Heterogeneous Vertical Tax Externalities, Capital Mobility, and the Fiscal Advantage of Natural Resources*

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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 levels of *fiscal advantage*, showing that tax increases can be expansionary – even without their reinvestment. States rich with natural resources have a fiscal advantage in the inter-state competition over production factors which allows them to respond better to changes 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 states with high fiscal advantage, through an increase in their tax base. Using the case of the U.S., and narrative-based measured federal tax shocks a-la Romer and Romer (2010), we provide empirical evidence for the various aspects of this mechanism. Specifically, our lower-bound 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 in the per capita tax base by approximately 1.6% in high fiscal advantage states at the end of it, on average.

JEL classifications: H77, H71, Q32

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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] This perspective, however, neglects an additional urging issue in federalism: fiscal equalization. One of the main challenges of a federal government is to ensure a reasonably homogenous level of public good provision across the nation; nonetheless, significant cross-state differences are observed even in those federations with major equalization payment schemes.[2] 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, through which we contribute to understanding vertical relations in fiscal federalism. Specifically, we show that some states respond better than others, leading to horizontal movements that can create expansionary effects –even without reinvestment of the taxes levied– and increase fiscal inequality across the nation, thus posing new challenges to federal tax coordination policies.

More generally, this paper presents a novel mechanism of heterogeneous vertical tax extenalities across levels of *fiscal advantage*. We define the latter to be the level of income that states receive from non-mobile sources; greater income from such sources, not being equally redistributed across the nation, gives these states more flexibility with taxing mobile tax bases, and hence provides them with 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. An example for the fiscal advantage borne by natural resources is the case of the Canadian province of Alberta; having the second largest 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. Recent studies find similar patterns in various additional federations.[3]

[1] See Besley and Rosen (1998), Dahlby and Wilson (2003), Devereux, Lockwood, and Redoano (2007), Esteller-More and Sole-Olle (2001), Fredriksson and Mamum (2008), Goodspeed (2000), Hayashi and Boadway (2001), Hoyt (2001), Keen (1998), and Raveh and Reingewertz (2015) - providing mixed results on states' fiscal reaction to federal tax shocks, focusing on the *average* state.

[2] Boadway (2006) discusses the case of Canada, a federation with a major redistributive scheme. Partial equalization is as well observed in various, developed and developing, federations (Martinez-Vazquez and Searle (2007)), and in the OECD (Blochliger and Charbit (2008)).

[3] James (2014) and Raveh (2013) provide evidence for the U.S.; Cai and Treisman (2005) do so for Russia, and Yao and Zhang (2008) for China.

Our main hypothesis is that fiscally advantageous states can respond better to federal tax shocks. To examine this conjecture, and its implications, we construct a model of heterogeneous vertical tax externalities. Motivated by the framework of Keen and Kotsogiannis (2002), we add heterogeneity in fiscal advantage levels to an otherwise standard model of vertical tax externalities and horizontal tax competition. The model captures the static 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 the level of fiscal advantage affects the reaction of states' capital tax rates to shocks in the federal one, and the patterns of cross-state capital reallocation that follows.

The starting point is that of a horizontal capital tax competition with varying levels of fiscal advantage. The natural resource rich states exploit the fiscal advantage borne by their resources to compete more aggressively in the inter-state competition over capital; much like in the motivating example of Alberta, their greater capital tax reductions allows them to attract capital from the other states, hence having larger per capita capital stocks in equilibrium. Considering the vertical implications of this, the model shows that following a federal tax increase the high fiscal advantage states respond with smaller relative capital tax increases, which then lead to further capital movement towards them. The intuition is simple. Having a common pool, an increase in federal tax rates contracts states' tax base; however, 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.

Importantly, the analysis indicates that from certain levels of fiscal advantage (and hence, equivalently, from some levels of capital inflows) a federal tax increase may actually *increase* the capital tax base, and in turn also increase output – irrespective of federal redistribution. This overturns two standard inter-related results in the literature: controlling for reinvestment of taxes levied, tax increases necessarily contract the taxed base, and in turn also contract output to some extent. Another implication of this is that some states may benefit from federal tax increases, regardless of federal transfers, on the account of the other states for which such increases are harmful, hence increasing fiscal inequality across the nation. These translate to having several empirical implications, which we address in the empirical part that follows.

We undertake an inter-state analysis of the U.S. economy, a case that is closely linked to our theoretical framework. Using an annual-based panel covering the period of 1963-2007, we put the implications of the model to the test, and provide evidence for some of its main features. The analysis is based on two key variables: fiscal advantage and federal tax shocks. Starting with the former, we measure fiscal advantage levels using the share of a state's severance tax income in

its total tax revenues.[4] Notably, there are vast inter-state differences in fiscal advantage levels. In Figure 1 we plot the distribution of average fiscal advantage levels across U.S. states, for our sample period (1963-2007). The 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 latter, we use data on narrative-based measured U.S. federal tax shocks from Romer and Romer (2010) (henceforth, RR), aggregated to an annual-level. RR used narrative sources such as presidential speeches and federal reports, among others, to classify the motivation of major federal tax changes, dividing them to endogenous and exogenous, and estimate their effect on federal tax revenue; our focus is on those shocks they classified as exogenous, through which we address related endogeneity concerns; this stands at the heart of our identification strategy. We elaborate on this in the empirical part.

We focus primarily on the interaction of the two to address a set of questions that follow the various stages of the model. In accordance with the starting point of the analysis, we first ask whether natural resource rich states present a more competitive fiscal environment, and whether this translates to them having larger per capita capital stocks. We provide supporting evidence, some based on previous work, for the applicability of this initial equilibrium. Thereafter, we turn to the main analysis to examine the, relatively short term, heterogeneous effects of a federal tax shock. Results support the various aspects of the mechanism. Specifically, we find that controlling for federal redistribution (and hence for the reinvestment of the taxes levied) 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, indicating that sufficient fiscal advantage levels can make non-redistributive federal tax increases beneficial for the state, are observed using different measures of tax rates, capital inflows, and fiscal advantage, as well as different estimation techniques, time periods, and specifications.

The model, however, emphasizes the capital side, considering capital tax competition and mobility. To substantiate this focus, we divide the analysis to capital and non-capital related factors, wherever possible, by making several disaggregations. First, we follow RR's documentation to divide the federal tax shock to corporate-related and non-corporate-related; in the (latter) former group we include all those tax changes that referred solely to (non-)corporations. Second, we look into corporate and non-corporate tax rates and revenues. Third, we distinguish between firm and labor movements. Results indicate that the various aspects of the mechanism are completely driven by the capital-related shocks and effects; it is the corporate-related federal shocks that affect capital

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

tax rates, revenues, and movement, with no observed effects on the labor side – consistent with the setting of the model. This distinction also enables us to interpret magnitudes; our lower-bound 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 in the per capita tax base by approximately 1.6% in high fiscal advantage states at the end of it, on average.

This paper contributes to three broad strands of literature. First is that 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 macreconomy, including output and composition of GDP, emphasizing their contracting nature and role in crowding out investment. Additional related studies examine similar links between federal 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), Suarez 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, both to the tax base as well as to output, even without reinvestment of tax revenues. 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.

Also related is the literature on fiscal equalization and disparities, and their challenges. As discussed in Qiao (1999), inter-state fiscal disparities is 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 the measures taken by federal governments to address these, most notably through equalization schemes, and the related challenges these present. We contribute to this literature by highlighting a new related aspect: federal tax policy. We show that federal tax shocks can exacerbate inter-state fiscal disparities and hence may pose an equalization-related challenge not considered previously.

Last, the paper also contributes to 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 (2015)), 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 levels of fiscal advantage,

through which we highlight the role of the horizontal channel when considering vertical shocks.

The paper is structured as follows. Section 2 presents 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 fiscally autonomous 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 takes 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.[5] Second, we follow the simplifying feature of having fixed populations. What is essentially required for the model results to hold is that labor is sufficiently less mobile than capital,[6] especially when moving towards natural resource rich areas; this is supported by evidence from Perez-Sebastian and Raveh (2015).[7] 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 e.g. Wilson and Wildasin (2004) for a survey). Last, the general focus is on capital rather than labor; we consider capital tax rates and mobility. This supports our focus on short term effects. We motivate this further in the following section, where we provide empirical evidence for this specific emphasis on capital.

In the model, there are state governments and a federal one. 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

[5] 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. Immigration flows are relatively low 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.

