period in our analysis. We, therefore, exclude post-2000 years, and re-estimate the model using this restricted sample. Regression 3 presents the results of this exclusion. Our main result on φ holds in sign and significance, with some notable increase in magnitude. Post-2000 years, thus, do not appear to drive our main findings.

Third, we test two additional measures of fiscal advantage levels, both looking more directly at the wealth of natural riches. The first is the conventional measure: GSP share of the mining sector. However, given the potential endogeneity of this proxy (see e.g. van der Ploeg (2011)), as well as that of the one used previously, we consider a second one which exploits the exogenous variation in the international price of oil. To construct the second measure, we take the GSP share of the mining sector in the initial year and multiply it by the international real price of crude oil at year t. Figure 7 illustrates that states' relative abundance in natural resources did not change much from 1963; this enables us to focus on the exogenous price variations by fixing natural wealth to that in 1963. Assuming that resource abundance in 1963 is predetermined, and since the price of oil is determined in the international market, this measure gives a plausibly exogenous proxy for fiscal advantage. Results appear in Regressions 4 and 5 for the output and price based measures,

[50] In addition, they imply that the horizontal tax competition equilibrium is set such that the average state operates in the left side of the Laffer Curve.

respectively. As the estimated coefficient of the interaction term indicates, the main result remains to hold even under these additional fiscal advantage proxies.

Fourth, we test whether our main results are driven by the most fiscally advantaged states, or by correlation between them. To do so, we undertake two tests. First, we exclude from the sample the states included in the NRR group; namely, Alaska, Louisiana, New Mexico, Texas, West Virginia, and Wyoming. Second, we estimate the complete sample under the assumption that standard errors are correlated within the NRR state-group, as well as within each of the remaining states, and years, and hence cluster the standard errors at that level. The results appear in Regressions 6 and 7, respectively. The positive and significant φ in both cases indicate that the main result holds even when we restrict the sample to states with relatively low fiscal advantage, or assume that standard errors are correlated across states in the NRR group.

Fifth, we test our main fiscal advantage proxy in its per capita form. Our usage of an income-share based measure is motivated by our definition of fiscal advantage. Nonetheless, we realize that a per capita based one may provide a more direct relation to the model's notion of it; in addition, it may also contribute to mitigating potential mechanical relation between the income-share based and average tax rate measures. Regression 8 performs this test using real severance tax per capita as the main fiscal advantage measure. Results are qualitatively the same, with the main coefficient maintaining its sign and significance.

Sixth, we test for the role of a political channel. Being predominantly Republican, the fiscally advantaged (natural resource rich) states may respond differently to federal tax changes due to inner party politics, or otherwise a *Regional Favoritism* effect a-la Hodler and Raschky (2014) where the federal and state regimes are connected via the party. To test that, in Regression 9 we add a control for the party affiliation of the Governor.[51] Again, the coefficient on our interaction term remains stable in all key aspects, indicating that the main result is robust to this.

Seventh, we add state-specific time trends. The fixed effects framework enables controlling for the fixed, unobserved, heterogeneity across years and states. More specifically, the former controls, for instance, for the nation-wide contractionary effects of a federal tax increase (RR), or other within-year business cycle effects, addressing the option that the patterns we observe are a result of mitigated responses to them. Nonetheless, to better capture the unobserved changes over time, we account for the potential divergent trends across states, by adding state-specific time trends. Results appear in Regression 10, indicating that the main result remains to hold under this framework.

Eighth, we consider the role of anticipated federal tax shocks. Mertens and Ravn (2012) illustrated that a key portion of RR's exogenous federal tax shocks are anticipated. Furthermore, they found that anticipation effects have been important during several U.S. business cycle episodes. In case they have differential effects across states' levels of fiscal advantage, they may affect the patterns we observe. To test that, we add in Regression 11 the anticipated exogenous federal tax shocks of Mertens and Ravn (2012), together with their interaction with fiscal advantage.[52] Interestingly, the coefficient on the additional interaction term is positive and significant; anticipated federal tax shocks represent a viable transmission channel of the proposed mechanism. Nonetheless, the coefficient on the main interaction term remains positive and significant, similar to the benchmark case, albeit with a slightly lower magnitude.

Ninth, in Regression 12 we test the robustness of the result to the usage of population-weighted federal tax changes. To this point we regarded the federal tax changes as uniform shocks occurring equivalently across the nation. However, the calculated changes in federal revenue are an aggregate over all states; consequently, some states may contribute more depending on the size of their tax base. To address that we follow the methodology of Nunn and Qian (2014) by adding plausibly

[51] Data is based on the U.S. Census, and limits our sample to 1983-2007. We thank James Snyder for sharing it.

[52] Mertens and Ravn (2012) construct a quarterly-based series of anticipated exogenous federal tax shocks. We use the annual aggregates of this series. In addition, this series limits the sample period tested in this case to 2006.

exogenous cross-sectional variation, based on cross-state population weights, to the time-based federal tax measure. We construct this by interacting the latter with the state population weights in 1960 (the earliest Census that includes all states), assuming these capture relatively persistent size differences across the sample period. This measure provides state-specific federal tax shocks, with which we estimate the benchmark specification (in lieu of the aggregated federal tax measure). The result on our interaction term of interest remains positive and significant (with a larger magnitude due to the interaction with the relatively small shares), indicating that the main result is robust to this specification.

Last, the analysis focused on the tax shocks RR categorized as exogenous. This specific focus had a central role in our identification strategy. As a final step, we test whether the patterns observed are specific to this focus. To do this, we examine the remaining federal tax shocks that RR categorized as endogenous. These include tax shocks that encompass 10 tax changes within our sample period. Hence, we follow the benchmark case, as per Regression 4 of Table 5, examining the GDP normalized changes in federal tax revenues, under these endogenous tax policies, as computed by RR. Results appear in Regression 13. The main result remains to hold in sign and significance. Interestingly, the magnitude is approximately half that of the one derived under the general exogenous measure (Regression 1 of Table 5), indicating that the time-horizon of the tax change may be important to the size of the effect but not necessarily to its sign.

