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STATE TAXES AND SPATIAL MISALLOCATION

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ABSTRACT

We study state taxes as a potential source of spatial misallocation in the United States. We build a spatial general equilibrium framework that incorporates salient features of the U.S. state tax system, and use changes in state tax rates between 1980 and 2010 to estimate the model parameters that determine how worker and firm location respond to changes in state taxes. We find that heterogeneity in state tax rates leads to aggregate welfare losses. In terms of consumption equivalent units, harmonizing state taxes increases worker welfare by 0.6 percent if government spending is held constant, and by 1.2 percent if government spending responds endogenously. Harmonization of state taxes within Census regions achieves most of these gains. We also use our model to study the general equilibrium effects of recently implemented and proposed tax reforms.

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1 Introduction

Regional fiscal autonomy varies considerably across countries. In some countries, such as France, Japan, and the United Kingdom, regional governments do not set tax policy. In others, such as Germany, Italy, and Spain, regional governments have varying degrees of autonomy to set tax rates, grant tax breaks, and introduce or abolish taxes. As a result, tax rates can vary considerably across regions. Over time, several countries have adjusted their reliance on regional tax policies; for example, Canada, Australia, and India have moved towards greater regional tax harmonization in recent decades. The reasoning from recent research studying dispersion in distortions – across firms, as in Restuccia and Rogerson (2008) and Hsieh and Klenow (2009), or across cities, as in Desmet and Rossi-Hansberg (2013) – suggests that regional tax heterogeneity may have negative aggregate effects by distorting the spatial allocation of resources. Early studies of local public finance reinforce this logic by showing that, in some cases, allocative efficiency requires equal tax payments across locations (Flatters et al., 1974; Helpman and Pines, 1980).

To the best of our knowledge, however, no quantitative evidence on the general equilibrium tradeoffs between centralized and decentralized tax systems exists. We develop a spatial general equilibrium model that incorporates salient features of the U.S. state tax code and quantify the aggregate effects of dispersion in tax rates across U.S. states. The United States is a typical example of a country with a decentralized tax structure, both in terms of the share of total tax revenue collected by regional governments and the degree of spatial dispersion in tax rates.[1] In our model, workers decide where to locate and how many hours to work based on each state's taxes, wage, cost of living, amenities, and availability of public goods, and firms decide where to locate, how much to produce, and where to sell based on each state's taxes, productivity, factor prices, market potential (a measure of other states' market sizes discounted by trade frictions), and provision of public goods. We use the over 350 changes in state tax rates implemented between 1980 and 2010 to estimate the model parameters that determine how workers and firms reallocate in response to changes in state taxes. Using the estimated model, we compute the general equilibrium effects on worker welfare and aggregate income of replacing the current U.S. state tax distribution with counterfactual distributions featuring varying degrees of dispersion in tax rates.

Overall, we find that tax dispersion leads to aggregate losses. In private consumption equivalent units, harmonizing state taxes increases worker welfare by 0.6 percent if every state's government spending is kept constant. The gains to workers increase to 1.2 percent when we take into account the impact that the change in taxes would have on each state's government spending. Importantly, most of these gains could be achieved by harmonizing taxes only across states located in the same U.S. Census region. We also use our model to study the general equilibrium effects of recently implemented and proposed state tax reforms, such as the limits to the State and Local Tax (SALT) deduction imposed by the 2017 tax reform. We find that eliminating SALT increases tax dispersion,

[1] According to data for the year 2011 from the OECD Fiscal Decentralization Database, the share of total tax revenue collected by U.S. states (20.9%) is very similar to that collected by regions in Germany (21.3%), Spain (23.1%), or Switzerland (24.2%). The standard deviation of the distribution of income tax rates across U.S. states (1.6 percentage points) is similar to that observed across regions in Spain (1.9 percentage points) but smaller than that observed across European Union countries (6.3 percentage points).

results in welfare losses, and has heterogeneous effects across states depending on each state's taxes, income distribution, and composition of trading partners.

Our model embeds a canonical local public finance environment with many states, several fixed (land and structures) and mobile (workers and firms) factors of production, and state governments that use the tax revenue to finance the provision of public services which may be valued by workers or used as intermediate goods in production. We generalize this framework in several directions. First, we account for the main sources of tax revenue of U.S. state governments – sales, individual income, and corporate income taxes apportioned through firm sales and factor usage – as well as for federal taxes. Second, we allow states to have heterogeneous productivities, amenities, endowments of fixed factors, and trade frictions with other regions; specifically, we model trade costs using the standard approach in the quantitative trade literature (Eaton and Kortum, 2002; Anderson and van Wincoop, 2003). Third, we assume that firms are monopolistically competitive, as in Dixit and Stiglitz (1977) and Krugman (1980). Fourth, we allow workers' preferences and firms' productivities to have idiosyncratic components that vary across states. These four ingredients allow our model to match the observed responses of workers and firms to changes in taxes, and to rationalize as an equilibrium outcome of our model the distribution of economic activity and trade flows observed in any given year.

Our framework can be mapped to existing quantitative models of trade and economic geography. We leverage properties of these models to implement counterfactuals with respect to the state tax distribution, since a change to the tax distribution in our model is equivalent to a specific set of changes in amenities, productivities, bilateral trade costs, and trade imbalances in a standard trade and economic geography model such as Redding and Rossi-Hansberg (2017). Importantly, determining this specific set of equivalent changes in fundamentals and trade imbalances requires using the general equilibrium relationships predicted by our model to determine how much tax bases change in the counterfactual.

We rely on a simpler version of our model to establish theoretically how worker welfare and aggregate output depend on features of the U.S. state tax distribution. Eliminating dispersion in state tax rates while keeping government spending constant may have a positive or negative effect on worker welfare. As pointed out by Wildasin (1980), for any fixed arbitrary distribution of public spending, efficiency requires equalization across states of tax payments per worker. The reason is that efficiency requires equalization across locations of the marginal product of labor (which is equal to the wage) net of the marginal social cost of attracting a worker to a location (which is equal to consumption per capita). Absent compensating differentials (e.g., Hsieh and Klenow, 2009), no dispersion in tax rates implies that tax payments are equalized. What is distinctive about a spatial environment like ours is that wages and consumption per capita vary across locations due to compensating differentials. Therefore, a change in tax rates may either increase or decrease allocative efficiency depending on its impact on the dispersion of tax payments per worker. Specifically, eliminating dispersion in tax rates increases welfare if the cross-state correlation between tax rates and fundamentals (productivity and amenities) is sufficiently large, since eliminating dispersion in tax rates reduces dispersion in tax payments per worker in this case. The impact of tax dispersion on real aggregate income is also theoretically ambiguous: eliminating tax dispersion may increase or decrease aggregate real income depending on the initial correlation between state tax rates and both state amenities and expenditure in public goods.

Four structural parameters are key for determining the impact of any change in taxes on worker welfare and aggregate output: the elasticities of worker and firm mobility with respect to after-tax real earnings and profits, respectively, and the weights that public services have in both workers' preferences and firms' productivity. To estimate these parameters, we use estimating equations derived from our model and a longitudinal dataset containing each state's number of workers and establishments, tax rates, and government revenue between 1980 and 2010. Our model generates a worker-location equation that models each state's employment share as a function of that state's after-tax real earnings and government spending, and a firm-location equation that models each state's share of establishments as a function of that state's after-tax market potential, factor prices, and government spending. We then use observed worker and firm responses to actual changes in taxes and state government spending to estimate the parameters entering these two equations. For example, small estimated partial elasticities of employment shares and firm shares with respect to government spending are rationalized in our model as a consequence of small weights of public services in worker preferences and firm productivity, respectively.

Our estimation procedure uses several approaches to instrument for each state's changes in taxes, factor prices, and government spending. We instrument for these potentially endogenous covariates using either taxes in other states or two Bartik-type instruments that exploit variation in each state's exposure to national industry shocks and national shocks that affect sources of tax revenue differentially. This latter instrument exploits the fact that if, for example, a state's tax revenue comes mostly from sales taxes, then national sales booms will generate especially high tax revenues for that state. Regardless of instrumentation strategy, the resulting estimates always imply that workers' and firms' location decisions are more responsive to after-tax real wages or profits, respectively, than to government spending. Our baseline estimates yield a partial elasticity of state employment with respect to after-tax real wages of 1.1 and with respect to government spending of 0.2, and a partial elasticity of the share of establishments in a state with respect to after-tax market potential of 0.8 and with respect to government spending of 0.1.

The outcomes of our counterfactuals also depend on state-specific production technologies, productivities, amenities, and trade costs. These additional parameters are calibrated such that the model exactly reproduces, as an equilibrium outcome, the distribution of labor and intermediate-input income shares, wages, employment, trade flows, and trade imbalances across states observed in 2007. We find that the distributions of states' GDP and tax revenue shares in GDP implied by the estimated model are very similar to those observed in the data, even though we do not use this information to quantify the parameters of our model.

Using the estimated model, we implement a series of counterfactuals that demonstrate the importance of state tax dispersion for aggregate outcomes in the U.S. From a theoretical perspective, the question of how the distribution of state tax rates impacts the allocation of workers and firms and, through it, aggregate outcomes, is distinct from the question of how the distribution of states' government spending impacts economic activity. Hence, when evaluating each counterfactual distribution of state taxes, we implement the analysis in two steps: first, holding the level of public spending of every U.S. state constant at its initial level; and, second, allowing state spending to change in response to the implied changes in tax revenue. The first step allows us to isolate the impact of the tax distribution operating through spatial efficiency. The second step allows us to take into account the impact of the tax distribution through changes in government spending.

As mentioned above, we find that dispersion in U.S. tax rates across states leads to aggregate welfare and output losses. These results are robust to alternative assumptions on how preferences for government spending vary across states. In particular, they hold both in the extreme case in which we assign zero weight to public services in workers' preferences and firms' productivity, and in the case in which we assume that the observed ratio of government spending to GDP in each state reflects its residents' preferences for public services. These results are also robust to alternative ways of measuring effective state tax rates; e.g., adjusting corporate tax rates for the share of establishments in a state that are C-corporations, and adjusting income, sales, and corporate taxes to account for local taxes.

We compute the aggregate implications of partial harmonizations that homogenize tax rates only across subsets of states. We find that, as taxes are harmonized across a greater number of U.S. states, the overall dispersion in tax payments per capita shrinks and, consequently, welfare gains increase. Quantitively, however, we find that harmonizing taxes across states within the same U.S. Census region generates welfare gains that are similar to those obtained under complete harmonization. This regional harmonization result suggests that regional coordination of tax policies could achieve most of the gains from harmonization across all U.S. states.

Our quantitative results show that the gains from tax harmonization would be different if the distribution of fundamentals across U.S. states were different from that implied by the 2007 data. Consistent with our theoretical analysis, a tax harmonization that keeps government spending constant would lead to a larger increase in worker welfare if there were a higher correlation between initial state tax rates and amenities or productivity. Therefore, the answer to the question of whether a harmonized tax system that keeps government spending constant through a system of transfers is superior to an alternative tax distribution that features dispersion in tax rates across regions will depend both qualitatively and quantitatively on the specific country in question.

In terms of evaluating proposed tax reforms, we focus on the effects of eliminating the State and Local Tax (SALT) deduction, which is one of the largest expenditures in the U.S. tax code and which was substantially reduced by the Tax Cuts and Jobs Act of 2017. Eliminating SALT would increase dispersion in tax payments, since places with high state taxes and high-income taxpayers would pay even higher taxes. Consequently, we find that eliminating SALT reduces welfare by roughly 0.6 percent and aggregate real GDP by approximately 0.3 percent if government spending is held constant, and by 0.8 and 0.4 percent, respectively, if government spending responds endogenously. Southeastern states experience the largest gains. The hardest hit states are those with a large share of high income people and high tax rates, especially in the Northeast. Cross-state trade linkages are also important for determining the winners and losers of the reform. For example, Mississippi enjoys the largest gains in real GDP despite having positive state income taxes, reflecting the concentration of gains in nearby states. Similarly, among states with no state income tax, Florida and Tennessee enjoy larger gains than states like Nevada, which is near states with high income tax rates.

We also use our model to study the general equilibrium impact of actual tax reforms that have taken place in the U.S. in recent years and of potential policy changes currently being discussed. Over the past thirty years, U.S. state tax rates have increased on average, and they have become more reliant on sales taxes. Overall, we find that these changes increased worker welfare and aggregate output, and that these gains are driven in part by less dispersion in tax payments per capita across states.

The rest of the paper is structured as follows. Section 2 relates our work to the existing literature. Section 3 describes features of the U.S. state tax system that motivate our analysis. Section 4 introduces our model and describes its general equilibrium implications. Section 5 studies theoretically how dispersion in taxes affects welfare and aggregate output in a simplified version of our model. Section 6 presents our estimation approach, and Section 7 discusses our analysis of counterfactual changes in taxes. Section 8 concludes. We provide additional derivations and figures, and details on both our estimation approach and data sources in an Online Appendix.

2 Relation to the Literature

Misallocation Our paper contributes to the literature on the aggregate effects of misallocation. Distortions across firms are often measured as an implied wedge between an observed allocation and a model-implied undistorted allocation, as in Hsieh and Klenow (2009). Recent papers have adopted a similar methodology to analyze misallocation across geographic units, such as Desmet and Rossi-Hansberg (2013), Brandt et al. (2013), and Behrens et al. (2017).[2] These wedges capture distortions that may be due to multiple sources. Rather than inferring distortions from wedges, we focus on quantifying the potential misallocation caused by dispersion in state taxes that we directly observe in the data, and we use the observed variation in these taxes to estimate key model parameters. Similarly, Albouy (2009) studies how federal tax progressivity impacts the allocation of workers and aggregate outcomes.

Trade and Economic Geography Our framework shares several components with recent quantitative economic geography models, such as Allen and Arkolakis (2014), Ramondo et al. (2016), Redding (2015), and Caliendo et al. (2018). Our research question – the impact of state taxes on the U.S. economy – drives our modeling choices, estimation approach, and counterfactuals. Relative to this literature, we incorporate into our framework the main taxes imposed by U.S. states and by the federal government as well as a government sector that uses tax revenue to finance public

[2]See also Hsieh and Moretti (2018). A related literature on spatial misallocation studies rural-urban income gaps; e.g., Gollin et al. (2013) and Lagakos and Waugh (2013) find productivity gaps between agricultural and non-agricultural sectors which are suggestive of misallocation, and Bryan and Morten (2018) study whether these income gaps reflect spatial misallocation.

services valued by workers and firms. Alongside workers with idiosyncratic preferences for location as in Tabuchi and Thisse (2002) and others, we also introduce imperfect firm mobility through firms that receive idiosyncratic productivity draws across states. A central feature of our analysis is that we perform counterfactuals with respect to policy variables that are directly observed (U.S. state tax rates) and use the observed variation in these same policies to identify the key model parameters.

Fiscal Competition The literature on fiscal competition, summarized among others by Oates (1999) and Keen and Konrad (2013), typically considers static and perfectly competitive economies with two or more regions and several factors of production, some of which are immobile and some of which are mobile, which may be used to produce a consumption good and a non-traded public good. These basic ingredients are included in our model. Our model generalizes this structure to a multi-region setting in which the distribution of state characteristics can be disciplined using data on the distribution of economic activity. A central question in this literature has been whether jurisdictions setting tax policies according to the equilibrium of a non-cooperative game deliver a socially efficient allocation. A recent quantitative study in the literature is Ossa (2018), who uses an economic geography model with home-market effects to compute the Nash equilibrium of a game where states use lump-sum taxes to finance firm subsidies. Our focus does not involve computing the equilibrium of a non-cooperative game, so it does not require taking a stand on the objective function or the information sets of policy makers, or on the process through which observed taxes are determined.[3]

Factor Mobility in Response to Tax Changes We estimate elasticities of firm and worker location with respect to taxes to identify key structural parameters. Evidence on the effect of taxes on worker mobility includes Bartik (1991) and, more recently, Moretti and Wilson (2017). Estimates of worker mobility across regions include Bound and Holzer (2000), Notowidigdo (2013), and Diamond (2016). In terms of firm mobility, Holmes (1998) uses state borders to show that manufacturing activity responds to business conditions, and a large literature studies the impact of local policies on business location. Within this literature, Suárez Serrato and Zidar (2016) provide evidence on the impact of corporate taxes on worker and firm mobility, Suárez Serrato and Wingender (2016) show that local economic activity responds to public spending, and Giroud

[3]Within this literature, a body of work following Tiebout (1956) illustrates how heterogeneity across workers in preferences for government services can play a central role in determining the efficiency properties of tax policies set as the outcome of a non-cooperative game among jurisdictions. Quantifying these heterogeneous preferences for a large set of worker types and states is empirically challenging and, therefore, our model assumes that all workers located in the same state have the same valuation for public spending (but this valuation may vary across states). However, as some of our counterfactuals hold real government spending fixed, worker location decisions in our counterfactuals do not vary depending on how workers value government services but only on how they value changes in after-tax real earnings. We show that our counterfactual results are robust to several alternative approaches to modeling the valuation that workers have for government services. Moreover, within most states, individuals with high valuations of public goods would be able to find a high public good community, and vice-versa for those with low valuations of public goods. Specifically, 36 states have a county that spends less than the national 25th percentile of per capita local government spending, and 43 states have a county that spends more than the national 75th percentile of per capita local government spending.

and Rauh (2015) show that C-corporations reduce their activity when states increase corporate tax rates.[4] Appendix D.9 compares our estimates to estimates from this prior literature. While the aim of this literature is to quantify the local effects of actual policy changes, we use similar empirical specifications and variation in the data to estimate key parameters of a general equilibrium model, and then use these estimates to study how counterfactual policy changes in one state or simultaneously in many states impact aggregate outcomes in the U.S. economy.[5]

3 Background on the U.S. State Tax System

Our benchmark analysis focuses on three sources of state tax revenue: personal income taxes, corporate income taxes, and sales taxes. The revenue raised through these three sources accounted, respectively, for 35, 7, and 32 percent of total state tax revenue in 2007, and collectively amounted to 4 percent of U.S. GDP.[6] In this section, we describe how we model each tax, present statistics summarizing the dispersion in tax rates across states, and provide some evidence on how state taxes relate to cross-state trade flows. Appendix F details the sources of the data we use.

3.1 Main State Taxes

Individual Income Tax States tax the individual income of their residents. In 2007, the average state income tax rate was 3.1%; the states with the highest average income tax rates were Oregon (6.0%), North Carolina (5.0%), Minnesota (4.8%), and New York (4.8%), while seven states had no income tax. State income tax rates tend to be progressive, but less so than federal income tax rates. In our analysis, we approximate the schedule of income keep tax rates in each state, defined as one minus the tax rate, through a log-linear function of income y: $1 - t_n^y(y) = a_{n,state}^y y^{-b_{n,state}^y}$. As Heathcote et al. (2017) recently argue, these functional forms accurately approximate U.S. tax schedules. We compute the parameters of this tax schedule, $(a_{n,state}^y, b_{n,state}^y)$, for each state and year using the average effective tax rate from NBER TAXSIM, which runs a fixed sample of tax returns through each state's income tax schedule every year and accounts for most features of the tax code. Appendix Table A.3 reports the 2007 income tax schedule parameters.

Corporate Income Tax States also tax businesses. The tax base and tax rate on businesses depend on the legal form of the corporation. In our baseline analysis, we treat all businesses

[4]Additionally, Devereux and Griffith (1998) estimate the effect of profit taxes on the location of production of U.S. multinationals, Goolsbee and Maydew (2000) estimate the effects of the labor apportionment of corporate income taxes on the location of manufacturing employment, Hines (1996) exploits foreign tax credit rules to show that investment responds to corporate tax regulations. Chirinko and Wilson (2008) and Wilson (2009) also provide evidence consistent with the view that state taxes affect the location of business activity.