[6] This could be due, for instance, to the non-pecuniary benefit that individuals derive from living in their home, from a preference for a particular region for cultural or nationalistic reasons, or from having access to the larger supply of amenities in more densely populated areas (e.g. Mansoorian and Myers (1993)).

[7] Implicit in this is the assumption that capital is relatively highly mobile across regions within the same nation. Previous studies support this notion. In particular, Kalemli-Ozcan, Reshef, Sorensen, and Yosha (2010) show the strong fit of neoclassical models when considering a within-U.S. framework.

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.[8]

Motivated by the general framework of Keen and Kotsogiannis (2002) and Zodrow and Mieszkowski (1986) we assume that private profit-maximizing firms in state i are owned by state residents, 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 distributed among their owners in the same proportion. Technology (1) implies an interest rate equal to:

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

In equilibrium, the return to capital 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.[9] In particular, state i chooses t_i to maximize the representative consumer's utility taking the behavior of other governments as given. 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

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

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

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

[9] This is a simplifying feature. The government's objective, within a tax competition context, can be expressed in several forms. While other models consider a leviathan government (Brennan and Buchanan (1980)) or a semi self-interest one (Cai and Treisman (2005)), this distinction would not affect our setting so long as the fiscal advantage feature is maintained and there are no systematic cross-state differences in the objective followed.

In expression (6), rents obtained from firms are the profits left after paying for capital. In particular:

$$\pi_i = y_i - rk_i. \tag{7}$$

The value of the elasticity parameter σ lies within the interval $(-\infty, 1]$. When σ equals $-\infty$ and 1, state and federal public goods are perfect complements and perfect substitutes, respectively. As will be evident, the substitution feature and its degree are central to the analysis; we elaborate on this later in this section.

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. In an analogous manner, the federal government provides its public good in the same amount to all states as follows:

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

In effect, the parameter ϕ generates 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 straight forward 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:

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

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

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:

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

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 discuss the implications of this below, and substantiate this further 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. 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:

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

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

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

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

$$\frac{\partial t_i}{\partial \tau} \longrightarrow \frac{k}{k_i} \tag{15}$$

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 stock of capital 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. 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.

As noted, the above assumes having sufficient complementarity between the state and federal public good provision. This assumption follows the fundamental allocative principle in fiscal federalism of *fiscal equivalence* (e.g. Inman and Rubinfeld (1997), Olson (1969)), motivating the co-existence 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. An implication of this is having complementary public good provision between the two levels of governments. 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.

This perspective is as well supported by previous studies; an example is Hafer and Landa (2007) who regard the public goods of the two governments as being complements in the their framework. Importantly, this pattern is also observed in the data. Taking the case of the U.S., Figure 2 presents the co-movement in the annual rate of change in the GDP share of federal and states' governments spending over the period of 1960-2010; the correlation of the two stands at 0.63, providing some indication for the said complementarity. The correlation is even higher (equals to 0.98) if we instead focus on the levels of federal and states' spending, excluding pension and interest payments – that is, considering only the expenditures most closely related to the provision of public goods.

Finally, before turning to the empirical part we sum up the main points of the analysis. Having sufficient complementarity between the state and federal public goods, 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 dominate

the negative federal shock and increase output. The take away message is that a federal tax increase may in fact *increase* the per capita tax base, despite the direct contractionary hit, and potentially increase overall output in some states even without getting some of those levied taxes back in the form of federal transfers, through the national capital reallocation. In short, this simple mechanism has, therefore, emphasized 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, as we show throughout the analysis things are rooted in the capital side.

Our analysis focuses on the case of the U.S., which presents several merits for the purposes of the given exercise, especially with respect to our two main variables of interest in the analysis; namely, fiscal advantage and federal tax shocks. First, its federal structure together with the high state fiscal autonomy levels it provides and lack of a fully equalizing transfers payment scheme, closely follows 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 an analysis over a relatively long period, using an annual-based panel of 50 U.S. states covering the years 1963-2007, while exploiting plausibly exogenous narrative-based measured federal tax shocks, covering approximately 50 act changes over the said period; the latter forms the basis of our identification strategy, as we further discuss below.

That said, 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 investigates heterogeneous vertical tax externalities. Sub-section 3.3 looks into cross-state factor movements. Sub-section 3.4 examines whether the above translate to systematic differences in output effects. Finally, sub-section 3.5 presents some robustness tests. The Appendix provides detailed descriptions, and sources, of all variables; Table 1 presents descriptive statistics and a correlation matrix.

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 translates to 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 do resource abundant states present a more competitive fiscal environment and do they have greater capital stocks per capita?

Starting with the first, previous studies show 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; examples include James (2014) and Raveh (2013).[10] Using a panel for the period of 1958-2008, the former finds that tax rates are indeed lower, and public good provision is higher, in resource abundant U.S. states; the latter provides similar evidence under a cross-sectional framework, concluding further that approximately 60% of resource-induced capital inflows are due to the business environment. Our own estimates in the upcoming exercises are consistent with these patterns as well; however, given the said previous findings, they are not reported, to avoid repetition.

Nonetheless, to better illustrate the specific case of corporate tax rates, in Figure 3 we plot the average GSP share of the mining sector in 2000-2005 against the average *Corporate Tax Climate Index* in 2006-2011,[11] for the 50 U.S. states; as can be seen, resource rich states have a more favorable tax environment (ρ=0.71).

Moving to the second, we next undertake a descriptive exercise to examine cross-state differences in per capita capital stocks under a conditional-correlations framework. We, hence, estimate the following model, for state i at year t (1963-2007):

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

where k denotes real capital stock per capita, FA is fiscal advantage, y is real per capita GSP, and ζ and η are state and year fixed effects, respectively. As mentioned, we proxy fiscal advantage, in this exercise and the following ones, by the share of severance tax revenues in total state tax

[10] Additional studies provide similar within-country evidence for Russia (Cai and Treisman (2005)) and China (Yao and Zhang (2008)).

[11] 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. Unlike other possible measures, this index is an objective one that directly compares the competitiveness of the tax environment of the various states.

revenues. Severance taxes are incurred on the extraction of non-renewable natural resources, such as oil and natural gas. The latter 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 the federal government levies for redistribution. The income from these severance taxes, measured as a share from total tax income, thus provides a direct measure for states' fiscal advantage level. y controls for cross-state heterogeneity, which we assume (again, here and throughout the various exercises to follow) is largely captured by income differences, given the relatively homogenous inter-state environment.[12] Data on capital stocks is retrieved from Garofalo and Yamarik (2002),[13] with the remaining ones taken from the U.S. Census Bureau and Bureau of Economic Analysis. Our focus is on β, indicating the association between fiscal advantage levels and per capita capital stocks.

We estimate various specifications of the above model; results appear in Table 2. Specifically, we start with excluding both levels of fixed effects and the GSP measure, to make a better focus on the cross-sectional variation. Next, we separately add state fixed effects, a time trend, year fixed effects (in lieu of the time trend), and finally real per capita GSP. These estimates are reported in Regressions 1-5, respectively. In all cases β is positive and significant, pointing at the association of interest.

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

3.2 Heterogeneous vertical tax externalities

Having established the points in the previous sub-section, we move to testing the model's first 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 so consequently to less negative vertical tax externalities.

To put this prediction to the test, we estimate models of the following type, using the same

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

[13] In effect, we use their extension of it available at the homepage of the second author.

panel framework, time frame, and notation:

$$tax_{i,t} = \alpha + \beta(FED)_{t-1} + \gamma(FA)_{i,t-1} + \delta(FED * FA)_{i,t-1} + \mu(\mathbf{X})_{i,t-1} + \lambda(Year) + \eta_i + \epsilon_{i,t}; \quad (17)$$

in addition to the notation described previously, tax denotes tax rates, FED represents federal tax shocks normalized by GDP, $Year$ is a time trend, and $\mathbf{X}$ is a vector of controls. To be consistent with the simultaneous sense of our framework, the relative short term effects it studies, and potential endogeneity concerns, we look into the effects of shocks in 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. To elaborate on the vector of controls, $\mathbf{X}$ includes real GSP per capita to control for income differences, and a *deductions* dummy that controls for whether the state deducts federal income and/or corporate taxes, following Taylor and Yucel (1996) who argue this may be a determinant of state fiscal behavior; this dummy can either take a value of 0 (no deductions), 1 (either corporate or income deductions) or 2 (deductions for both cases).