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Table 1-A: Descriptive statistics and correlations of the key variables

A. Descriptive Statistics

	Mean	Std. Dev.	Min.	Max.		Mean	Std. Dev.	Min.	Max.
Federal tax shocks	-6.333	38.644	-148.370	75.667	Average tax rates	0.048	0.011	0.009	0.104
Federal tax shocks: corporate related	-5.310	27.165	-126.400	68.112	Top corporate tax rates	5.85	2.98	0	12.25
Federal tax shocks: non-corporate related	-1.022	17.429	-40.81	36.047	Top income tax rates	5.61	3.92	0	19.8
GSP per capita	31619.69	11151.97	11351.48	110865.7	Deductions dummy	0.26	0.63	0	2
GSP per capita, other states	32454.53	8875.79	17970.17	48353.43	Transfers	584.75	539.83	27.20	4061.26
Fiscal advantage	0.03	0.09	0	0.77	Number of firms (total)	95373.78	101374.1	6990	657744
Mining share	0.03	0.07	0	0.50	Inter-state migration	-433.47	54983.93	-293320	266709
Price measure	1.42	2.79	0.007	30.11	Corporate taxes per capita	116.27	179.35	0	4686.82
Capital stock per capita	26.85	8.65	9.25	68.29	Non-corporate taxes per capita	1412.62	625.31	212.79	5003.60
Severance tax per capita	88.35	447.68	0	10286.62	Governor's Party Affiliation	0.49	0.5	0	1

All variables are at the state level, unless noted specifically to be at the federal level. 'Federal tax shocks': the narrative-based exogenous federal tax shocks, in $Billions; '(non-) corporate-related' refers to the (non-) corporate related shocks. 'GSP per capita': the log of real Gross State Product divided by state population. 'GSP per capita other states': the log of the average real GSP per capita over all states with the exclusion of the state inspected. 'Fiscal advantage': the share of severance tax revenues in total tax revenues. 'Mining share': the GSP share of the mining sector. 'Price measure': the international real price of oil at time t multiplied by the 'Mining share' in 1963. 'Capital stocks per capita': state-level capital stock, divided by state population, in constant prices. 'Average tax rates': non-severance tax revenues normalized by GSP. 'Top tax rates': the top state tax corporate or income tax rates. 'Deductions': dummy variable for whether the state deducts federal income and/or corporate taxes; takes value of 0 (no deductions), 1 (either corporate or income deductions) or 2 (deductions for both cases). 'Transfers': Real per capita transfers from central government. 'Number of firms': number of firms within the state. 'Inter-state migration': number of migrations coming from other states. 'Non-corporate/Corporate taxes': state non-corporate/corporate tax revenues per capita in real terms, respectively. 'Severance tax per capita': severance tax income divided by state population. 'Governor's party affiliation': an indicator for whether the Governor is affiliated with the Democratic or Republican parties. For further information on variables see data Appendix.

Table 1-B: Descriptive statistics and correlations of the key variables

B. Correlations

	Federal tax shocks	Federal tax shocks: corporate related	Federal tax shocks: non-corporate related	GSP per capita	GSP per capita, other states	Fiscal advantage	Mining share	Price measure	Capital stock per capita
Federal tax shocks	1								
Federal tax shocks: corporate related	0.7568	1							
Federal tax shocks: non-corporate related	0.1059	-0.0275	1						
GSP per capita	0.2229	0.1515	0.2518	1					
GSP per capita, other states	0.2784	0.2287	-0.0034	-0.3884	1				
Fiscal advantage	0.0179	-0.0243	0.5123	0.088	0.0021	1			
Mining share	-0.0063	-0.0472	0.5129	-0.0436	0.0596	0.8454	1		
Price measure	0.0288	-0.0522	0.4268	-0.2321	0.0663	0.5196	0.8437	1	
Capital stock per capita	0.2156	0.1347	0.2113	0.6966	-0.3166	0.44	0.4622	0.2507	1
Average tax rates	0.1372	0.1165	-0.2372	-0.404	-0.0363	-0.47	-0.3141	-0.0528	-0.4719
Top corporate tax rates	0.1328	0.0689	0.003	0.0123	-0.0777	-0.0011	-0.1654	-0.2105	-0.1702
Top income tax rates	0.0345	0.006	-0.0681	-0.2497	-0.09	-0.213	-0.2583	-0.088	-0.3479
Deduction dummy	-0.0019	-0.0018	0.0714	-0.2081	0.1136	0.0368	0.0719	0.1251	-0.1493
Transfers	0.1233	0.1229	-0.0377	-0.059	0.0648	0.676	0.6013	0.354	0.2225
Number of firms (total)	0.0127	0.0127	-0.0907	0.2261	-0.3261	-0.2353	-0.1999	-0.1709	0.2452
Inter-state migration	-0.002	-0.0019	n/a	0.1722	-0.4073	0.0111	0.0006	-0.0091	0.2081
Corporate taxes per capita	0.149	0.1475	0.3698	0.3655	-0.2365	0.466	0.1515	-0.1749	0.2563
Non-corporate tax per capita	0.1673	0.1657	-0.0088	0.2932	-0.3937	-0.4242	-0.415	-0.2869	0.0282

	Average tax rates	Top corporate tax rates	Top income tax rates	Deduction dummy	Transfers	Number of firms (total)	Inter-state migration	Corporate taxes per capita	Non-corporate tax per capita
Average tax rates	1								
Top corporate tax rates	0.1874	1							
Top income tax rates	0.5471	0.5926	1						
Deduction dummy	-0.0588	0.2681	0.2419	1					
Transfers	-0.1856	0.1165	0.0233	0.0835	1				
Number of firms (total)	-0.0453	-0.0047	-0.0617	-0.1128	-0.1921	1			
Inter-state migration	0.1201	0.2172	0.2966	0.0487	0.2148	0.2685	1		
Corporate taxes per capita	-0.3902	0.3687	-0.1229	-0.1192	0.3376	0.0001	0.1883	1	
Non-corporate tax per capita	0.6679	0.2543	0.4091	-0.1727	-0.0734	0.1722	0.3463	0.3314	1

See notes in Table 1-A for description of variables. Correlation of Inter-state migration and non-corporate-related federal tax shocks is not provided given that that for years the former is available, the latter has no positive values.

Table 2: State fiscal advantage, tax rates, and capital stock

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Tax rates			Capital stock			
Dependent variable:	Average tax rates	Average tax rates	Change in average tax rates	Capital stock	Capital stock	Average tax rates (1st stage)	Capital stock, 2SLS (2nd stage)
Fiscal advantage	-0.049***	-0.046***		12.39***	8.49**		
	(0.009)	(0.01)		(3.02)	(3.88)		
Change in fiscal advantage			-0.04***				
			(0.008)				
GSP per capita		-0.01	-0.0002		17.49***	-0.02***	3.55
		(0.009)	(0.0005)		(2.15)	(0.001)	(3.99)
Average tax rates							-533.07***
							(136.52)
Reserves of oil and gas						-0.03***	
						(0.005)	
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.47	0.49	0.17	0.87	0.91	0.78	0.52
Observations	2250	2250	2200	2250	2250	2160	2160

Standard errors are robust, clustered by state, and appear in parentheses for independent variables. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance. Sample includes the 50 U.S. states (48 contiguous U.S. states in Regressions 6-7) over the period 1963-2007. All regressions include an intercept. 'Capital stock' is real capital stock per capita. 'Fiscal advantage' is the share of severance tax revenues in total tax revenues. 'GSP per capita' is the log of real Gross State Product per capita. 'Average tax rates' are non-severance tax revenues normalized by GSP. 'Reserves of oil and gas' is the income share of oil and gas reserves obtained from James (2015). In Regression 6 the F-Statistic is 49. For further information on variables see data Appendix.