[5]Our paper is also related to the literature that has analyzed the general equilibrium effects of tax changes. Shoven and Whalley (1972) and Ballard et al. (1985) point out the importance of general equilibrium effects when analyzing large changes in policy. See Nechyba (1996) for an early Computable General Equilibrium (CGE) model of local public goods. A large literature in macroeconomics also studies the dynamic effects of taxes in the standard growth and real business cycle model; Mendoza and Tesar (1998), among others, study dynamic effects of taxes in an international setting.

[6]We focus on general sales taxes in our analysis. Selective sales taxes (e.g., alcohol sales taxes) jointly account for an extra 15% of tax revenue. The biggest remaining category is license taxes (6.2%).

as C-corporations — traditional corporations subject to the corporate income tax — since they account for the majority of businesses' net income in the United States.[7] In 2007, the average state corporate income tax rate was 6.6%; the states with the highest corporate tax rates were Iowa (12%), Pennsylvania (10%), and Minnesota (9.8%), while five states had no corporate tax. State tax authorities determine the share of a C-corporation's national profits allocated to their state using apportionment rules, which aim to measure the corporation's activity share in their state. To determine this activity share, states put different weight on three apportionment factors: the share of the corporation's national payroll, property value, and sales. Payroll and property factors thus depend on where goods are produced and typically coincide; the sales factor depends on where goods are sold.[8] Apportionment through sales tends to be more prevalent: thirteen states exclusively apportion through sales, while roughly three quarters of the remaining states apply either a 50 or 33 percent apportionment through sales.

Sales Tax Sales taxes are usually paid by the consumer upon final sale, and states typically do not levy sales taxes on firms for purchases of intermediate inputs or goods that they will resell. In 2007, the average statutory general sales tax rate was 4.9%; the states with the highest sales tax rates were California (7.25%), Mississippi (7%), New Jersey (7%), Maryland (7%), and Tennessee (7%), while five states had no sales taxes.

3.2 Stylized Facts on State Taxes

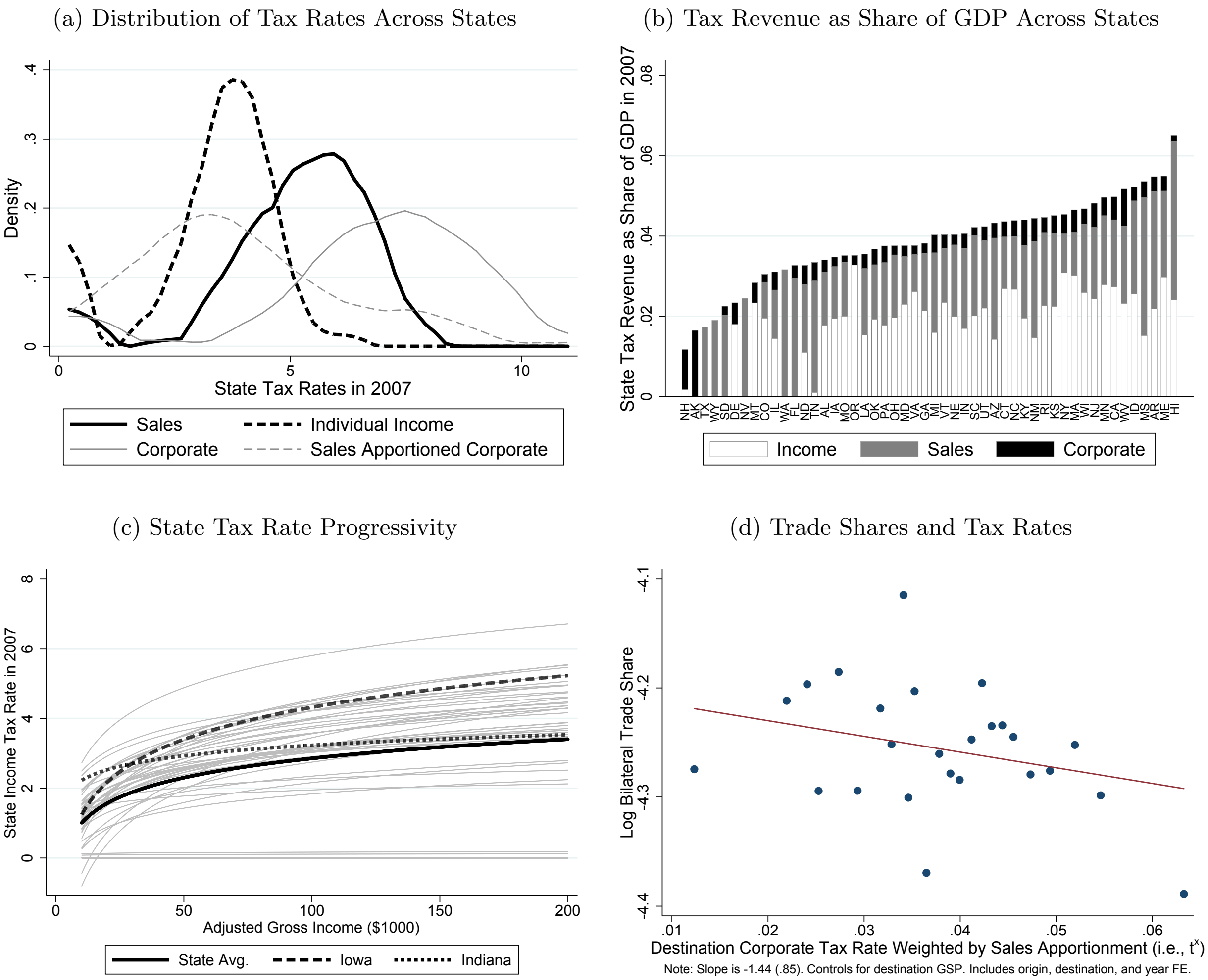
Panels (a) to (c) of Figure 1 show that tax rates and tax revenue vary considerably across states. Panel (a) shows the 2007 distribution of sales, income, corporate, and sales-apportioned corporate tax rates.[9] Corporate tax rates are the most dispersed; the 90-10 percentiles of the distributions of general sales, average personal income, and corporate income tax rates are 6.8%-1.5%, 4.6%-0%, and 9.2%-1.0%, respectively. For each type of tax, there are at least five states with 0% rates.

[7] C-corporations are incorporated and officially registered business entities whose owners enjoy limited liability. The other main type of business entities are private "pass-through" businesses, which are taxed at the owner rather than the entity level, i.e., the income that these private businesses earn passes through to the owners, who pay personal income taxes on their share of the firm's income. C-corporations accounted for 66% percent of total business receipts in 2007 (PERAB, 2010). In robustness checks, we also explore how our results change when we adjust state corporate tax rates for the fraction of C-corporations revenue in each state's total business revenue.

[8] For example, a single-plant firm j located in state i with sales share s_{ni}^{j} in each state n pays a corporate tax rate of $\bar{t}^{j} = t_{fed}^{corp} + t_{i}^{l} + \sum_{n} s_{ni}^{j} t_{n}^{x}$, where t_{fed}^{corp} is the 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 tax rate of state n and θ_{n}^{x} is its sales apportionment), and $t_{i}^{l} = (1-\theta_{i}^{x})\, t_{i}^{corp}$ is the corporate tax apportioned through property and payroll in state i.

[9] The sales-apportioned corporate tax rate is the product of the sales apportionment factor and the corporate rate; i.e. $t_{n}^{x} = \theta_{n}^{x} t_{n}^{corp}$ (see footnote 8). Table A.2 in Appendix F.2 shows the state tax rates in 2007 in all 50 states. Table A.1 shows the federal income, corporate, and payroll tax rates in 2007.

Figure 1: Stylized Facts on State Taxes



NOTES: Panel (a) shows the density of tax rates across states in 2007. Specifically, sales (t_n^c) and corporate income (t_n^{corp}) tax rates are statutory, while individual income tax rates (t_n^y) are estimated using NBER's tax simulator TAXSIM. For each state, we compute average state tax liabilities and divide them by average Adjusted Gross Income (AGI) in that state. Finally, we compute sales apportioned corporate income tax rates (t_n^x) by multiplying t_n^{corp} by sales apportionment weights. Panel (b) shows state government tax revenue as a share of state GDP. Individual income, corporate income, and general sales tax revenues are drawn from Census Government Finances. Panel (c) shows how average state income tax rates in 2007 vary with taxpayer AGI for each state. For each level of AGI, we compute each state's tax rate as $t_{n,state}^y = 1 - a_{n,state}^y y^{-b_{n,state}^y}$. Progressivity is heterogeneous across states. For instance, the effective tax rate in Indiana is higher than Iowa for AGI below $30K, while the opposite is true for AGI above $30K. Panel (d) shows the OLS estimate of the coefficient from a regression of intra-U.S. trade flows on state corporate tax rates. Specifically, we compute bilateral trade shares as $s_{in} = \frac{x_{in}}{\sum_i x_{in}}$, where x_{in} denotes sales from state n to state i, and sales-apportioned corporate tax rates (t_i^x) in destination states. The panel includes information on bilateral trade flows among the 48 contiguous states for the years 1993, 1997, 2002, 2007, and 2012. Each observation is an origin-destination-year triplet. We account for origin state, destination state, and year fixed effects. Observations are weighted by destination state population. Table A.4 provides further evidence on the relationship between state bilateral trade shares and trade-dispersion costs.

These differences in tax structures across states are associated with differences in the total tax revenue collected. Panel (b) shows the distribution of tax revenue as a share of state GDP by type of tax. The share of the sum of income, general sales, and corporate tax revenue in GDP varies across states between 1.1% and 6.5%. Local (sub-state) governments also tax residents. State taxes amount to roughly 65% of state and local tax revenue combined.[10] Panel (c) plots our estimated individual income tax schedules for all states in 2007. Some states like Indiana have flatter average tax rates as a function of income, whereas others like Iowa have substantially more progressive tax rates. Finally, panel (d) shows that inter-state exports are lower to destinations with high sales-apportioned corporate taxes (see Table A.4 in Appendix A for additional evidence), after controlling for state and year fixed effects.

3.3 State Tax Revenue and Government Spending

Besides taxes, transfers from the federal government are a major source of revenue for U.S. state governments. On average across states, these transfers amounted to roughly 3.3% of their GDP in 2007. Once these federal government transfers are taken into account, state governments typically have balanced budgets (Poterba, 1994). Federal transfers therefore allow state spending to exceed state tax revenue. The actual process determining these transfers is complex. However, empirically, for the period 1980 to 2010, the size of the total direct expenditures of each state is well approximated by a state-specific multiplier of that state's tax revenue. Letting R_{nt} be state n's tax revenue and $E^G_{nt} = (1+\psi_n) R_{nt}$ be state n's direct expenditures in year t, of which $\psi_n R_{nt}$ is the part financed through federal transfers, the estimates of the regression

$$\ln E^G_{nt} = \ln(1+\psi_n) + \ln R_{nt} + \varepsilon_{nt} \quad (1)$$

yield an R^2 of 0.97.[11] We adopt this relationship when modeling federal transfers in our quantitative model.

4 Economic Geography Model with State Taxes and Public Goods

We model a closed economy with N states indexed by n or i. A mass of workers, normalized to be of measure one, receives idiosyncratic preference shocks, which impact how they sort across states. After the location decision has been made, each worker receives a productivity draw and chooses how many hours to work. In our baseline model, a fixed mass of firms, also normalized to be of measure one, sorts across states according, in part, to idiosyncratic productivity draws. For

[10] Heterogeneity in tax rates across states is also present when both state and local taxes are taken into account. Figure A.1 in Appendix A reproduces panel (a) of Figure 1 using the sum of state and local tax rates. It shows that cross-state differences in tax rates increase when local tax rates are taken into account. Local governments rely mostly on property taxes. State tax revenue make up roughly 92%, 87%, and 79% of consolidated state and local revenue from income, corporate, and sales taxes, respectively, but only 3% of consolidated property tax revenue.

[11] We measure the variable E^G_{nt} using "state direct expenditures" from the Census of Governments. The main direct-expenditure items include: education, public welfare, hospitals, highways, police, correction, natural resources, parks and recreation, government administration, and utility expenditure. Panel (a) of Appendix Figure A.2 illustrates the close relationship between E^G_{nt} and R_{nt} in 2007.

robustness, we also examine an alternative model in which firms freely enter each location subject to entry costs. We let L_n and M_n be the measure of workers and firms that locate in state n.

Each state n has an endowment H_n of fixed factors of production (land and structures), an amenity level u_n, and a productivity level z_n. There is an iceberg cost $\tau_{ni} \geq 1$ of shipping from state i to state n (if one unit is shipped from i to n, $1/\tau_{ni}$ units arrive). Firms are single-plant and sell differentiated products. They use the fixed factor, workers, and intermediate inputs to produce output. Workers only receive labor income, which they spend in the state where they live. Firms and fixed factors are owned by immobile capital owners exogenously distributed across states.

State governments collect personal income taxes $t_n^y(y)$ that depend on individual income y, sales taxes t_n^c, and corporate income taxes apportioned through sales, t_n^x, and through payroll and property, t_n^l. Each state uses the tax revenue to finance the provision of public services, which enter as shifters of both that state's amenity and productivity. The sensitivity of a state's amenity to public services may vary across states.

The federal government collects personal income taxes $t_{fed}^y(y)$, payroll taxes t_{fed}^w, and corporate taxes t_{fed}^{corp}. Federal taxes are used to finance federal transfers to state governments as well as federal public goods that benefit any worker independently of their location (e.g., national defense).

4.1 Workers

A continuum of workers $l \in [0,1]$ decides in which state to work and consume. Each worker l observes a vector $\{\epsilon_n^l\}_{n=1}^N$ of idiosyncratic state-specific preferences and decides the state of residence. Then, the worker discovers her own productivity level z_n^l in that state. This productivity draw captures heterogeneity in job opportunities and gives rise to a non-degenerate income distribution within each state. After observing her productivity in state n, each worker l chooses her number of working hours, h_n^l. The total income of a worker l in state n is thus $w_n h_n^l z_n^l$, where w_n is the wage per efficiency unit and $h_n^l z_n^l$ are the efficiency units that worker l supplies in that state.

Workers have preferences over amenities, public goods, and final consumption goods, and experience disutility from working.[12] The direct utility of a worker who lives in state n, consumes c_n units of the private good, and works h_n hours is $\epsilon_n^l U_n(c_n, h_n)$, where

$$U_n(c,h) = u_n g_n^{\alpha_{W,n}} c^{1-\alpha_{W,n}} d_n(h). \tag{2}$$

The amenity level u_n captures both natural characteristics, like the weather, and the rate at which the government transforms total real spending into services valued by workers; this rate includes the fraction of the state budget used to finance public services valued by workers. It may also capture utility from a national public good provided by the federal government. The parameter $\alpha_{W,n}$ captures the weight of state-provided services in preferences. This weight may vary across states, reflecting complementarities between state-specific features such as the weather or natural

[12] The framework could be generalized to allow for direct consumption of the fixed factor by workers in the form of housing. Furthermore, housing supply could be allowed to be elastic. While adding these elements would be straightforward, measuring state-specific property taxes or housing supply elasticities would be less so because they vary considerably across cities within states, as documented by Saiz (2010).

amenities and government services. In turn, real government spending enjoyed by each worker in state n, g_n, equals total real government spending, G_n, normalized by a function of the total number of workers living in state n, $L_n^{\chi_W}$:

$$g_n = \frac{G_n}{L_n^{\chi_W}}. \tag{3}$$

The parameter χ_W captures the degree to which public goods are rival, and ranges from $\chi_W = 0$ (non-rival) to $\chi_W = 1$ (rival). Workers also face disutility from effort, captured by the term $d_n(h)$. This disutility function is allowed to vary by state in order to give the model enough flexibility to match cross-state differences in the per-worker number of hours worked. The indirect utility of a worker l living in state n is $\epsilon_n^l v_n$, where

$$v_n \equiv \mathbb{E}_n \left[\max_h U_n \left(c_n \left(w_n h z \right), h \right) \right] \tag{4}$$

is the expected value over the possible realizations of the individual productivity shock z in state n, and where $c_n(y)$ is the quantity of final goods consumed by an individual with income y in state n. We refer to v_n as the "appeal" of state n.

From the consumer's budget constraint, and letting P_n be the price of the final good in state n, the final good consumption of an individual with income y living in state n is

$$c_n(y) = \frac{1 - T_n(y)}{P_n} y, \tag{5}$$

where the real keep-tax rate is

$$1 - T_n(y) \equiv \frac{(1 - t_{fed}^y(y))(1 - t_n^y(y))}{1 + t_n^c}. \tag{6}$$

This formulation takes into account that state income taxes can be deducted from federal taxes.

The idiosyncratic taste draw ϵ_n^l is assumed to be independent and identically distributed across individuals l and states n. Hence, the fraction of workers located in state n is $L_n = \Pr\left[n = \arg\max_{n'} v_{n'} \epsilon_{n'}^l\right]$. Assuming that the idiosyncratic taste draws follow a Fréchet distribution, $\Pr(\epsilon_n^l < x) = \exp(-x^{-\varepsilon_W})$ with $\varepsilon_W > 1$, then

$$L_n = \left(\frac{v_n}{v} \right)^{\varepsilon_W}, \tag{7}$$

where

$$v \equiv \left(\sum_n v_n^{\varepsilon_W} \right)^{1/\varepsilon_W}. \tag{8}$$

The ex-ante expected utility of a worker over the distribution of taste draws $\{\epsilon_n^l\}_{n=1}^N$ is proportional to v. A larger value of ε_W implies that idiosyncratic taste draws are less dispersed across states; as a result, locations become closer substitutes and an increase in the relative appeal of a location (an increase in v_n/v) leads to a larger response in the fraction of workers who choose to locate there.

We make additional functional-form assumptions to reach a closed-form solution for v_n. First, we assume log-linear keep-tax schedules at the state and federal levels: $1 - t_n^y(y) = a_{n,state}^y y^{-b_{n,state}^y}$ and $1 - t_{fed}^y(y) = a_{fed}^y y^{-b_{fed}^y}$. These schedules are progressive (regressive) when the coefficients $b_{n,state}^y$ and b_{fed}^y adopt positive (negative) values. Together with (6), these forms imply

$$1 - T_n(y) = \frac{a_n^y y^{-b_n^y}}{1 + t_n^c}, \tag{9}$$

where

$$a_n^y \equiv a_{fed}^y \left(a_{n,state}^y\right)^{1-b_{fed}}, \tag{10}$$

$$b_n^y \equiv b_{n,state}^y + b_{fed}^y - b_{n,state}^y b_{fed}^y. \tag{11}$$

Second, we assume disutility from hours worked of the form

$$d_n(h) = \exp\left(-\alpha_{h,n} \frac{h^{1+1/\eta}}{1+1/\eta}\right). \tag{12}$$

Together with (4), this functional form implies that utility is separable between consumption and leisure and, thus, all workers in a state n work the same number of hours:

$$h_n = \left(\frac{1-\alpha_{W,n}}{\alpha_{h,n}}\left(1 - b_n^y\right)\right)^{\frac{1}{1+1/\eta}}. \tag{13}$$

Finally, we assume that productivity draws across workers located in state n follow a Pareto distribution with scale and shape parameters $(z_{L,n}, \zeta_n)$:

$$\Pr\left[z_n^l \leq Z\right] = 1 - \left(\frac{Z}{z_{L,n}}\right)^{-\zeta_n}. \tag{14}$$

This assumption leads to the empirically consistent prediction of a fat-tailed income distribution. The expressions (9) to (14) imply the following solution for the common component of utility defined in (4):

$$v_n = \frac{\zeta_n}{\zeta_n - \left(1 - b_n^y\right)\left(1 - \alpha_{W,n}\right)} u_n g_n^{\alpha_{W,n}} \left(\frac{a_n^y}{\left(1 + t_n^c\right) P_n}\left(w_n z_{L,n}\left(h_n e^{-1}\right)^{\frac{1}{1+1/\eta}}\right)^{1-b_n^y}\right)^{1-\alpha_{W,n}}. \tag{15}$$

Equation (15) captures several forces determining workers' location. The first term reflects wage heterogeneity within the state. Wage heterogeneity vanishes as $\zeta_n \to \infty$, in which case the individual productivity distribution converges to a mass point at $z_{L,n}$. The average returns to locating in state n are also a function of the common component of amenities, public spending per capita, after-tax wages and hours worked.