Importantly, $\mathbf{X}$ also includes real per capita transfers from the federal government. In the context of the current exercise their inclusion is motivated by Smart (1998) who shows they affect state fiscal behavior. However, including federal redistribution takes further essential roles in the empirical analysis more generally, including in the exercises to follow. First, given it controls for differences in federal aid it helps our fiscal advantage proxy to make a cleaner measure of that advantage. Second, controlling for it enables us to capture the effects of tax increases that are net of their reinvestment. The latter point contributes to deriving a more focused observation of our proposed mechanism, and highlights the distinction between our analysis and previous studies that examine the macro-level effects of tax shocks (e.g. RR).

One of the main variables in this analysis, and the ones to follow, is FED, our proxy for the plausibly exogenous changes in federal tax rates. As mentioned, 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 to 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 year of announcement.

We use their data, yet aggregate their quarterly-based estimations to be at an annual level,[14] and

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

consider the shocks they regarded as exogenous. Our main identification assumption is, hence, based the latter point, though we do elaborate further in a later section on related aspects regarding the fiscal advantage measure (including testing different measures of it). Taken together, this enables to discuss causality within an OLS panel framework, which we adopt in the analyses to follow. That said, to observe the distribution of these plausibly exogenous federal shocks across our period of interest, we plot in Figure 4 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.

We focus on δ, the coefficient on our interaction term of interest. Results appear in Table 3. In our benchmark cases, namely Regressions 1-6, we look into non-severance average state tax rates. Hence, tax is non-severance state tax revenues divided by GSP. Given that the federal shocks are uniform across states by definition, year fixed effects absorb them; thus, to see their direct effect, we initially include a time trend instead. This represents our benchmark specification in Regression 1. In the second regression, we add a spatially-oriented GSP measure, to control for potential spatial effects; in effect, we include the average real per capita GSP of all states excluding that of the state inspected. In the third case we test a dynamic setting, including in addition a lagged dependent variable. In Regression 4 we then add year fixed effects in lieu of the time trend, and hence drop the federal shock which is now absorbed. As can be seen, in all cases δ is negative and significant; moreover, in those that include the federal shock, β is precisely estimated with a positive sign. Hence, increases in federal tax rates increase state tax rates for the average state, yet the increase is lower in fiscally advantageous states.

The model indicates that state and federal tax rates work in the same direction, so long as g and G are sufficiently complements (which as discussed, we assume they are). These results suggest that resource rich states may actually decrease their tax rates in response to increases in federal ones. To realize that the result on the interaction indicates that these latter states simply make a weaker response, we next divide the sample into two groups of high and low fiscal advantage levels. The threshold for the former is a share of 0.15 of severance tax revenues in total tax revenues.[15] Results appear in Regressions 5 and 6, which replicate the benchmark specification of Regression 1 for these two separate estimations. Given the division, we are now interested in the direct effect of FED. Seeing that β is statistically significant only in the low fiscal advantage cases, we conclude that the difference observed through the interaction term is a relative one; meaning, states with low

[15] This is an arbitrary threshold we use consistently in the various cases throughout the empirical analysis. We adopt it to make a more extreme distinction between those states with higher fiscal advantage and those with lower; nonetheless, the same patterns are observed if we otherwise use the average or median levels of fiscal advantage as alternatives. The states in the high fiscal advantage group are (included even if above threshold in at least one year): Alaska, Louisiana, Montana, New Mexico, North Dakota, Oklahoma, Texas, and Wyoming.

fiscal advantage increase their tax rates in response to an increase in the federal ones,[16] whereas the states with high fiscal advantage do not appear to react as strongly, if at all. This is thus consistent with the model's notion of this.

Next, we touch on some further related points. First, albeit being a commonly used benchmark measure of tax rates, average tax rates is not a direct measure of tax rates per se; despite controlling for GSP, the observed decrease could be a result of other indirect channels that affect the denominator. Second, the model is specific about the type of tax rates considered, as it focuses on the capital side. This has two implications; one is that it is essentially only state corporate tax rates that are expected to react, and two it is mainly corporate-related federal tax shocks that are expected to make the trigger.

To address these issues we modify the analysis in three ways. First, we consider an alternative, direct, measure of tax rates: the state top bracket tax rate. Second, we look separately into corporate and income top tax rates. Data is retrieved from the World Tax Database at the University of Michigan, which provides only the top bracket for the corporate-related tax rates, hence motivating our focus on that type specifically. Last, we disaggregate the federal tax shocks to corporate-related and non-corporate-related; we do so by following RR's documentation. They record the aim of each tax bill, and the type of tax it affected; we then aggregate the shocks for all the bills that are mentioned to affect federal (non-)corporate taxes only and classify them under the (non-)corporate-related group. The division is fairly equal, with a slight bias towards the non-corporate side. Interestingly, the two groups have virtually zero correlation; hence, shocks in either group appear to be independent.

Results appear in Regressions 7-10. Each replicates the benchmark specification of Regression 1, with the difference of using the abovementioned disaggregation, in an alternating way. Regressions 7-8 (9-10) look into the top corporate (income) state tax rates, whereas Regressions 7 and 9 (8 and 10) use the (non-)corporate-related federal shock. As can be seen, the main result is observed only in, and thus entirely driven by, the capital side; meaning, in the case that has corporate tax rates and corporate-related federal shocks (Regression 7), where the fiscally advantageous states make a relatively better response, observed through the negative and significant δ. This is consistent with the theoretical setting, and provides some initial motivation for our focus on capital. We will, however, continue to dig deeper into this as the analysis progresses, and will maintain this corporate/non-corporate division (in the federal shocks), in the exercises to follow.

[16] To interpret the magnitude, we note that a 1% increase in the GDP share of federal tax revenues increases the average tax rate in low fiscal advantage states by about a tenth of that.

3.3 Cross-state capital movements

A second prediction of the model is that following a federal tax change, the better fiscal response of the fiscally advantageous states leads to capital inflows from other parts of the nation. In this sub-section we test this implication from various aspects. First, we look directly into changes in states' real per capita capital stocks, then we turn to study changes in tax revenues, and finally we investigate firm movements and inter-state migration.[17]

In all cases we estimate models of the following type, for state i at year t:

$$x^{g}_{i,\Delta(t-1,t)} = \alpha+\kappa(x)_{i,t-1}+\beta(FED)_{t-1}+\gamma(FA)_{i,t-1}+\delta(FED*FA)_{i,t-1}+\mu(\mathbf{X})_{i,t-1}+\lambda(Year)+\eta_i+\epsilon_{i,t}; \tag{18}$$

this is essentially similar to the type of specification presented previously, with the difference of examining growth rates. Despite having similar results under either setting, this one is more in line with our objective in the upcoming cases to track factor movements. We also find it consistent with the model; albeit adopting a static framework, this exercise can be regarded as testing the dynamics described within that period. Hence, our dependent variable is the annual rate of change from $t-1$ to t in an outcome variable, x; we also add its level equivalent at the initial period in all cases, to control for convergence. The remaining controls follow previous definitions. Based on the results in the previous sub-section and the improved fit to our framework, we continue to adopt the corporate/non-corporate division on the federal shock to better understand the difference; hence, unless otherwise specified, in all upcoming cases FED represents either the corporate-related or non-corporate-related shocks. Once again, our main focus is on δ.

3.3.1 Capital stocks

As we conjecture about capital movements, we first look into capital stocks, covering our complete sample period of 1963-2007. Hence, our outcome variable (x) in this first exercise is k – real per capita capital stock. In effect, we seek to realize whether the rate of change in states' real capital stock per capita is systematically different across levels of fiscal advantage, following a federal tax shock. Controlling for the initial capital stock level, assuming similar depreciation rates across the nation, and following the various assumptions made and motivated in the theoretical part (for instance, a closed economy setting), such systematic differences can be informative about the direction and magnitude of capital reallocation across the nation.

Results appear in Table 4. Regressions 1-3 replicate Regressions 1-3 of Table 3 in terms of the specification followed, with the difference of having growth rates and a focus on the corporate-related

[17] Given the closed economy setting of our framework, we abstract from considering state-level FDI inflows.

federal shocks. Regression 4 is then the same as its former, only using non-corporate-related federal shocks. In the time-trend cases (Regressions 1-2) β is estimated to be negative and significant. A corporate-related federal tax increase decreases the capital tax base for the average state. However, in all the corporate-related cases (1-3), δ is positive and significant; the contractionary effect on the capital tax base is strongly mitigated in fiscally advantageous states, to the extent of being expansionary. As for Regression 4, once again we note that effects are completely driven by the corporate-side, as we observe no differential effect following a non-corporate-related shock.

