State Taxes and Spatial Misallocation

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Abstract

The distribution of tax rates varies substantially across U.S. states and has evolved over time due to multiple tax reforms. What are the effects of the state tax structure on the distribution of economic activity and aggregate outcomes in the U.S. economy? We build a general-equilibrium model with imperfect factor mobility and trade frictions that accommodates realistic heterogeneity in state taxes. We use it to estimate the elasticities of firm mobility, labor mobility, and trade with respect to taxes using data on economic activity and state finances from 1980-2010. Then, we quantify the general-equilibrium impact of actual state tax policies implemented over time, and of reforms typically put forth in public-policy debates.

1 Introduction

In 2012, U.S. states collected roughly $800 billion in tax revenue relying on substantially different tax structures. Across states, the 90-10 percentiles of the distribution of sales, average personal income, and corporate income tax rates was 7%-1%, 5%-0%, and 9%-0%, respectively. State tax systems also vary substantially over time; the share of total state tax revenue from income taxes has increased by nearly a factor of four in the post-war period, the share from sales taxes declined 10 percentage points between 1950 and 1980, and the share of the corporate income tax has fallen in half since 1980. These differences in tax structures are associated with differences in spending by state governments, which range from 7% to 20% of state GDP, and which, combined across states, amount to roughly one quarter of total government spending in the United States (Baicker et al., 2012).

Proposals to reform state tax systems abound, and are often subject to intense debate. At the state level, proponents of lower taxes argue that they help create jobs, while opponents counter that these reforms erode public good provision with little effect on employment.[1] At the national level, differences in tax rates across states may lead to misallocation by concentrating factors of production in less productive places. In line with the concern about the aggregate effects of tax dispersion, some maintain that uniform-tax schemes would be beneficial and help curtail "beggar-thy-neighbor" scenarios,[2] while others propose shifting the tax structure towards sales taxes or sales-based apportionment of corporate income taxes.[3]

How large are the effects of alternative state tax structures on the distribution of economic activity, aggregate real income, and welfare in the U.S. economy? How would specific states be impacted by alternative tax schemes? What were the effects of changes in policy observed over recent decades? To the best of our knowledge, no clear answers to these questions exist, especially in regard to quantifying the aggregate effects of simultaneous tax changes across states.[4] This lack of answers may be due to the challenges implied by these questions. Evaluating the costs and benefits of alternative tax structures, from either an economy-wide or a state-specific perspective, requires the quantification of complex general-equilibrium effects. Tax changes in one or in many states will induce reallocations of workers and firms into or away from those states, but also into or away from other states; these reallocations will change conditions in local factor and goods markets, impacting on wages, rents, goods prices, and trade; ultimately, the effects across states will be asymmetric depending on their degree of economic integration.

To answer these questions, in this paper we first build a general-equilibrium model that accommodates several types of spatial interactions among states and realistic heterogeneity in tax structures. We draw on tools from recent trade and economic geography models, and combine them

[1] E.g., see "Kansas' Ruinous Tax Cuts," *The New York Times*, Editorial Board, July 13, 2014, and Wilson (2015).
[2] "How to End State Subsidies," *The New York Times*, Eduard Allen and Rebecca Strauss, May 9, 2014.
[3] See, for instance, a discussion of these ideas in Auerbach (2013) and Auerbach and Devereux (2015).
[4] See the poll of members of the IGM Economic Experts Panel of Chicago Booth on Local Tax Incentives from March 24, 2015.
`http://www.igmchicago.org/igm-economic-experts-panel/poll-results?SurveyID=SV_9mead4nHknibSxn`.

in a model that includes salient features of the U.S. state tax system. Then, we use the model to specify structural relationships that allow us to estimate the elasticities of firm mobility, labor mobility and trade with respect to taxes using data on economic activity and state finances from 1980-2010. Using the estimated model, we measure the general-equilibrium impact of actual state tax policies implemented over time, and of the reforms typically put forth in public-policy debates.

In the model, imperfectly mobile workers decide where to locate based on each state's taxes, wages, cost of living, and amenities; while imperfectly mobile firms decide where to locate, how much to produce, and where to sell based on each state's taxes, productivity, trade costs with other states, factor prices, and cost of intermediate inputs. These decisions depend on the cross-state distribution of the main taxes used by the states in the U.S. (sales, individual income, and payroll- or sales-apportioned corporate income taxes) both in partial equilibrium given relative prices and state spending, and in general-equilibrium through changes in relative prices and in state-provided public goods which are valued by both workers and firms. While taxes impact the economy through multiple channels, the model readily implies that, in terms of determining the allocation, higher income or sales taxes in one state are equivalent to lower amenities in that state, higher payroll-apportioned corporate taxes are equivalent to lower productivity, and higher sales-apportioned corporate taxes are equivalent to a certain distortion in the distribution of trade costs across states.

The effect of taxes on the allocation and on real income depends on three key elasticities: firm mobility with respect to profits, worker mobility with respect to real income, and import demand with respect to import prices. Formally, the firm- and worker- mobility elasticities result from dispersion in idiosyncratic productivity and amenity shocks across states. The effects also depend on the preference for government spending. In our preliminary exercises, we set the factor-mobility elasticities and the government-share parameters to estimates from the literature on responses of local economic activity to state taxes and we set the demand elasticity to a central value in the international trade literature. We plan to estimate these elasticities using structural relationships that relate variation in trade, worker, and firm counts to variation in sales, income, and corporate taxes across states and over time. For example, the model implies that differences in corporate taxes between states have an effect similar trade costs: the larger are corporate taxes in an exporter state relative to an importer state, the higher the prices faced by the importer and the lower its import share in the goods from that exporter. Therefore, variation in corporate taxes can be used to estimate the trade elasticity. In this preliminary draft, we set these elasticities to central values from the literature.

We perform exploratory counterfactual exercises on the state tax distribution. The role of the counterfactuals is to isolate the impact of policies that have been implemented over time and of reforms typically put forth in public-policy debates on observables (the distribution of economic activity and real income), unobservables (welfare of workers) and aggregate outcomes (aggregate real income in the U.S.). We feed actual policies to initial scenarios where the model either matches the distribution of economic activity (employment, firms, wages, and trade) at the time in which the policy was implemented or the distribution of economic activity currently observed in the U.S. We then use the model to decompose these effects into a direct effect from taxes (keeping prices and government spending constant) and general-equilibrium effects (allowing these variables to change).

The preliminary results align with standard optimal-tax intuitions. In counterfactuals where public spending is not valued and taxes are eliminated, the welfare gains per worker are slightly larger than the tax revenue share in GDP, consistent with a marginal excess burden from distortionary taxation greater than unity. We also find that the welfare gains from eliminating all taxes simultaneously are larger than the sum of the gains from eliminating each tax at a time, which suggests that the distortions caused by each tax may be exacerbated by the presence of the other taxes. Our preliminary results also suggest that moving to full sales-based apportionment of corporate income leads to modest welfare gains. On the contrary, eliminating personal and corporate income taxes and relying solely on sales taxes (a type of reform similar to recent proposals in Kansas) leads to a sizable decrease in welfare when implemented across the U.S., aligning with the concept that narrowing the tax base may increase efficiency costs.

The paper is related to a recent literature that uses quantitative economic-geography models such as Allen and Arkolakis (2013), Caliendo et al. (2014), Ramondo et al. (2012), Redding (2012), Bartelme (2014), and Monte (2014).[5] In terms of question, our paper is distinguished by the study of state taxes and spatial misallocation. This focus drives our modeling choices, estimation, and counterfactuals. The model combines a number ingredients already present these studies, as well as a few new ones dictated by our question.[6] New ingredients include imperfect firm mobility (needed to account for the response of firms to state taxes), a tax structure that encompasses the main taxes used by U.S states, and public goods financed by these taxes which are valued by workers and firms. Methodologically, a central feature of our analysis is the focus on a policy variable that can be directly observed (the distribution of state taxes). In contrast, counterfactuals in this literature are done with respect to variables, such as trade costs or productivity, which are not directly observed.[7] We use the variation in taxes to estimate key elasticities in the model, and we then study the effects of tax changes implemented over time and of reforms typically put forth in public-policy debates. In this sense, our approach shares features with Caliendo and Parro (2014), who, in an international trade context, estimate trade elasticities using changes in tariffs and then simulates their general-equilibrium impact.

Our paper also contributes to the literature on the aggregate effects of misallocation. A com-

[5]These papers have in common the introduction of labor mobility into quantitative trade models with CES preferences such as Eaton and Kortum (2002) or Anderson and Van Wincoop (2003).

[6]As in Redding (2012), labor mobility in our model is imperfect and there is agglomeration through the mobility of imperfectly competitive firms; as in Caliendo et al. (2014), the model allows for heterogeneous production technologies across states and for trade in intermediate inputs, although for simplicity we abstract from the full set of input-output linkages across sectors which are the central feature of their analysis; as in all these papers, congestion depends on decreasing returns to the amount of labor in a given location, in our case generated by an immobile factor of production.

[7]A few recent papers are also concerned with the impact of policies in models of trade and labor mobility. Gaubert (2014) studies subsidies in a model with with heterogeneous firms and externalities from city size, while Ossa (2012) simulates optimal state subsidies.

mon approach consists of measuring distortions as an implied wedge between the observed and the undistorted allocation. In this spirit, Hsieh and Klenow (2007) and Restuccia and Rogerson (2008) focus on the effects distortions in the allocation across firms, while a couple papers analyze misallocation across geographic units: Desmet and Rossi-Hansberg (2013) study misallocation across U.S. cities and Brandt et al. (2013) analyze misallocation across Chinese provinces. Our contribution is to study the spatial misallocation generated by taxes in an environment that captures several spatial linkages. Rather than inferring distortions from wedges, this environment allows us to directly observe the distortions (the distribution of taxes) and to use their variation to estimate the key elasticities (in labor, firm, and good mobility) that determine misallocation.

Finally, our paper also connects with a tradition in public finance of analyzing general equilibrium effects of tax changes. Since at least Harberger (1962), public finance economists recognized the need for a general-equilibrium approach when considering large tax reforms that may affect several sectors or margins of behavior. For example Shoven and Whalley (1972), Ballard et al. (1985), and Ballard et al. (1985), emphasize the importance of general equilibrium effects when analyzing multiple and large changes in policy. These considerations are especially relevant in the context of fundamental state tax reforms.. While recent papers such as Haughwout and Inman (2001), Suárez Serrato and Wingender (2011), and Suárez Serrato and Zidar (2014) quantify local effects of policy changes, we quantify how policy changes in one or in many states impact outcomes in every state and the aggregate economy. Hence, the model can be used to assess the impact of policies, such as tax harmonization across states or a nationwide shift into sales-based taxes, that involve changes in several taxes in many states.[8] The aggregate and regional effects implied by the model depend on elasticities of local economic activity with respect to taxes, and in tune with a large body of work on the local effects of taxes, our work in progress involves the estimation of these elasticities from observed policy changes.[9] Additionally, the presence of trade frictions makes it possible to analyze how state taxes affect bilateral trade flows, and to analyze the distortions on these flows caused by the sales apportionment of corporate income taxes.