Table 3: Federal tax shocks and state tax rates

	Non-severance-based average tax rates						Statutory tax rates				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Dependent variable: average or statutory tax rates	Year fixed effects excluded	Year fixed effects included	Dynamic setting	State division, total tax rates	State division, corporate-related	State division, non-corporate-related	Individual income tax rates	Top income tax rates	Top corporate tax rates	Sales-apportioned corporate tax rates	Capital gains tax rates
Federal tax shocks, in t-1	0.04***										
	(0.009)										
FA * Federal tax shocks, in t-1	-0.35***	-0.35***	-0.07**								
	(0.12)	(0.13)	(0.035)								
FA * Corporate-related tax shocks, in t-1							0.005	-1.32	-1.25***	-0.57**	-0.86***
							(0.28)	(1.39)	(0.47)	(0.28)	(0.33)
FA * Non-corporate-related tax shocks, in t-1							0.86	-0.33	0.51	0.52	0.31
							(0.64)	(1.6)	(0.54)	(0.51)	(0.19)
NRR * Federal tax shocks, in t-1				0.0004							
				(0.02)							
NRR * Corporate-related tax shocks, in t-1					0.07						
					(0.08)						
NRR * Non-corporate-related tax shocks, in t-1						0.09					
						(0.09)					
NRP * Federal tax shocks, in t-1				0.032***							
				(0.009)							
NRP * Corporate-related tax shocks, in t-1					0.126***						
					(0.03)						
NRP * Non-corporate-related tax shocks, in t-1						-0.35					
						(0.25)					
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
Time trend and commodity prices (t-1)	Yes	No	No	Yes	Yes	Yes	No	No	No	No	No
R-squared	0.81	0.81	0.94	0.79	0.79	0.79	0.93	0.83	0.85	0.94	0.31
Observations	2250	2250	2250	2250	2250	2250	1450	1883	1903	1500	600

Standard errors are robust, clustered by state and year, and appear in parentheses for independent variables. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance. Sample coverage in terms of U.S. states and years changes across regressions, depending on data availability; see Data Appendix for further details. Dependent variable is average tax rates (Regressions 1-6) or statutory tax rates (Regressions 7-11). 'Average tax rates' are non-severance tax revenues normalized by GSP. 'FA' is the share of severance tax revenues in total tax revenues. 'NRR' is a dummy that captures the 8 most fiscally advantaged states, including AK, LA, MT, NM, ND, OK, TX, and WY; 'NRP' is a dummy that captures the remaining states. 'Federal/Corporate-related/Non-corporate-related tax shocks' are the narrative-based exogenous federal tax shocks, normalized by GDP; 'Federal' refers to the total shock; '(Non-)Corporate-related' refers to the (non-)corporate related shocks. 'Commodity prices' include the international average prices of oil, natural gas, and coal, in t-1. Regressions also include: 'GSP per capita': the log of real Gross State Product per capita; 'Transfers': Real per capita transfers from central government; 'Deductions': dummy variable for whether the state deducts federal income and/or corporate taxes; 'GSP per capita other states': the log of the average real GSP per capita over all states with the exclusion of the state inspected. Regression 3 includes also the lagged dependent variable. All independent variables are in t-1. All regressions include an intercept and the separate components of all interactions. For further information on variables see data Appendix.

Table 4: Federal tax shocks and inter-state capital movement

Dependent variable: Change in capital stock per capita, Δ(t-1,t)	(1)	(2)	(3)	(4)	(5)	Additional tests (6) Dependent variable in levels	(7) State capital as share of national capital	(8) Treatment in changes
Corporate-related tax shocks (t-1)	-0.45***							
	(0.12)							
FA * Corporate-related tax shocks, in t-1	4.41***	4.28***		4.2***		157.34**	0.05**	
	(1.71)	(1.56)		(1.5)		(72.22)	(0.02)	
FA * Non-corporate-related tax shocks, in t-1			1.32	1.14				
			(1.77)	(1.67)				
NRR * Corporate-related tax shocks, in t-1					0.68**			
					(0.33)			
NRP * Corporate-related tax shocks, in t-1					-0.44***			
					(0.12)			
FA * Change in corporate-related tax shocks, in t-1								2.67**
								(1.08)
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Time trend and commodity prices	Yes	No	No	No	Yes	No	No	No
R-squared	0.09	0.29	0.28	0.29	0.09	0.95	0.97	0.29
Observations	2200	2200	2200	2200	2200	2200	2200	2200

Standard errors are robust, clustered by state and year, and appear in parentheses for independent variables. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance. Sample includes the 50 U.S. states over 1963-2007. Dependent variable is the change in real capital stock per capita (in Regression 6 it is in levels, and in Regression 7 it is the share of state capital stock in the national capital stock). 'FA' is the share of severance tax revenues in total tax revenues. 'NRR' is a dummy that captures the 8 most fiscally advantaged states, including AK, LA, MT, NM, ND, OK, TX, and WY; 'NRP' is a dummy that captures the remaining states. 'Corporate-related/Non-corporate-related tax shocks' are the narrative-based exogenous federal tax shocks, normalized by GDP; '(Non-)Corporate-related' refers to the (non-)corporate related shocks. 'Commodity prices' include the international average prices of oil, natural gas, and coal, in t-1. Regressions also include: 'GSP per capita': the log of real Gross State Product per capita; 'Transfers': Real per capita transfers from central government; 'Deductions': dummy variable for whether the state deducts federal income and/or corporate taxes; 'GSP per capita other states': the log of the average real GSP per capita over all states with the exclusion of the state inspected. All independent variables are in t-1. All regressions include an intercept, lagged dependent variable (in levels), and the separate components of all interactions. For further information on variables see data Appendix.