To better understand, however, the sharp distinction between the high and low fiscal advantage cases under the corporate-related scenarios, we once again divide the sample to these two groups, using the same threshold of 0.15 on FA. Regressions 5 and 6 follow the specification of Regression 1, without the interaction term, for each of the high and low fiscal advantage cases, respectively. The opposite result on β highlights the distinction. Unlike the tax rates' analysis, here the result on the interaction term does 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 the low fiscal advantage states as would be expected, it actually increases it in the high fiscal advantage ones. In addition, the magnitude, which we note is a lower-bound estimate given the division, shows this is economically meaningful; in the 8 fiscally advantageous states, a 1% increase in the GDP share of corporate-related federal tax revenues increases the growth in real per capita capital stock by approximately 1.6% on average, controlling for redistribution.

3.3.2 Tax Revenues

Next, we test the same hypothesis from an additional angle, looking into differences in tax revenues. Under the same above-mentioned assumptions, systematic cross-state differences in per capita tax revenues following a federal shock, can shed further light on the factor reallocation process. This becomes even more acute given the differences in tax rates discussed earlier, as will be evident below. This exercise as well covers the full sample period of 1963-2007.

That said, we now consider x to be per capita state tax revenues, thus focusing on its annual rate of change. Results appear in Table 5. In Regressions 1-4 we focus on corporate tax revenues, whereas in the fifth case we examine non-corporate revenues. Regressions 1-4 replicate estimations 1-4 of Table 4, only using the tax revenues in lieu of capital stocks. Results are qualitatively the same as in the previous exercise. In Regressions 1 and 2 β is negative and significant, indicating a corporate-related federal tax shock contracts the tax base and decreases the income derived from it, in the average state.

However, in Regressions 1-3 the positive and significant coefficient on the interaction term shows

that things are quite the opposite in fiscally advantageous states. Interpreting the magnitude using the baseline case, being at our threshold of fiscally advantageous state (0.15) a 1% increase in the GDP share of corporate-related federal tax revenues increases the growth in per capita corporate tax revenues by approximately 0.1%. Despite the relatively small increase, it is surprising to note that an increase in a tax rate that directly pertains to a specific tax base increases the income collected from that tax base.[18] This, in conjunction with the observation that corporate tax rates are generally lower in those high fiscal advantage states, and following the same previously mentioned assumptions, suggest that the corporate tax base increased in those states through capital inflows, coming from other parts of the nation.

To show that things are, once again, rooted at the corporate side, Regression 4 tests the non-corporate-related federal shocks, and Regression 5 (which follows the specification of Regression 3) looks into the effect on per capita non-corporate tax revenues. Both cases show no clear patterns. Meaning, it is neither the non-corporate shocks that make a clear effect nor the non-corporate revenues that are significantly affected. These results provide further affirmation for our general focus on capital.

3.3.3 Firms and labor

The final perspective we take on this is through a direct examination of the movement of firms and labor. Albeit not affecting results, in this case we focus on the 48 contiguous states, to minimize differences in mobility costs. We start with firm analysis and use state-level data from the U.S. Census Bureau, covering the period of 1977-2007, on the number of firms per capita which next takes the role of x in our empirical equation. As before, we look into the annual rate of change, which under the same set of assumptions provides some indication about the direction and magnitude of capital reallocation following a federal tax shock. Realizing that elasticity changes across levels of firms' size, such that for instance smaller firms would be less willing to move given a stronger local attachment, we test two separate size groups; first is those that have up to 4 employees, and second is the remaining ones, having 5 or more. Each group comprises around half of the total number of firms.

Results appear in Regressions 1-5 of Table 6. Regression 1 looks into firms with up to 4 employees and replicates the benchmark specification as in Regression 1 of Table 5. Regressions 2-5 examine firms with 5 or more employees and follow specifications of Regressions 1-4 of Table 5, in the same respective order; specifically, Regressions 2-4 (5) test (non-)corporate-related shocks.

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

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 2-4 points at the patterns observed in the previous cases. Following a corporate-related federal tax increase the number of firms with 5 or more employees increases in states with high fiscal advantage;[19] specifically, a 1% increase in the GDP share of corporate-related federal tax revenues increases the growth in the per capita number of firms (with 5 or more employees) in those states by approximately a tenth 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 there is firm movement towards the fiscally advantageous states. Regression 5 then illustrates once again these patterns are entirely driven by corporate-related shocks.

To further examine the distinction between the capital and labor aspects of this, we next look into inter-state migration. Data on the latter 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 Regressions 6-8, which replicate Regressions 2-4 with the exception of x now being per capita migration inflows from other states. Unlike the cases with firms, labor does not appear responsive, having an imprecisely estimated interaction term in all cases.[20] This further strengthens our focus on capital, as we observe movements are restricted to firms and corporate-related shocks.

3.4 Federal tax shocks and state output

To this point we provided evidence for the various aspects of the proposed mechanism; namely, we observed that fiscally advantageous states have a better absorption of federal tax shocks 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. We address this in this sub-section.

Hence, we estimate models of the following type, for state i at year t (1963-2007):

$$y^{g}_{i,\Delta(t-1,t)} = \alpha+\kappa(y)_{i,t-1}+\beta(FED)_{t-1}+\gamma(FA)_{i,t-1}+\delta(FED*FA)_{i,t-1}+\mu(\mathbf{X})_{i,t-1}+\lambda(Year)+\eta_i+\epsilon_{i,t}; \tag{19}$$

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

[20] 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.

this is essentially a similar model to the previous, with the difference of using y which denotes, as before, real per capita GSP. 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. In addition, given the growth framework 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, as documented for instance in RR, would be mitigated in fiscally advantagous states to the extent of being expansionary, despite controlling for federal redistribution.

We test this in Table 7. As our focus lies in the corporate-related shocks, this time we start initially with the two other cases; namely, the total federal shocks and the non-corporate-related ones. These are presented in Regressions 1 and 2 respectively, which replicate the benchmark specification, as in Regression 1 in the previous table (only with GSP as x). The first case, using the total federal shocks, shows firstly through β 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.

Following that, we move to the corporate-related cases in Regressions 3-5. These replicate Regressions 2-4 of the previous table, only focusing on output; meaning, the first and second cases have a time trend, with the second one having the spatial-GSP added, and the third one has year fixed effects and the exclusion of the federal shock. The first two estimations, with the latter included, again points at the average state's contractionary effect through the negative and significant β. All three, however, show the main result holds, through the positive and significant δ. Interestingly, its magnitude is more than four times that estimated under the total shock; moreover, it is as well significantly higher than β in absolute terms, hence suggesting a federal tax shock can be potentially expansionary.

To make a clearer investigation of the distinction and the potential of having an expansionary effect, next we divide the sample to high and low fiscal advantage levels, as was done in the previous cases. We maintain the same threshold of a severance tax share of 0.15 in total revenues (yet, again, note that results hold as well under the average or median values). Regressions 5 and 6 follow the benchmark specification, only without the interaction term, with the former (latter) restricting the sample to high (low) fiscal advantage cases. The result on β shows the distinction; in the high (low) fiscal advantage cases a corporate-related federal tax increase is expansionary (contractionary). To

better interpret the magnitude, a 1% increase in the GDP share of corporate-related federal revenues increases the growth in output by approximately 0.1% in the 8 fiscally advantageous states. We note that given the sample division, this represents a lower bound. This, therefore, indicates these states benefit from corporate-related tax increases, irrespective of federal redistribution which is held constant. More generally, this illustrates tax increases do not necessarily lead to contraction when controlling for government expenditure (reinvestment), as observed in previous studies (e.g. Blanchard and Perotti (2002)).

3.5 Robustness tests

Following the various steps of the analysis, we next undertake some robustness tests. Realizing the distinct stages come together, eventually, to affect output, we focus on the latter's more concluding result on differential growth effects. Nonetheless, this is merely a representation of the other stages; we note that the various tests presented next hold as well in each of the intermediate steps. All results are presented in Table 8; the general specification in all cases follows that of Equation (19) in its strictest form; namely, with year fixed effects and the federal shocks excluded, with the focus being on the interaction between the corporate-related federal shocks and a fiscal advantage proxy.