From the definitions of L_n and v_n in (7) and (15), the partial elasticity of the share of workers who locate in state n with respect to the nominal wage per efficiency unit is $\varepsilon_W\left(1 - b_n^y\right)\left(1 - \alpha_{W,n}\right)$

while $\varepsilon_W \alpha_{W,n}$ is the partial elasticity with respect to real government services per worker, g_n. We will rely on these relationships to estimate ε_W and $\{\alpha_{W,n}\}_{n=1}^N$ in Section 6.2.

4.2 Capital Owners

Immobile capital owners located in state n own a fraction ω_n of a portfolio that includes the profits of all firms in the economy and the payments to all fixed factors. In our model, a larger ownership rate relative to other states results in larger trade imbalances. Therefore, we will calibrate the ownership shares ω_n to match the observed trade imbalances across states.[13] Capital owners spend their income locally, pay sales taxes on consumption, and pay the highest marginal rate for both federal and state income taxes (Cooper et al., 2016). We do not need to specify the number of capital owners or their utility function at any stage of our analysis.

4.3 Final Good

In each state, a competitive sector assembles a final good from differentiated varieties through a constant elasticity of substitution aggregator with elasticity σ,

$$Q_n = \left(\sum_i \int_{j \in J_i} \left(q_{ni}^j \right)^{\frac{\sigma-1}{\sigma}} dj \right)^{\frac{\sigma}{\sigma-1}}, \tag{16}$$

where J_i denotes the set of varieties produced in state i and q_{ni}^j is the quantity of variety j produced in state i which is used for production of the final good in state n. Letting p_{ni}^j be the price of this variety in state n, the cost of producing one unit of the final good in state n (and also its price before sales taxes) is

$$P_n = \left(\sum_i \int_{j \in J_i} \left(p_{ni}^j \right)^{1-\sigma} dj \right)^{\frac{1}{1-\sigma}}. \tag{17}$$

The final good Q_n is non-traded and can be used by consumers (workers and capital-owners) for aggregate consumption of workers and capital owners (C_n^L and C_n^K), by firms as an intermediate input in production (I_n), and by state governments (G_n) and the federal government (G_n^{fed}) as an input for the supply of public services:

$$Q_n = C_n^L + C_n^K + I_n + G_n + G_n^{fed}. \tag{18}$$

4.4 Firms

In our baseline model, we assume that there exists a fixed mass of firms which must decide in which state to locate.[14] Assuming that these firms heterogeneous in terms of their productivity across locations, this approach enables us to use data on firms' location choices to estimate a

[13] Two alternative modeling approaches would be to assume that all workers own equal shares of the national portfolio, or that the returns of that portfolio are spent outside of the model. Under these approaches, the model would lead to empirically inconsistent predictions for trade imbalances across states.

[14] This modeling approach is similar to Martin and Rogers (1995). See also Chapter 3 of Baldwin et al. (2005).

parameter determining the elasticity of the number of firms located in a state with respect to its taxes. In this approach, taxes do not affect the mass of firms in the economy. To account for this possible effect of taxes, we also explore the implications of an alternative model that features free entry of firms with homogeneous productivity to each location, as in Krugman (1991) and Helpman (1998). We describe the main implications of this alternative model at the end of this section.

Production Technologies Each firm $j \in [0,1]$ produces a differentiated variety and is endowed with state-specific productivities $\{z_i^j\}_{i=1}^N$. To produce quantity q_i^j in region i, firm j combines its own productivity in that location z_i^j, a fixed factor h^j, efficiency units of labor l^j, and intermediate inputs i^j, through a Cobb-Douglas technology:

$$q_i^j = z_i^j \left[\frac{1}{\gamma} \left(\frac{h^j}{\beta} \right)^{\beta} \left(\frac{l^j}{1-\beta} \right)^{1-\beta} \right]^{\gamma} \left(\frac{i^j}{1-\gamma} \right)^{1-\gamma}, \tag{19}$$

where γ is the value-added share in production and $1-\beta$ is the labor share in value added. The fixed factor acts as a source of congestion: the higher the number of firms and workers located in a given state, the higher the relative price of this fixed factor.

Profit Maximization given Firm Location Each firm decides in which state to produce and how much to sell in every state. Firms are monopolistically competitive. Consider a firm j located in state i whose productivity is z. Its profits are

$$\pi_i(z) = \max_{\{q_{ni}^j\}} \left(1 - \bar{t}_i^j\right) \left(\sum_{n=1}^{N} x_{ni}^j - \frac{c_i}{z} \sum_{n=1}^{N} \tau_{ni} q_{ni}^j \right), \tag{20}$$

where $\bar{t}_i^j$ is the corporate tax rate of firm j if it were to locate in state i, $x_{ni}^j = P_n Q_n^{\frac{1}{\sigma}} (q_{ni}^j)^{1-\frac{1}{\sigma}}$ are its sales to state n, and

$$c_i = \left(\left(\left(1 + t_{fed}^w\right) w_i \right)^{1-\beta} r_i^{\beta} \right)^{\gamma} P_i^{1-\gamma} \tag{21}$$

is the the minimum unit cost of a bundle of factors and intermediate inputs, where w_i is the wage per efficiency unit, r_i stands for the cost of a unit of land and structures in state i and t_{fed}^w are federal payroll taxes. This definition of c_i accounts for the fact that, unlike consumers, firms do not face sales taxes when purchasing the final good to use it as an intermediate.

All firms face corporate taxes apportioned through sales, payroll, and land and structures. A firm j located in state i whose share of sales to state n is s_{ni}^j pays a share $s_{ni}^j t_n^x$ of its pre-tax national profits in corporate taxes to state n. Firms located in i also pay a fraction t_i^l of its pre-tax national profits in corporate taxes to state i, and a rate t_{fed}^{corp} in federal corporate income taxes. As a result, the overall corporate tax rate of firm j is:

$$\bar{t}_i^j = t_{fed}^{corp} + t_i^l + \sum_{n=1}^{N} t_n^x s_{ni}^j. \tag{22}$$

Due to the sales apportionment of corporate taxes, the decision of how much to sell in each state is not separable across states. When a firm increases the fraction of its sales to state n (i.e., when s^j_{ni} increases), the average tax rate on the firm's national profits changes depending on the sales-apportioned corporate tax in state n, t^x_n. Firms thus trade off the marginal pre-tax benefit of exporting more to a given state against the potential marginal cost of increasing the corporate tax rate on all its profits.

Pricing Distortion Through Corporate Taxes Despite the non-separability of the sales decision across markets, the solution to the firm optimization problem in (20) retains convenient aggregation properties inherited from the standard CES maximization problem with constant marginal production costs in Krugman (1980) or Melitz (2003). We describe these properties here and refer to Appendix B.1 for details. Specifically, all firms located in a state i choose the same sales shares across destinations irrespective of their productivity; i.e., $s^j_{ni} = s_{ni}$ for all firms j located in i. From (22), this property leads to a common corporate tax rate across firms, $\bar{t}^j_i = \bar{t}_i$. Additionally, firms set identical, constant markups over marginal costs, but these markups vary bilaterally depending on corporate taxes. The price set in n by a firm with productivity z located in state i is:

$$p_{ni}(z) = \tau_{ni} \frac{\sigma}{\sigma - \tilde{t}_{ni}} \frac{\sigma}{\sigma - 1} \frac{c_i}{z}, \tag{23}$$

where

$$\tilde{t}_{ni} \equiv \frac{t^x_n - \sum_{n'} t^x_{n'} s_{n'i}}{1 - \bar{t}_i}. \tag{24}$$

The term $\tilde{t}_{ni}$ is a pricing distortion due to heterogeneity across states in the sales-apportioned corporate tax rates. This distortion increases with the sales tax in the importing state, t^x_n, implying that prices will be higher in states with higher sales-apportioned corporate taxes.[15] If sales-apportioned corporate tax rates were common across all states ($t^x_n = t^x$ for all n, and, thus $\tilde{t}_{in} = 0$ for all i and n), firms' prices would be as predicted in the standard CES framework; i.e., the markup over marginal cost would equal $\sigma/(\sigma - 1)$.

Firm Location Choice We assume that firm-level productivity z^j_i can be decomposed into a term z^0_i common to all firms located in i and a firm- and state-specific component ϵ^j_i, i.e., $z^j_i = z^0_i \epsilon^j_i$. The common component of productivity is assumed to be:

$$z^0_i = \left(\frac{G_i}{M_i^{\chi_F}} \right)^{\alpha_F} z_i^{1-\alpha_F}. \tag{25}$$

This common component has an endogenous part that depends on the amount of public spending and an exogenous part, z_i. The endogenous part equals total real government spending, G_i, divided by a function of the number of firms located in state i, $M_i^{\chi_F}$, where the parameter χ_F captures rivalry among the mass of firms M_i in the access to public goods. The exogenous part captures natural characteristics that impact productivity, like natural resource availability, the rate at which

[15] This relationship is consistent with the stylized fact shown in panel (d) of Figure 1 and the regressions in Appendix A.2.

the government transforms real spending into services valued by firms, and the share of public goods provided by state governments that increase the productivity of the firms located in their states. Firm j decides to locate in state i if $i = \arg\max_{i'} \pi_{i'}(z^j_{i'})$. The idiosyncratic component of productivity, ϵ^j_i, is independent and identically distributed across firms and states and is drawn from a Fréchet distribution, $\Pr(\epsilon^j_i < x) = \exp(-x^{-\varepsilon_F})$. As a result, the profits of firm j when it locates in state i, $\pi_i(z^j_i) = \pi_i(z^0_i)(\epsilon^j_i)^{\sigma-1}$, are also Fréchet-distributed with shape parameter $\varepsilon_F/(\sigma-1) > 1$. The fraction of firms located in state i is thus

$$M_i = \left(\frac{\pi_i\left(z^0_i\right)}{\bar{\pi}}\right)^{\frac{\varepsilon_F}{\sigma-1}}, \tag{26}$$

where $\pi_i(z)$ is defined in (20) and $\bar{\pi}$ is proportional to the expected profits before drawing the idiosyncratic productivity shocks $\{\epsilon^j_i\}^N_{i=1}$. Equation (26) indicates that the fraction of firms located in n depends on the common component of profits in n, $\pi_i(z^0_i)$, relative to that in other locations. A larger value of $\varepsilon_F/(\sigma-1)$ implies that the idiosyncratic productivity draws are less dispersed across states; as a result, states become closer substitutes and an increase in the relative profitability of a state leads to a larger response in the fraction of firms that choose to locate in it.

Equilibrium State Productivity Distribution and Aggregation As firms choose where to locate based on their state-specific productivity draws, the productivity distribution in each state is endogenous. State-level outcomes can be formulated as a function of a single moment $\tilde{z}_i$ of the productivity distribution in each state i:[16]

$$\tilde{z}_i = z^0_i M_i^{-\frac{1}{\varepsilon_F}}. \tag{27}$$

The productivity of the representative state-i firm, $\tilde{z}_i$, is larger than the unconditional average of the distribution of productivity draws (i.e., $\tilde{z}_i > z^0_i$), reflecting selection. This equation describes one of the congestion forces in the model: as firms are heterogeneous and self-select based on productivity, a higher number of firms locating in a state i is associated with lower average productivity in that state.

Aggregate outcomes in state i can be constructed as if all of the M_i firms located there had the (endogenous) productivity level $\tilde{z}_i$. Appendix B.2 presents the expressions for the state-level outcomes needed to compute the general equilibrium of the model.

Alternative Model with Free Entry of Firms For robustness, we also perform counterfactuals under the alternative assumption of free entry in each state i of firms with a common productivity level z^0_i defined in (25). Conditional on entering state i, firms solve the problem (20) for $z = z^0_i$, leading also to (22) to (24). To enter state i, firms must pay a cost equal to $f_{E,i}$ units of the cost-minimizing bundle of factors and inputs c_i in (21). In this alternative model, the zero-profit

[16]By definition, $\tilde{z}_i = (\int_{j\in J_i}(z^j_i)^{\sigma-1}dj)^{\frac{1}{\sigma-1}}$. To reach (27), we use the equality $\pi(\tilde{z}_i) = \bar{\pi}$ (implied by the Fréchet assumption on the distribution of productivity draws), equation (26), and the relationship $\pi_i(z^0_i)/\pi_n(\tilde{z}_i) = (z^0_i/\tilde{z}_i)^{\sigma-1}$.

condition $\pi_i(z_i^0) = c_i f_{E,i}$ thus determines the number of firms in each state i. Appendix B.2 presents the expressions for the state-level outcomes needed to compute the general equilibrium of the model under this free entry assumption. As in the baseline model, the number of firms in each state turns out to also be proportional to aggregate sales in the state.[17]

4.5 State Governments

State governments use state tax revenue R_n and transfers from the federal government $T_n^{fed\to st}$ to finance spending in public services, $P_n G_n$. The budget constraint of state n is thus

$$P_n G_n = R_n + T_n^{fed\to st}, \tag{28}$$

where the tax revenue collected by the state is

$$R_n = R_n^{corp} + R_n^y + R_n^c, \tag{29}$$

and where R_n^{corp}, R_n^c, and R_n^y denote government revenue from corporate, sales, and income taxes, respectively. These expressions are defined in (A.15) to (A.17) in Appendix B.2.

Consistent with the empirical evidence in Section 3.3, we assume that transfers from the federal government to state governments are proportional to the tax revenue collected by these state governments, where the constant of proportionality ψ_n may vary by state: $T_n^{fed\to st} = \psi_n R_n$. Combined with (28), this relationship implies that $P_n G_n = (1+\psi_n) R_n$. While the distribution of federal transfer rules $\{\psi_n\}_{n=1}^N$ impacts all model outcomes in levels, they do not have any impact on the counterfactual results we report in Section 7.

4.6 Federal Government

The federal government uses income and corporate taxes to finance transfers to state governments and to purchase the final good produced in each state, G_n^{fed}, which it employs as an input in the production of a national public good. Our analysis assumes that public services from the federal government are valued in the same way across locations.

4.7 General Equilibrium

A general equilibrium of this economy consists of distributions of workers and firms $\{L_n, M_n\}_{n=1}^N$, aggregate quantities $\{Q_n, C_n^L, C_n^K, I_n, G_n, G_n^{fed}\}_{n=1}^N$, wages per efficiency unit and cost of fixed factors $\{w_n, r_n\}_{n=1}^N$, and final good prices $\{P_n\}_{n=1}^N$ such that: i) final good producers optimize, setting their prices according to (17); ii) workers make consumption, work hours and location decisions optimally, as described in Section 4.1; iii) budget constraints of capital owners hold; iv) firms make

[17] Under free entry, the number of firms in state i is $M_i = (1-\bar{t}_i)X_i/(\sigma c_i f_{E,i})$. Under a fixed mass of ex-ante heterogeneous firms, $M_i = (1-\bar{t}_i)X_i/(\sigma\bar{\pi})$. The free-entry model has thus an additional parameter per state, the entry cost $f_{E,i}$, which can be calibrated to exactly match the observed number of firms per state. However, as illustrated in Section 6.4, the distribution of firms across states is well approximated by our baseline model.

production, sales, and location decisions optimally, as described in Section 4.4; v) government budget constraints hold, as described in Section 4.5; vi) final good markets clear in every location, i.e., (18) holds for all n; vii) the labor market clears in every state, i.e., labor supply (7) equals labor demand (given by (A.7) in Appendix B.2) for all n; viii) the land market clears in every state, i.e., (A.8) in Appendix B.2 holds; and ix) the national labor market clears, i.e., $\sum_n L_n = 1$.

4.8 Adjusted Fundamentals and Implementation of Counterfactuals

According to our model, taxes in any state may affect outcomes in every state. However, as shown in Appendix B.3, state tax rates $\left\{t_n^c, t_n^y(\cdot), t_n^x, t_n^l\right\}_{n=1}^N$ only impact state outcomes through their effect on a set of *adjusted fundamentals*, $\{\{\tau_{in}^A\}_{i=1}^N, z_n^A, u_n^A\}_{n=1}^N$,

$$z_n^A = \left(\frac{1-\bar{t}_n}{\sigma-1}\right)^{\frac{1}{\sigma-1}-\left(\frac{1}{\varepsilon_F}+\alpha_F\chi_F\right)} G_n^{\alpha_F} z_n^{1-\alpha_F}, \tag{30}$$

$$\tau_{in}^A = \frac{\sigma}{\sigma-\tilde{t}_{in}}\tau_{in}, \tag{31}$$

$$u_n^A = \left(\frac{1-T_n\left(z_n^L w_n\right)}{1+t_n^c}\right)^{1-\alpha_{W,n}} G_n^{\alpha_{W,n}} u_n, \tag{32}$$

and on the set of relative trade imbalances $\{P_nQ_n/X_n\}_{n=1}^N$ (i.e., the ratio between state expenditures and sales). Adjusted fundamentals $(z_n^A, \tau_{in}^A, u_n^A)$ become identical to state fundamentals (productivity z_n, amenity u_n, and trade costs τ_{in}) if we assume away preferences for government spending ($\alpha_F = \alpha_{W,n} = 0$) and set all tax rates to zero.

In our model, the distribution of outcomes across states depends on the distributions of adjusted fundamentals and relative trade imbalances similarly to how it depends on the state fundamentals and relative trade imbalances in standard economic geography models such as Allen et al. (2014) or Redding (2015). Therefore, the effect of a counterfactual change in the tax distribution predicted by our model is identical to the effect of a specific set of changes in amenities, productivities, trade costs, and trade imbalances in a standard economic-geography model. Importantly, the mapping from taxes to adjusted fundamentals and relative trade imbalances depends on the specific features of the tax system that we incorporate in our framework. Thus, to compute our model-predicted impact of counterfactual changes in the tax distribution, we simultaneously use a mapping from changes in fundamentals to changes in outcomes that is standard in existing economic-geography models, as well as a mapping from changes in taxes to changes in adjusted fundamentals that is specific to our environment. The first mapping is presented in (A.35) to (A.42) in Appendix B.5, and the second one in (A.43) to (A.46).

4.9 Agglomeration and Congestion Forces

Our model features agglomeration forces that push workers and firms to locate in the same state, as well as congestion forces that push them to spread across different states. Specifically, our model features agglomeration through standard home market effects. Because of trade costs, workers (who consume final goods) and firms (which purchase intermediate inputs) have an incentive to locate near or in states with low price indices and large markets; in turn, the price index of a state decreases with the number of firms located in that state, and its market size increases with the number of workers located in it. Our model also features agglomeration through public service provision as long as public goods are not fully rival (i.e., as long as either χ_F or χ_W are less than one). States with a larger number of firms and workers have higher tax revenue and public spending and, thus, higher utility per worker (see (4)) and firm productivity (see (25)).