Table 5: Federal tax shocks and state output

Dependent variable: Change in real GSP per capita, Δ(t-1,t)	(1)	(2)	(3)	(4)	(5)	(6)
Federal tax shocks, in t-1	-0.07***					
	(0.005)					
Corporate-related tax shocks, in t-1			-0.15***			
			(0.02)			
Non-corporate-related tax shocks, in t-1		-0.38				
		(0.25)				
FA * Federal tax shocks, in t-1	0.23**					
	(0.1)					
FA * Corporate-related tax shocks, in t-1			0.99***	0.89***	0.89***	
			(0.33)	(0.32)	(0.32)	
FA * Non-corporate-related tax shocks, in t-1		0.08			-0.43	
		(0.73)			(0.76)	
NRR * Corporate-related tax shocks, in t-1						0.13***
						(0.05)
NRP * Corporate-related tax shocks, in t-1						-0.1***
						(0.02)
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	Yes	Yes	No
Time trend and commodity prices (t-1)	Yes	Yes	Yes	No	No	Yes
R-squared	0.19	0.16	0.17	0.35	0.35	0.17
Observations	2200	2200	2200	2200	2200	2200

Standard errors are robust, clustered by state and year, and appear in parentheses for independent variables. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance. Sample includes the 50 U.S. states over 1963-2007. Dependent variable is the change in real GSP per capita. 'FA' is the share of severance tax revenues in total tax revenues. 'NRR' is a dummy that captures the 8 most fiscally advantaged states, including AK, LA, MT, NM, ND, OK, TX, and WY; 'NRP' is a dummy that captures the remaining states. 'Federal/Corporate-related/Non-corporate-related tax shocks' are the narrative-based exogenous federal tax shocks, normalized by GDP; '(Non-)Corporate-related' refers to the (non-)corporate related shocks; 'Federal' refers to the total shock. 'Commodity prices' include the international average prices of oil, natural gas, and coal, in t-1. Regressions also include: 'GSP per capita': the log of real Gross State Product per capita; 'Transfers': Real per capita transfers from central government; 'Deductions': dummy variable for whether the state deducts federal income and/or corporate taxes; 'GSP per capita other states': the log of the average real GSP per capita over all states with the exclusion of the state inspected 'Pop_g': population growth. All independent variables are in t-1. All regressions include an intercept, lagged dependent variable (in levels), and the separate components of all interactions. For further information on variables see data Appendix.

Table A1: Spending categories at different levels of government

Categories			% in total spending			Correlations	
Federal	State / State-and-Local	Number	Federal	State	State and local	Federal and State governments	Federal and State-and-Local Governments
Contracts	Capital outlays	(1)	14.8	9.4	11.2	0.13	0.066
Grants	[Current-operations - (4)]	(2)	18.3	51.5	47.9	0.685	0.628
Nonretirement	Unemployment and disaster reimbursement	(3)	26.7	8.9	4.5	0.535	0.53
Retirement	Pensions	(4)	29.9	12.1	6.9	-0.124	-0.184
Salaries and wages		(5)	10.2	18.2	29.5	0.467	0.22
Total spending			100	100	100	0.518	0.36
Intergovernmental revenue		(6)	-	38.4	19.5	-	-
Intergovernmental expenditure		(7)	-	37.2	0.2	-	-
[(1) + (2) + (3) + (5)]		(8)	70.1	87.9	93.1	0.552	0.42
[(2) + (5)]		(9)	28.5	69.6	77.4	0.752	0.566
[(8) - (6) + (7)]		(10)	70.1	86.7	73.8	0.478	0.354

Spending is calculated in per capita terms, deflated using the CPI with 2005 as the base year. For further details on the variables used see the Appendix.

Table A2: Exogenous Federal tax Changes

Title	Capital-related (CR) / Non-capital-related (NCR)
Social Security Amendments of 1961	NCR
Changes in Depreciation Guidelines and Revenue Act of 1962	CR
Revenue Act of 1964	CR
Excise Tax Reduction Act of 1965	NCR
Tax Adjustment Act of 1966	NCR
Public Law 90-26 (Restoration of the Investment Tax Credit)	CR
Social Security Amendments of 1967	NCR
Tax Reform Act of 1969	CR
Reform of Depreciation Rules	CR
Revenue Act of 1971	CR
1972 Changes to Social Security	NCR
Tax Reform Act of 1976	NCR
Tax Reduction and Simplification Act of 1977	NCR
Social Security Amendments of 1977	NCR
Revenue Act of 1978	CR
Crude Oil Windfall Profit Tax Act of 1980	NCR
Economic Recovery Tax Act of 1981	CR
Tax Equity and Fiscal Responsibility Act of 1982	NCR
Social Security Amendments of 1983	NCR
Deficit Reduction Act of 1984	NCR
Tax Reform Act of 1986	CR
Omnibus Budget Reconciliation Act of 1987	NCR
Omnibus Budget Reconciliation Act of 1990	NCR
Omnibus Budget Reconciliation Act of 1993	NCR
Balanced Budget Act of 1997	NCR
Economic Growth and Tax Relief Reconciliation Act of 2001	NCR
Jobs and Growth Tax Relief Reconciliation Act of 2003	CR

The table lists the 27 major federal tax changes, 1945-2003, from Romer and Romer (2010), categorized by the latter to be plausibly exogenous. 'Capital-related/Non-capital-related' refers to whether the federal tax change is related to capital or not. In case the tax change directly affects capital, investment, and/or corporations it is classified as capital-related; otherwise, it is categorized as non-capital-related. For further information on these federal tax changes see Romer and Romer (2010).

Table A3: Federal tax shocks and state tax revenues

Dependent variable: Change in real tax income per capita, Δ(t-1,t)	CORPORATE TAXES					NON-CORPORATE TAXES
	(1)	(2)	(3)	(4)	(5)	(6)
Corporate-related tax shocks, in t-1	-0.03	0.02				
	(0.02)	(0.02				
FA * Corporate-related tax shocks, in t-1	0.49***	0.26**	0.47***		0.46**	0.002
	(0.15)	(0.12)	(0.23)		(0.23)	(0.05)
FA * Non-corporate-related tax shocks, in t-1				0.09	0.07	
				(0.31)	(0.29)	
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	Yes	Yes	Yes	Yes
Time trend and commodity prices (t-1)	Yes	Yes	No	No	No	No
Tax base rules	No	Yes	No	No	No	No
R-squared	0.07	0.11	0.12	0.14	0.14	0.15
Observations	2010	1288	2010	2010	2010	2010