2 The State Tax System: Background and Motivating Evidence

In our analysis we focus on three important sources of tax revenue: personal income taxes, corporate income taxes, and sales taxes. These taxes respectively accounted for 35%, 5%, and 47% of total state tax revenue in 2012.[10] Here, we give a quick presentation of each tax, briefly describe

[8]A notable exception to the lack of general-equilibrium analysis of regional taxes is Albouy (2009), who considers the aggregate effects of the distortions in the allocation across U.S. cities caused by federal tax progressivity and nominal wage indexing. Our analysis is in spirit also similar to Altig et al. (2001), who simulate fundamental tax reforms at the federal level in life-cycle economy.

[9]E.g., Bakija and Slemrod (2004), Kleven et al. (2013), and Kleven et al. (2014) estimate the effects of income taxes on migration decisions, Devereux and Griffith (1998) estimate the effect of profit taxes on the location of production of US multinationals, and Goolsbee and Maydew (2000) estimate the effects of labor apportionment of corporate income taxes on the location of manufacturing employment.

[10]The reminder 13% is split between property taxes and other taxes. We abstract from them because property taxes are largely collected at the local level and have very complex and non-systematic rules and structures across

how we introduce each tax in the model, and then show evidence on dispersion in tax rates across states and over time. For our benchmark analysis, we prioritize using the state-level tax rates that can be measured transparently. In the empirical section we discuss how the results change when these rates are modified to account for several institutional features of each tax.

2.1 Main State Taxes

Personal Income Tax Rates States tax the personal income of their residents. The base for personal income taxes includes both labor and capital income. To make comparisons across states, we focus on the average effective tax rate for those whose incomes equal \$50,000 in real 2005 dollars.[11] In 2010, this measure was 3% on average; the states with the highest average income tax rates were Oregon (6%), Hawaii (5.2%), North Carolina (5%), while 7 states had no income tax.[12] In our benchmark analysis we use a flat state income tax common to every resident of each state. This simplification abstracts from the progressivity of the state individual income tax rates.[13] In the empirical section below, we discuss how much we miss by using average tax rates, and how the results depend on applying alternative definitions of the average tax rate.

Corporate Income Tax Rates States also tax the income of corporations. The tax base and tax rate on business income depends on corporate form. The tax base of C corporations is national profits.[14] Tax authorities determine the share of a C corporation's national profits allocated to their state using apportionment rules, which are based on the corporation's activity share within their state. To determine that activity share, states put different weight on three apportionment factors: payroll, property, and sales. Payroll and property factors depend on where goods are produced, and the sales factor depends on where the good is consumed.[15] In 2012, the average corporate tax rate across states was 6.4%; the states with the highest corporate tax rates were Iowa (12%), Pennsylvania (10%), and Minnesota (10%), while 6 states had no corporate tax. Apportionment through sales tends to be more prevalent: 19 states exclusively apportion corporate taxes through sales, while roughly half of the remaining states are divided between 50% or 33% apportionment through sales. Since C corporations account for the majority of net income in the United States, we undertake our baseline analysis treating all business as C-corporations. Then, we discuss how our results change when we apply alternative tax rates. In particular, we take into account that

local areas across the United States.

[11] $t_n^y = \frac{1}{2}\left(\frac{taxfam}{50000} + \frac{taxsngl}{50000}\right)$ where $taxfam$ and $taxsngl$ are tax liabilities for 2 child families and single people. Both groups are from income group 3, which corresponds to \$50,000 in income in 2005 dollars.

[12] Note that 2010 is the most recent year for which TAXSIM individual income tax rate data are available. The 2012 rates are likely fairly similar to those reported here.

[13] The schedule of state tax rates on personal income tends to be progressive, but it is typically flatter than the federal income tax schedule.

[14] Most states limit the tax base for apportionment to profits earned within the "water's edge", i.e., profits from domestic activity.

[15] For example, a single-plant firm j located in state i who with export share s_{ni}^j to each state n pays an corporate tax rate of $\overline{t}^j = t_{fed}^{corp} + t_i^l + \sum_n s_{ni}^j t_n^x$, where t_{fed}^{corp} federal tax rate, $t_n^x = \theta_n^x t_n^{corp}$ is the corporate tax apportioned through sales in state n (where t_n^{corp} is the corporate income tax of state i and θ_n^x is the sum of payroll and property apportionment), and $t_i^l = (1 - \theta_i^x)\, t_i^{corp}$ is the corporate tax apportioned through property and payroll in state i.

business activity from non-C-corporations typically flows through the personal income tax base and is taxed accordingly, and we also take into account that some states grant firm subsidies through corporate tax reductions.

Sales Tax Rate There are two types of sales taxes at the state level: general sales taxes and select sales taxes. General sales taxes are usually paid by the consumer upon final sale at the sales tax rate, and states typically do not levy sales taxes on firms for intermediate inputs or goods that they will resell. In 2012, the average sales tax rate across states was 5%; some of the states with the highest corporate tax rates in 2012 were California (7.5%), Indiana (7%), and New Jersey (10%), while 5 states had no sales taxes. Select sales taxes are applied on specific goods like alcohol, gasoline, or tobacco. In addition, some states provide sales tax abatements and subsidies through sales-tax reductions. We undertake our baseline analysis using general the sales tax rate applied only to final consumer sales, and later on discuss how our results change when we compute an effective sales rate that incorporates select tax sales and sales-tax reductions.

2.2 Dispersion in Tax Rates across States and Over Time

A first type of motivating evidence for our question concerns the degree of dispersion in tax base and tax rates across states and over time. Dispersion across states may plausibly lead to misallocation by distorting the location of firms or workers. Changes in this dispersion over time help motivate specific counterfactuals, in which we use the estimated model to isolate the general-equilibrium effects of actual changes in policy.

Dispersion Across States There is substantial dispersion in the both the structure and scale of state tax systems. Figure 1 shows how much the tax base and rates vary across states. Most states collect both income and sales tax revenue, but some rely almost exclusively on sales tax revenue, such as Texas and Nevada. Others are sales tax free like New Hampshire and Oregon.[16] Panel (a) of Figure 1 shows the dispersion in the tax base across states. The share of tax revenue from sales taxes nearly spans the full support – sales revenue shares range from 5% to 85% of all state tax revenues. Differences in revenue shares reflect differences in tax rates. Panel (b) of Figure 1 shows the 2010 distribution of four key state tax rates: sales, income, corporate, and sales apportioned corporate tax rates. Each type varies across states and corporate tax rates are the most dispersed. For each type of tax, there are at least 4 states with 0% rates. State taxes also differ in scale and thus the size of government. Per capita direct government expenditures ranged from \$3,000 to \$13,00 and averaged roughly \$7,000 in 2010.[17]

[16]Note that no states had zero rates for each type of tax in 2010. States also rely on other revenue sources in addition to taxes such as license fees, service charges for hospitals and schools, insurance trust revenue, and intergovernmental transfers from the federal government.

[17]As a share of sate GDP, direct state spending amounted to 7 to 20 percent in 2010.

Changes over Time Several tax reforms have altered the distribution of state taxes over time. Figure 2 shows the number of state tax rate changes for each type of tax since 1978. In any given year, there are a handful of states that change tax rates by more than 0.5 percentage points for each type of tax. Figure 3 puts these changes into a broader context of the state tax system. It shows how the tax base and rates have evolved. Panel (a) shows that the importance of income tax base has grown.[18] Although this growth did not occur in all states (see Panel (c)), Panel (e) shows that standardized measures of dispersion in the income tax base declined substantially over the last 60 years. Panel (b), (d), and (f) show these measures for state tax rates. With the exception of income taxes, which have been fairly flat, tax rates have increased slightly since 1980. Several state policymakers have been increasing the importance of sales for apportioning corporate income (see Panel (a)), but not all states have followed this trend (see Panel (c)). On a standardized basis, t_n^x has been pretty stable and the dispersion in the other tax rates have been declining since 1980 (see Panel (f)). These differences in state financing structures are becoming increasingly important in aggregate for the U.S. economy. States spending has doubled as a share of GDP since 1950 and now represents roughly one quarter of all government spending (Baicker et al., 2012).

2.3 Relationship Between State Tax Rates and Economic Activity

A second type of motivating evidence for our question concerns the relationship between taxes and economic activity. The impact of tax dispersion across states and over time heavily depends on whether firms, workers, and trade respond to differences in tax rates across states.

Reduced Form Evidence State economic activity tends to increase following tax cuts. Figure 4 shows the correlation between tax changes and factor mobility. Panel (a) shows that state employment shares tend to increase when personal income tax rates decline. For instance, the share of national employment in Colorado increased by 12.5 basis points or roughly 140,000 people following a 2.1 percentage point cut in individual income tax rates from 1995 to 2000. Panel (b) shows a similar negative correlation between state establishment shares and state corporate taxes.[19] Both of these figures use changes in state factor shares and taxes, which difference out time invariant state characteristics. Nonetheless, they are correlations and should be interpreted accordingly.

Trade flows are also correlated with taxes. Figure 5 shows that import shares are negatively correlated with tax rate differences between origin and destination states. Panel (a) shows that states with higher than average sales apportioned corporate tax rates tend to have lower import shares. Panel (b) shows a similar pattern for states with relatively high sales tax rates. Both of these figures report the mean import share for 45 bins of relative taxes. They also include origin and destination fixed effects.[20]

[18] An increase in the revenue share of individual income taxes has been the primary driver of the growth in the importance of the income tax base.

[19] Both of these figures show results from changes that exceed 0.25 percentage points in absolute value.

[20] Note that own trade shares are not shown in these Figures for graphical simplicity, since own trade shares are

Evidence from the Literature There is also some existing evidence on the effects of state taxes on labor mobility and firm mobility. In terms of firm mobility, Holmes (1998) uses state borders to show that manufacturing activity responds to business conditions.[21] Hines (1997) provides perhaps the best evidence by exploiting foreign tax credit rules to show that investment responds to state corporate tax conditions. Suárez Serrato and Zidar (2014) provide evidence on worker and firm mobility and corporate taxes. They show that people and firms move into local areas following business tax cuts. Finally, to the best of our knowledge, there is very little causal evidence on state taxes and internal trade. The reduced-form evidence in this paper is a new contribution to the public finance literature.[22]

3 Model

We model a closed economy with N states which are typically indexed by n or i. A mass M of firms and L workers respectively receive idiosyncratic productivity and preference shocks, which governs how they sort across states. Each state n is characterized by an endowment H_n of fixed factors of production (land and structures), an amenity level u_n common to all consumers, a productivity level z_n common to all firms, and an iceberg trade cost $\{\tau_{in}\}_n$ to every other state $i = 1, .., N$.

Firms are single-plant and sell differentiated products. To produce, they use the fixed factor, workers, and intermediate inputs. Workers receive labor income, which they spend in the state where they live. The returns to the fixed factor and firm profits are aggregated to a national portfolio owned by immobile consumers in different states.

State governments collect income taxes t_n^y, sales taxes t_n^c, corporate income taxes apportioned through sales t_n^x, and corporate income taxes apportioned through payroll and structures, t_n^l. Each state uses the tax revenues to employ workers and fixed factors in order to supply public goods, which enter as shifters in the amenities and the productivity of the workers and firms that locate in that state.

3.1 Aggregate Output

In each state, output of a final good is assembled locally from domestically and imported varieties through a constant elasticity of substitution aggregator (CES) with elasticity σ.[23] Aggregate output

substantially larger than bilateral import shares on average. Regressions that include own trade shares show similar patterns and are provided in the appendix [TO BE ADDED]

[21] Bartik (1991) surveys a substantial amount of evidence on state taxes and business location. In addition, Devereux and Griffith (1998) estimate the effect of profit taxes on the location of production of US multinationals and Goolsbee and Maydew (2000) estimate the effects of labor apportionment of corporate income taxes on the location of manufacturing employment.