At the same time, our baseline model features congestion through immobile factors in production, leading to a higher marginal production cost in a state as employment increases in that state (see (A.8) in Appendix B.2); through selection of heterogeneous firms, leading to a lower average firm productivity in a state as the number of firms increases (see (27)); and through the presence of immobile capital owners, who spend their income where they are located.[18]

5 Impact of Tax Dispersion in Simple Theoretical Frameworks

In this section, we discuss theoretically how changes in the dispersion in state tax rates holding government spending constant in every state impacts two aggregate outcomes: the welfare of the representative U.S. worker, as defined in (8), and the aggregate real income of all factors. We defer to Section 7 for a discussion of the additional effects caused by the changes in government spending implied by the changes in taxes.

We consider a special case of the model presented in Section 4. We assume away trade frictions, workers' intensive margin of labor supply, and heterogeneity in firms and workers, and impose that the public good is non-rival. We also assume that state sales and income taxes are the only taxes in the economy. This simplified version retains the ingredients of existing frameworks in the macro and local public finance literatures, including key spatial economics forces such as location-specific amenities and local congestion through fixed factors of production. We provide here an intuitive discussion of the predictions of this simplified model followed by formal propositions, and relegate the proofs to Appendix C. As we shall see in Section 7, the intuitions derived in this simpler model hold up in the full quantitative model.

To gain intuition, suppose momentarily that, in addition to the restrictions from the previous paragraph, there were no differences in public spending per capita or amenities across states ($g_n = g$ and $u_n = u$ for all n). In this case, the production side of the model would be the same as in standard models of labor allocation across firms, such as Hsieh and Klenow (2009), where the

[18] When there is no dispersion in sales-apportioned corporate taxes across states ($t_n^x = t^x$ for all n), no cross-ownership of assets across states, and same preferences for government spending across states ($\alpha_{W,n} = \alpha_W$ for all n), our baseline model fits in the class of models studied by Allen et al. (2014). Conditions (A.33) and (A.34) in Appendix B.4 show the restrictions to our model parameters implied by the relevant uniqueness condition included in that paper. Our baseline estimates satisfy these restrictions. While we do not derive an analogous uniqueness condition for the general version of our model, we have found no evidence of multiple equilibria in the system of equations we employ to compute the counterfactual predictions discussed in Section 7. Specifically, when numerically computing these counterfactual predictions, we experiment with multiple different starting values of our algorithm and always find the same results, suggesting that the system of equations we employ to compute such predictions indeed has a unique solution.

aggregate production function of each location can be interpreted as a firm. Spatial efficiency, defined as any allocation on the utility frontier that takes into account the utility of workers and capital owners, would then be attained by maximizing total output through equalization of the marginal products of labor across locations, $MPL_n = MPL_{n'}$ for all n and n'.

In this context, dispersion in tax rates would create dispersion in marginal products, which is inefficient. To see why, note that in any spatial equilibrium workers must be indifferent about where to locate, leading to the same consumption per worker everywhere. That is, denoting as c_n^L the consumption of a worker in state n, any spatial equilibrium with homogeneous workers would require $c_n^L = c_{n'}^L$ for any two states n and n'. In a world without trade costs, uniform per-capita consumption across states would imply that after-tax wages would be equal across any two states; i.e., $(1 - T_n) w_n = (1 - T_{n'}) w_{n'}$. Since wages equal marginal products, spatial dispersion in sales or income tax rates entering in T_n would result in spatial dispersion in the marginal product of labor, and in a spatial equilibrium that is inefficient.

Consider now the more relevant case in which public spending per capita and amenities differ across states. Given any distribution of these variables, spatial efficiency is no longer attained by maximizing total output. Instead, it requires the equalization of $MPL_n - c_n^L$ across locations. To see why, note that reallocating a worker from one location to another entails an output gain (equal to the difference in the marginal product of labor across those two locations) as well as a cost in terms of final goods consumed (equal to the difference in the per capita consumption c_n^L of those two locations). In any spatial equilibrium of this more general model, consumption per worker c_n^L will vary across locations to compensate for the differences in public spending per capita and amenities. Because $MPL_n = w_n$, this means that $w_n - c_n^L$, the tax payment per worker, must be equalized across locations for efficiency. This point was established by Flatters et al. (1974), Wildasin (1980), and Helpman and Pines (1980). Note that, as a result, efficiency now requires dispersion in the marginal product of labor across locations.

We summarize these results in the following proposition.

Proposition 1. *Consider a tax structure with only sales and income taxes. Assume no trade costs ($\tau_{in} = 1$ for all i, n), perfect substitutability across varieties ($\sigma \to \infty$), homogeneous firms ($\varepsilon_F \to \infty$), homogeneous workers with constant labor supply ($\varepsilon_W \to \infty$, $\zeta_n \to \infty$ and h_n constant), and non-rival public goods ($\chi_W = 0$). Then:*

i) (Hsieh and Klenow, 2009) In the absence of compensating differentials (g_n and u_n constant across locations), no dispersion in state wages, w_n, is necessary for efficiency. This requirement implies that no dispersion in tax rates T_n across states is necessary for efficiency.

ii) (Flatters et al., 1974; Wildasin, 1980; Helpman and Pines, 1980) In the presence of compensating differentials (g_n and u_n may vary across locations), no dispersion in state wages minus personal consumption expenditures, $w_n - c_n^L$, is necessary for efficiency. This requirement implies that no dispersion in the per capita tax payments $T_n w_n$ across states is necessary for efficiency.

The first part of this proposition is a special case of the second one. In the absence of compensating differentials, we have that $(1 - T_n) w_n = (1 - T_{n'}) w_{n'}$ for all states n and n'. Therefore, the condition of tax payment equalization established in the second part of the proposition implies tax rate equalization. As pointed out by Wildasin (1980), this reasoning holds for any arbitrary distribution of public service provision, including the efficient one, and regardless of whether that distribution is determined within the model to satisfy a government budget constraint or exogenously given. Under more general conditions than those assumed in the proposition, some dispersion in per capita tax payments may be required for efficiency. However, in assessing the implications of the full quantitative model, we shall see that the intuition provided by the second part of Proposition 1 is consistent with the results: the gains from changes in tax rates given a distribution of spending in public services are larger in counterfactuals in which the reduction in the dispersion in tax payments per capita is larger.

Proposition 1 implies that, given a distribution of spending in public services, an elimination of dispersion in tax rates will increase the efficiency of the allocation if it reduces the dispersion of the tax payments per capita, $T_n w_n$. The next proposition formalizes that the impact of dispersion in tax rates on dispersion in tax payments per capita depends on the relationship between state tax rates and fundamentals in the initial allocation.

Proposition 2. *In addition to the restrictions from Proposition 1, assume no cross-state dispersion in preferences for government spending ($\alpha_{W,n} = \alpha_W$ for all n). Then, eliminating the dispersion in the real keep-tax rates (i.e., setting $T_n = T$ for all n), while keeping constant both its mean and the government spending in every state:*

i) increases worker welfare if $corr(Z_n^{\frac{1}{\beta}}, (1-T_n)^{\frac{1}{\beta}})$ is low enough, and decreases worker welfare if $corr(Z_n^{\frac{1}{\beta}}, (1-T_n)^{\frac{1}{\beta}})$ is large enough, where $Z_n = \left(z_n^0/\gamma\right)^{1/\gamma} H_n^{\beta} \left(u_n G_n^{\alpha_W}\right)^{\frac{1}{1-\alpha_W}}$; and

ii) may increase or decrease the aggregate real income depending on the joint distribution of T_n, u_n, and G_n.

The first part of the proposition reflects that, when the correlation between T_n and fundamentals is sufficiently large (in the sense that $corr(Z_n^{\frac{1}{\beta}}, (1-T_n)^{\frac{1}{\beta}})$ is low enough), so is the correlation between taxes and wages, leading to high dispersion in tax payments per capita in the initial allocation.[19] In this case, eliminating dispersion in T_n increases welfare through less dispersion in tax payments per capita. To understand the second part of Proposition 2, bear in mind that aggregate real income is maximized when marginal products of labor are equalized across regions. Therefore, eliminating dispersion in worker keep tax rates will increase or decrease aggregate real income depending on whether this change in the tax system reduces or increases cross-state dispersion in the marginal product of labor. It is straightforward to construct examples in which an elimination of tax dispersion reduces output; for example, this result may happen in cases with an initially negative correlation between keep tax rates and amenities.[20] However, as implied by the first part of Proposition 1, an elimination of tax dispersion will necessarily increase aggregate output if there

[19]In the proof of Proposition 2 in Appendix C, we provide a more general correlation condition that does not impose restrictions on ε_W and χ_W.

[20]E.g., let $A_n \equiv u_n G_n^{\alpha_W}$ and $B_n = (1-T_n)^{1-\alpha_W}$. Consider a case with two states, $n = 1, 2$ and two levels of keep tax rates, $B_1 = 1/A_1$ and $B_2 = 1/A_2$. In this case, output is maximized because marginal products of labor are equalized across both states in equilibrium ($v^{1/(1-\alpha_W)} = MPL_n$ for $n = 1, 2$). Therefore, in this example, eliminating tax dispersion increases dispersion in marginal products, reducing output.

is no dispersion in compensating differentials ($u_n = u$ for all n and either $G_n = G$ for all n or $\alpha_W = 0$).

An important implication of Proposition 2 is that the model described in Section 4 includes forces pushing aggregate outcomes in opposite directions in response to a reduction in the dispersion in income and sales taxes. Furthermore, the relative strength of these opposing forces and thus the resulting impact of such a counterfactual change in taxes depends on the value of parameters such as the amenities and productivities of each state.

6 Data and Estimation

This section describes how we quantify the model parameters. Section 6.1 discusses the calibration of the production function, preference parameters, state fundamentals, and ownership of capital by state. Section 6.2 discusses the estimation of the elasticities of employment and firm mobility with respect to state taxes, and the estimation of the weights of public goods on workers' preferences and firms' productivity. Section 6.3 describes how these parameter estimates collectively determine the location of workers and firms. Section 6.4 shows that the estimated model matches features of data not used in our parametrization. Appendix F describes the data sources that we use.

6.1 Calibrated Parameters

Production Technologies, Preference Parameters, and the Distribution of Efficiency Units The value-added share γ and share of labor in value added $1 - \beta$ are calibrated from KLEMS Data for the U.S. We use 2007 data to compute $1 - \gamma = .45$ as the ratio of expenditure in intermediate inputs to gross output, and $1-\beta = .62$ as the ratio of labor compensation to gross value added. In our model, the elasticity of substitution across varieties σ impacts the partial elasticity of import shares with respect to bilateral trade costs. A common practice in the international trade literature is to identify this elasticity from variation in tariffs across countries. No tariff applies to the exchange of goods between U.S. states, complicating the estimation of σ in our context. Therefore, we set its value to 4, which is a central value in the range of estimates used in the international trade literature; see Head and Mayer (2014). We set the disutility of effort $\eta = 2.84$ following Chetty et al. (2011). Finally, the parameters $(z_{L,n}, \zeta_n)$ that characterize the distribution of efficiency units within each state are chosen to match the distribution of hourly wages across individuals within each state, as described in Appendix D.2.1.

Fundamentals The system of equations (A.35)-(A.46) that characterizes the general equilibrium impact of changes in taxes, described in Appendix B.5, is a function of all fundamentals across states (endowments of land and structures H_n, productivities z_n, parameters ζ_n and $z_{L,n}$ of the skill distributions, amenities u_n, disutility from labor $\alpha_{h,n}$, trade costs τ_{in}, and, in the version of the model with free entry of firms, entry costs $f_{E,n}$). According to this system, these fundamentals affect the equilibrium of the economy through the joint distribution of expenditures, sales revenue, and employment shares across states. This property of the system of equilibrium conditions allows us to compute the effect of counterfactual changes in these fundamentals without having to separately determine the value of each different fundamental.[21] Specifically, one only needs to set the composite of the fundamentals A_{in} defined in (A.29) to be consistent with the observed expenditure shares through (A.27).[22]

Ownership Rates Equation (A.23) in Appendix B.2 shows that the set of ownership rates $\{\omega_n\}_{n=1}^N$ are uniquely identified as a function of observables, technology parameters in state n, and the parameter σ. The parametrized model exactly matches the distribution of trade imbalances across states in 2007. We measure these trade imbalances as the ratio of aggregate expenditures to sales.

6.2 Estimated Elasticities

In this section, we describe how we estimate the parameters governing the dispersion of workers' idiosyncratic preferences for each state, ε_W, the share of public goods in worker preferences, $\{\alpha_{W,n}\}_{n=1}^N$, the dispersion of firms' idiosyncratic productivities in each state, ε_F, and the share of public goods in firms' productivity, α_F. Appendix D.9 shows that our baseline estimates are in line with the previous literature, which relies on alternative identifying assumptions.

6.2.1 Estimation of Workers' Location Preferences and Value of Public Goods

Combining the definition of the state appeal in (4), the labor supply equation in (7), the expression for hours worked in (13), and the government budget constraint in (28), we obtain the following expression for the share of workers living in state n:

$$\ln L_{nt} = a_{0,n} \ln \tilde{y}_{nt} + a_{1,n} \ln \tilde{R}_{nt} + a_{2,n} \ln A_{nt} + \psi_t^L + \xi_n^L + \nu_{nt}^L, \tag{33}$$

where the coefficients $a_{0,n} \equiv \varepsilon_W(1-\alpha_{W,n})/(1+\chi_W\varepsilon_W\alpha_{W,n})$, $a_{1,n} \equiv \varepsilon_W\alpha_{W,n}/(1+\chi_W\varepsilon_W\alpha_{W,n})$ and $a_{2,n} \equiv \varepsilon_W/(1+\chi_W\varepsilon_W\alpha_{W,n})$ are functions of structural parameters. The variables $\tilde{y}_{nt}$ and $\tilde{R}_{nt}$ are measures of after-tax real labor earnings and real government spending, respectively, and A_{nt} is a

[21] This feature of our model is shared by the trade and economic geography models discussed in the Introduction. Dekle et al. (2008) show how to undertake counterfactuals with respect to trade costs without having to identify all fundamentals separately.

[22] Appendix Table A.5 shows that the model-predicted relation between the composite of the fundamentals A_{in} and proxies of both trade costs between states i and $n$and amenities in each of these two states are consistent with the data.

measure of within-state wage dispersion. Specifically:

$$\tilde{y}_{nt} \equiv \frac{a^y_{nt}}{1+t^c_{nt}} \frac{\left(h_{nt} z^L_n w_{nt}\right)^{1-b^y_{nt}}}{P_{nt}}, \tag{34}$$

$$\tilde{R}_{nt} \equiv \frac{R_{nt}}{P_{nt}}, \tag{35}$$

$$A_{nt} \equiv \frac{\zeta_n}{\zeta_n - (1-b^y_{nt})(1-\alpha_{W,n})}. \tag{36}$$

Finally, the term $\psi^L_t + \xi^L_n + \nu^L_{nt} \equiv (\varepsilon_W/(1+\chi_W \varepsilon_W \alpha_{W,n})) \ln u_{nt}/v_t$ accounts for year and state fixed effects and deviations from these state and year fixed effects in states' amenities, u_{nt}. To construct the covariates in (34)-(36), we measure state-specific after-tax labor earnings combining hours and earnings data from the March Current Population Survey (CPS), information on sales tax rates from the Book of States and on income tax rates from NBER's TAXSIM, and regional price index data from the Bureau of Labor Statistics (BLS). We construct a measure of real government spending as the sum of sales, individual income, and corporate income tax revenue reported in the U.S. Census of Governments divided by the corresponding regional price index. The wage dispersion term A_{nt} depends on the wage distribution parameter ζ_n, income tax schedule parameters b^y_{nt} (from NBER's TAXSIM), and the structural parameter $\alpha_{W,n}$. We provide in Appendix F.3 detailed descriptions of how we construct each of these covariates.

The structural parameters $\{\alpha_{W,n}\}^N_{n=1}$ enter (33) through $\{(a_{0,n}, a_{1,n})\}^N_{n=1}$ and $\{A_{nt}\}^N_{n=1}$. In practice, as shown in Appendix Table A.8, the terms $\{A_{nt}\}^N_{n=1}$ have minimal effect on the estimates. Therefore, intuitively, we can think of the parameter $\alpha_{W,n}$ as being identified by the vector $(a_{0,n}, a_{1,n})$; i.e., $\alpha_{W,n} = a_{1,n}/(a_{0,n} + a_{1,n})$. The parameters ε_W and χ_W are however not separately identified from the coefficients in (33) alone. We thus present estimates of the parameter ε_W conditional on different values of χ_W.

Endogeneity If state amenities $\{u_{nt}\}^{N,T}_{n=1,t=1}$ are not fully captured by the year $\{\psi^L_t\}^T_{t=1}$ and state $\{\xi^L_n\}^N_{n=1}$ fixed effects, our model predicts that the state-year specific error term in (33), ν^L_{nt}, will be correlated with the regressors $\tilde{y}_{nt}$ and $\tilde{R}_{nt}$. The key source of this correlation is the impact that amenities have on the location of workers. If, for example, there is a positive amenity shock in California, then workers will move to this state. This outward shift of the labor supply curve would lower wages, thus causing a reduction in the after-tax labor earnings in California. Thus, following a positive amenity shock, we would observe an increase in the number of workers in California. Ceteris paribus, this inflow of workers would generate a decrease in wages and, as a result, after-tax labor earnings. This negative correlation between amenity improvements and after-tax labor earnings would tend to generate a downward bias in Ordinary Least Squares (OLS) estimates of the parameters $\{a_{0,n}\}^N_{n=1}$. Similarly, our model predicts that an amenity-induced increase in the number of workers in a state raises tax revenue in this state, therefore increasing government service provision and generating a positive correlation between amenity improvements in a state and the state's real government spending. This positive correlation would tend to generate an upward bias in the OLS estimates of $\{a_{1,n}\}_{n=1}^{N}$. Since our estimates of the parameters capturing workers' preferences for government services in state n, $\alpha_{W,n}$, are decreasing in our estimates of the reduced-form parameter $a_{0,n}$ and increasing in our estimates of $a_{1,n}$, OLS estimates of $a_{W,n}$ will tend to be biased upwards. To obtain consistent estimates of $\{a_{W,n}\}_{n=1}^{N}$, we rely on two different sets of instruments: (1) a vector of "external" state tax rates $\boldsymbol{Z}_{nt}^{T}$; and, (2) a vector of Bartik-type instruments $\boldsymbol{Z}_{nt}^{B}$.

Instruments For each state n, the instrument vector $\boldsymbol{Z}_{nt}^{T}$ is a weighted-average of tax rates in states other than n. Specifically, $\boldsymbol{Z}_{nt}^{T} \equiv (t_{nt}^{*c}, t_{nt}^{*y}, t_{nt}^{*x})$ is a vector of inverse-distance weighted averages of sales (indexed as c), income (y), and sales-apportioned corporate (x) tax rates in every state other than n:

$$t_{nt}^{*z} \equiv \sum_{i \neq n} d_{ni} t_{it}^{z}, \quad \text{with} \quad d_{ni} = \frac{\ln(dist_{ni})^{-1}}{\sum_{i' \neq n} \ln(dist_{ni'})^{-1}} \quad \text{for} \quad z = c, y, x. \tag{37}$$

These instruments will be relevant as long as they affect after-tax earnings and tax revenues in state n. Our model is consistent with the relevance of the instrument vector $\boldsymbol{Z}_{nt}^{T}$: it predicts that, for example, an income tax increase in Oregon would cause some workers to move to other states, affecting the after-tax equilibrium earnings and total tax earnings in the states to which they move. Conversely, our model does not take a stand on the political process that determines states' tax rates and, thus, is silent about the validity of the instrument vector $\boldsymbol{Z}_{nt}^{T}$. However, all variables in vector $\boldsymbol{Z}_{nt}^{T}$ are valid instruments if changes in taxes in nearby states are not correlated with state n's residual amenity level ν_{nt}^{L}.