Standard errors are robust, clustered by state and year, and appear in parentheses for independent variables. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance. Sample includes the 46 U.S. states with positive corporate tax rates. 'Non-corporate/Corporate taxes': state non-corporate/corporate tax revenues per capita in real terms, respectively; 'non-corporate' excludes severance tax revenues. The former is the dependent variable in Regression 6, whereas the latter is the one in the remaining cases. 'FA' is the share of severance tax revenues in total tax revenues. 'Corporate-related/Non-corporate-related tax shocks' are the narrative-based exogenous federal tax shocks, normalized by GDP; '(Non-)Corporate-related' refers to the (non-)corporate related shocks. 'Tax base rules' include indicators that capture the following rules: sales apportionment weight, franchise tax, federal income tax deductibility, and federal income as state tax base, obtained from Serrato and Zidar (2018). 'Commodity prices' include the international average prices of oil, natural gas, and coal, in t-1. Regressions also include: 'GSP per capita': the log of real Gross State Product per capita; 'Transfers': Real per capita transfers from central government; 'Deductions': dummy variable for whether the state deducts federal income and/or corporate taxes; 'GSP per capita other states': the log of the average real GSP per capita over all states with the exclusion of the state inspected. All independent variables are in t-1. All regressions include an intercept, lagged dependent variable (in levels), and the separate components of all interactions. For further information on variables see data Appendix.

Table A4: Federal tax shocks and inter-state firm and labor movement

	Firm Analysis					Labor Analysis		Two-stage procedure	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable:	Change in number of firms per capita, Δ(t-1,t): 1 to 4 employees	Change in number of firms per capita, Δ(t-1,t): 5+ employees	Change in number of firms per capita, Δ(t-1,t): 5+ employees	Change in number of firms per capita, Δ(t-1,t): 5+ employees	Change in number of firms per capita, Δ(t-1,t): 5+ employees	Change in inter-state immigration per capita, Δ(t-1,t)	Change in state population, Δ(t-1,t)	Change in number of firms per capita, Δ(t-1,t): 5+ employees	Change in inter-state immigration per capita, Δ(t-1,t)
Corporate-related tax shocks, in t-1		-0.03							
		(0.09)							
FA * Corporate-related tax shocks, in t-1	1.54	2.59***	1.7**		1.61**	202.71	-0.43		
	(1.32)	(0.89)	(0.78)		(0.68)	(273.89)	(0.41)		
FA * Non-corporate-related tax shocks, in t-1				-4.23	-3.12				
				(6.95)	(6.89)				
Change in predicted tax rates, in t-1								-51.11***	-920.39
								(12.38)	(772.69)
Change in predicted tax rates * Corporate-related tax shocks, in t-1								-56.78***	-1361.71
								(13.51)	(1211.82)
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time trend and commodity prices (t-1)	No	Yes	No	No	No	No	No	No	No
R-squared	0.36	0.33	0.65	0.65	0.65	0.04	0.33	0.59	0.29
Observations	1485	1485	1485	1485	1485	336	2160	1485	336

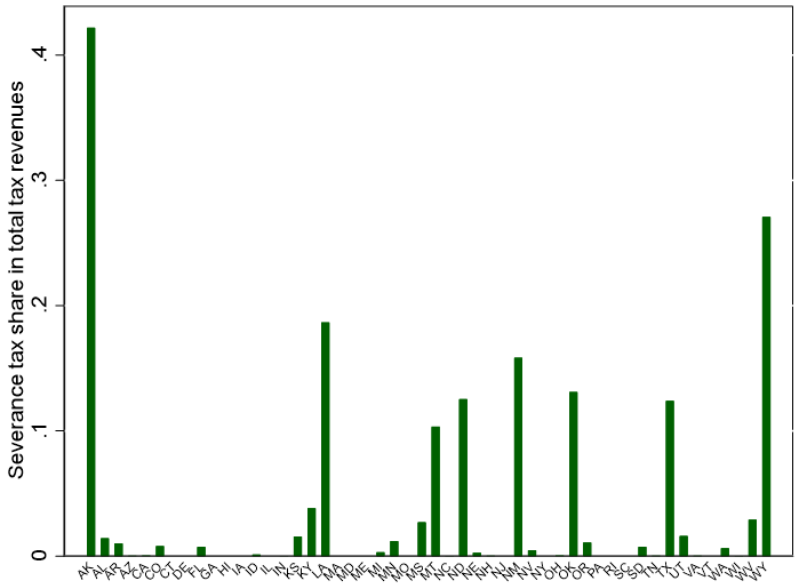
Standard errors are robust, clustered by state and year, and appear in parentheses for independent variables. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance. Sample includes the 48 contiguous U.S. states over the period 1977-2007 (Regressions 1-5, 8), 2001-2007 (Regressions 6, 9), or 1963-2007 (Regression 7). 'FA' is the share of severance tax revenues in total tax revenues. 'Corporate-related/Non-corporate-related tax shocks' are the narrative-based exogenous federal tax shocks, normalized by GDP; '(Non-)Corporate-related' refers to the (non-)corporate related shocks. 'Commodity prices' include the international average prices of oil, natural gas, and coal, in t-1. 'Predicted tax rates' are the predicted values from Regression 1 of Table 2. Regressions also include: 'GSP per capita': the log of real Gross State Product per capita; 'Transfers': Real per capita transfers from central government; 'Deductions': dummy variable for whether the state deducts federal income and/or corporate taxes; 'GSP per capita other states': the log of the average real GSP per capita over all states with the exclusion of the state inspected. All independent variables are in t-1. All regressions include an intercept, lagged dependent variable (in levels), and the separate components of all interactions. For further information on variables see data Appendix.

Table A5: Federal tax shocks and state output, robustness tests

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	Level Regression	Arellano-Bond	Post-2000 excluded	Mining share	Price-based measure	Fiscally advantaged states excluded	Correlation across resource-rich states	Severance Tax Per capita	Political Channel	State-specific time trends	Anticipated federal tax shocks	Population-weighted tax shocks	Endogenous tax shocks
Dependent variable:	GSP per capita	GSP per capita	Change in real GSP per capita, Δ(t-1,t)	Change in real GSP per capita, Δ(t-1,t)	Change in real GSP per capita, Δ(t-1,t)	Change in real GSP per capita, Δ(t-1,t)	Change in real GSP per capita, Δ(t-1,t)	Change in real GSP per capita, Δ(t-1,t)	Change in real GSP per capita, Δ(t-1,t)	Change in real GSP per capita, Δ(t-1,t)	Change in real GSP per capita, Δ(t-1,t)	Change in real GSP per capita, Δ(t-1,t)	Change in real GSP per capita, Δ(t-1,t)
FA * Corporate-related tax shocks, in t-1	426390**	535813.9***	1.07***			1.31**	0.89**	0.001***	0.49**	0.79***	0.61***		
	(206150.8)	(190490.24)	(0.39)			(0.61)	(0.39)	(0.00)	(0.23)	(0.28)	(0.28)		
Mining share * Corporate-related tax shocks, in t-1				1.29***									
				(0.41)									
Price measure * Corporate-related tax shocks, in t-1					0.02***								
					(0.006)								
FA * Anticipated federal tax shocks, in t-1											0.004**		
											(0.002)		
FA * Population-weighted corporate-related tax shocks, in t-1												19.97**	
												(8.53)	
FA * Federal tax shocks (endogenous), in t-1													0.1***
													(0.04)
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared, within	0.98	n/a	0.38	0.37	0.34	0.54	0.35	0.35	0.38	0.39	0.38	0.37	0.36
Observations	2200	2200	1800	2200	2200	1848	2200	2200	1271	2200	2150	2200	2200