[22] Gordon and Hines (2002) for a survey of the international public finance literature.

[23] There is no international trade in the model. We use the word "imports" to refer to state-to-state trade.

is:

$$Q_n = \left(\sum_i \int_{j \in J_i} \left(q^j_{ni} \right)^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}}$$

where J_i denotes the set of firms in state i and q^j_{ni} is quantity supplied to state n by firm j from state i. The pre-tax price of the final good in n is

$$P_n = \left(\sum_i \int_{j \in J_i} \left(p^j_{ni} \right)^{1-\sigma} dj \right)^{\frac{1}{1-\sigma}}, \tag{1}$$

where p^j_{ni} is the price in n of the good produced by firm j. Aggregate output is used for final consumption by individual consumers, and as an intermediate good by firms:

$$Q_n = C_n + I_n,$$

where C_n is the aggregate quantity of final goods demanded by consumers in state n, and I_n is the aggregate quantity of intermediate goods demanded by firms.

Each unit of the final good costs P_n when purchased by a firm as an intermediate good, and $(1 + t^c_n) P_n$ when purchased by an individual consumer for final consumption.

3.2 Workers

There is a continuum of workers $l \in [0, L]$ who decide in which state to live and consume. Each worker l is characterized by a vector of tastes for each state $\{\epsilon^l_n\}_{n=1}^N$. The indirect utility worker l in state n is

$$v^l_n = v_n \epsilon^l_n, \tag{2}$$

where v_n is a level of utility common to all workers who locate in n. This common component of utility is:

$$v_n = u_n \left(G^c_n \right)^{\alpha_W} \left(\frac{1 - t^y_n - t^y_{fed} - t^w_{fed}}{1 + t^c_n} \frac{w_n}{P_n} \right)^{1-\alpha_W}. \tag{3}$$

All workers value the amenities u_n of state n, which act as shifter of Cobb-Douglas preferences between the quantity of public goods G^c_n and the consumption of final goods. In state n, every worker receives a wage rate of w_n, a fraction t^y_n of which is paid in personal income taxes; workers also pay federal income tax t^y_{fed} and federal payroll tax t^w_{fed}. Therefore, each worker's income net of taxes, equal to the expenditure in final goods, is $\left(1 - t^y_n - t^y_{fed} - t^w_{fed}\right) w_n$. Real consumption equals this amount of expenditures normalized by the price of final goods faced by consumers, $(1 + t^c_n) P_n$.[24]

[24] For simplicity we abstract from the non-linearity of the federal income tax scheme. In our empirical analysis we set the value of these taxes to the average rate in the U.S.. As the federal income tax schedule is defined on nominal wages, it may lead to spatial distortions, as analyzed by Albouy (2009). We also note that, in some states, state income taxes can be deducted from federal taxes. This would change the definition of real consumption to

The idiosyncratic taste draw ϵ_n^l is assumed to be iid across consumers and states, and with density described by a Frechet distribution:

$$\Pr\left(\epsilon_n^l < x\right) = e^{-x^{-\varepsilon_W}}, \tag{4}$$

where we assume that $\varepsilon_W > 1$. The location decision of worker l solves $n = \arg\max_i v_i \epsilon_i^l$. Combining (2) and (4), the fraction of workers located in state n is

$$\frac{L_n^S}{L} = \left(\frac{v_n}{v}\right)^{\varepsilon_W}, \tag{5}$$

where

$$v \equiv \left(\sum_n v_n^{\varepsilon_W}\right)^{1/\varepsilon_W}. \tag{6}$$

The distributional assumption on the idiosyncratic taste draw implies that the ex-ante expected utility of a worker before drawing $\{\epsilon_n^l\}$ and the average ex-post utility of agents that locate in every state is proportional to v.[25] Therefore, we use v as our measure of worker welfare. In our counterfactuals, we also report the change real consumption in the aggregate economy as a second welfare measure.

A larger value of ε_W implies that the idiosyncratic shocks become less dispersed across states; as a result, locations become closer substitutes, and an increase in the appeal of a location v_n/v leads to larger response in the fraction of workers. Given wages, prices, amenities, and public goods, ε_W also stands for the partial elasticity of the fraction of workers who locate in state n with respect to the state and federal taxes on income and sales, as captured by the term $\frac{1-t_n^y-t_{fed}^y-t_{fed}^w}{1+t_n^c}$.

3.3 Firms

There is a continuum of firms $j \in [0, M]$ who decide in which state to locate and produce and how much to sell to every state. Each firm j is endowed with a vector of productivities $\left\{z_i^j\right\}_{i=1}^N$ across states. Firms are owned by immobile agents in different states, who consume where they live.

All firms face corporate taxes apportioned through sales, payroll, and property. This means that a firm j located in state i with pre-tax profits $\tilde{\pi}_i^j$ whose share of sales to state n is s_{ni}^j pays $s_{ni}^j t_n^x \tilde{\pi}_i^j$ in corporate taxes to state n apportioned through sales. Because firms are assumed to be single-plant, the same firm also pays $t_i^l \tilde{\pi}_i^j$ in corporate income taxes to state i apportioned through payroll and through land and structures.[26] Finally, firms also pay a fractiont_{fed}^{corp} of pre-tax profits

$\frac{\left(1-t_{fed}^y\right)\left(1-t_n^y\right)-t_{fed}^w}{1+t_n^c}\frac{w_n}{P_n}$. In our empirical analysis we inspect the implications of this assumption.

[25]The constant of proportionality equals $\Gamma\left(\frac{\varepsilon_W-1}{\varepsilon_W}\right)$, where m $\Gamma(\cdot)$ is the gamma function.

[26]We are implicitly assuming that all companies are C-corporations, so that companies pay corporate income taxes. In practice, many companies are set up as S-corporations which are not subject to corporate income taxes. In the empirical section, we also allow for only a subset of firms to be C-corporations.

in federal corporate income taxes.

To produce in region i, firm j uses its own productivity in that location, z_i^j, and combines it with land land and structures h^j, workers l^j and intermediate inputs i^j through a Cobb-Douglas technology. The production technology of firm j if it locates in state i is

$$q^j = z_i^j \left[\frac{1}{\gamma_i} \left(\frac{h^j}{\beta_i} \right)^{\beta_i} \left(\frac{l^j}{1-\beta_i} \right)^{1-\beta_i} \right]^{\gamma_i} \left(\frac{i^j}{1-\gamma_i} \right)^{1-\gamma_i}, \tag{7}$$

where γ_i is the value-added share in production of every firm in state i, and where $1-\beta_i$ is the labor share in value added in state i.[27] Firms also use the final good as as intermediate input. Because the sales tax t_i^c applies only to sales of consumption goods, the cost of a unit of intermediate goods is simply P_i. The cost of a bundle of factors and intermediate inputs is

$$c_i = \left(w_i^{1-\beta_i} r_i^{\beta_i} \right)^{\gamma_i} P_i^{1-\gamma_i}, \tag{8}$$

where r_i stands for the cost of a unit of land and structures in state i.

Firm productivity z_i^j is decomposed into a term z_i^1 which is common to all firms who locate in i and a firm-state specific component ϵ_i^j:

$$z_i^j = z_i^1 \epsilon_i^j.$$

In turn, the common component includes a state-specific fundamental z_i and the amount of public goods G_i^f:

$$z_i^1 = z_i^{1-\delta} \left(G_i^f \right)^{\delta}. \tag{9}$$

Profit Maximization Conditional on Location When firm j from state i sets price p_{ni}^j in state n, the quantity and value exported to state n are:

$$q_{ni}^j = Q_n \left(\frac{p_{ni}^j}{P_n} \right)^{-\sigma}$$

$$x_{ni}^j \equiv p_{ni}^j q_{ni}^j = E_n \left(\frac{p_{ni}^j}{P_n} \right)^{1-\sigma}$$

where $E_n \equiv P_n Q_n$ are aggregate expenditures in state n.

The after-tax profits of firm j if it locates in state i is then

$$\pi_i^j = \max_{\{p_{ni}^j\}} \left(1 - \overline{t}_i^j \right) \left(\sum_{n=1}^{N} x_{ni}^j - \sum_{n=1}^{N} \frac{\tau_{ni} c_i}{z_i^j} q_{ni}^j \right)$$

[27]Production functions are allowed to vary by state. This flexibility is needed to match the shares of of labor and intermediate inputs used by firms in each state.

where the tax rate paid by firm j is $\bar{t}_i^j = t_{fed}^{corp} + t_i^l + \sum_{n=1}^N t_n^x s_{ni}^j$, and where $s_{ni}^j = x_{ni}^j / \sum_{n=1}^N x_{ni}^j$ is the share of firm $j's$ sales to state n.

Except for the presence of taxes, this is a standard production and export decision. Due to the sales apportionment of corporate taxes, the decision of how much to sell to each state is not separable across states: when a firm increases the fraction of its sales to state n (so that s_{ni}^j increases), the average tax rate $\bar{t}_i^j$ may increase or decrease depending on the sales-apportioned corporate tax in state n, t_n^x, relative to other states. Since the corporate tax rate is applied on the national pre-tax profits of the firm, the firm trades off the benefit of exporting more to one state against the cost of reducing its nationwide after-tax profits.

Despite this interdependency, the solution to the firm problem retains several convenient features of the standard CES maximization problem that allows for aggregation. First, all firms located in the same state choose the same export shares, $s_{ni}^j = s_{ni}$, implying that all firms receive the same average tax rate:

$$\bar{t}_i = t_{fed}^{corp} + t_i^l + \sum_{n=1}^N t_n^x s_{ni}. \tag{10}$$

for all $j \in J_i$.

Second, firms set constant markups over marginal costs. However, these markups vary bilaterally depending on corporate taxes. The price set in n by a firm with productivity z located in state i is:

$$p_{ni}(z) = \tau_{ni} \frac{\sigma}{\sigma - \tilde{t}_{ni}} \frac{\sigma}{\sigma - 1} \frac{c_i}{z}, \tag{11}$$

where

$$\tilde{t}_{ni} \equiv \frac{t_n^x - \sum_{n'} t_{n'}^x s_{n'i}}{1 - \bar{t}_i}. \tag{12}$$

The term $\tilde{t}_{ni}$ is markup distortion created by heterogeneity in sales-apportioned corporate taxes. Markups are higher to states with higher sales-apportioned taxes t_n^x and from states with higher average tax rates $\bar{t}_i$. If there is no dispersion in sales-apportioned corporate tax ($t_n^x = t^x$ for all states n) then $\tilde{t}_{in} = 0$ for all i and n, implying that the pricing decision is undistorted through this margin.

For some manipulations below, it is useful to write down the expression for bilateral firm-level exports. Since firms are heterogeneous in productivity only, we define $x_{ni}\left(z_i^j\right) \equiv x_{ni}^j$ as the exports from n to i of firm j when it locates in n:

$$x_{ni}(z) = E_n \left(\frac{p_{ni}(z)}{P_n}\right)^{1-\sigma}. \tag{13}$$

Finally, firm profits are proportional to total revenues. The after-tax profits of a firm located in i whose total sales are x are:

$$\pi_i(z) = (1 - \bar{t}_i) \frac{x_i(z)}{\sigma}. \tag{14}$$

where $x_i(z) = \sum_{n=1}^{N} x_{ni}(z)$ are total exports of a firm with productivity z located in i. Pre-tax profits of this firm are $\frac{x_i(z)}{\sigma}$.