Our second instrument vector $\boldsymbol{Z}_{nt}^{B} \equiv (\text{BtkP}_{nt}, \text{BtkTR}_{nt})$ includes two Bartik (1991)-type instruments:

$$\text{BtkP}_{nt} = \sum_{k} \frac{L_{kn,1974}}{L_{n,1974}} \frac{PAY_{kt} - PAY_{k,t-10}}{PAY_{k,t-10}}, \quad \text{BtkTR}_{nt} = \sum_{\tau=\{c,y,x\}} \frac{REV_{\tau,n,1974}}{REV_{n,1974}} \frac{REV_{\tau,t} - REV_{\tau,t-10}}{REV_{\tau,t-10}}, \tag{38}$$

where k indexes one-digit SIC industries, PAY denotes real annual payroll, τ indexes different types of taxes (i.e., personal income taxes, corporate income taxes, and sales taxes), and REV denotes tax revenue. The instrument BtkP_{nt} uses variation in each state's exposure to national industry shocks.[23] For example, if a state n is very dependent on a particular industry k (i.e., $L_{kn,1974}/L_{n,1974}$ is high) and this industry experiences relative growth at the national level, then after-tax real earnings in state n are likely to grow. The instrument BtkTR_{nt} uses variation in each state's exposure to revenue-source national shocks. Suppose a state relies mostly on sales taxes for tax revenue (i.e., $REV_{sales,n,1974}/REV_{n,1974}$ is relatively high), then national sales booms (i.e., $(REV_{\tau,t} - REV_{\tau,t-10})/REV_{\tau,t-10}$ is relatively high for $\tau = sales$) will cause especially high

[23] There is a recent literature exploring the properties of shift-share instruments. See Goldsmith-Pinkham, Sorkin, and Swift (2018) and Borusyak, Hull, and Jaravel (2018) for a discussion of identification approaches in this setting. See Adão, Kolesár, and Morales (2018) for discussion of inference procedures.

tax revenues for that state and, consequently, a growth in government spending. Empirically, initial revenue-share weighted national tax revenue shocks are good predictors of state tax revenue changes.[24]

We use data on $\tilde{y}_{nt}$, $\tilde{R}_{nt}$, and A_{nt}, a fixed value of χ_W, and a vector of instruments $\boldsymbol{Z}_{nt}^L$ (where $\boldsymbol{Z}_{nt}^L$ may equal either $\boldsymbol{Z}_{nt}^T$ or $\boldsymbol{Z}_{nt}^B$) to identify the parameters ε_W and $\{\alpha_{W,n}\}_{n=1}^N$ in the following moment conditions:

$$\mathbb{E}[\nu_{nt}^L * (\boldsymbol{Z}_{nt}^L, \boldsymbol{\xi}^L, \boldsymbol{\psi}^L)'] = 0, \tag{39}$$

where ν_{nt}^L is the residual from equation (33). This orthogonality restriction assumes that the state-year specific amenity shocks, ν_{nt}^L, are mean independent of the vector of instruments $\boldsymbol{Z}_{nt}^L$, conditional on $\boldsymbol{\xi}^L$, which denotes a complete set of state dummies, and $\boldsymbol{\psi}^L$, which denotes a complete set of year dummies. Given the unconditional moment conditions in (39), we use the optimal two-step Generalized Method of Moments (GMM) estimator (Hansen, 1982) to estimate the parameters of interest. We report the resulting estimates in Table 1.

Estimates of Worker Preferences Our estimates exploit several approaches to deal with the potential variability in $\alpha_{W,n}$ across states.

First, we impose the assumption that $\alpha_{W,n} = \alpha_W$ for every state n. Conditional on imposing that public goods enjoyed by workers are rival (i.e., $\chi_W = 1$), our estimates of ε_W and α_W using external taxes as instruments, $\boldsymbol{Z}_{nt}^L = \boldsymbol{Z}_{nt}^T$, equal 2.10 and 0.23, with standard errors 0.8 and 0.07, respectively. The results using the Bartik-style instruments, $\boldsymbol{Z}_{nt}^L = \boldsymbol{Z}_{nt}^B$, are similar. Combining both vectors of instruments, $\boldsymbol{Z}_{nt}^L = (\boldsymbol{Z}_{nt}^T, \boldsymbol{Z}_{nt}^B)$, we obtain estimates of ε_W and α_W equal to 1.73 and 0.16. We use this last set of estimates as our baseline specification.

Second, we allow for workers' preferences for public goods to vary by state and use the observed ratio of tax revenue to GDP in each state to calibrate the corresponding parameter $\alpha_{W,n}$. Specifically, we assume that $\alpha_{W,n} = R_n/GDP_n$, where R_n/GDP_n denotes the average ratio of tax revenue to GDP during the sample period. This approach yields estimates of $\alpha_{W,n}$ between 0.01 and 0.06. Conditional on these calibrated values of the parameter vector $\{\alpha_{W,n}\}_{n=1}^N$ and $\chi_W = 1$, the resulting estimate of ε_W is 1.48 (0.33).

Third, rows five and six present estimates of ε_W under two alternative assumptions. First, we impose again the assumption that $\alpha_{W,n} = \alpha_W$ for every state n and calibrate the value of α_W to equal the cross-state mean value of the states' tax revenue to GDP ratio (i.e., $\alpha_{W,n} = 0.04$). Second, we impose the extreme assumption that public services have no impact on workers' utility (i.e., $\alpha_{W,n} = 0$ for every state n). Under these assumptions, we obtain estimates of ε_W equal to 1.25 (0.35) and 1.04 (0.30), respectively.

As columns 1 and 3 in Table 1 show, imposing instead the assumption that public goods are non-rival (i.e., $\chi_W = 0$) does not affect the estimated value of α_W, and only slightly decreases the estimates of ε_W. Appendix D.6 provides additional estimates, robustness tests, and discussion.

[24] See, e.g., columns 2 and 5 of Appendix Table A.11, which shows a regression of the endogenous covariates in 33 on BtkP_{nt} and BtkTR_{nt}. Appendix Table A.13 shows a similar table for firms. Appendix D.6 and D.7 provide additional discussion.

Table 1: GMM Estimates of Worker Parameters

Instruments	Restrictions on $\alpha_{W,n}$	ε_W		α_W	
		$\chi_W = 0$	$\chi_W = 1$	$\chi_W = 0$	$\chi_W = 1$
$\boldsymbol{Z}_{nt}^T$	$\alpha_{W,n} = \alpha_W$	1.42***	2.1***	.23***	.23***
		(.36)	(.8)	(.07)	(.07)
$\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = \alpha_W$	1.79***	2.25**	.11*	.11*
		(.63)	(.93)	(.06)	(.06)
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = \alpha_W$	1.36***	1.73***	.16***	.16***
		(.3)	(.52)	(.06)	(.06)
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = \frac{R_n}{GDP_n}$	.75***	1.48***		
		(.23)	(.33)		
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = 0.04 = \text{Mean}\frac{R_n}{GDP_n}$	1.19***	1.25***		
		(.32)	(.35)		
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = 0$	1.04***	1.04***		
		(.3)	(.3)		

NOTES: This table shows the GMM estimates for structural parameters entering the labor mobility equation. The data are at the state-year level. Each column uses information on 712 observations. Every specification includes state and year fixed effects. Observations are weighted using state population. The instrument vectors used to compute the estimates in each row are indicated under the heading "Instruments". Similarly, restrictions on $\alpha_{W,n}$ are described under the heading "Restrictions on $\alpha_{W,n}$". Robust standard errors are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

Interpretation of Estimates of Worker Preferences Our model assumes that workers can move across locations without any need to pay a fixed cost of moving. Consequently, the estimating equation in (33) predicts that the share of workers located in a state in any given period depends exclusively on that period's values of after-tax labor earnings and real government spending. In a more general model with fixed costs of mobility, the population share in a location in a period t would depend on the corresponding share in every location in period $t-1$. Furthermore, in this general model, a permanent change in any of the economic determinants of workers' locations will have a different impact on the short and long run. While building a fully dynamic model of worker location is beyond the scope of this paper, we present in Appendix D.8 simulation results that explore how close our estimates are to capturing the long-run impact of after-tax real earnings and real government spending on the number of workers living in each state.[25] Our simulation shows that, given the large amount of persistence in all the regressors entering (33), our estimates of $\{(a_{0,n}, a_{1,n})\}_{n=1}^N$ are closer to the true long-run than to the short-run impact of changes in these regressors on the number of workers living in each state. Consistent with this finding, re-estimating ε_W and α_W under the assumption that each period in our model corresponds to a half-decade yields only modestly larger estimates for ε_W and very similar estimates of α_W.

[25] For general equilibrium models of labor mobility that allow for migration costs, see Artuç et al. (2010) and Caliendo et al. (2015).

6.2.2 Estimation of Firms' Location Preferences and Value of Public Goods

Combining the pricing equation in (23), the definition of productivity in (25), the firm-location equation in (26), and the definition of profits in (A.10), our model yields the following expression for the share of firms in state n:

$$\ln M_{nt} = b_0 \ln\left(\left(1-\bar{t}_n\right) MP_{nt}\right) + b_1 \ln c_{nt} + b_2 \ln \tilde{R}_{nt} + \psi_t^M + \xi_n^M + \nu_{nt}^M, \tag{40}$$

where $b_0 \equiv \left(\varepsilon_F / \left(\sigma-1\right)\right) / \left(1+\chi_F \alpha_F \varepsilon_F\right)$, $b_1 \equiv -\varepsilon_F / \left(1+\chi_F \alpha_F \varepsilon_F\right)$, and $b_2 \equiv -\alpha_F b_1$; ψ_t^M is a time effect, and $\xi_n^M + \nu_{nt}^M$ accounts for state effects and deviations from state and year effects in log productivity, $\ln z_{nt}$. Unit costs are $c_{nt} = (w_{nt}^{1-\beta} r_{nt}^{\beta})^{\gamma} P_{nt}^{1-\gamma}$.[26] MP_{nt} is the market potential of state n in year t,

$$MP_{nt} = \sum_{n'} E_{n't} \left(\frac{\tau_{n'nt}}{P_{n't}} \frac{\sigma}{\sigma - \tilde{t}_{n'nt}} \frac{\sigma}{\sigma-1} \right)^{1-\sigma}, \tag{41}$$

where $E_{n't} \equiv P_{n't} Q_{n't}$ denotes aggregate expenditures in state n'. The market potential of state n is a measure of the market size for a firm located in state n, once trade costs with other states are taken into account. Details on how we construct measures of all the covariates entering (41) are in Appendix D.2.1.

Given values of the reduced-form parameters b_0, b_1, and b_2, the impact of government spending on productivity is identified as $\alpha_F = -b_2/b_1$.[27] The parameters ε_F and χ_F are however not separately identified from the coefficients in (40) alone. We thus present estimates of the parameter ε_F conditional on different values of χ_F.

The problem of endogeneity in this case arises from the potential that unobserved productivity shocks in ν_{nt}^M may be positively correlated with local wages, and therefore with c_n. Since firms are likely to locate in more productive places, such a shock might bias b_1 toward a positive value. This bias, in turn, may bias α_F toward zero, and may even result in a negative value. We overcome this problem by using a similar set of instruments as the ones we used to estimate the worker location equation.

Conditional on assumed values of χ_F and σ, we estimate parameters ε_F and α_F using an optimal two-step GMM estimator that uses the following moment conditions:

$$\mathbb{E}[\nu_{nt}^M * (\boldsymbol{Z}_{nt}^M, \boldsymbol{\xi}^M, \boldsymbol{\psi}^M)'] = 0, \tag{42}$$

where $\boldsymbol{Z}_{nt}^M = (\boldsymbol{Z}_{nt}^T, \boldsymbol{Z}_{nt}^B, MP_{nt}^*)$ is a vector of instruments, $\boldsymbol{\xi}^M$ denotes a full set of state dummies, and $\boldsymbol{\psi}^M$ denotes a full set of year dummies. The instrument vector $\boldsymbol{Z}_{nt}^T$ is as defined in (37). The instrument vector $\boldsymbol{Z}_{nt}^B$ combines the instrument BtkTR_{nt} defined in (38) with the following Bartik-type instrument:

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[26] We define here the unit cost exclusive of the federal payroll tax, which is absorbed by the time effect. I.e., $\psi_t^M \equiv -\varepsilon_F / \left(\left(\sigma-1\right)\left(1+\chi_F \alpha_F \varepsilon_F\right)\right) \ln(\sigma \bar{\pi}_t) + b_1 \left(1-\beta\right) \gamma \ln(1+t_{fed}^w)$ and $\xi_n^M + \nu_{nt}^M \equiv (1-\alpha_F)\varepsilon_F / \left(1+\chi_F \alpha_F \varepsilon_F\right) \ln z_{nt}$.

[27] One could try to identify the parameter vector σ using (40) and (41). However, the identification of σ from these equations is very sensitive to the particular proxy that we adopt for the trade costs between any two regions n and n', $\tau_{n'nt}$. Given that we do not have a precise measure of these trade costs, we fix σ to a standard value in the international trade literature (see Section 6.1 for details).

$$\text{BtkW}_{nt} = \sum_k \frac{L_{kn,1974}}{L_{n,1974}} \frac{W_{kt} - W_{k,t-10}}{W_{k,t-10}},$$

where W_{kt} denotes the average hourly wage in industry k and year t. The reason why we substitute the instrumental variable BtkP_{nt} used in the estimation of workers' location preferences and public goods for the instrumental variable BtkW_{nt} is that the endogenous variable in this case is unit costs, which depend on hourly wages rather than total earnings. Finally, the instrument MP^*_{nt} is an exogenous shifter of market potential, as defined in Appendix D.3.

Table 2: GMM Estimates of Firm Parameters

Instruments	Restrictions on α_F	ε_F		α_F	
		$\chi_F = 0$	$\chi_F = 1$	$\chi_F = 0$	$\chi_F = 1$
$\boldsymbol{Z}^T_{nt}$	None	2.45***	2.84***	.06	.06
		(.27)	(.62)	(.07)	(.07)
$\boldsymbol{Z}^B_{nt}$	None	2.81***	2.46***	-.05	-.05
		(.36)	(.46)	(.08)	(.08)
$\boldsymbol{Z}^T_{nt}$, $\boldsymbol{Z}^B_{nt}$	None	2.44***	2.63***	.03	.03
		(.27)	(.46)	(.06)	(.06)
$\boldsymbol{Z}^T_{nt}$, $\boldsymbol{Z}^B_{nt}$	$\alpha_F = 0.04 = \text{Mean}\frac{R_n}{GDP_n}$	2.43***	2.7***		
		(.26)	(.32)		
$\boldsymbol{Z}^T_{nt}$, $\boldsymbol{Z}^B_{nt}$	$\alpha_F = 0$	2.45***	2.45***		
		(.26)	(.26)		

NOTES: This table shows the GMM estimates for structural parameters entering the firm mobility equation. The data are at the state-year level. Each column uses information on 587 observations. The number of observations is lower than in Table 1 due to missing data in variables required to construct the measures of market potential and unit costs (see Appendix D.3 for details). Every specification includes state and year fixed effects. The instrument vectors used to compute the estimates in each row are indicated under the heading "Instruments". Similarly, restrictions on α_F are described under the heading "Restrictions on α_F". Robust standard errors are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

As Table 2 shows, conditional on assuming that public goods enjoyed by firms are rival (i.e., $\chi_F = 1$) and relying solely on the external tax instruments, $\boldsymbol{Z}^T_{nt}$, we obtain estimates of ε_F and α_F equal to 2.84 and 0.06, with standard errors 0.62 and 0.07, respectively. As in Table 1, the second row estimates only use the Bartik-type instruments in the vector $\boldsymbol{Z}^B_{nt}$, which yields an estimates of ε_F equal to 2.46 (0.46) and of α_F that, although negative, is not statistically different from zero. The third row combines both types of instruments, which yields our baseline firm estimates for ε_F and α_F of 2.63 and 0.03, respectively. The final two rows present estimates in which we calibrate α_F and estimate ε_F subject to the calibrated value of α_F. We use two different calibration strategies for α_F. First, similar to the calibration performed on α_W above, we assume that α_F is equal to the cross-state average of tax revenue over GDP; i.e., $\alpha_F = 0.04$. As our baseline estimate of α_F is very close to this value, the impact of this calibration on our estimate of ε_F is minimal. Second, we impose the extreme assumption that firms' productivity is unaffected by the provision of government services; i.e., $\alpha_F = 0$. In this case, we obtain an estimate of ε_F that is somewhat smaller than the baseline estimate when public goods are assumed to be rival, $\chi_F = 1$, and almost the same as the baseline estimate when they are assumed to be are non-rival, $\chi_F = 0$. Appendix D.7 provides supplemental estimates and discussion.

6.3 Reduced-Form Elasticities

The estimated coefficients from the third row of Table 1, which is our baseline, imply that the change in employment in state n are consistent with the estimated relationship

$$\ln L_{nt} = 1.14 * \ln \tilde{y}_{nt} + 0.22 * \ln \tilde{R}_{nt} + 1.36 * \ln A_{nt} + \psi_t^L + \xi_n^L + \nu_{nt}^L. \tag{43}$$

Similarly, the estimated coefficients from the first row of Table 2 imply that the change in the number of firms in state n are consistent with the estimated relationship

$$\ln M_{nt} = 0.81 * \ln \left(\left(1 - \bar{t}_n\right) MP_{nt} \right) - 2.44 * \ln c_{nt} + 0.07 * \ln \tilde{R}_{nt} + \psi_t^M + \xi_n^M + \nu_{nt}^M. \tag{44}$$

For these values of the parameter vector, workers are about five times more responsive to after-tax real earnings than to government spending, while firms are about twelve times more responsive to after-tax market potential than to government spending. We note that the assumed values of χ_W and χ_F do not matter for these reduced form elasticities.