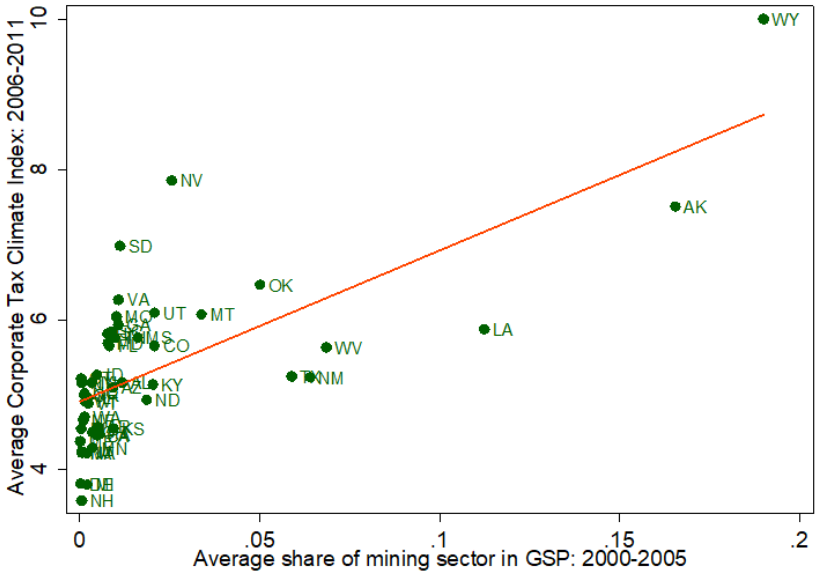
Standard errors are robust, clustered by state and year, and appear in parentheses for independent variables. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance. Unless specified otherwise, sample includes the 50 U.S. states and covers the period of 1963-2007. 'Federal tax shocks' are the narrative-based exogenous federal tax shocks, normalized by GDP; 'corporate-related' refers to the corporate related shocks. 'FA' is the share of severance tax revenues in total tax revenues. Regressions also include the following controls in t-1: 'GSP per capita': the log of real Gross State Product per capita; 'Transfers': Real per capita transfers from central government; 'Deductions': dummy variable for whether the state deducts federal income and/or corporate taxes; 'GSP per capita other states': the log of the average real GSP per capita over all states with the exclusion of the state inspected. 'Pop_g': population growth. Some regressions also include: 'Severance tax per capita': severance tax income divided by state population. 'Governor's party affiliation': an indicator for whether the Governor is affiliated with the Democratic or Republican parties. All regressions include lagged dependent variable in levels, and an intercept. Regression 1 has its dependent variable in levels. Regression 2 uses the Arellano-Bond (1991) estimation procedure with dependent variable in levels. Regression 3 excludes post-2000 years. Regression 4 (5) uses 'Mining share' ('Price measure') in lieu of 'FA'; 'Mining share' ('Price measure') defined as the GSP share of the mining sector (the international real price of oil at time t multiplied by the 'Mining share' in 1963). Regression 6 excludes the 8 most fiscally advantaged states, namely AK, LA, MT, NM, ND, OK, TX. In Regression 7 standard errors are clustered across states and years such that the 8 most fiscally advantaged states are considered one group. Regression 8 uses severance tax per capita as the measure of fiscal advantage. Regression 9 adds the governor's party affiliation as a control; sample period is 1983-2007. Regression 10 adds state-specific time trends. Regression 11 adds anticipated federal tax shocks (derived from Mertens and Ravn (2012)) and its interaction with FA as controls, restricting the sample period to 1963-2006. Regression 12 uses population-weighted federal tax shocks; the latter is an interaction between states' population share in 1960 and the corporate-related federal tax shocks. Regression 13 examines tax shocks classified as endogenous. For further information on variables see data Appendix.

Figure 1: *Fiscal Advantage* levels across U.S. states



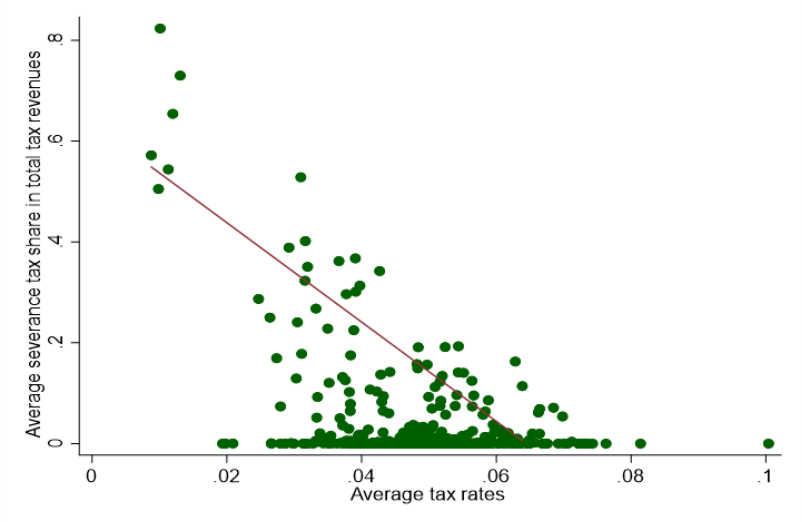
The figure presents the share of severance tax revenues in total tax revenues, averaged over the sample period (1963-2007), across U.S. states (Source: U.S. Census Bureau).