Firm Location Using (14), firm-level profits can be written as:

$$\pi_i\left(z_i^j\right) = \pi_i\left(z_i^1\right)\left(\epsilon_i^j\right)^{\sigma-1}. \tag{15}$$

As with consumers, the idiosyncratic component is iid across firms and states, and drawn from a Frechet distribution, $\Pr\left(\epsilon_i^j < x\right) = e^{-x^{-\varepsilon_F}}$. This leads to a Frechet distribution for firm profits:

$$\Pr\left(\pi_i\left(z_i^j\right) < x\right) = e^{-x^{-\frac{\varepsilon_F}{\sigma-1}}}, \tag{16}$$

where we assume that $\varepsilon_F > \sigma - 1$. The location of firm j solves is $n = \arg\max_i \pi_i\left(z_i^j\right)$. Combining (15) and (4), the fraction of firms located in state n is

$$\frac{M_n}{M} = \left(\frac{\pi_n\left(z_n^1\right)}{\bar{\pi}}\right)^{\frac{\varepsilon_F}{\sigma-1}}, \tag{17}$$

where

$$\bar{\pi} = \left(\sum_i \pi_i\left(z_i^1\right)^{\frac{\varepsilon_F}{\sigma-1}}\right)^{\frac{\sigma-1}{\varepsilon_F}}. \tag{18}$$

Equation (17) says that that the fraction of firms located in n depends on a measure of market potential, $\pi_n\left(z_n^1\right)$, relative to other locations.

The Frechet distribution implies that average profits in every location are proportional to $\bar{\pi}$.[28] A larger value of $\varepsilon_F/\sigma-1$ implies that the idiosyncratic shocks become less dispersed across states. As a result, locations become closer substitutes, and an increase in relative market potential $\pi_n\left(z_n^1\right)/\bar{\pi}$ leads to larger response in the fraction of firms.

Average Productivity As in Melitz (2003a), the aggregation of firm-level decisions allows to characterize state-level outcomes as function of the geometric average of productivities,

$$\tilde{z}_n = \left(\int_{j\in J_n} \left(z_n^j\right)^{\sigma-1} dj\right)^{\frac{1}{\sigma-1}}.$$

[28]The constant of proportionality is $\Gamma\left(1 - \frac{\sigma-1}{\varepsilon_F}\right)$ where $\Gamma(\cdot)$ is the gamma function.

Average profits in state n equal $\pi(\tilde{z}_n)$, i.e. they correspond to the level of profits made by the a with productivity $\tilde{z}_n$. In turn, the distributional assumption on the idiosyncratic productivity draws implies that $\pi(\tilde{z}_n) = \bar{\pi}$ in every state. Combining this with (17) and noting that by definition $\pi_n(z_n^1) = \pi_n(\tilde{z}_n)(z_i^1/\tilde{z}_i)^{\sigma-1}$, we can express average productivity of firms located in n as:

$$\frac{\tilde{z}_n}{z_n^1} = \left(\frac{M_n}{M}\right)^{-\frac{1}{\varepsilon_F}}. \tag{19}$$

The average productivity of firms located in i is larger that the unconditional average of the distribution of productivity draws, $\tilde{z}_n/z_n^1 > 1$, reflecting selection. This equation describes one of the congestion forces in the model: because firms are heterogeneous and self-select based on productivity, a higher fraction of firms in a particular state is associated with lower average productivity in that state.

3.4 State Aggregates

Trade Flows and Prices Using (13), aggregate exports from state i to state n are $X_{ni} = M_i x_{ni}(\tilde{z}_i)$. Combining with (11) and (19) we obtain:

$$\begin{aligned} X_{ni} &= M^{\frac{\sigma-1}{\varepsilon_F}} M_i^{1-\frac{\sigma-1}{\varepsilon_F}} x_{ni}(z_i^1) \\ &= M^{\frac{\sigma-1}{\varepsilon_F}} M_i^{1-\frac{\sigma-1}{\varepsilon_F}} E_n \left(\frac{\tau_{ni}}{P_n}\frac{\sigma}{\sigma-1}\frac{\sigma}{\sigma-\tilde{t}_{ni}}\frac{c_i}{z_i^1}\right)^{1-\sigma}, \end{aligned} \tag{20}$$

This is a standard expression for exports in monopolistic competition setups except for 2 features. First, the partial elasticity of exports with respect to the measure of firms is $1 - \frac{\sigma-1}{\varepsilon_F} < 1$. As $\varepsilon_F \to \infty$ firms become perfectly mobile, which corresponds to the case in Krugman (1980) or Melitz (2003b) in which exports are proportional to the measure of firms. Second, the difference between corporate taxes at origin and destination, as captured by $\tilde{t}_{ni}$, create a distortion akin to a the bilateral trade cost.

Using (20), we obtain aggregate sales from state i,

$$X_i = \sum_n M^{\frac{\sigma-1}{\varepsilon_F}} M_i^{1-\frac{\sigma-1}{\varepsilon_F}} E_n \left(\frac{\tau_{ni}}{P_n}\frac{\sigma}{\sigma-1}\frac{\sigma}{\sigma-\tilde{t}_{ni}}\frac{c_i}{z_i^1}\right)^{1-\sigma}, \tag{21}$$

and, combining (20) with (21), we obtain the export shares needed to compute the tax rates $\{\bar{t}_i, \tilde{t}_{ni}\}$ in (10) and (12):

$$s_{ni} \equiv \frac{X_{ni}}{X_i} = \frac{E_n\left(\frac{\tau_{ni}}{P_n}\frac{\sigma}{\sigma-\tilde{t}_{ni}}\right)^{1-\sigma}}{\sum_{n'} E_{n'}\left(\frac{\tau_{n'i}}{P_{n'}}\frac{\sigma}{\sigma-\tilde{t}_{ni}}\right)^{1-\sigma}}. \tag{22}$$

where $X_n \equiv \sum_{i=1}^N X_{in}$ are aggregate sales in n.

In these expressions, the price index results from combining (1), (11), and (19):

$$P_n = \left(M^{\frac{\sigma-1}{\varepsilon_F}} \sum_i M_i^{1-\frac{\sigma-1}{\varepsilon_F}} p_{ni} \left(z_i^1\right)^{1-\sigma} dj \right)^{\frac{1}{1-\sigma}}. \tag{23}$$

We remind the reader that, in these expressions, the productivity of each state, z_i^1 is given by the composite between the state's fundamental and government spending in (9).

Factor Demand Let L_n^F and H_n^F be the aggregate labor and and land demanded by firms (as discussed below, governments also employ labor and land), let I_n be the aggregate demand for intermediate goods. The Cobb-Douglas technology assumption (7) coupled with CES demand and monopolistic competition then implies the following division of sales in state n into payments to intermediate inputs, workers, and land:

$$P_n I_n = (1-\gamma_n) \frac{\sigma-1}{\sigma} X_n, \tag{24}$$

$$w_n L_n^F = (1-\beta_n) \gamma_n \frac{\sigma-1}{\sigma} X_n, \tag{25}$$

$$r_n H_n^F = \beta_n \gamma_n \frac{\sigma-1}{\sigma} X_n. \tag{26}$$

The difference between X_n and sum of these components equals pre-tax profits in state n,

$$\tilde{\Pi}_n = \frac{X_n}{\sigma}. \tag{27}$$

After corporate income taxes, aggregate profits are

$$\Pi_n = \left(1 - \bar{t}_n\right) \frac{X_n}{\sigma}.$$

Aggregate Spending We turn to how these payments factor of productions show up in aggregate demand. Consider, first, personal consumption expenditures in final goods. L_n^S workers located in state n spend their after-tax income $\left(1 - t_n^y - t_{fed}^y - t_{fed}^w\right) w_n$ in final goods. Additionally, we must take a stand on where the returns to fixed factors and firms is spent. We assume a fraction b_n of the national portfolio of land and firm profits is spent in state n. Therefore, personal consumption expenditures of state n are:

$$\left(1+t_n^c\right) P_n C_n = \left(1 - t_n^y - t_{fed}^y - t_{fed}^w\right) w_n L_n^S + \left(1 - t_n^y - t_{fed}^y\right) b_n \left(\Pi + R\right), \tag{28}$$

where $R = \sum_n r_n H_n$ are national returns to land and structures and $\Pi = \sum_n \Pi_n$ is the national portfolio of firm profits. Gross domestic income of state n is therefore $w_n L_n + b_n \left(\Pi + R\right)$.

Combining (24) and (28), aggregate expenditures $E_n \equiv P_n \left(C_n + I_n\right)$ in state n are:

$$E_n = \frac{1 - t_n^y - t_{fed}^y - t_{fed}^w}{1 + t_n^c} w_n L_n^S + \frac{1 - t_n^y - t_{fed}^y}{1 + t_n^c} b_n (\Pi + R) + (1 - \gamma_n) \frac{\sigma - 1}{\sigma} X_n. \tag{29}$$

Because of the returns to the factors of production in one state may be owned by residents of other states, spending and sales in each state are not the same. States that hold a higher-than average share of the returns to fixed factors and profits will also spend more than what they sell, $X_n > D_n$, giving rise to a trade deficit. By construction, $X_n = E_n$ in every state if all taxes are zero and the payments to firms and land are spent locally. In the quantitative analysis, we will set set the distribution of payments b_n in 29 such that the deficits predicted by the model are consistent with the data.

3.5 State Government

Revenue Government revenue in state n equals the sum of revenue for corporate, sales, and income taxes:

$$R_n = R_n^{corp} + R_n^c + R_n^y$$

Corporate taxes collected through sales and payroll are:

$$\begin{aligned} R_n^{corp} &= t_n^x \sum_{n'} s_{nn'} \tilde{\Pi}_{n'} + t_n^l \tilde{\Pi}_n \\ &= \left(t_n^x D_n + t_n^l \right) \frac{X_n}{\sigma} \end{aligned}$$

where the second line uses 27 and the definition of the measure of deficit,D_n. In turn, revenues from sales and income taxes are, respectively:

$$\begin{aligned} R_n^c &= t_n^c P_n C_n, \\ R_n^y &= t_n^y \left(w_n L_n + b_n (\Pi + R) \right). \end{aligned}$$

Spending Government use tax revenues R_n to finance the provision of public goods.[29] To supply public goods, the government combines labor and land using to a Cobb-Douglas technology. The total amount of public goods in state n are:[30]

$$G_n = \frac{z_n^G R_n}{w_n^{1-\beta_n^G} r_n^{\beta_n}}, \tag{30}$$

[29]We do not model the use of federal revenues, which is consistent with assuming that federal spending does not affect the allocation of workers across states or over time. This is the case if federal revenue is spent in the provision of public goods, such as national defense of social security, whose availability is common in all states.