6.4 Over-Identification Checks

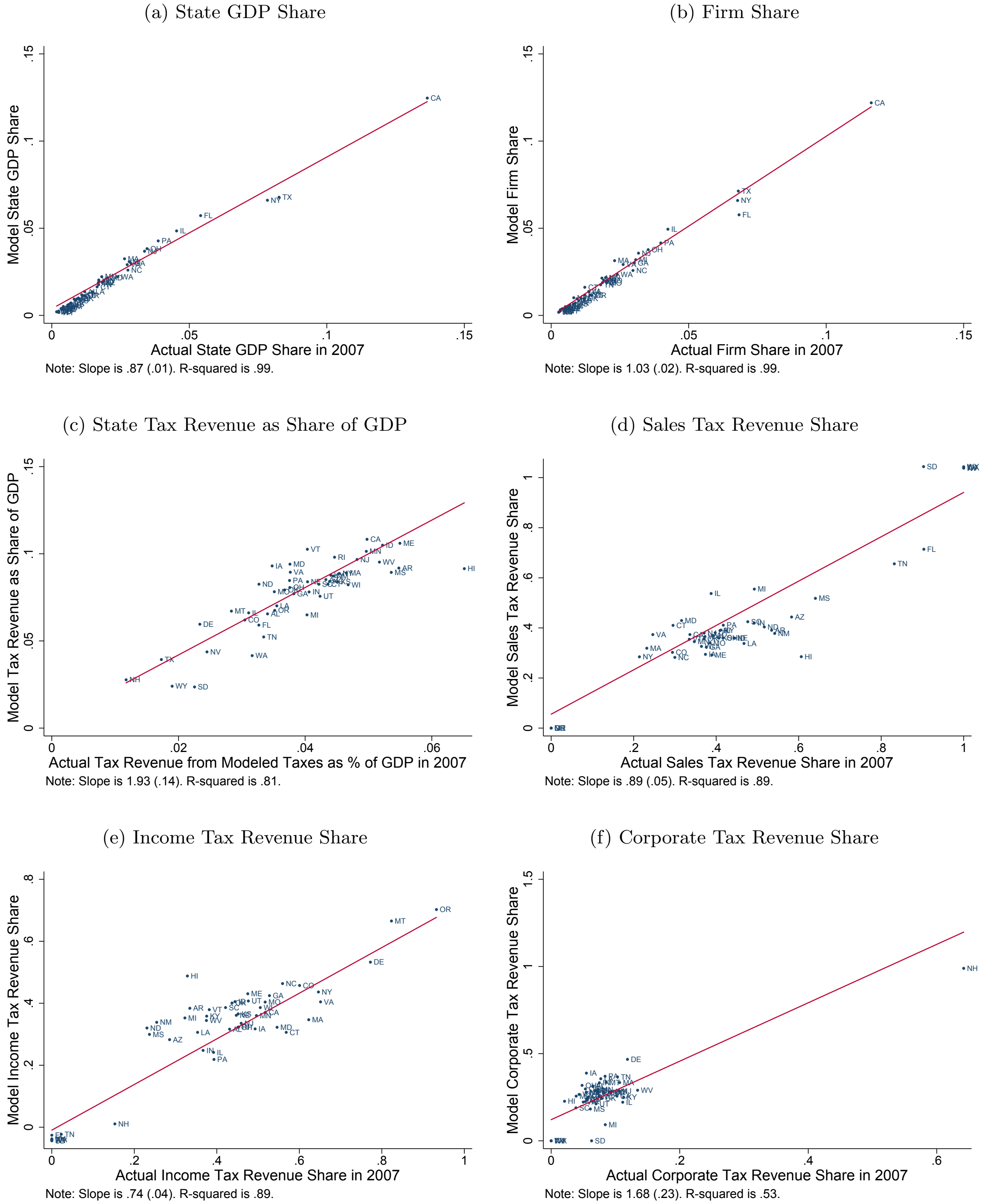
This section shows that our model's predictions for moments that are not targeted in our calibration align well with the data.

First, panel (a) of Figure 2 compares the model implications for the share of each state in national GDP against the data in 2007. Model predictions and data line up almost perfectly, which reflects that, in the data, state GDP is roughly proportional to state sales (which our calibration matches), as our model predicts. Similarly, panel (b) shows that the model's share of firms in each state against the actual share in 2007 lines up closely as well, also reflecting the number of firms and total sales are close to proportional in the model.

Second, we verify the implications of the estimated model for the share of government revenue in state GDP. Panel (c) compares the model-implied share of government revenue in GDP with its empirical counterpart; there is a positive correlation between both, although the model tends to over-predict the share of government revenue in GDP.

Third, panels (d) to (f) compare, for each type of tax, the model-implied and the observed share of revenue from this tax in total state tax revenue. There is a positive correlation between the data and the model-implied shares, although the model tends to over-predict the importance of corporate income taxes and under-predict the importance of individual income taxes. These differences are due in part to the model assumption that all companies are C-corporations and, therefore, pay corporate taxes.

Figure 2: Over-identifying Moments: Model vs. Data



NOTES: This figure compares 2007 data with model predictions for non-targeted moments. Panel (a) shows state GDP shares, panel (b) plots state firm shares, and panel (c) displays state tax revenue as a share of state GDP. Panels (d)-(f) plot general sales, individual income, and corporate income tax revenue as a share of total tax revenue, respectively.

7 Counterfactuals

In this section, we quantify the aggregate impact of changes in U.S. state taxes. We parametrize the fundamentals of each state as described in Section 6, and, unless otherwise indicated, use the parameter estimates reported in the third row of Tables 1 and 2.

Aggregate Outcomes For each counterfactual change in taxes that we consider, we compute our model's predicted changes in worker welfare expressed as equivalent changes in private consumption. Specifically, by combining (7) and (8), worker welfare in a counterfactual equilibrium relative to its actual value may be written as an employment-weighted average of the changes in each state's appeal,

$$\widehat{v} = \left(\sum_{n} L_n \widehat{v}_n^{\varepsilon_W} \right)^{\frac{1}{\varepsilon_W}}, \tag{45}$$

where L_n is the fraction of U.S. workers living in state n in the initial equilibrium, and $\widehat{v}_n$ is the value of state n's appeal in the counterfactual equilibrium relative to its initial value. Any combination of changes in private consumption and provision of public goods across states leading to a change in welfare equal to $\hat{v}$ can be chosen as an equivalent welfare metric. In particular, the welfare change $\widehat{v}$ is equivalent to a particular $100(\hat{c}-1)$ percent increase in private consumption in every state, keeping labor supply and the consumption of public goods constant. In most of our parametrizations, where $\alpha_{W,n}$ does not vary by state, $\hat{c} = \widehat{v}^{\frac{1}{1-\alpha_W}}$. We report the percent welfare increase in terms of this private consumption equivalent measure in the tables below.[28]

We also report model-predicted changes in aggregate real GDP and in the real private consumption of workers and capital-owners. Equations (A.12) to (A.14) in Appendix B.2 report the expressions used to construct these variables.

G-Constant Counterfactuals For every counterfactual change in taxes we analyze, we report results both using the full general equilibrium equations of our model and using a "G-constant" version of our model in which we artificially keep government spending constant in every state ($\hat{G_n} = 1$ for all n). These "G-constant" counterfactuals generate changes in welfare that are exclusively due to the impact that different distributions of state taxes have on allocative efficiency. To implement these "G-constant" counterfactuals, we keep government spending constant in every state and drop the budget constraint of each state government as a restriction that must be satisfied in the counterfactual equilibrium. An interpretation of these counterfactuals is that they implement both a change in state taxes and a transfer of revenue from the federal government to the states.

[28] As shown in Appendix E.1, this is also the consumption equivalent welfare change under any monotone transformation of the workers' indirect utility. Hence, the computation of the consumption equivalent welfare metric $\hat{c}$ does not rely on the assumption that the indirect utility of an individual l located in a state n is linear in $v_n \epsilon_n^l$; it would also be a valid consumption equivalent metric if we had assumed instead that the welfare of individual l located in n is $W\left(v_n \epsilon_n^l\right)$, for any monotone transformation $W(\cdot)$. See Shourideh and Hosseini (2018) for derivations of similar properties under alternative extreme-value distributions of the idiosyncratic shocks. When $\alpha_{W,n}$ varies by state, the relative change $\hat{c}$ is chosen such that $\left(\sum_n L_n \hat{c}^{\left(1-\alpha_{W,n}\right)\varepsilon_W}\right)^{\frac{1}{\varepsilon_W}} = \widehat{v}$.

7.1 General Equilibrium Impact of the North Carolina Income Tax Cuts

To illustrate some of the key forces at work, we start by studying the impact of a tax reform affecting one single state in isolation. We focus on North Carolina, which over the past decade has substantially reduced the level and progressivity of its individual income tax schedule (Washington Post, 2017). In 2007, North Carolina had a progressive tax schedule with a top rate of 8.25%. In contrast, the individual income tax rate in 2016 was a flat rate of 5.5%. We use our model to compute the general equilibrium impact of a change in the state tax parameters $(a^y_{NC,state}, b^y_{NC,state})$ that mimics the change in taxes that North Carolina experienced between 2007 and 2016. Figure A.3 in Appendix E.3 shows the actual and estimated tax schedules before and after the reform.

Consider first the effects that the North Carolina tax changes would have if government spending were to be kept constant in every state. From (32), the reduction in the income tax rate in North Carolina is analogous to an increase in the amenity level in this state. Attracted by this change in amenities, workers migrate to North Carolina and, as a result, the North Carolina workforce increases by 0.3%. This increase in labor supply decreases the equilibrium nominal wage before taxes. The larger workforce and lower nominal wages make North Carolina more attractive for firms, both through a decrease in production costs and through a bigger market size; as a result, the number of firms increases by 0.11%. Combined, the inflow of workers and firms increases real GDP by 0.13%.

However, once we take into account the impact of the North Carolina tax changes on government spending, our model predictions are reversed. According to our model, the tax reform leads to a 1.8% percent decrease in government spending in North Carolina. This decrease in government spending reduces amenities and firm productivity in North Carolina. This negative effect partially offsets the direct positive effect of the lower tax rates. Overall, North Carolina's employment is fairly stable and its total number of firms and state GDP shrink.

The data shows that the tax revenue coming from corporate, individual, and general sales taxes

Table 3: The North Carolina Income Tax Cuts

Change in	Government Spending	
	Constant	Variable
Employment	0.31	0.02
(Pre-Tax) Nominal Wage	-0.17	-0.06
Firms	0.11	-0.06
Real GDP	0.13	-0.08
Real Government Spending	0.00	-1.77
Consumption of K	0.02	-0.02
Consumption of L	0.55	0.33

Notes: This table reports the percentage changes in several outcome variables associated with the 2014-2016 individual income tax cuts in North Carolina. Counterfactual income tax parameters, $a^y_{NC,2016}$ and $b^y_{NC,2016}$, are estimated as explained in Appendix F.1. Counterfactual predictions are based on the general equilibrium conditions described in Section 4.7. Parameters are calibrated as in Section 6.1. Worker and firm parameters are set equal to the estimates from the third row of Tables 1 and 2, respectively.

did actually decrease in North Carolina between 2007 and 2015 by 11.4 percent, exceeding the average tax revenue decline (of 4.9 percent) among other states in the same U.S. Census division. Relative to these states, employment changes were similar, establishment growth was lower, and GDP growth was higher in North Carolina. Because several other fundamentals may have changed simultaneously to the implementation of the tax cuts and because our model is aimed to capture long-run effects of changes in taxes, we do not expect our model predictions to quantitatively match the observed changes in economic activity experienced by North Carolina in the years that immediately followed the implementation of the tax changes.

7.2 Tax Harmonization

Various countries have harmonized regional tax policies over the last few decades, and some recent proposals in the U.S. have advocated for increased tax coordination across states.[29] We now ask how dispersion in state taxes impacts aggregate outcomes in the U.S.. Table 4 presents our model predictions for the impact of replacing the actual distribution of state taxes in 2007 with counterfactual tax distributions that feature less dispersion across states. The first row considers a counterfactual scenario in which all sales, corporate, and individual income tax rates are replaced by their mean values across all U.S. states. In the second row, we perform a more limited harmonization: we eliminate dispersion in tax rates across states located in the same Census region, but allow for differences in taxes across these broad geographic regions. The results presented in the last row correspond to an even more limited tax harmonization: we homogenize tax rates only within each of the nine Census divisions.

We find worker welfare gains from tax harmonization, and the welfare gains are larger the larger the geographical area on which we impose tax harmonization. However, our results also show that, conditional on holding government spending constant, most of the gains of a hypothetical nation-

Table 4: Tax Harmonization

Case	Welfare		U.S. GDP		C_K		C_L	
	G Con	G Var	G Con	G Var	G Con	G Var	G Con	G Var
Within All U.S.	0.61	1.17	0.03	-0.16	0.26	0.12	-0.05	0.62
Within Regions	0.57	1.06	0.02	-0.11	0.28	0.17	-0.07	0.49
Within Divisions	0.37	1.08	0.01	-0.02	0.20	0.19	0.05	0.45

NOTES: This table reports the percentage changes in welfare in terms of private consumption equivalent units, U.S. GDP, consumption of capital owners, and consumption of workers associated with tax harmonization to the national, region, and division means. Counterfactual predictions are based on the general equilibrium conditions described in Section 4.7. Parameters are calibrated as in Section 6.1. Worker and firm parameters are set equal to the estimates from the third row of Tables 1 and 2, respectively.

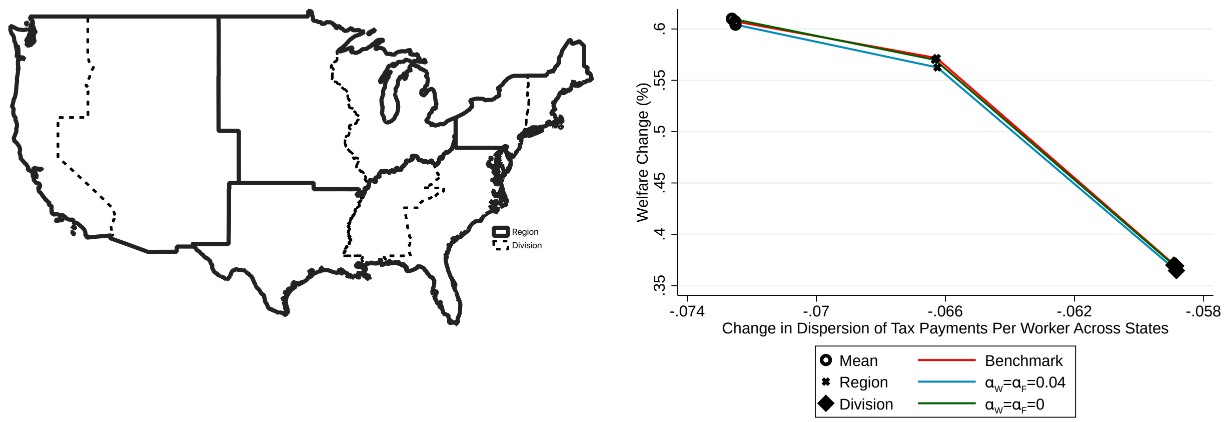
[29]Canada adopted a Harmonized Sales Tax in 1997. In 2000, Australia replaced state-level sales taxes as well as other regional duties through state cooperation. Most recently, India harmonized regional taxes by introducing a Goods and Services Tax nationwide in 2017. In the U.S., Alden and Strauss (2014) and Wilson (2015) suggest that tax collaboration in the spirit of a WTO-like agreement across states may improve overall welfare. Other U.S. institutions, such as the Streamlined Sales Tax Governing Board, facilitate tax policy coordination across states.

wide tax harmonization are due to the harmonization of taxes across states that are geographically close to each other. Simply harmonizing tax rates across states within the same Census division generates 61 percent of the welfare gains when states' government spending is held constant, and almost all the gains when we account for how spending would change in reaction to the change in tax rates. Furthermore, conditional on harmonizing tax rates within Census divisions or regions, the gains from further doing so for the entire country are negligible. Therefore, our results suggest that the main distortive effects of the overall U.S. tax dispersion are due to dispersion in tax rates across states that are geographically close to each other.[30]

Figure 3: U.S. Census Regions and Divisions and the Dispersion of Tax Payments

(a) U.S. Census Regions and Divisions

(b) Changes in Dispersion of Tax Payments



NOTES: Panel (a) shows U.S. Census regions and divisions. The Census splits the U.S. territory into four regions (Northeast, Midwest, South, and West), each of which contains two or more divisions. Panel (b) plots the change in welfare in terms of private consumption equivalent units against the change in dispersion of tax liabilities per worker associated with tax harmonization to the national, region, and division means under constant government spending.

We can link these results to the theoretical analysis in Section 5. As shown in Proposition 1, given any distribution of spending in public services across states, a necessary condition for efficiency in a simpler version of our model is equalization of tax payments per capita across states. Therefore, if the forces highlighted in the proposition operate in the more general model on which we base our counterfactual predictions, we should observe a greater reduction in dispersion in tax payments when we harmonize taxes nationally than when we do so only at the Census region or Census division level. Figure 3 verifies that this result applies: we see a larger reduction in the dispersion of per capita tax payments across states in those cases in which our model predicts larger welfare gains.

A comparison of the first two columns of Table 4 shows that the welfare effects of tax harmonization are magnified through the general equilibrium response of government spending to the tax

[30]We find welfare gains from tax harmonization of about 1% in consumption-equivalent terms. To put this magnitude in perspective, Albouy (2009) reports welfare losses from heterogeneous geographic burden of federal taxation equivalent to 0.23 percent of income whereas Altig et al. (2001) find welfare gains equivalent to 4.5 percent of GDP when simulating several margins of fundamental federal tax reform in a dynamic model.

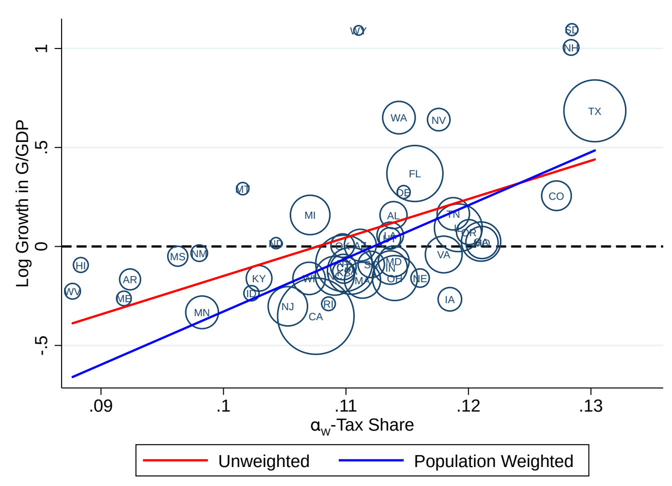
changes. To guide our understanding of where these additional gains come from, we return to a simpler version of our model analogous to that analyzed in Proposition 1.[31] As shown in Appendix E.2, to a first-order approximation around an initial equilibrium, in the simpler model, the change in the welfare of workers associated with a change in income or sales taxes is:

$$d\ln v = \sum_n L_n d\ln GDP_n + \sum_n L_n \left(\frac{\alpha_W - G_n/GDP_n}{1 - G_n/GDP_n}\right) d\ln\left(\frac{G_n}{GDP_n}\right). \tag{46}$$

The first term reflects that, keeping government spending constant, the effects of tax changes on welfare are captured, to a first-order approximation, by a population-weighted sum of the changes in value added in each state.[32] The second term reflects the impact of changes in government spending, and it predicts that an increase in government spending as a share of GDP in a state n has a positive effect on worker welfare as long as the share of government spending in that state's GDP in the initial equilibrium is less than the weight of government spending in preferences, α_W.

The second term in (46) shows why workers' welfare gains from tax harmonization are magnified through the response of government spending. According to our benchmark estimation, the ratio of public spending to GDP is below α_W in every state. When taxes are harmonized, taxes and government spending increase in states with an initially low public spending share of GDP. In these states, the numerator of the gradient of welfare improvement from higher spending, $\alpha_W - G_n/GDP_n$, is relatively large. At the same time, taxes and spending shrink in states with a relatively high

Figure 4: Changes in Spending and Gradient of Welfare Gain



NOTES: This figure plots the growth in government spending as a share of state GDP against the difference between the weight of public services in worker utility and government spending as a share of GDP (i.e., $\alpha_W - \frac{G_n}{GDP_n}$) for the full tax harmonization counterfactual under variable government spending.

[31] Specifically, we consider an special case with no trade costs ($\tau_{in} = 1$ for all i, n), perfect substitutability across varieties ($\sigma \to \infty$), homogeneous firms ($\varepsilon_F \to \infty$), constant labor supply (h_n constant), and identical preferences for government spending across states ($\alpha_{W,n} = \alpha_W$).