Figure 2: Natural resources and corporate tax environment, U.S. states



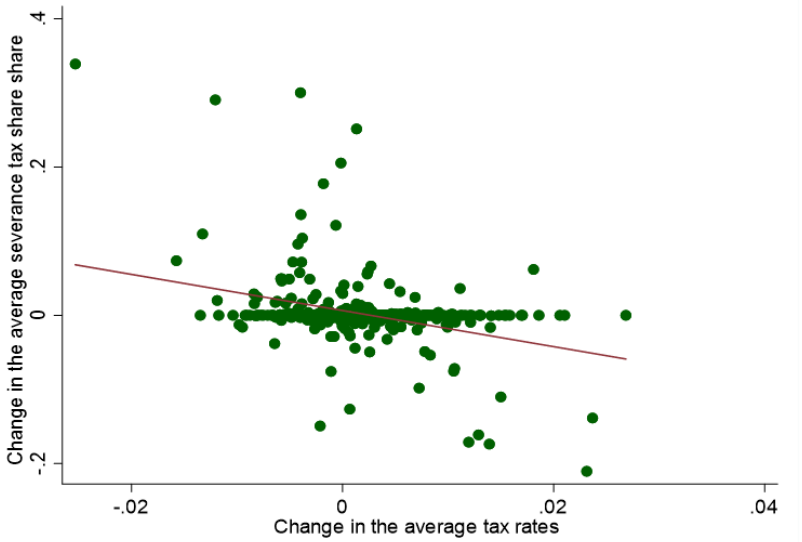
The Figure presents the correlation between the average share of mining sector in GSP in 2000-2005, and the average *Corporate Tax Climate* Index in 2006-2011; ρ=0.71 (Source: U.S. Tax Foundation).

Figure 3: Fiscal advantage and average tax rates across U.S. states, in levels, 5-year intervals



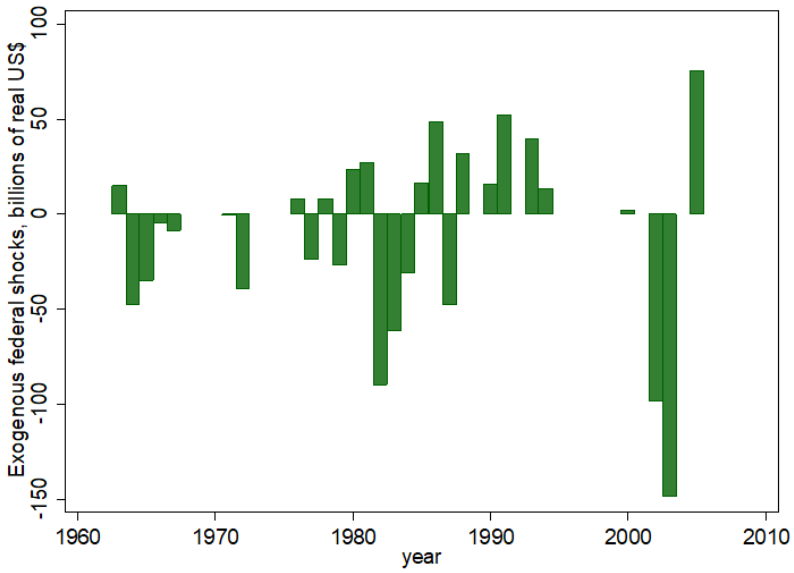
The figure presents the correlation between the average share of severance tax revenues in total tax revenues and the non-severance average tax rates in 5-year intervals (1963-2007), across U.S. states; ρ=-0.45 (Source: U.S. Census Bureau).

Figure 4: Fiscal advantage and average tax rates across U.S. states, in changes, 5-year intervals



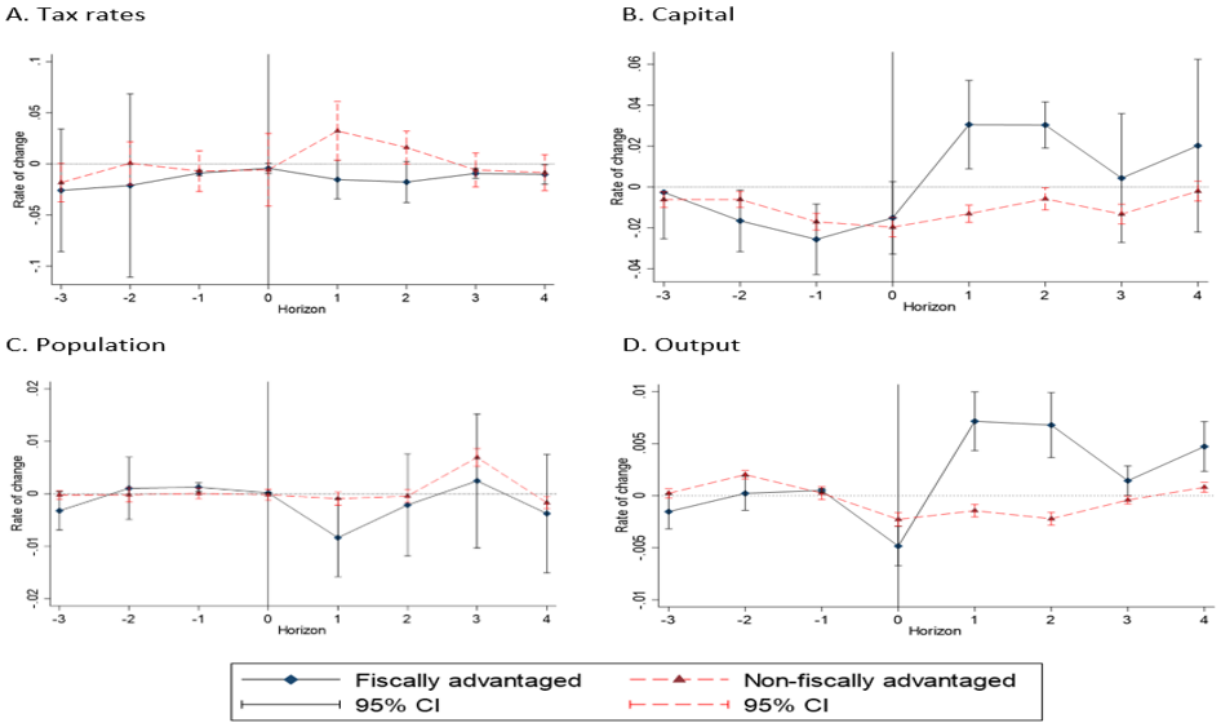
The figure presents the correlation between the change in the average share of severance tax revenues in total tax revenues and the change in the non-severance average tax rates in 5-year intervals (1963-2007), across U.S. states; ρ=-0.35 (Source: U.S. Census Bureau).