First, we test two additional specifications. In the first, we use level regression, in lieu of the growth one presented so far. This means that we follow the abovementioned specification only with $y_{i,t}$ on the LHS. Results appear in Regression 1. In the second, we estimate this latter level version using the Arellano-Bond procedure (Arellano and Bond (1991)), examining first differences while instrumenting variables using their lagged values, with the results appearing in Regression 2. The main result holds in both cases, as the positive and significant result on δ indicates.

Second, we test whether results are driven by post-2000 effects. As Figure 4 illustrates, post-2000 federal shocks are relatively stronger thus potentially being the dominant stage in our analysis. We, therefore, exclude post-2000 years, and re-estimate the model using this restricted sample. Regression 4 presents the results of this exclusion. Our main result on δ remains to hold 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 GSP share of the mining sector, being the conventional measure. However, given the potential endogeneity of this measure (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 first take the GSP share of the mining sector in the initial year, and then multiply it by the international real price

of crude oil at year t. As Figure 5 illustrates, states' relative abundance in natural resources did not change much from 1963, making the cross-state differential effect of changes in the oil price relatively constant, hence enabling 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 some plausibly exogenous proxy for fiscal advantage. Results appear in Regressions 4 and 5, for the output and price based measures, respectively. As the result on the interaction term of interest 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 resource rich states. To do that, we exclude from the sample all the states with an average GSP share of the mining sector greater than 0.1 (averaged over the entire sample period); these include: Alaska, Louisiana, New Mexico, Texas, West Virginia, and Wyoming. Estimates using this restricted sample appear in Regression 6; the positive and significant δ indicates the main result remains applicable, in largely the same magnitude, even when we restrict the sample to states that are not highly resource dependent.

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. Hence, in Regression 7 we use severance tax per capita as our main fiscal advantage measure; results are qualitatively the same, with the main coefficient maintaining its sign and significance.

Last, we test for the role of a political channel. Being predominantly Republican, the 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 8 we add a control for the party affiliation of the Governor.[21] As the coefficient on our interaction term remains stable in all key aspects, the main result appears robust to this.

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

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

abundance.

The theory builds on the notion that natural rich states have a fiscal advantage in the inter-state competition over factors which they exploit to attract capital from other parts of the nation through fiscal means. The consequent greater per capita capital stocks leads high fiscal advantage states to better absorb changes in federal tax rates, especially those related to capital, which then leads to capital movement to (from) high (low) fiscal advantage states. The capital inflow (outflow) to (from) the high (low) fiscal advantage states mitigates (strengthens) the accompanying contractionary effects. Specifically, in the fiscally advantageous states the effect can be overturned, and become expansionary, increasing output through an increase in the capital tax base.

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 of 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, we followed the narrative-based approach of RR for examining the predictions of the model, finding 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. In addition, we have shown 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 firms (with no observable effects on labor movement), hence motivating our focus on capital. These results have demonstrated, together with the analytical framework, that a tax increase on a specific tax base can increase that tax base and lead to increases in output irrespective of redistribution, with sufficient factor mobility and fiscal advantage levels.

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 the horizontal channel when coordinating vertical taxes, as previous ones did not consider heterogenous effects, the consequent potential exacerbation of fiscal inequality, and the possibly inefficient factor reallocation across the nation, following a federal tax shock. Nonetheless, we note that our conclusions are limited to the cases of the U.S. and natural resources. Future research may consider the cases of other federations, or examine other forms of non-mobile regional differences.

Appendix

A Data

In the regressions 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.

Variable definitions

Federal tax shocks: Narrative-based federal tax shocks (Source: **?**). 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. For further information on the endogenous/exogenous decomposition and its motivation, 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 shocks to be (non-)corporate-related if within the description of the bill it is specifically mentioned to be related only to (non-)corporate taxes.

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 (Source: World Tax Database, University of Michigan).

Top income tax rates: Top state tax income tax rates (Source: World Tax Database, University of Michigan).

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 within the state, divided to those with 1-4 employees, and those with 5 or more; used in per capita terms.

Inter-state migration: Number of migrations coming from other states; used in per capita terms.

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.

Governor's party affiliation: An indicator for whether the Governor is affiliated with the Democratic or Republican parties.

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Table 1: Descriptive Statistics and Correlations

A. Descriptive Statistics

	Mean	Std. Dev.	Min.	Max.		Mean	Std. Dev.	Min.	Max.
Federal tax shocks	-0.004	0.015	-0.073	0.025	Average tax rates	0.048	0.011	0.009	0.104
Federal tax shocks: corporate related	-0.002	0.004	-0.015	0.006	Top corporate tax rates	5.85	2.98	0	12.25
Federal tax shocks: non-corporate related	0.0003	0.002	-0.01	0.034	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	0.82	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	0.0000514	10286.62	Governor's Party Affiliation	0.4988198	0.5001954	0	1

'Federal tax shocks': the narrative-based exogenous federal tax shocks, normalized by GDP; '(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

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.

Table2: Cross-state regressions; state fiscal advantage and state capital stock per capita (panel, period: 1963-2007, 1-year intervals, OLS)

Dependent variable: State capital stock per capita	(1)	(2)	(3)	(4)	(5)
Fiscal advantage	**24.49****	**22.78****	**11.84*****	**12.39*****	**8.49****
	(10.21)	**(10.21)**	**(2.89)**	**(3.02)**	**(3.88)**
GSP per capita					17.49***
					(2.15)
State fixed effects	No	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	Yes	Yes
Time trend	No	No	Yes	No	No
R-squared, within	0.03	0.04	0.86	0.87	0.91
Observations	2250	2250	2250	2250	2250

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. All regressions include an intercept. 'State capital stocks per capita' is state-level capital stock, divided by state population, in constant prices. 'Fiscal advantage' is the share of severance tax revenues in total tax revenues. 'GSP per capita' is the log of real Gross State Product divided by state population. For further information on variables see data Appendix.

Table 3: Cross-state regressions; federal tax shocks and state tax rates (panel, 1-year intervals, OLS)

	Non-severance-based average tax rates						Top tax rates			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent variable:	Average tax rates	Average tax rates	Average tax rates, dynamic setting	Average tax rates, dynamic setting	High fiscal advantage	Low fiscal advantage	Top corporate tax rates	Top corporate tax rates	Top income tax rates	Top income tax rates
Federal tax shocks: total, in t-1	0.06***	0.05***	0.02***		-0.02	0.05***				
	(0.005)	(0.005)	(0.003)		(0.02)	(0.001)				
Federal tax shocks: corporate-related, in t-1							8.87		3.59	
							(5.72)		(8.65)	
Federal tax shocks: non-corporate-related, in t-1								13.35		37.83
								(24.63)		(36.07)
Fiscal advantage * Federal tax shocks: total, in t-1	**-0.35*** **	**-0.33*** **	**-0.08** **	**-0.07** **						
	(0.05)	**(0.07)**	**(0.04)**	**(0.03)**						
Fiscal advantage * Federal tax shocks: corporate-related, in t-1							**-125.57** **		**-186.01**	
							(54.17)		**(120.71)**	
Fiscal advantage * Federal tax shocks: non-corporate-related, in t-1								**60.28**		**-1.12**
								(67.04)		**(131.48)**
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	Yes	No	No	No	No	No	No
Time trend	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
R-squared, within	0.33	0.34	0.79	0.82	0.26	0.3	0.3	0.3	0.09	0.09
Observations	2250	2250	2250	2250	155	2095	1903	1903	1883	1883

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. All regressions include an intercept. Sample includes the 50 U.S. states. Regressions 1-6 (7-10) use a balanced (unbalanced) panel for the period of 1963-2007 (1965-2007). 'Average tax rates' are non-severance tax revenues normalized by GSP. 'Top tax rates' are the top state tax corporate (Regressions 7-8) or income (Regressions 9-10) tax rates. 'Federal tax shocks' are the narrative-based exogenous federal tax shocks, normalized by GDP; 'total' refers to the total shock; '(non-)corporate-related' refers to the (non-)corporate related shocks. Regressions also include: 'GSP per capita': the log of real Gross State Product divided by state population. 'Fiscal advantage': the share of severance tax revenues in total tax revenues. 'Transfers': Real per capita transfers from central government. '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). Included in addition in Regressions 2-4 is 'GSP per capita other states': the log of the average real GSP per capita over all states with the exclusion of the state inspected. Regressions 3-4 include also lagged dependent variable. All independent variables are with one lag, in t-1. In Regressions 5-6 'High fiscal advantage' is defined as severance tax share in total tax revenue higher than 0.15; 'Low fiscal advantage' represents the balance. The former group includes (included even if below threshold in some years): Alaska, Louisiana, Montana, New Mexico, North Dakota, Oklahoma, Texas, and Wyoming. For further information on variables see data Appendix.