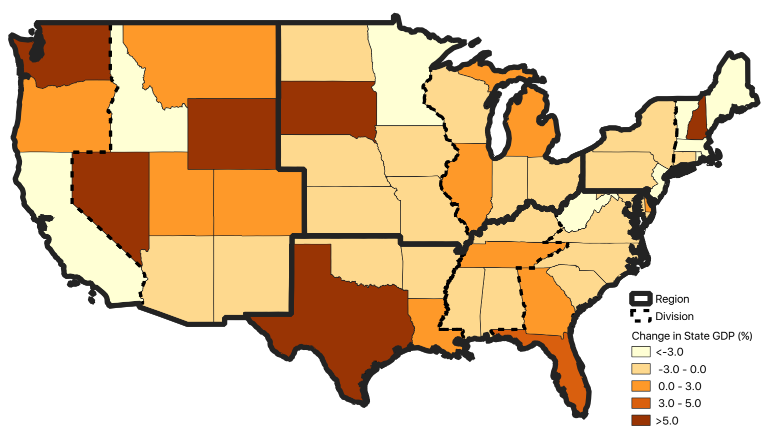
[32] However, as discussed in Section 5, for large changes in tax rates such as those that we implement, and keeping government spending constant, changes in value added are not sufficient to assess the overall changes in welfare.

initial spending share of GDP, where this gradient is smaller. Moreover, in the initial allocation, population shares are larger in states with lower spending and taxes and, consequently, most of the U.S. population is concentrated in states that benefit the most from the changes in public spending implied by tax harmonization. These forces can be seen in Figure 4. Government spending increases where the gains of raising spending are larger, and the best linear fit of the relationship between the changes in government spending predicted in the counterfactual and the welfare gradient with respect to these changes is steeper when states are weighted by their initial population shares.

The remaining columns of Table 4 indicate the impact of tax harmonization on aggregate U.S. GDP and real consumption of workers and capital owners. Columns 3 and 4 illustrate that welfare and GDP may move in opposite directions, as implied by our discussion in Section 5. When holding government spending in every state constant, predicted changes in GDP are negligible, and they generally become negative when we allow government spending to vary. In the counterfactuals that hold government spending constant, we also predict negligible changes in the real private consumption of workers, implying that the predicted welfare gains are due to a reallocation of workers to states with higher compensating differentials. However, the private consumption gains of workers are considerable when government spending changes.

Figure 5 shows that states experiencing higher GDP growth are concentrated in the West and South, while the Northeast is the main loser from tax harmonization. However, there is considerable variation in the effects on state GDP, even within Census regions. Some of the biggest winners, such as Texas, Florida, Nevada and New Hampshire, are states from Figure 4 that experience large increases in government spending as a share of GDP, which is partly driving these gains.

Figure 5: Tax Harmonization and State-level Changes in Real GDP



Notes: This map shows the change in real state GDP associated with tax harmonization to the U.S. mean under variable government spending.

Alternative Distributions of Fundamentals As the discussion in Section 5 suggests, the effect of eliminating dispersion in state taxes while keeping government spending constant depends on the correlation between the initial state tax rates and the state fundamentals (i.e., amenities and productivities). This mechanism is also present in the more general model that we use in our counterfactual analysis. The dependence of the results on the correlation between initial taxes and fundamentals is important, as it implies that the effects of eliminating tax dispersion across regions of a country may be both qualitatively and quantitatively different in other countries.

Table 5 shows the results from eliminating tax dispersion in scenarios where wages, income, and trade flows across states are the same as those observed in the initial equilibrium, but state employment shares are reassigned across states so as to maximize or minimize their correlation with the initial state taxes.[33] As we increase the cross-state correlation between initial worker tax rates and employment shares, the welfare effect of eliminating tax dispersion while keeping the provision of public goods in every state constant increases. This relationship is consistent with Proposition 2 in Section 5. Table 5 also shows that this finding is robust to whether we harmonize taxes only within Census divisions, only within Census regions, or across all states in the country.

Table 5: Spending Constant Counterfactual under Alternative Distribution of Fundamentals

Case	$RankCorr(T_n, L_n) = 1$		Actual Data		$RankCorr(T_n, L_n) = -1$	
	Welfare	GDP	Welfare	GDP	Welfare	GDP
Within All U.S.	1.07	-0.09	0.61	0.03	-1.37	0.20
Within Regions	0.94	-0.07	0.57	0.02	-1.30	0.18
Within Divisions	0.93	-0.04	0.37	0.01	-1.18	0.16

Notes: This table reports the percentage changes in welfare in terms of private consumption equivalent units and U.S. GDP associated with tax harmonization to the national, region, and division means under alternative distribution of fundamentals. Counterfactual predictions are based on the general equilibrium conditions described in Section 4.7. Parameters are calibrated as in Section 6.1. Worker and firm parameters are set equal to the estimates from the third row of Tables 1 and 2, respectively.

7.3 Eliminating the State and Local Tax Deduction

When filing a federal income tax return, taxpayers can lower their taxable income by deducting their state and local tax payments. The State and Local Tax deduction (SALT) is one of the largest tax expenditures in the U.S. tax code. Many tax reform plans, such as the 2005 President's Advisory Panel on Federal Tax Reform, have proposed eliminating it, and the 2017 tax reform (also known as the Tax Cuts and Jobs Act) substantially limited it.

The SALT deductions has the largest impact on taxpayers living in places with high state taxes. As a result, eliminating SALT deductions increases cross-state dispersion in taxes. To study the effects of SALT deductions within our model, we re-estimate the income tax schedule parameters $\{a_n^y, b_n^y\}_{n=1}^N$ under the assumption that state tax liabilities are not deductible for federal income tax purposes. The resulting effective tax rates by state and income group are listed in Appendix Table A.18, and their distribution is illustrated in Appendix Figure A.4. The elimination of the SALT

[33] As discussed in Section 6.1, state fundamentals impact the system of equations that we use to compute the effect of counterfactual changes in taxes through a composite that we measure using information on the observed number of workers, wages, income, and trade flows across states in an initial equilibrium. Thus, changing the initial value of the state fundamentals in our system of equations is equivalent to changing the initial value of the variables used to recover those state fundaments.

deduction has two effects. First, the average effective income tax rates faced by workers increases in all states except in those with zero income tax rates. Second, the tax schedule is more dispersed across locations – the standard deviation in average effective tax rates nearly doubles from 1.1 to 2.1 percentage points. To isolate the effect of the second channel, we recalibrate the income tax schedule parameters $\{a_n^y, b_n^y\}_{n=1}^N$ so that their mean value across states is kept constant at their initial level: only the dispersion in a_n^y and b_n^y changes in the counterfactual scenario.

Table 6 reports the results. Eliminating the SALT deduction while keeping state government spending constant reduces welfare, consumption, and real GDP. As discussed in Section 5, this result is a consequence of the increase in the dispersion of tax payments per worker resulting from the elimination of SALT. The effects of eliminating SALT are heterogeneous across states. Panel (a) of Figure 6 shows the spatial distribution of predicted changes in real GDP and Panel (b) shows the change in each state's real GDP against the initial income tax rate. States that experience the largest declines in real GDP tend to have high state taxes and high shares of high-income taxpayers, with states in the Northeast like New York and Massachusetts being among the hardest hit, and Southeastern states such as Mississippi, Florida, and Tennessee enjoying the largest gains. The distribution of predicted impacts also reflects the importance of spatial linkages. For example, Mississippi enjoys the largest gains in real GDP despite having positive state income taxes, reflecting the concentration of gains in nearby states. Similarly, the figure shows that among states with no state income tax, Florida and Tennessee enjoy larger gains than states like Nevada and New Hampshire, which are near states with high income tax rates.

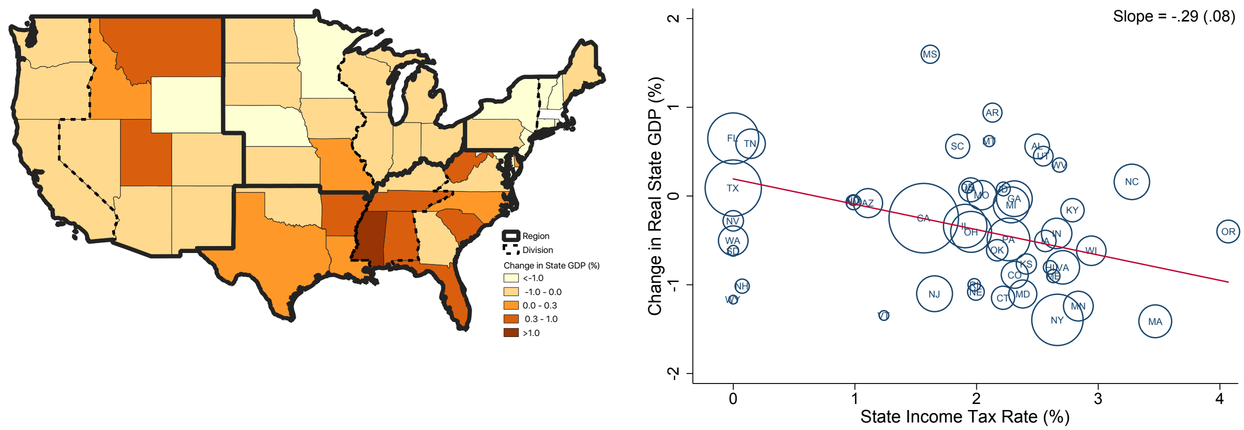
Table 6: Eliminating the State and Local Tax Deduction

Case	Welfare		U.S. GDP		C_K		C_L	
	G Con	G Var	G Con	G Var	G Con	G Var	G Con	G Var
Benchmark	-0.75	-0.89	-0.33	-0.37	-0.32	-0.36	-1.56	-1.60
$\alpha_{W,n} = \frac{R_n}{GDP_n}, \alpha_F = 0$	-0.84	-0.86	-0.33	-0.34	-0.33	-0.33	-1.56	-1.56
$\alpha_W = \alpha_F = .04$	-0.78	-0.84	-0.33	-0.38	-0.32	-0.37	-1.56	-1.61
Mean-constant a_n^y, b_n^y	-0.84	-0.88	-0.05	-0.07	-0.04	-0.06	-0.76	-0.78

NOTES: This table reports the percentage changes in welfare in terms of private consumption equivalent units, U.S. GDP, consumption of capital owners, and consumption of workers associated with the elimination of the State and Local Tax (SALT) deduction. Counterfactual income tax parameters for rows 1-3, a_n^y and b_n^y, are reported in Table A.18. In row 4, a_n^y and b_n^y are recalibrated so that their mean across states is unchanged. Counterfactual predictions are based on the general equilibrium conditions described in Section 4.7. Parameters are calibrated as in Section 6.1. In rows 1 and 4, worker and firm parameters are set equal to the estimates from the third row of Tables 1 and 2, respectively. In row 2, they are set equal to the estimates from the fourth row of Table 1 and the fifth row of Table 2, respectively. In row 3, they are set equal to the estimates from the fifth row of Table 1 and the fourth row of Table 2, respectively.

Figure 6: Eliminating the State and Local Tax (SALT) Deduction

(a) Change in Real State GDP (%) (b) Changes in Real State GDP and State Income Tax Rates



NOTES: Panel (a) displays the changes in real state GDP associated with the elimination of the State and Local Tax (SALT) deduction under variable government spending. Panel (b) plots changes in real state GDP against state income tax rates. Counterfactual income tax parameters, a_n^y and b_n^y, are reported in Table A.18. Counterfactual predictions are based on the general equilibrium conditions described in Section 4.7. Parameters are calibrated as in Section 6.1. Worker and firm parameters are set equal to the estimates from the third row of Tables 1 and 2, respectively.

7.4 Rolling Back Taxes

U.S. state taxes have changed substantially over the last thirty years. Tables A.2 and A.19 in Appendix A report the sales, income, and corporate tax rates for each state in 2007 and in 1980. As the first two columns in Table 7 illustrate, states moved away from individual income taxes towards sales and sales-apportioned corporate taxes, with a slight decrease in dispersion.[34] We compute the impact of replacing the 2007 state tax distribution with the distribution of tax rates in 1980. The results thus indicate how different the equilibrium in 2007 would have been if, over the 1980-2007 period, every fundamental of the economy had changed as it did, but state taxes had remained at the initial levels.

Table 7 shows the model predictions for different outcomes. In each of the first three rows, we illustrate the impact of bringing only one type of tax to its 1980 level; and the last row reports results for the case in which all taxes are simultaneously rolled back to 1980. Given that U.S. state taxes have increased on average between 1980 and 2007, our model predicts that, if the public provision of public goods had remained constant, the observed tax increases would have reduced worker welfare. However, following the same logic discussed in the previous section, the 1980-2007 tax increases were associated with an increase in public spending that, overall, caused aggregate welfare to increase by 3.15 percent. Given that both its rate and base increase over time, the changes in sales taxes account for the the bulk of the welfare gain. The final columns of the table show that the bulk of the consumption gains under variable government spending accrued to workers instead

[34] For sales and corporate taxes, these columns report the raw data. For income taxes, we show the changes in the average income tax rate; i.e. $t_n^y(\bar{w}_n)$, where $\bar{w}_n$ denotes the average wage of state n.

of capital owners.

Table 7: Rolling Back Taxes

	80-07 Chg.		Welfare		U.S. GDP		C_K		C_L	
	Mean	CV	G Con	G Var	G Con	G Var	G Con	G Var	G Con	G Var
Sales	1.36	-0.05	1.47	-2.05	-0.01	-0.69	1.41	0.69	-1.35	-1.77
Income	-0.48	-0.10	-0.54	-0.29	0.01	0.04	0.03	0.06	-0.35	-0.27
Corporate	1.58	-0.04	0.06	-0.66	0.03	-0.12	0.36	0.21	0.00	-0.36
All			0.97	-3.15	0.03	-0.80	1.81	0.92	-1.69	-2.41

NOTES: This table reports the percentage changes in welfare in terms of private consumption equivalent units, U.S. GDP, consumption of capital owners, and consumption of workers associated with rolling back taxes to 1980. Columns 1 and 2 report the level change in the mean and in the coefficient of variation of general sales, effective individual income tax rates, and corporate income tax rates between 1980 and 2007, respectively. Counterfactual tax rates are reported in Table A.19. Counterfactual income tax parameters are reported in Table A.20. Counterfactual predictions are based on the general equilibrium conditions described in Section 4.7. Parameters are calibrated as in Section 6.1. Worker and firm parameters are set equal to the estimates from the third row of Tables 1 and 2, respectively.

7.5 Alternative Parametrizations

We now inspect how the results of our counterfactuals depend on the parameter estimates described in Section 6.2. Each row of Table 8 considers a different parametrization. The first row considers the benchmark case; the second and third rows consider the cases where we use estimates that only rely on the external-tax instruments $\boldsymbol{Z}_{nt}^{T}$ and $\boldsymbol{Z}_{nt}^{B}$, respectively; the fourth row considers the case in which we assume that states' ratio of public spending to GDP reflects workers' preferences for public goods and that these do not affect firms' productivity (i.e., $\alpha_{W,n} = R_n/GDP_n$ and $\alpha_F = 0$); the fifth row considers the case where we assume that the weight of public goods in workers' preferences and firms' productivity is equal to the U.S. ratio of public spending in GDP, i.e., $\alpha_{W,n} = \alpha_F = 0.04$; and the last row considers the case where we assume that public spending has no impact on amenities and productivity, i.e., $\alpha_{W,n} = \alpha_F = 0$. The columns show the change in worker welfare in the different counterfactuals that we have previously discussed.

The alternative parametrizations differ based on the parameters that govern the value of public goods. The second row uses a slightly higher value of public goods, and the remaining rows take lower values. The results are very similar to the benchmark when public spending is held constant. However, in rows three through six, the lower valuation for public goods reduces the magnification effect that arises through the endogenous adjustment in public spending. When studying the impact of rolling back taxes to their 1980 levels, assuming a parametrization that eliminates workers' and firms' valuation for public goods naturally implies that the tax increases observed between 1980 and 2007 must have been detrimental for welfare. Finally, the effects of eliminating SALT deductions are similar across the different parametrizations.

Table 8: Welfare Change Under Alternative Parametrizations

Case	Harmonization		Eliminate SALT		Roll Back	
	G Con	G Var	G Con	G Var	G Con	G Var
Benchmark	0.61	1.17	-0.75	-0.89	0.97	-3.15
$\boldsymbol{Z}_{nt}^{T}$ Estimates	0.61	1.82	-0.72	-0.97	0.96	-6.08
$\boldsymbol{Z}_{nt}^{B}$ Estimates	0.61	0.84	-0.87	-0.94	0.98	-1.03
$\alpha_{W,n} = \frac{R_n}{GDP_n}, \alpha_F = 0$	0.59	0.39	-0.81	-0.83	0.94	0.44
$\alpha_W = \alpha_F = .04$	0.60	0.78	-0.78	-0.84	0.97	-1.04
$\alpha_W = \alpha_F = 0$	0.61	0.61	-0.75	-0.75	0.97	0.97

NOTES: This table reports the percentage changes in welfare in terms of private consumption equivalent units associated with tax harmonization to the national mean, the elimination of the State and Local Tax (SALT) deduction, and rolling back taxes to 1980 under alternative parametrizations. Counterfactual predictions are based on the general equilibrium conditions described in Section 4.7. Parameters are calibrated as in Section 6.1 ($\chi_W = \chi_F = 0$). Row 1 reports benchmark counterfactual changes from Tables 4, 6, and 7. In row 2, worker and firm parameters are set equal to the estimates from the first row of Tables 1 and 2, respectively. In row 3, worker and firm parameters are set equal to the estimates from the second row of Tables 1 and 2, respectively. We set $\alpha_F = 0$ in this parameterization. In row 4, they are set equal to the estimates from the fourth row of Table 1 and the fifth row of Table 2, respectively. In row 5, they are set equal to the estimates from the fifth row of Table 1 and the fourth row of Table 2, respectively. In row 6, they are set equal to the estimates from the sixth row of Table 1 and the fifth row of Table 2, respectively.

7.6 Robustness

We now explore the robustness of our results to alternative modeling assumptions and decisions we made when constructing the data. We also explore further the impact that labor and firm mobility elasticities have on our results. We compare our the results to our benchmark numbers, which are reported in the first row of Table 9.

The second row in Table 9 shows the results when, as discussed in Section 4.4, we assume free entry of homogeneous firms instead of mobility of a fixed mass of ex-ante heterogeneous firms. In this case, we find larger gains from tax harmonization when government spending is kept constant, as well as larger losses from eliminating the SALT deduction. Formally, the key impact of allowing for free entry is to modify the composite elasticities entering the system of equilibrium conditions.[35] We can inspect how these elasticities magnify the welfare changes by considering similar arguments to those used in Section 7.2. Figure A.5 in Appendix E.6 reproduces Figure 3b for the benchmark and for the free entry case. Under free entry, the reduction in the dispersion of tax payments from each harmonization counterfactual is larger than in the benchmark, and so are the aggregate welfare gains.

The third row in Table 9 shows results under an alternative definition of corporate taxes. Contrary to the baseline assumption in our model, some firms (S-corporations, partnerships, and

[35]See the composite elasticities (A.30)-(A.32) entering in the system of equilibrium conditions (A.24)-(A.28) in Appendix B.3. The coefficient χ^{FE} entering in that system is equal to one in the free entry case and zero in the benchmark model. At the U.S. level, the case with free entry leads to a negligible change in the number of firms. This property follows from the fact that, under free entry and constant markups, the number of firms in each state is proportional to the number of workers in each state. Hence, aggregate firm entry is limited by the aggregate supply of workers in the U.S..

sole proprietorships) do not pay corporate taxes; only personal income taxes are paid by their owners when profits are distributed. To account for this fact, we scale down the statutory corporate tax rate used in our benchmark analysis by the share of establishments registered as C-corporations in each state in 2010 relative to the total number of establishments in that state. As a result, we obtain less dispersion in the initial tax distribution, implying somewhat smaller gains from tax harmonization.