[30]It is equivalent to assume that public goods are offered by a competitive sector that supplies only the government at a cost of $\frac{w_n^{1-\beta_n^G} r_n^{\beta_n}}{z_n^G}$ or that the government hires labor and land and structures directly.

where z_n^G captures the efficiency of state n in the production of public goods, and where$1-\beta_n^g$ and β_n^g are the shares of labor and of land and structures in government revenue:

$$1-\beta_n^G = \frac{w_n L_n^G}{R_n}, \tag{31}$$

$$\beta_n^G = \frac{r_n H_n^G}{R_n}. \tag{32}$$

Finally, we let the public goods valued by consumers and firms be, respectively, constant fractions of the total amount of public goods: $G_n^c = \theta_n^c G_n$ and $G_n^f = \theta_n^f G_n$.

3.6 General Equilibrium

We are now in conditions to define the general equilibrium. An equilibrium consists of worker utility v, a profit rate $\overline{\pi}$, wages $\{w_n\}_{n=1}^N$, rental rates $\{r_n\}_{n=1}^N$, price indexes $\{P_n\}_{n=1}^N$, a labor allocation $\left\{L_n^F, L_n^G\right\}_{n=1}^N$, an allocation of land and structures $\left\{H_n^F, H_n^G\right\}_{n=1}^N$, a firm allocation $\{M_n\}_n$, aggregate sales $\{X_n\}_n$, such that:

1. the budget constraint clears in every state, i.e. the distribution of aggregate sales $\{X_n\}$ is consistent with (21) for all n, where spending E_n is given by (29);
2. the price index $\{P_n\}$ in each state n is given by (23);
3. wages $\{w_n\}$are such that the labor market clears within each state, i.e. $L_n^F + L_n^G = L_n^S$, where L_n^S is given by (5) , L_n^F is given by (25), and L_n^G is given by (31);
4. rental rates $\{r_n\}$are such that the land and structures market clears for each n, i.e. $H_n^F + H_n^G = H_n$, H_n^F is given by (26), and H_n^G is given by (32);
5. the number of firms $\{M_n\}$ is given by (17) for all n;
6. states have balanced budgets, i.e. G_n is given by (30);
7. the utility level v is given by (6); and
8. the profit rate $\overline{\pi}$ is given by (18).

3.7 General Equilibrium in Relative Changes

The model inherits a number of properties from existing models of trade and economic geography which facilitate the implementation of counterfactuals. First, given parameters (preferences and technology) and taxes, the model has enough flexibility in the fundamentals (productivity, amenities, and trade costs) to rationalize the observed distribution of economic activity (employment, firms, wages, and trade) as an equilibrium outcome. Second, as in Dekle et al. (2008), the percentage changes in aggregate outcomes and in the distribution of economic activity stemming from percentage changes in taxes and in fundamentals (productivity, amenities, and trade costs) can be fully determined using information on the observed distribution of economic activity (employment, firms, wages, and trade) and the parameters (preferences and technology) , without the need to specify the values of these fundamentals. Appendix A describes the system of equations used for the counterfactuals.

4 Preliminary Parametrization

4.1 Data Sources and Construction of Variables

In this section, we describe each variable used in estimation and briefly discuss how we construct it. We assembled data on state economic activity state fiscal policy from several sources. In terms of economic activity, we have data on factor allocations, prices, trade flows, income, and expenditures. We have fiscal policy data on tax rates, tax revenues, and government spending.

Data on factor allocations, i.e., fractions of firms M_n and employment L_n, and payroll w_nL_n are from the County Business Patterns (CBP) and are available from 1986-2010. [31] We use the Commodity Flow Survey (CFS) to measure the value of trade flows, X_{in}^M, which is available for the following years: 1993, 1997, 2002, 2007, and 2012. Data on sales X_i are from the Economic Census of the United States (Economic Census) and are also available every five years. However, the most recent Economic Census data available are from 2007.[32] In terms of income, the Bureau of Economic Analysis (BEA) provides data on factor payments, i.e., $w_nL_n^F + r_nH_n^F$, and on value added, i.e., $value.added = \tilde{\Pi}_n + w_nL_n^F + r_nH_n^F$, from 1963 to 2012. The difference between sales and value added gives expenditures on intermediate goods: P_nI_n. Expenditures on final goods, P_iC_i, are also available from a new dataset from the BEA on Personal Consumption Expenditures from 1997 to 2012. We combine this data with the trade data to measure the trade deficit $D_i \equiv \frac{E_i}{X_i} = \frac{P_iI_i + P_iC_i}{X_i}$ as well as a consistent value of own-trade $X_{ii} = X_i - \sum_n X_{ni}^M$.[33]

Tax rate, tax revenue, and government spending data are from several sources. Data on sales taxes, personal income tax rates, corporate taxes, and other taxes are available 1975-2012, 1977-2010, 1978-2012, and 1950-2012, respectively. The sales tax rate t_n^c is from Table 7.10 State Excise Tax Rates in the Book of States. State individual income tax rate t_n^y is an average effective state tax rate on individual income from NBER TAXSIM.[34] We use state corporate tax rate and apportionment data on t_n^x and t_n^l are from Suárez Serrato and Zidar (2014). Data on state tax revenue and expenditures are from the Census of Governments. Both total tax revenues and revenues from individual income, corporate income, and sales are available from 1950-2012. Spending in public

[31] Hurst et al. (2015) generously shared price P_n data in recent years.

[32] Note that payroll and establishment data are also available from the Economic Census. For consistency, we use the same source, i.e., the Economic Census, for years in which we have sales data available when doing counterfactuals. For estimtation we use CBP, which avoids the concern than switching data sources will affect our results. Overall, both measures are very similar.

[33] This consistent definition is needed since data on sales from the Economic Census is for the entire economy, while trade data from the CFS are available for a subset of trade-related sectors.

[34] In particular, $t_n^y = \frac{1}{2}\left(\frac{taxfam}{50000} + \frac{taxsngl}{50000}\right)$ where $taxfam$ and $taxsngl$ are tax liabilities for 2 child families and single people. Both groups are from income group 3, which corresponds to $50,000 in income in 2005 dollars. `http://users.nber.org/~taxsim/state-tax-tables/`

goods only by state as well as government spending by category are available from X-Z. We use direct government spending as our preferred measure of government spending to avoid complications related to transfers from the federal government. Finally, state government spending on labor $w_n^G L_n^G$ as well as the value added from state government are from the BEA from 1963 to 2012. The difference between state government value added and labor compensation gives state government spending on intermediate goods, which we use when characterizing the production functions of state governments.

4.2 Calibrated Parameters

We set the technology parameters in the model to match direct empirical counterparts in the the data, as described in Table 1. Additionally, we set the asset positions $\{b_n\}$ to match the trade deficits observed in the data. In the model, the ratio between expenditures and sales is given by:

$$\frac{E_n}{X_n} = b_n \frac{1 - t_n^y - t_{fed}^y}{1 + t_n^c} \sum_i \left(\frac{1 - \overline{t_i} + \beta_i^H}{\sigma} \right) \frac{X_i}{X_n} + \frac{1 - t_n^y - t_{fed}^y - t_{fed}^w}{1 + t_n^c} \frac{w_n L_n}{X_n} + (1 - \gamma_n) \frac{\sigma - 1}{\sigma}$$

where $\beta_i^H \equiv \beta_n \gamma_n (\sigma - 1) + \beta_{G,n} \frac{R_n}{X_n}$ equals the share of returns to land in total sales. Using the parameters, taxes, and observed distributions $\{E_n, X_n, w_n L_n, R_n\}$, this equation determines a unique value of b_n for each region.

Parameter	Notation	Match in the Data	Average
Share of intermediates in production in state n	$1 - \gamma_n$	$1 - \gamma_n = \frac{\sigma}{\sigma - 1} \frac{P_n I_n}{X_n}$	0.62
Labor Share in Production in State n	$1 - \beta_n$	$1 - \beta_n = \frac{\sigma}{\sigma - 1} \frac{w_n L_n^F}{\gamma_n X_n}$	0.68
Labor Share in Government Production in State n	$1 - \beta_n^G$	$1 - \beta_n^G = \frac{w_n L_n^G}{R_n}$	0.47

Table 1: Calibrated Parameters

4.3 Elasticities and Preference for Government Spending Parameters

In our preliminary exercises, we set the labor mobility parameter ε_W and the firm mobility parameter ε_F to reduced-form estimates of the impact of taxes on local economic activity from Suárez Serrato and Wingender (2011). We also inspect counterfactuals in which there is either no preference for public spending by either workers or firms ($\alpha_F = \alpha_W = 0$), and counterfactuals where these parameters are set to the reduced-form estimations of the impact of public spending on local economic activity from Suárez Serrato and Wingender (2011). Finally, the demand elasticity σ is set to a central value from the range of estimates reported by Head and Mayer (2013).

The parameters are summarized in Table 2. In work in progress, we estimate these parameters using structural relationships that relate variation in trade, worker, and firm counts to variation in sales, income, and corporate taxes across states and over time.

Parameter	Notation	Value	Source
Demand Elasticity	σ	4.5	Head and Mayer (2013)
Labor supply elasticity	ε_W	1.5	Suárez Serrato and Zidar (2014)
Firm supply elasticity	ε_F	3.5	
Share of public goods preferences	α_W	$\{0, 0.3\}$	Suárez Serrato and Wingender (2011)
Share of public goods technology	α_F	$\{0, 0.1\}$	

Table 2: Elasticities and Preference for Government Spending

5 Preliminary Counterfactuals

We undertake exploratory counterfactuals to assess the effects of alternative tax structures on the distribution of economic activity and aggregate outcomes. The model matches the initial distribution of economic activity (fraction of establishments, employment, import shares, and export shares) in 2012 for these counterfactuals.

5.1 Removing Taxes when $\alpha_W = \alpha_F = 0$

We consider first a scenario with no preference for public goods by workers and no use of public goods by firms: $\alpha_W = \alpha_F = 0$. Since tax revenue is not rebated to workers, reduction in taxes directly translate to an increase in consumption. Consider first reducing the average personal income tax in California from its actual value of 2.85% to 0%. Since there is no preference for public goods, this counterfactual necessary entails a welfare gain. Since California represents 13% of U.S. GDP, the direct effect of this reform (keeping the distribution of economic activity and prices constant) is similar to increasing expenditures per worker by $13\% * 2.85\% = 0.3\%$. Consistent with the presence of distortionary taxation, we find a slightly larger welfare gain of 0.4%. This implies that raising 0.3% of GDP incurs an excess burden (in terms of workers' welfare) of 0.1%. Table 3 shows the impact of this reform on California and on average across states of the U.S. Lower income taxes in California lead to an inflow of workers and firms and to an increase in the real wage and GDP, and to a reduction in these variables in the rest of the U.S.

Figure 6 shows how this tax change impacts every state. The upper panel shows the percentage change in the keep rate (one minus the tax rate) of each tax in every state. The reduction in taxes in California leads to heterogeneous effects across states. Some states with close economic links with California (such as Oregon) experience an increase in economic activity thanks to the inflow of firms and workers to California, while most states lose. Across states, there is a strong correlation between the changes in employment, firms, and real wages.

A benefit of our approach is the ability to analyze the effects of multiple, simultaneous tax changes. We next consider the effects of reducing income tax rates to 0% in every state. The results are displayed in Figure 7. There is a relatively smaller increase in employment, firms, and real wages in California relative to the case in which only California income taxes are reduced. Additionally, states that initially had low income tax rates (such as Texas) are affected by especially sharp reductions in economic activity. Figure 8 further shows the impact of reducing every tax rate to 0% in every state. Some states with relatively high income taxes (such as Oregon on Montana), which saw an increase in economic activity when only income taxes were reduced, experience a reduction in economic activity.