Table 4: Cross-state regressions; federal tax shocks and inter-state capital movement(panel, period: 1963-2007, 1-year intervals, OLS)

Dependent variable: Annual change rate in state capital stock per capita, Δ(t-1,t)	(1)	(2)	(3)	(4)	(5) High fiscal advantage	(6) Low fiscal advantage
Federal tax shocks: corporate-related, in t-1	-0.24***	-0.23**			1.57***	-0.25***
	(0.09)	(0.09)			(0.37)	(0.09)
Federal tax shocks: non-corporate-related, in t-1						
Fiscal advantage * Federal tax shocks (corporate-related), in t-1	**4.57*** **	**4.66*** **	**4.28*** **			
	(0.77)	**(0.78)**	**(0.69)**			
Fiscal advantage * Federal tax shocks (non-corporate-related), in t-1				**1.31**		
				(2.29)		
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	Yes	Yes	No	No
Time trend	Yes	Yes	No	No	Yes	Yes
R-squared, within	0.09	0.09	0.31	0.3	0.22	0.07
Observations	2200	2200	2200	2200	151	2049

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. All regressions include an intercept. Sample includes the 50 U.S. states. 'State capital stocks per capita' is state-level capital stock, divided by state population, in constant prices. 'Federal tax shocks' are the narrative-based exogenous federal tax shocks, normalized by GDP; '(non-)corporate-related' refers to the (non-)corporate related shocks. Regressions also include: 'GSP per capita': the log of real Gross State Product divided by state population. 'Fiscal advantage': the share of severance tax revenues in total tax revenues. 'Transfers': Real per capita transfers from central government. '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). Included in addition in Regressions 2-4 is '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 regressions include lagged dependent variable in levels. All independent variables are with one lag, in t-1. In Regressions 5-6 'High fiscal advantage' is defined as severance tax share in total tax revenue higher than 0.15; 'Low fiscal advantage' represents the balance. The former group includes (included even if below threshold in some years): Alaska, Louisiana, Montana, New Mexico, North Dakota, Oklahoma, Texas, and Wyoming. For further information on variables see data Appendix.

Table 5: Cross-state regressions; federal tax shocks and state tax revenues(panel, period: 1963-2007, 1-year intervals, OLS)

Dependent variable: Annual change rate in real taxes per capita, Δ(t-1,t)	CORPORATE TAXES				NON-CORPORATE TAXES
	(1)	(2)	(3)	(4)	(5)
Federal tax shocks: corporate-related, in t-1	-0.05**	-0.04**			
	(0.02)	(0.02)			
Fiscal advantage * Federal tax shocks (corporate-related), in t-1	**0.44*** **	**0.49*** **	**0.47*** **		**0.002**
	(0.14)	**(0.15)**	**(0.16)**		**(0.03)**
Fiscal advantage * Federal tax shocks (non-corporate-related), in t-1				**0.09**	
				(0.17)	
State fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	Yes	Yes	Yes
Time trend	Yes	Yes	No	No	No
R-squared, within	0.06	0.07	0.14	0.14	0.15
Observations	2010	2010	2010	2010	2010

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. All regressions include an intercept. 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 5, whereas the latter is the one in the remaining cases. 'Federal tax shocks' are the narrative-based exogenous federal tax shocks, normalized by GDP; '(non-)corporate-related' refers to the (non-)corporate related shocks. Regressions also include: 'GSP per capita': the log of real Gross State Product divided by state population. 'Fiscal advantage': the share of severance tax revenues in total tax revenues. 'Transfers': Real per capita transfers from central government. '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). Included in addition in Regressions 2-4 is '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 regressions include lagged dependent variable in levels. All independent variables are with one lag, in t-1. For further information on variables see data Appendix.

Table 6: Cross-state regressions; federal tax shocks and inter-state firm and labor movement(panel, 1-year intervals, OLS)

	Firm Analysis: 1977-2007					Inter-state migration: 2001-2007		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	Annual change rate in number of firms per capita, Δ(t-1,t): 1 to 4 employees	Annual change rate in number of firms per capita, Δ(t-1,t): 5+ employees	Annual change rate in number of firms per capita, Δ(t-1,t): 5+ employees	Annual change rate in number of firms per capita, Δ(t-1,t): 5+ employees	Annual change rate in number of firms per capita, Δ(t-1,t): 5+ employees	Annual change rate in inter-state immigration per capita, Δ(t-1,t)	Annual change rate in inter-state immigration per capita, Δ(t-1,t)	Annual change rate in inter-state immigration per capita, Δ(t-1,t)
Federal tax shocks: corporate-related, in t-1	-0.43***	0.13	0.07			-2.55	-61.36	
	(0.1)	(0.1)	(0.11)			(52.37)	(48.09)	
Federal tax shocks: non-corporate-related, in t-1								
Fiscal advantage * Federal tax shocks (corporate-related), in t-1	**0.44**	**2.31****	**2.15****	**1.69****		**-8.16**	**65.61**	**198.96**
	(1.24)	**(0.99)**	**(1.01)**	**(0.78)**		**(328.92)**	**(290.98)**	**(283.67)**
Fiscal advantage * Federal tax shocks (non-corporate-related), in t-1					**4.49**			
					(2.73)			
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	Yes	Yes	No	No	Yes
Time trend	Yes	Yes	Yes	No	No	Yes	Yes	No
R-squared, within	0.09	0.18	0.18	0.65	0.65	0.00	0.00	0.04
Observations	1485	1485	1485	1485	1485	336	336	336

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. All regressions include an intercept. Sample includes the 48 contiguous U.S. states. Firm-level analysis (Regressions 1-5) covers the period of 1977-2007; Inter-state migration analysis (Regressions 6-8) cover the period of 2001-2007. In the former case the dependent variable is the annual rate of change in the number of firms per capita of size 1-4 employees (Regression 1), and 5+ employees (Regressions 2-5). In the latter case the dependent variable is the annual rate of change in inter-state migration per capita. 'Federal tax shocks' are the narrative-based exogenous federal tax shocks, normalized by GDP; '(non-)corporate-related' refers to the (non-)corporate related shocks. Regressions also include: 'GSP per capita': the log of real Gross State Product divided by state population. 'Fiscal advantage': the share of severance tax revenues in total tax revenues. 'Transfers': Real per capita transfers from central government. '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). Included in addition in Regressions 3-5 and 7-8 is '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 regressions include lagged dependent variable in levels. All independent variables are with one lag, in t-1. For further information on variables see data Appendix.

Table 7: Cross-state regressions; federal tax shocks and state output(panel, period: 1963-2007, 1-year intervals, OLS)

Dependent variable: Annual change rate in real GSP per capita, Δ(t-1,t)	(1)	(2)	(3)	(4)	(5)	(6) High fiscal advantage	(7) Low fiscal advantage
Federal tax shocks: total, in t-1	-0.07***						
	(0.006)						
Federal tax shocks: corporate-related, in t-1			-0.18***	-0.17***		0.14**	-0.18***
			(0.01)	(0.01)		(0.05)	(0.01)
Federal tax shocks: non-corporate-related, in t-1		-0.32***					
		(0.09)					
Fiscal advantage * Federal tax shocks: total, in t-1	**0.22****						
	(0.08)						
Fiscal advantage * Federal tax shocks (corporate-related), in t-1			**0.92*****	**0.99*****	**0.88*****		
			(0.09)	**(0.09)**	**(0.08)**		
Fiscal advantage * Federal tax shocks (non-corporate-related), in t-1		**0.09**					
		(0.2)					
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	No	Yes	No	No
Time trend	Yes	Yes	Yes	Yes	No	Yes	Yes
R-squared, within	0.13	0.09	0.11	0.13	0.37	0.34	0.09
Observations	2200	2200	2200	2200	2200	152	2048

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. All regressions include an intercept. Sample includes the 50 U.S. states. 'Federal tax shocks' are the narrative-based exogenous federal tax shocks, normalized by GDP; '(non-)corporate-related' refers to the (non-) corporate related shocks. Regressions also include: 'GSP per capita': the log of real Gross State Product divided by state population. 'Fiscal advantage': the share of severance tax revenues in total tax revenues. 'Transfers': Real per capita transfers from central government. '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). 'Pop_g': Rate of population growth. Included in addition in Regressions 4-5 is '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 regressions include lagged dependent variable in levels. All independent variables are with one lag, in t-1. In Regressions 6-7 'High fiscal advantage' is defined as severance tax share in total tax revenue higher than 0.15; 'Low fiscal advantage' represents the balance. The former group includes (included even if below threshold in some years): Alaska, Louisiana, Montana, New Mexico, North Dakota, Oklahoma, Texas, and Wyoming. For further information on variables see data Appendix.