Figure 5: Exogenous federal tax shocks, 1963-2007



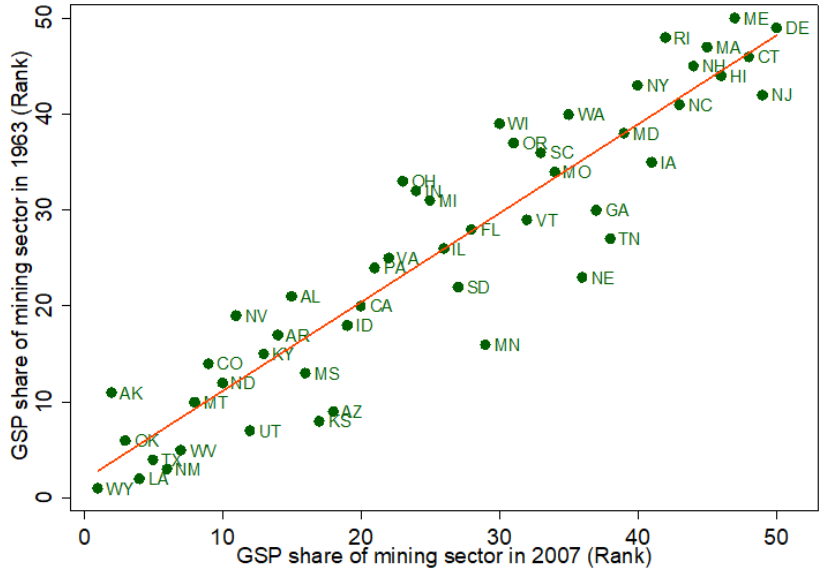
The figure presents the federal tax shocks classified as exogenous (Romer and Romer (2010)), in billions of real U.S. Dollars.

Figure 6: Event analysis -- impacts on changes in state tax rates, capital, population, and output, across state groups



The figure presents the impacts on changes in state average tax rates, real capital stock per capita, population, and real output per capita in the three years prior and four years past a major corporate-related federal tax change (defined as being at least half a standard deviation higher than the mean) across fiscally advantaged (NRR) and non-fiscally advantaged (NRP) state groups, over the period 1963-2007. The states included in the former group include: Alaska, Louisiana, Montana, New Mexico, North Dakota, Oklahoma, Texas, and Wyoming.

Figure 7: Spearman correlation, GSP share of mining sector 1963 vs. 2007



The figure presents the correlation between the relative ranking of the GSP share of the mining sector in 1963 and 2007; ρ=0.93 (Source: U.S. Bureau of Economic Analysis).

Figure A1: Residuals of expenditures, federal VS. state, U.S. governments (2005-2012)

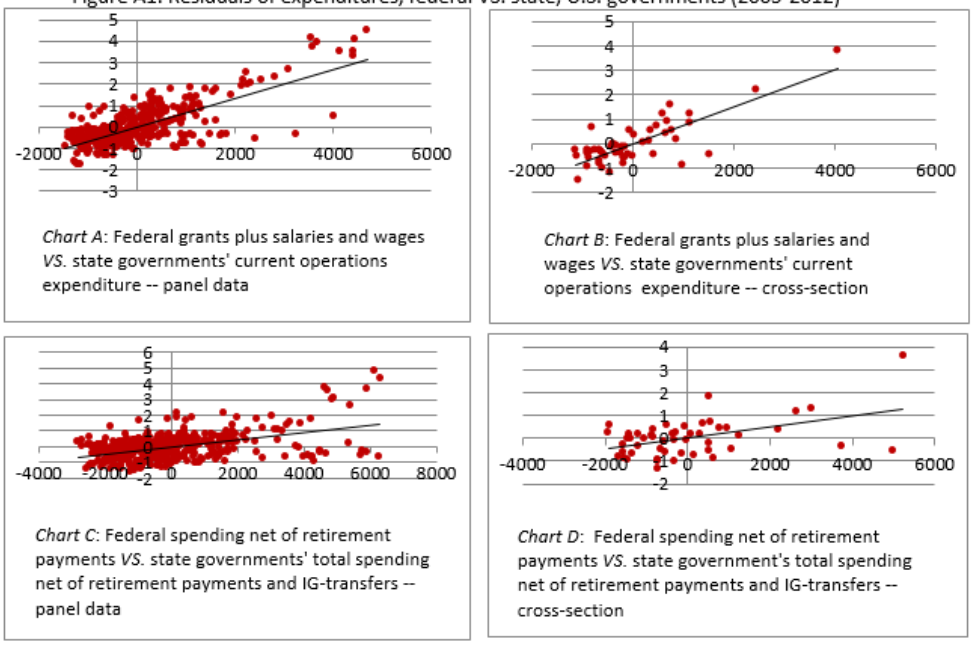


Chart A: Federal grants plus salaries and wages *VS.* state governments' current operations expenditure -- panel data

Chart B: Federal grants plus salaries and wages *VS.* state governments' current operations expenditure -- cross-section

Chart C: Federal spending net of retirement payments *VS.* state governments' total spending net of retirement payments and IG-transfers -- panel data

Chart D: Federal spending net of retirement payments *VS.* state government's total spending net of retirement payments and IG-transfers -- cross-section

The Figure presents the correlation between the residuals of U.S. governments' (federal VS. states) real per capita expenditures regressed on real per capita GSP in the states' cases, or real per capita U.S. GDP in the case of the federal government. Expenditures for the federal government are defined as total spending minus retirement benefits and intergovernmental transfers; expenditures for the state governments are defined as current-operations. For further details see the Appendix (Source: U.S. Census Bureau).

Figure A2: Residuals of expenditures, federal VS. state-and-local, U.S. governments (2005-2012)

Chart E: Federal grants plus salaries and wages *VS.* state and local governments' current operations expenditure -- panel data

Chart F: Federal grants plus salaries and wages *VS.* state and local governments' current operations expenditure -- cross-section

Chart G: Federal spending net of retirement payments *VS.* state and local governments' total spending net of retirement payments and IG-transfers -- panel data

Chart H: Federal spending net of retirement payments *VS.* state and local governments' total spending net of retirement payments and IG-transfers -- cross-section

The figure presents the correlation between the residuals of U.S. governments' (federal VS. state-and-local) real per capita expenditures regressed on real per capita GSP in the state-and-local cases, or real per capita U.S. GDP in the case of the federal government. Expenditures for the federal government are defined as total spending minus retirement benefits and intergovernmental transfers; expenditures for the state-and-local governments are defined as current-operations. For further details see the Appendix (Source: U.S. Census Bureau). (Source: U.S. Census Bureau).