Table 4 shows how counterfactuals in which taxes are removed impact worker's welfare and average real wages across states. When all taxes are removed, welfare increases by 14% and real wages increase on average by 9% across states, as government spending is not valued in this counterfactual. The table also shows results when each tax is removed. The ranking of these taxes in terms of their impact on welfare and real wages follows their ranking in revenue shares, although the impact of the sales taxes relative to other taxes is larger than its share in revenues relative to other taxes. We also find that the effect on welfare from removing all taxes is larger than the sum of the effects from removing each individual tax. This complementarity suggest that the distortions caused by each tax may be exacerbated by the presence of the other taxes.

Change in	California	Average in rest of US
v	0.4%	0.4%
$\frac{w_i}{P_i}$	5%	-0.1%
Employment	12%	-2%
Firms	17%	-3%
GDP	15%	-3%

Parameters: $\varepsilon_W = 1.5$; $\varepsilon_F = 3.5$; $\sigma = 4.5$

Table 3: Income Tax to Zero in California

Counterfactual	Change in v	Average Change in $\frac{w_i}{P_i}$
All state taxes to zero	14%	9%
Only sales tax to zero	7%	5%
Only income tax to zero	4%	2.5%
Only corporate taxes to zero	0.6%	1%

Parameters: $\varepsilon_W = 1.5$; $\varepsilon_F = 3.5$; $\sigma = 4.5$

Table 4: Taxes to Zero in Every State

5.2 Removing Tax Dispersion

The next counterfactual examines the effects of removing tax dispersion by replacing the tax rate for each type of tax in every state with the average tax rate across states for each type of tax.[35] Table 5 presents the results for a case in which only workers value public goods, and for a case in which firms also use public goods. In the first case, reducing tax dispersion leads to an increase in worker welfare and real wages. This effect results partly from a reduction in misallocation and from

[35] In this counterfactual, the level of taxes distorts the allocation of workers and firms compared to a situation in which there are no taxes due to the interaction between endogenous government spending and heterogeneous technologies across states. If either of these margins is shut down, the level of taxes does not affect the equilibrium distribution of employment, firms, or wages.

an increase in government spending. When firms have a higher valuation for government spending, the impact from reducing tax dispersion on welfare is larger, and also partly operates though a larger increase in government spending.

Preference for G	Change in v	Average change in $\frac{w_i}{P_i}$	Average Change in G_i
$\alpha_W = 0.3$; $\alpha_F = 0$	0.9%	0.4%	13%
$\alpha_W = 0.3$; $\alpha_F = 0.04$	1.4%	0.7%	18%

Parameters: $\varepsilon_W = 1.5$; $\varepsilon_F = 3.5$; $\sigma = 4.5$

Table 5: Removing Tax Dispersion

5.3 Alternative Tax Schemes

We explore alternative tax schemes that reflect the current tax-reform proposals that have been discussed in the introduction. Table 6 shows the effect on worker welfare, v, that results from replacing the distribution of tax rates that we currently observed with alternative tax distributions. We perform each counterfactual in a case where public goods is not consumed by workers and not used by firms ($\alpha_W = \alpha_F = 0$) and another cases in which it is valued by both workers and firms.

The first line considers what would happen if the apportionment of corporate tax rates was done exclusively through payroll. This amounts to setting the sales-apportioned corporate tax of state i (t_i^x) to a new value $(t_i^x)' = 0$, and to setting the payroll-apportioned corporate tax (t_i^l) to a new value $(t_i^l)' = t_i^l + t_i^x$. As a result of this reform, welfare is reduced in the case with no preference for public goods, but it increases when there is valuation for government spending. To the contrary, welfare increases slightly in the case of a movement to full corporate sales apportionment ($(t_i^x)' = t_i^l + t_i^x$) when public goods are not valued, but it decreases otherwise.

The third line considers what would be the effect of removing income taxes (on both individuals and corporations), at the same time that sales taxes are sufficiently increased to preserve a constant share of government revenue in total sales. We find that this would result in a welfare loss. The welfare loss is approximately the same regardless of preference for government spending, which is a consequence of keeping public revenues relative to total revenues constant.[36] Hence we can interpret the welfare effect as stemming almost exclusively from factor reallocations. The result suggests that a full sales-based tax system would not be welfare-enhancing at the current levels of government size.

Counterfactual	$\alpha_W = \alpha_F = 0$	$\alpha_W = 0.3;\alpha_F = 0.1$
No corporate-sales apportionment	-1.2%	0.8%
Full corporate-sales apportionment	0.03%	-0.5%
Only sales taxes, $\frac{R_i}{X_i}$ constant	-3%	-2.8%

Parameters: $\varepsilon_W = 1.5$; $\varepsilon_F = 3.5$; $\sigma = 4.5$

Table 6: Change in Worker Welfare under Alternative Tax Schemes

[36] Even though $\frac{R_i}{X_i}$ is constant, government spending per worker may still change in this counterfactual.

5.4 Rolling Back the Tax Distribution to 1980

Finally, to have a sense of what was the effect of the changes in the tax distribution that took place in the last few decades, we undertake a counterfactual where we replace the current distribution of tax rates for the 1980 distribution. Table 7 reports the results under different valuations for public goods. As we have noted before, the average rate across states has increased since 1980 for all the types of taxes that we consider, while the coefficient of variation across states has decreased.

The first line suggests that replacing the current tax structure for the 1980 tax structure would result in an increase in worker welfare if there is workers and firms do not use public goods. This results from the fact that the lower tax rates from 1980 lead to lower average government spending. However, when workers or firms use public goods, replacing the current tax structure for the 1980 one results in a welfare loss. This suggests that increase in the average tax rates and the reduction in the dispersion of tax rates experienced since 1980 resulted in higher welfare.

Preference for G	Change in v	Average change in G_i
$\alpha_W = 0$; $\alpha_F = 0$	1.9%	-13.5%
$\alpha_W = 0$; $\alpha_F = 0.1$	-2.5%	-11.3%
$\alpha_W = 0.3$; $\alpha_F = 0$	-2.9%	-12.2%
$\alpha_W = 0.3$; $\alpha_F = 0.1$	-5.9%	-12.1%

Parameters: $\varepsilon_W = 1.5$; $\varepsilon_F = 3.5$; $\sigma = 4.5$

Table 7: Change in Worker Welfare under Alternative Tax Schemes

6 Conclusion and Work in Progress

This draft offers a preliminary exploration of the effects of alternative tax structures on the distribution of economic activity and aggregate outcomes in the U.S. economy. We construct a general-equilibrium model that accommodates several types of spatial interactions among states and realistic heterogeneity in tax structures. We draw on tools from recent trade and economic geography models, and combine them in a model that includes salient features of the U.S. state tax structure. Using the estimated model, we measure the general-equilibrium impact of actual state tax policies implemented over time, and of the reforms typically put forth in public-policy debates.

The results so far are exploratory and preliminary. Our work in progress includes estimation of the key parameters $\{\sigma, \varepsilon_W, \varepsilon_F, \alpha_W, \alpha_F\}$ using variation in taxes and in economic activity. Using these parameters, we plan to undertake a number of additional counterfactuals relative to those presented in this preliminary draft. Specifically, we will consider counterfactuals aimed at measuring misallocation, where we reduce tax dispersion keeping government spending constant. Additionally, we will assess the impact and measure the magnitude of the reallocations implied by actual tax reforms by calibrating the model to an initial year at the moment of the reform, instead of fitting the model to 2012 data, as we do now. Finally, we will decompose reallocations and welfare changes into direct effects (stemming from changes in taxes keeping prices and government spending constant) and general-equilibrium effects (where prices and government spending are allowed to change) in order to understand the importance of general-equilibirum effects in driving the welfare effects of tax changes.

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A Model Solution in Relative Changes

TBD.

B Tables and Figures

Figure 1: Dispersion in State Taxes in 2010

(a) Distribution of Tax Base Across States

(b) Distribution of Tax Rates Across States

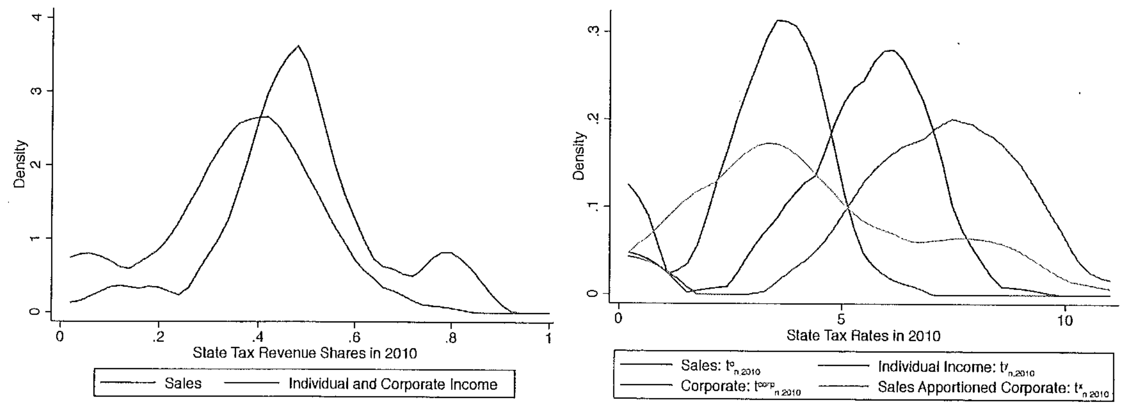
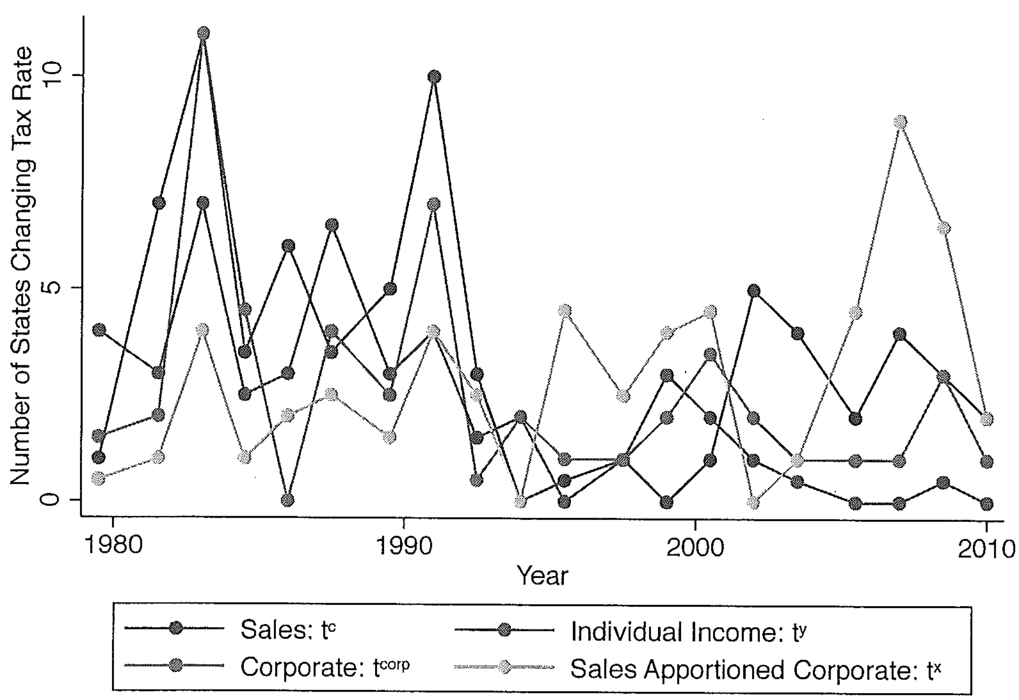