Table 8: Cross-state regressions; federal tax shocks and state output, robustness tests (panel, 1-year intervals, OLS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Level Regression	Arellano-Bond	Post-2000 excluded	Mining share	Price-based measure	Resource-rich states excluded	Severance Tax Per capita	Political Channel
Dependent variable:	GSP per capita	GSP per capita	Annual change rate in real GSP per capita, Δ(t-1,t)	Annual change rate in real GSP per capita, Δ(t-1,t)	Annual change rate in real GSP per capita, Δ(t-1,t)	Annual change rate in real GSP per capita, Δ(t-1,t)	Annual change rate in real GSP per capita, Δ(t-1,t)	Annual change rate in real GSP per capita, Δ(t-1,t)
Fiscal advantage * Federal tax shocks (corporate-related), in t-1	**426390*** **	**535813.9*** **	**1.07*** **			**1.25*** **	**0.001*** **	**0.49*** **
	(75583.59)	**(99519.91)**	**(0.15)**			**(0.21)**	**(0.00)**	**(0.11)**
Mining share * Federal tax shocks (corporate-related), in t-1				**1.29*** **				
				(0.21)				
Price measure * Federal tax shocks (corporate-related), in t-1					**0.02*** **			
					(0.004)			
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared, within	0.98	n/a	0.38	0.37	0.34	0.51	0.35	0.38
Observations	2200	2200	1800	2200	2200	1936	2200	1271

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. All regressions include an intercept. 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. Regressions also include: 'GSP per capita': the log of real Gross State Product divided by state population. 'Fiscal advantage': the share of severance tax revenues in total tax revenues. 'Transfers': Real per capita transfers from central government. '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). 'Pop_g': Rate of population growth. 'GSP per capita other states': the log of the average real GSP per capita over all states with the exclusion of the state inspected. 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. All independent variables are with one lag, in t-1. 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 'Fiscal advantage'; '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 states with an average GSP share of the mining higher than 0.1 (over the entire sample period) from the sample; specifically these include: Alaska, Louisiana, New Mexico, Texas, West Virginia, and Wyoming. Regression 7 uses severance tax per capita as the measure of fiscal advantage. Regression 8 adds the governor's party affiliation as a control; sample period is 1983-2007. For further information on variables see data Appendix.

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

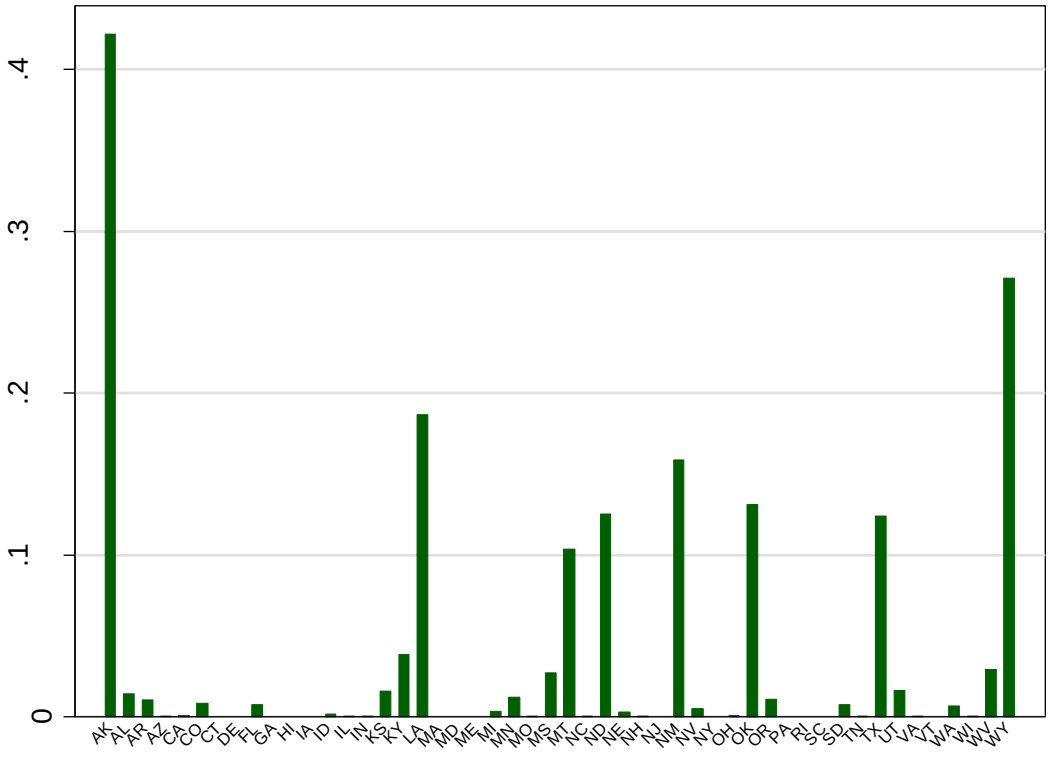

Figure presents the share of severance tax revenues in total tax revenues, averaged over the sample (1963-2007), across U.S. states (Source: U.S. Census Bureau).

Figure 2: Federal vs. State governments' spending, annual rate of change, 1960-2010

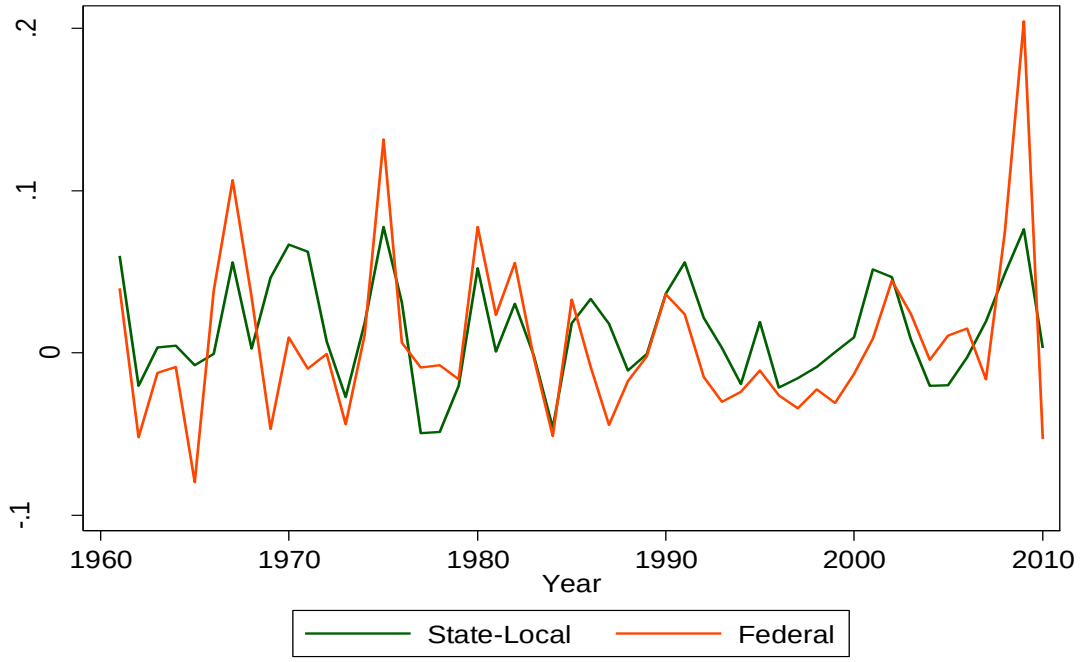

Figure presents the co-movement of the annual rate of change in the GDP share of federal and state governments' spending over the period of 1960-2010; ρ=0.63 (Source: U.S. Census Bureau).