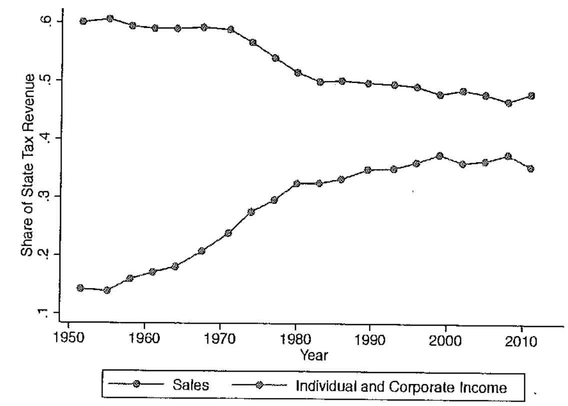
Figure 2: Number of States Changing Tax Rates since 1978



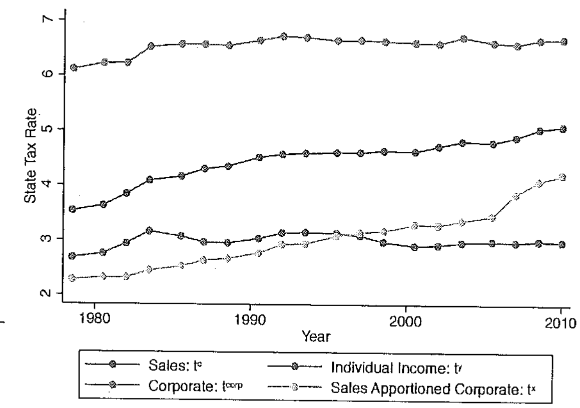
Note that a tax rate change occurs when $|t_t - t_{t-1}| >= .5$

Figure 3: Changes in State Tax Structure Over Time

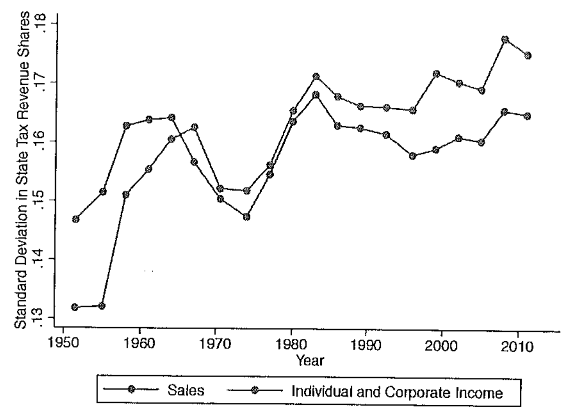
(a) Average Tax Base



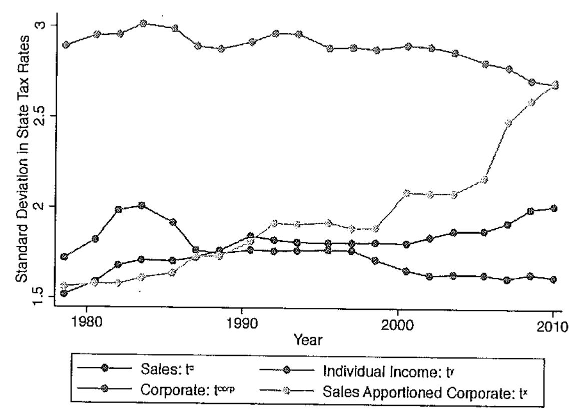
(b) Average Tax Rates



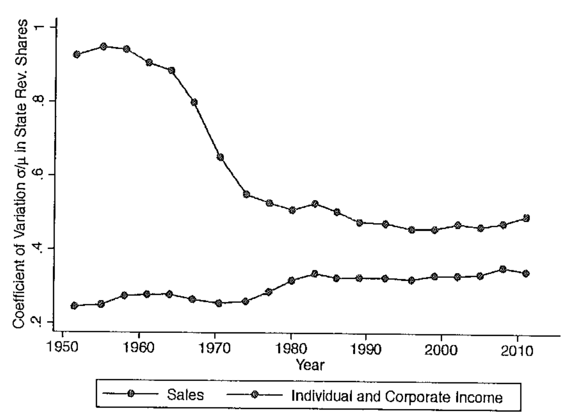
(c) Standard Deviation in Tax Base



(d) Standard Deviation in Tax Rates



(e) Coefficient of Variation $\frac{\sigma}{\mu}$ in Tax Base



(f) Coefficient of Variation $\frac{\sigma}{\mu}$ in Tax Rates

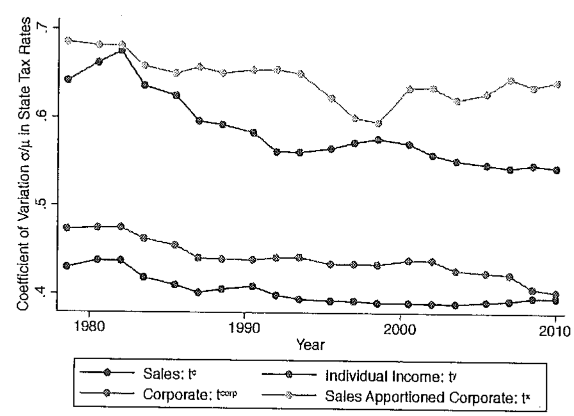
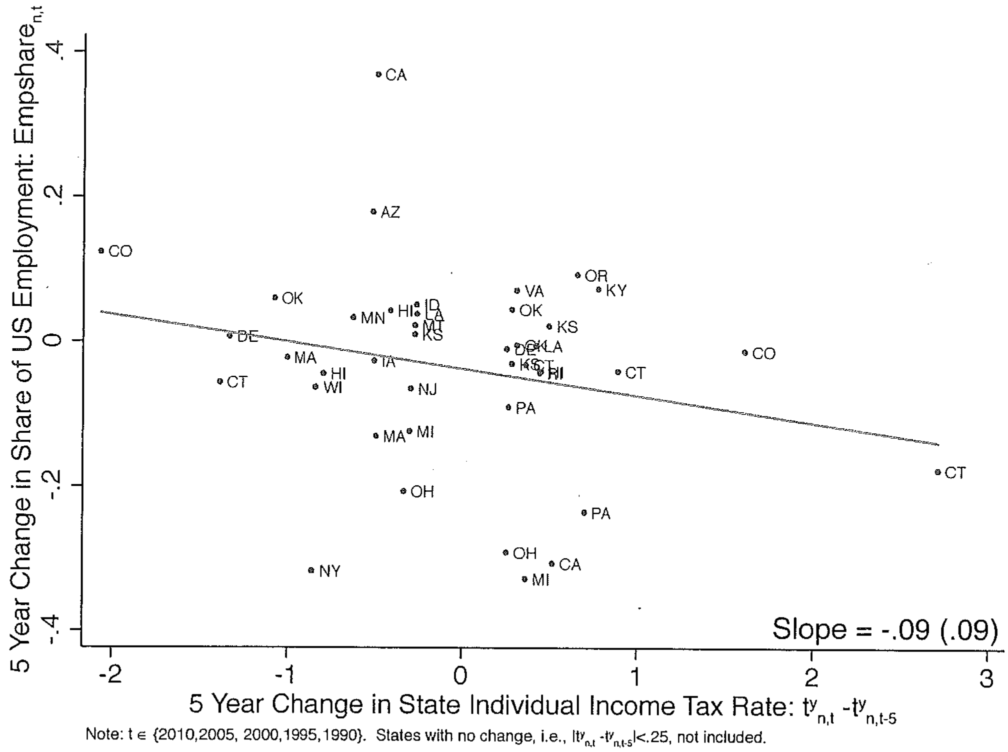


Figure 4: Changes in State Tax Rates and Economic Activity

(a) Changes in Individual Income Tax Rates and Employment Shares



(b) Changes in Corporate Income Tax Rates and Establishment Shares

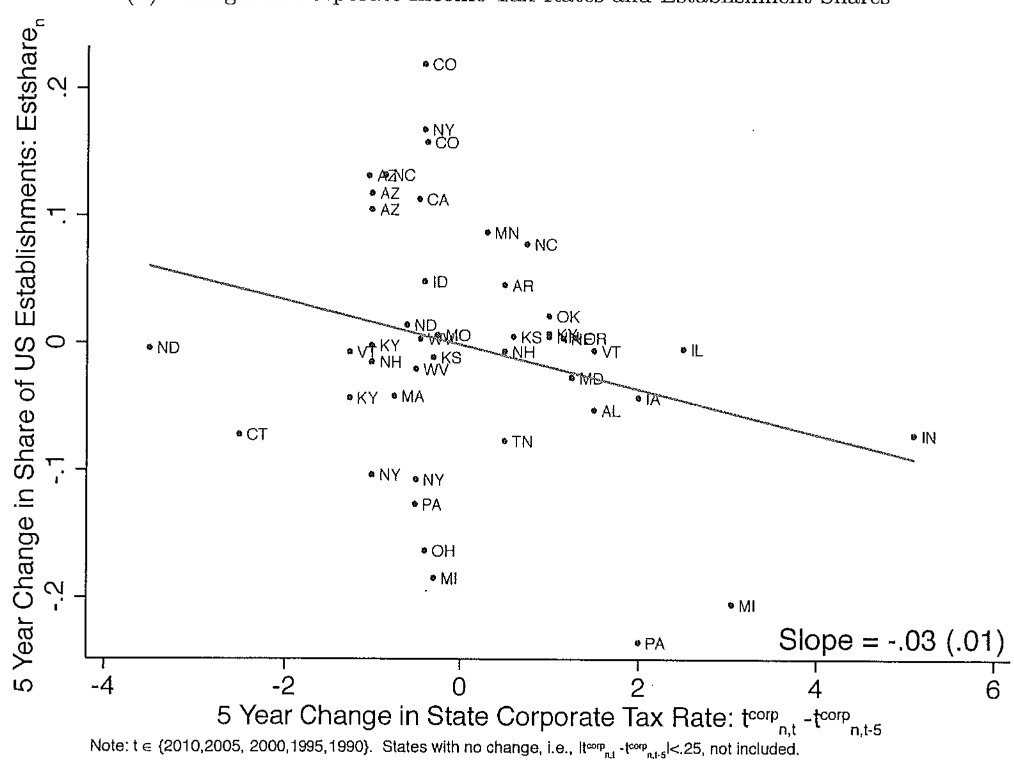
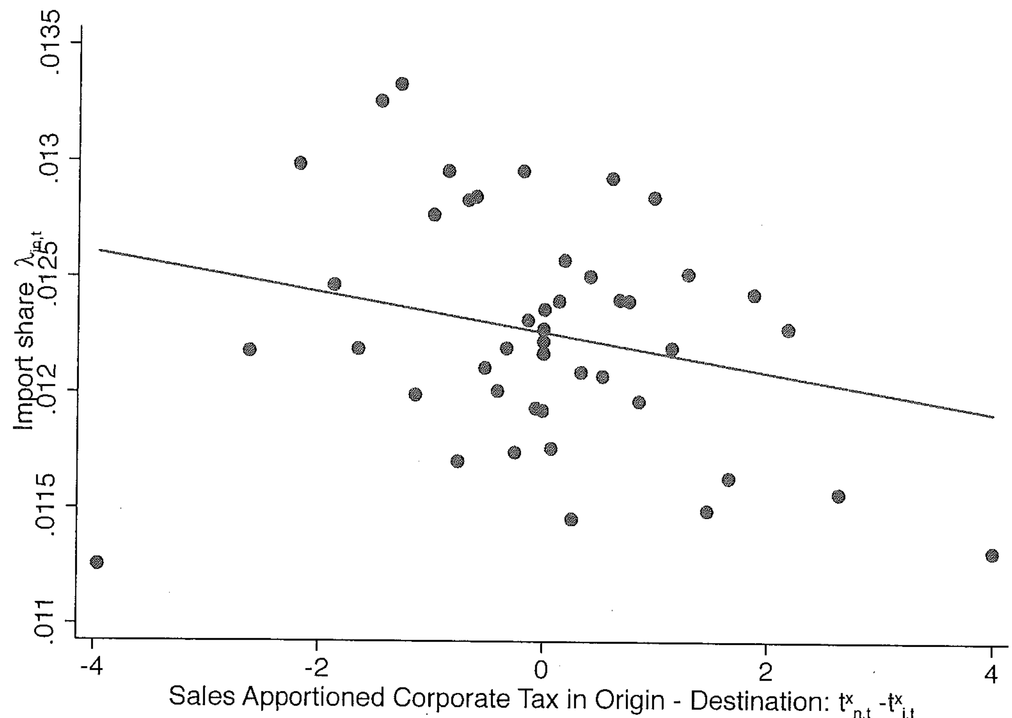


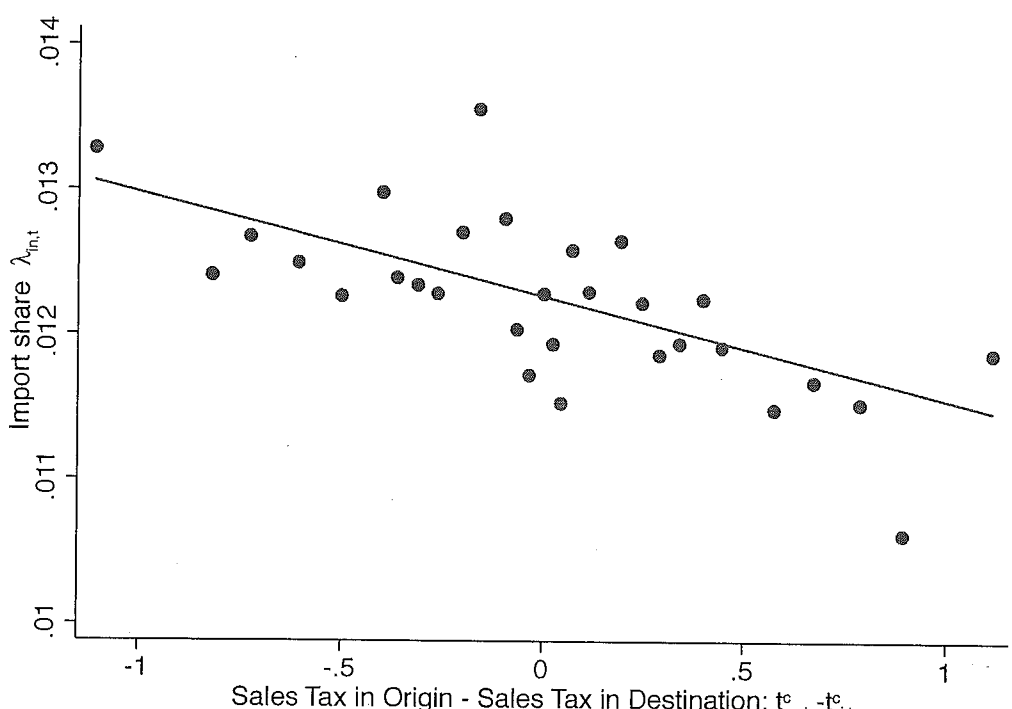
Figure 5: Bilateral Tax Differences and Trade Flows

(a) Sales Apportioned Corporate Tax Rate



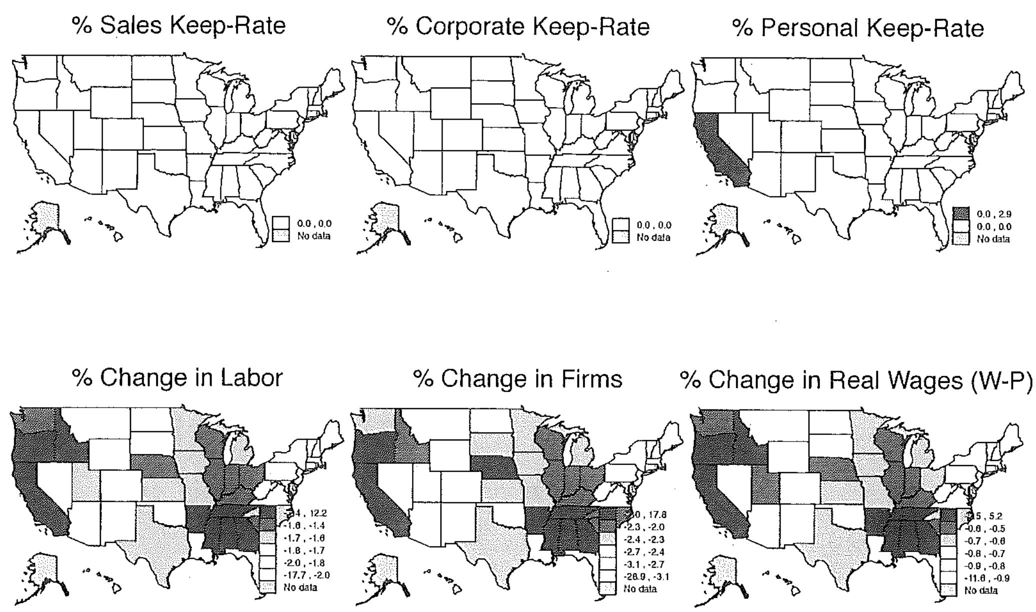
Note: t ∈ {2012, 2007, 2002, 1997, 1993}. Specification includes origin and destination fixed effects. Own trade shares not shown in Fig

(b) Sales Tax Rate



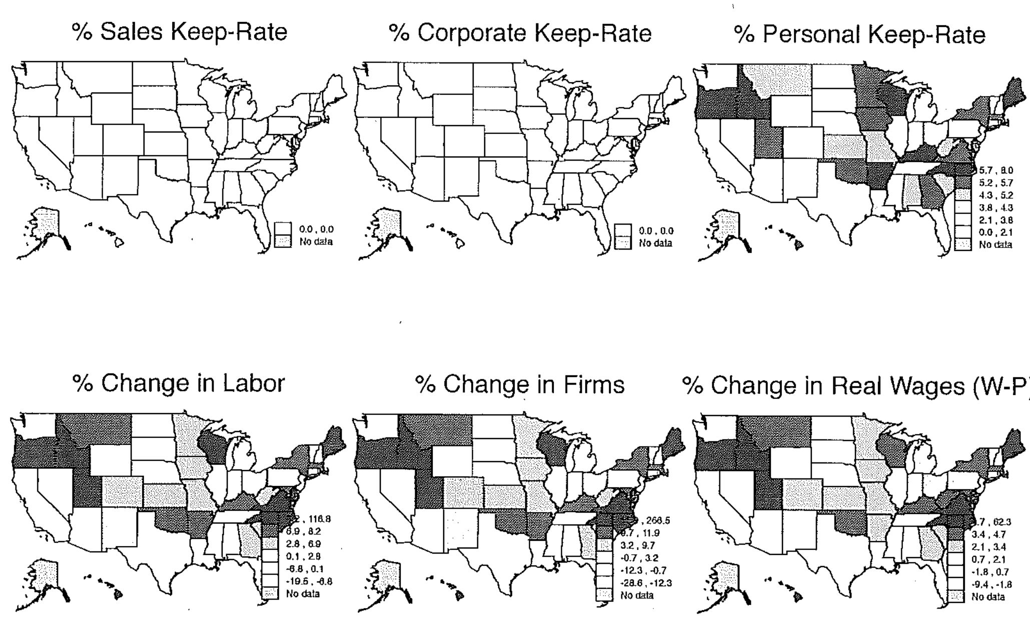
Note: t ∈ {2007, 2002, 1997, 1993}. Specification includes origin and destination fixed effects. Own trade shares not shown in Figure.

Figure 6: Income Tax to Zero in California



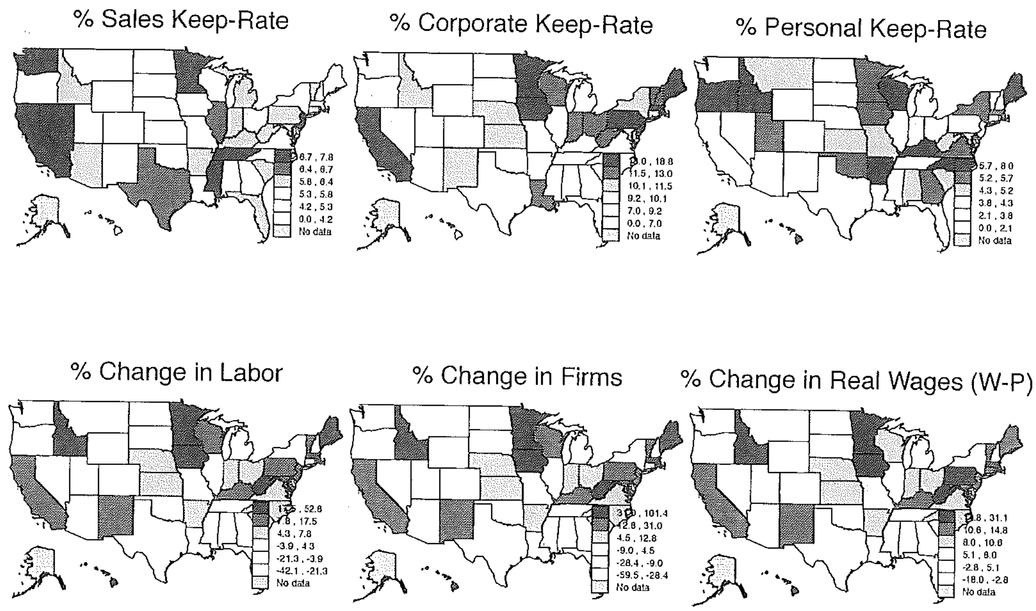
Notes: σ=4.5, ε_W=1.5, ε_F=3.5, α_W=0, α_F=0, % Change in Welfare=.4

Figure 7: Income Tax to Zero in All States



Notes: σ=4.5, ε_W=1.5, ε_F=3.5, α_W=0, α_F=0, % Change in Welfare=4.4

Figure 8: Every Tax Zero in Every State



Notes: σ=4.5, ε_W=1.5, ε_F=3.5, α_W=0, α_F=0, % Change in Welfare=13.6