Figure 3: Natural resources and corporate tax environment, U.S. states

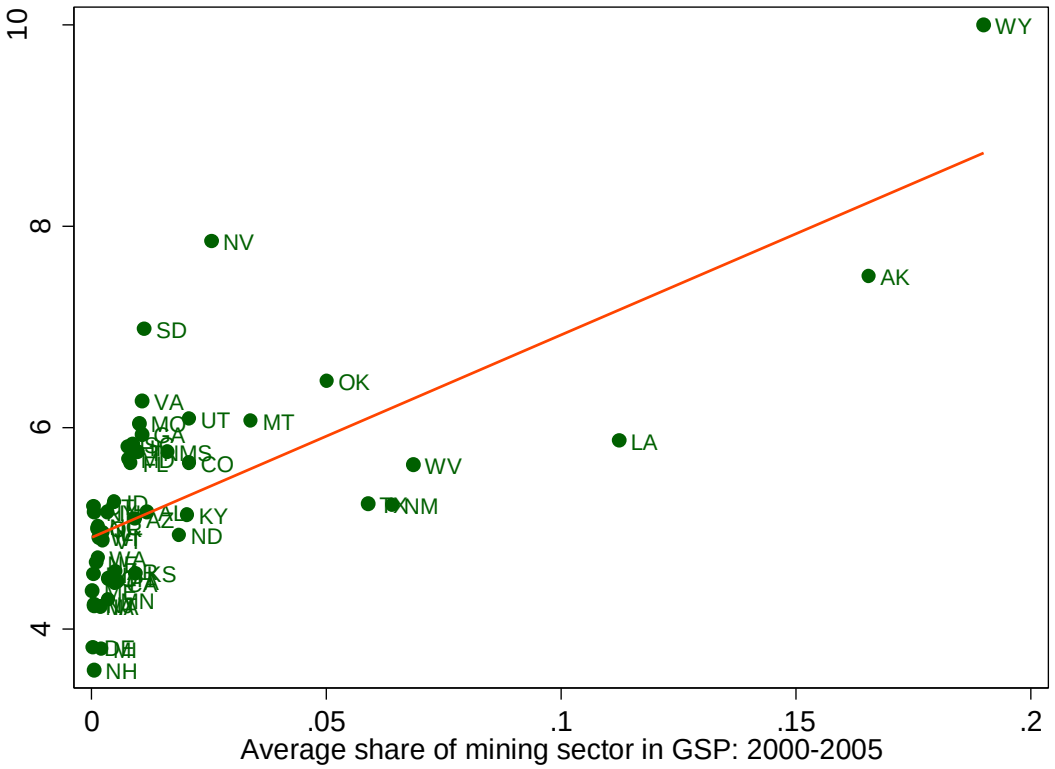

Figure presents the correlation between the average share of mining sector in GSP in 2000-2005, and the average *Corporate Tax Climate* Index in 2006-2011; ρ=0.71 (Source: U.S. Tax Foundation).

Figure 4: Exogenous federal tax shocks, 1963-2007

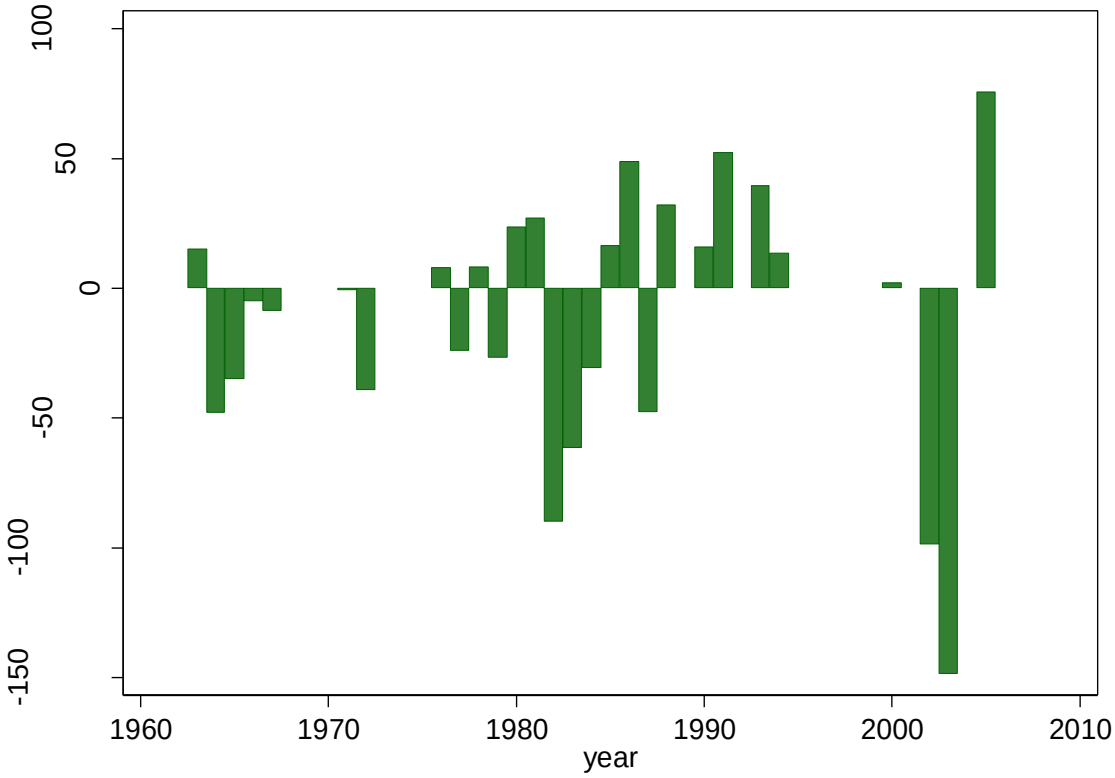

Figure presents the federal tax shocks classified as exogenous (Romer and Romer (2010)), in billions of real U.S. Dollars.

Figure 5: Spearman correlation, GSP share of mining sector 1963 vs. 2007

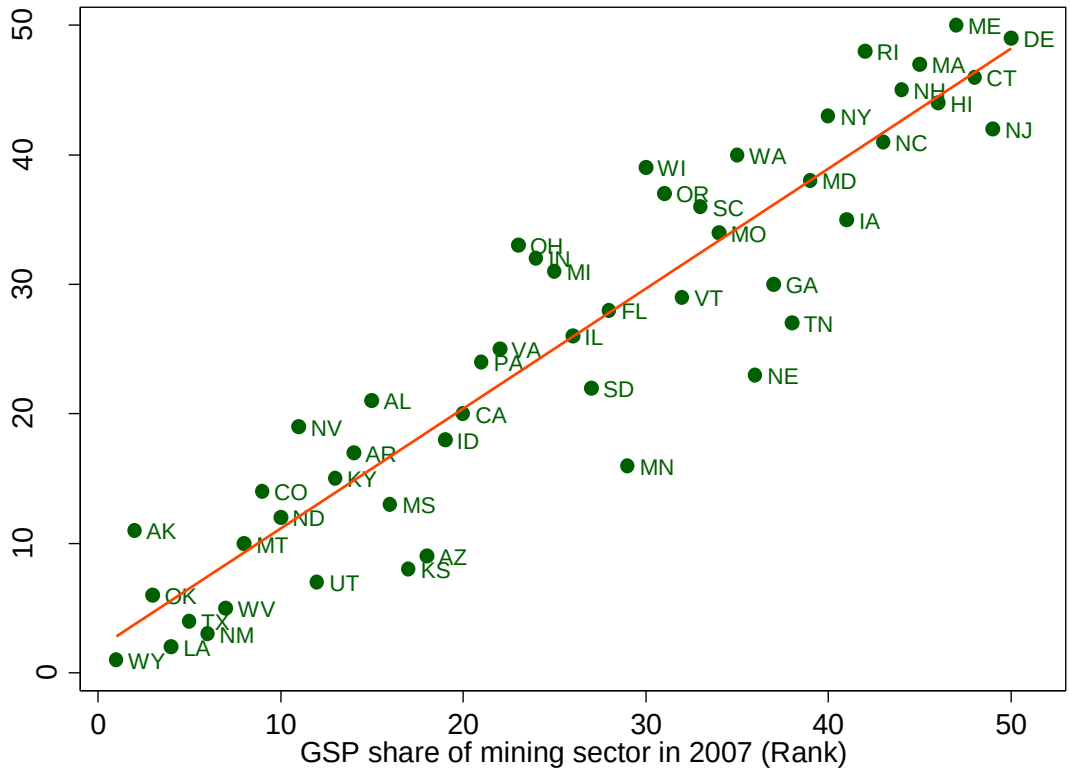

Figure presents the correlation between the relative ranking of the GSP share of the mining sector in 1963 and 2007; ρ=0.93 (Source: U.S. Bureau of Economic Analysis).