Our benchmark analysis ignores the existence of local taxes. To account for them, in the fourth row we compute adjusted tax rates that account for average local tax rates within each state, as reported in Appendix Figure A.1.[36] Allowing for state and local taxes increases the initial dispersion and, therefore, the magnitude of the tax harmonization, also increasing the welfare gains.

The following four rows implement our counterfactuals under either higher or lower values of the labor and firm mobility elasticities ε_W or ε_F. We choose a high value of ε_W and ε_F equal to 5, which is above the upper bound of existing parameter estimates reviewed in Appendix D.9. For their low values, we choose numbers for ε_W and ε_F equal to 0.01 plus their lower theoretical bounds of 1 and $\sigma - 1$, respectively. We find that increasing or reducing ε_F and ε_W relative to

Table 9: Welfare Change Robustness

Case	Harmonization		Eliminate SALT		Roll Back	
	G Con	G Var	G Con	G Var	G Con	G Var
Benchmark	0.61	1.17	-0.75	-0.89	0.97	-3.15
Free Entry	0.85	1.19	-1.02	-1.29	1.62	-2.45
Alternate Def. of Corp. Taxes	0.58	0.71	-0.75	-0.90	0.71	1.29
State and Local Taxes	0.95	0.71	-0.59	-0.71	2.50	-4.73
High ε_W	0.58	1.16	-1.04	-1.19	0.99	-3.08
Low ε_W	0.63	1.18	-0.62	-0.75	0.95	-3.17
High ε_F	0.64	1.17	-0.75	-0.89	0.99	-3.16
Low ε_F	0.62	1.17	-0.75	-0.89	0.98	-3.15
No Worker Heterogeneity	0.67	1.06	-0.42	-0.54	0.94	-3.18
No Int. Margin Labor Supply	0.52	1.08	-1.29	-1.36	1.00	-3.13

NOTES: This table reports the percentage changes in welfare in terms of private consumption equivalent units associated with tax harmonization to the national mean, the elimination of the State and Local Tax (SALT) deduction, and rolling back taxes to 1980 under alternative modeling and data construction assumptions. Counterfactual predictions are based on the general equilibrium conditions described in Section 4.7. Row 1 reports benchmark counterfactual changes from tables 4, 6, and 7. Row 2 allows for free entry of firms, i.e., $\chi_{FE} = 1$. In row 3, state corporate tax rates are adjusted for the state share of C-corporations. In row 4, state tax rates are adjusted to account for local taxation. In rows 5-6, ε_W is 5 and 1.01, respectively. In rows 7-8, ε_F is 5 and 3.01, respectively. In row 9, worker parameters are set equal to the estimates from the third row of Table A.8. In row 10, worker parameters are set equal to the estimates from the third row of Table A.9.

[36] We scale our baseline income, sales, and corporate tax rates by the ratio of state plus local to state tax revenue. While property taxes are a minimal source of tax revenue for states, they are key for local entities; therefore, we also include consolidated local and property taxes in this version of the model, and model them as a tax on the return of the fixed factor in each state. In this counterfactual, we interpret the budget constraint of each state government as the consolidated budget constraint of that state government and all local governments located in the same state.

the benchmark (while keeping all other parameters constant) does not have a strong impact on the welfare predictions. Finally, the last two rows shut down the channels of skill dispersion within each state ($\zeta_n \to \infty$) and intensive margin of labor supply (fixing the number of hours h_n to be constant at the initial value). The welfare effects are quite similar to those predicted by the baseline model in both cases.

8 Conclusion

In this paper, we quantify the effects of dispersion in U.S. state tax rates on aggregate real income and worker welfare in the U.S. economy. We develop a spatial general equilibrium framework that incorporates salient features of the U.S. state tax system. Implementing counterfactuals in our framework requires simultaneously using a mapping from changes in fundamentals to changes in outcomes that is standard in existing trade and economic geography models, as well as a mapping from changes in taxes to equivalent changes in fundamentals that is specific to our environment.

We estimate the key model parameters that determine how workers and firms reallocate in response to changes in state taxes using the over 350 changes in state tax rates implemented between 1980 and 2010. Using the estimated model, we compute the effects on worker welfare and aggregate real income of replacing the current U.S. state tax distribution with counterfactual distributions with different levels of regional tax dispersion.

We find that tax dispersion leads to aggregate losses. Keeping the government spending of every state constant, eliminating tax dispersion would increase worker welfare, measured in private consumption equivalent terms, by 0.6 percent. Through the endogenous responses of state spending to the tax changes, these gains increase to 1.2 percent. Our results suggest that regional coordination of tax policies could achieve most of the gains from harmonization across all U.S. states. We also evaluate past and proposed policies. We find that the changes in the U.S. state tax distribution that have taken place over the last thirty years have increased worker welfare. Additionally, we conclude that the elimination of State and Local Tax deduction would generate welfare losses through an increase in the dispersion of state tax rates.

The framework and estimation approach we introduce could be combined with data from European countries to inform ongoing debates concerning cross-country tax harmonization within the European Union, or with data from other countries featuring large tax dispersion across subnational entities (e.g., Switzerland) to study the impact of tax dispersion in those contexts. It could also be used to study other related questions, such as how the state tax structure affects states' responses to state- or aggregate-level shocks (e.g., productivity shocks), what the advantages and disadvantages of corporate-, sales-, or income-based tax systems are, or to characterize the optimal distribution of state taxes.

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Online Appendix to "State Taxes and Spatial Misallocation"

A Appendix to Section 3

Figure A.1: Dispersion in State and Local Tax Rates in 2007

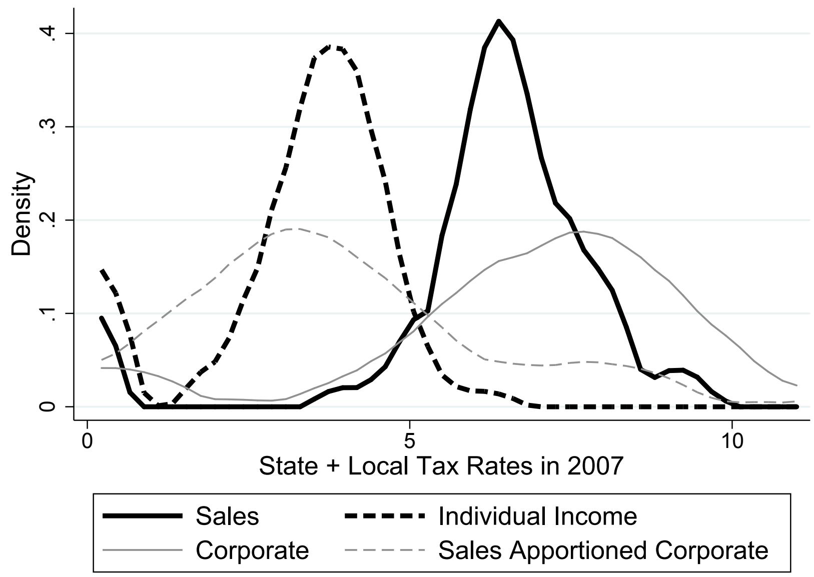


Table A.1: Federal Tax Rates in 2007

Type	Federal Tax Rate
Income Tax t^{y}_{fed}	11.7
Corporate Tax t^{corp}_{fed}	18
Payroll Tax t^{w}_{fed}	7.3

Notes: This table shows federal tax rates in 2007 for individual income, corporate, and payroll taxes. The income tax rate is the average effective federal tax rate from NBER's TAXSIM across all states in 2007. The TAXSIM data we use provides the effective federal tax rate on individual income after accounting for deductions. The corporate tax rate is the average effective corporate tax rate: we divide total tax liability (including tax credits) by net business income less deficit, using data from IRS Statistics of Income on corporation income tax returns. Finally, for payroll tax rates, we use data from the Congressional Budget Office on federal tax rates for all households in 2007. This payroll rate is similar to the employer portion of the sum of Old-Age, Survivors, and Disabilty Insurance and Medicare's Hospital Insurance Program.

Table A.2: State Tax Rates in 2007

State	t_n^y	t_n^c	t_n^{corp}	t_n^x
AL	3.1	4	6.5	2.2
AZ	2.2	5.6	7	4.2
AR	3.7	6	6.5	3.2
CA	4	7.2	8.8	4.4
CO	3.3	2.9	4.6	1.5
CT	4	6	7.5	3.8
DE	3.5	0	8.7	2.9
FL	0	6	5.5	2.7
GA	4	4	6	5.4
HI	4.5	4	6.4	2.1
ID	4.5	6	7.6	3.8
IL	2.3	6.3	4.8	4.8
IN	3.1	6	8.5	5.1
IA	4.2	5	12	12
KS	4.1	5.3	7.3	2.5
KY	4.1	6	7	3.5
LA	3.1	4	8	8
ME	4.6	5	8.9	8.9
MD	3.5	6	7	3.5
MA	4.5	5	9.5	4.7
MI	3.1	6	1.9	1.8
MN	4.8	6.5	9.8	7.6
MS	2.8	7	5	1.7
MO	3.5	4.2	6.3	2.1
MT	3.7	0	6.8	2.3
NE	3.9	5.5	7.8	7.8
NV	0	6.5	0	0
NH	.2	0	8.5	4.3
NJ	4.2	7	9	4.5
NM	2.9	5	7.6	2.5
NY	4.8	4	7.5	7.5
NC	5	4.3	6.9	3.4
ND	2.1	5	7	2.3
OH	3.5	5.5	8.5	5.1
OK	3.5	4.5	6	2
OR	6	0	6.6	6.6
PA	2.9	6	10	7
RI	3.6	7	9	3
SC	3.6	6	5	5
SD	0	4	0	0
TN	.3	7	6.5	3.2
TX	0	6.3	0	0
UT	4	4.7	5	2.5
VT	3.4	6	8.5	4.3
VA	4.1	5	6	3
WA	0	6.5	0	0
WV	4.2	6	8.7	4.4
WI	4.5	5	7.9	6.3
WY	0	4	0	0

NOTES: This table shows state tax rates in 2007 for individual income (t_n^y), general sales (t_n^c), corporate (t_n^{corp}), and sales-apportioned corporate (t_n^x) taxes, which is the product of the statutory corporate tax rate and the state's sales apportionment weight. See Section 3.1 for details.

Table A.3: State Income Tax Parameters and Effective Tax Rates in 2007

State	$a_{n,state}$	$b_{n,state}$	State tax rates if AGI is				Overall tax rates if AGI is			
			25K	50K	100K	200K	25K	50K	100K	200K
AL	1.025	0.005	2.0	2.4	3.1	3.4	14.8	18.1	22.9	25.2
AK	1.000	0.000	0.0	0.0	0.0	0.0	13.1	16.2	20.6	22.7
AZ	1.078	0.008	0.2	1.0	2.2	2.7	13.4	17.0	22.2	24.7
AR	1.092	0.011	1.2	2.1	3.6	4.3	14.1	17.9	23.3	25.9
CA	1.102	0.011	0.3	1.3	2.7	3.5	13.4	17.2	22.7	25.3
CO	1.066	0.008	1.3	2.0	3.2	3.7	14.2	17.8	23.0	25.5
CT	1.087	0.010	0.9	1.8	3.2	3.9	13.9	17.7	23.0	25.6
DE	1.067	0.008	1.0	1.7	2.9	3.4	14.0	17.6	22.8	25.2
FL	1.000	0.000	0.0	0.0	0.0	0.0	13.1	16.2	20.6	22.7
GA	1.132	0.014	0.8	2.1	4.0	5.0	13.8	17.9	23.7	26.4
HI	1.136	0.015	1.2	2.5	4.5	5.5	14.1	18.2	24.1	26.8
ID	1.166	0.017	0.5	2.1	4.4	5.5	13.6	17.9	24.0	26.8
IL	1.019	0.004	1.4	1.8	2.3	2.5	14.3	17.6	22.3	24.6
IN	1.019	0.004	2.2	2.6	3.2	3.5	15.0	18.3	23.1	25.3
IA	1.122	0.014	1.2	2.5	4.3	5.2	14.2	18.2	23.9	26.6
KS	1.066	0.009	1.6	2.4	3.6	4.2	14.5	18.1	23.3	25.8
KY	1.070	0.009	1.9	2.7	4.0	4.6	14.7	18.4	23.6	26.1
LA	1.082	0.010	1.0	1.9	3.2	3.8	14.0	17.7	23.0	25.5
ME	1.131	0.015	1.2	2.5	4.5	5.5	14.1	18.2	24.0	26.8
MD	1.055	0.007	1.5	2.2	3.2	3.7	14.4	17.9	23.0	25.4
MA	1.055	0.008	2.4	3.1	4.2	4.8	15.1	18.7	23.8	26.2
MI	1.049	0.007	1.5	2.1	3.1	3.5	14.4	17.9	22.9	25.3
MN	1.108	0.013	1.4	2.5	4.2	5.1	14.3	18.2	23.8	26.5
MS	1.010	0.003	1.4	1.6	1.9	2.1	14.3	17.5	22.1	24.3
MO	1.065	0.008	1.3	2.0	3.1	3.7	14.2	17.8	23.0	25.4
MT	1.093	0.011	1.1	2.1	3.6	4.3	14.1	17.9	23.3	25.9
NE	1.109	0.012	0.8	1.9	3.6	4.4	13.8	17.7	23.3	25.9
NV	1.000	0.000	0.0	0.0	0.0	0.0	13.1	16.2	20.6	22.7
NH	1.000	0.000	0.1	0.1	0.1	0.1	13.2	16.3	20.7	22.8
NJ	1.054	0.007	0.8	1.4	2.3	2.8	13.8	17.3	22.4	24.8
NM	1.183	0.017	-0.8	0.8	3.1	4.3	12.5	16.8	23.0	25.9
NY	1.099	0.012	1.3	2.4	4.0	4.7	14.3	18.1	23.6	26.2
NC	1.055	0.009	2.5	3.2	4.4	5.0	15.2	18.8	23.9	26.4
ND	1.052	0.006	0.5	1.0	1.8	2.2	13.5	17.0	22.0	24.4
OH	1.061	0.008	1.2	1.9	2.9	3.4	14.1	17.7	22.8	25.2
OK	1.146	0.016	0.7	2.1	4.2	5.2	13.7	17.9	23.8	26.6
OR	1.107	0.014	2.7	4.0	5.8	6.7	15.4	19.4	25.0	27.7
PA	1.046	0.007	1.5	2.1	3.0	3.5	14.4	17.9	22.9	25.3
RI	1.095	0.011	0.8	1.7	3.2	3.9	13.8	17.6	23.0	25.6
SC	1.071	0.009	1.1	1.9	3.0	3.6	14.1	17.7	22.9	25.4
SD	1.000	0.000	0.0	0.0	0.0	0.0	13.1	16.2	20.6	22.7
TN	1.001	0.000	0.1	0.1	0.2	0.2	13.2	16.3	20.7	22.8
TX	1.000	0.000	0.0	0.0	0.0	0.0	13.1	16.2	20.6	22.7
UT	1.087	0.011	1.4	2.3	3.8	4.5	14.3	18.1	23.5	26.0
VT	1.177	0.017	-0.5	1.1	3.4	4.6	12.8	17.1	23.2	26.1
VA	1.076	0.010	1.6	2.4	3.7	4.4	14.4	18.1	23.4	25.9
WA	1.000	0.000	0.0	0.0	0.0	0.0	13.1	16.2	20.6	22.7
WV	1.062	0.009	1.9	2.7	3.9	4.4	14.8	18.4	23.5	26.0
WI	1.086	0.011	1.8	2.8	4.2	4.9	14.6	18.4	23.8	26.4
WY	1.000	0.000	0.0	0.0	0.0	0.0	13.1	16.2	20.6	22.7

NOTES: This table shows state income tax parameters in 2007 as well as effective tax rates for different levels of Adjusted Gross Income (AGI). Tax rates reported in columns 4-7 are state-only, while tax rates in columns 8-11 combine federal and state taxation. Federal taxation includes individual income taxes and the employee portion of payroll (FICA) taxes.

A.1 Supplemental Stylized Facts on State Taxes

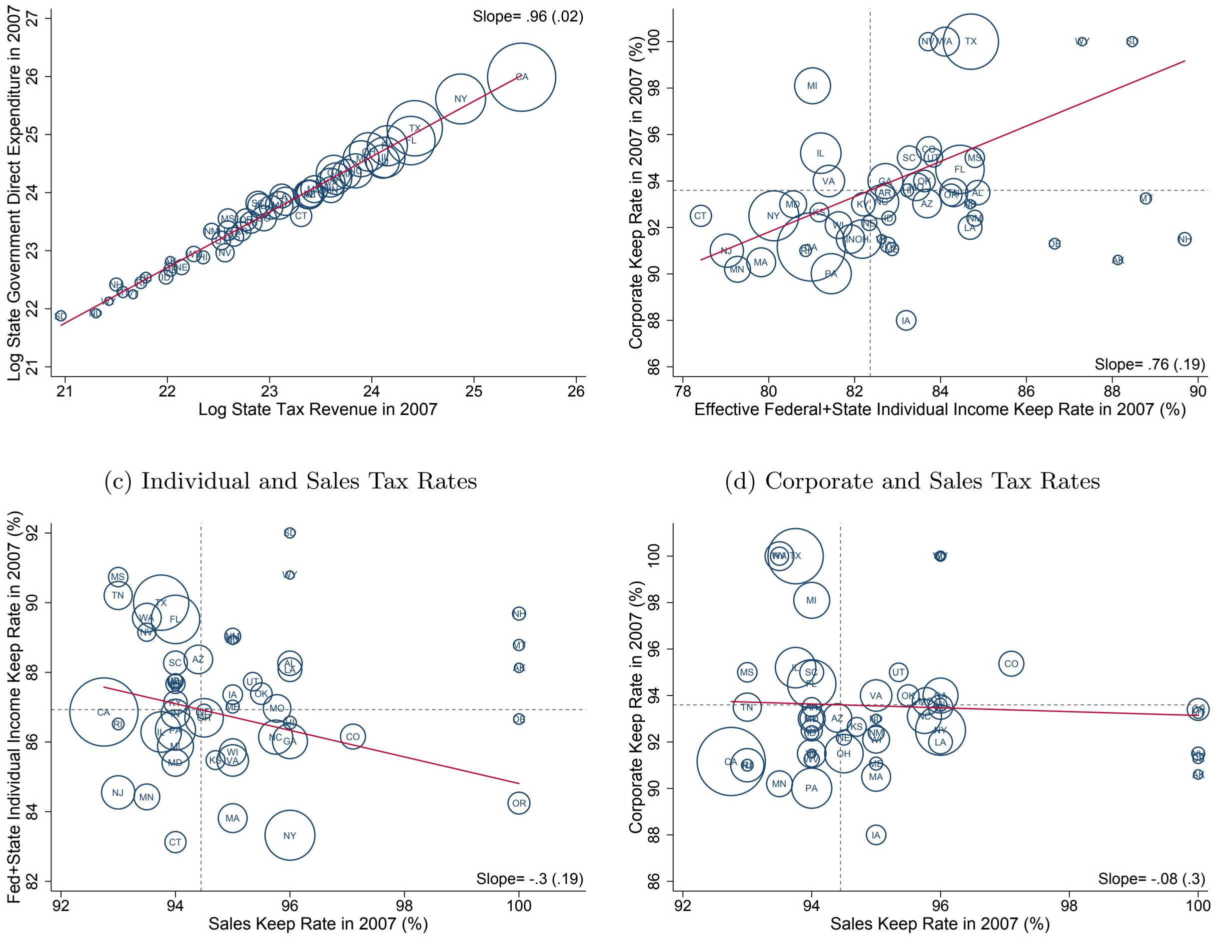
Figure A.2: Supplemental Stylized Facts on State Taxes

(a) State Tax Revenue and Government Spending

(b) Firm and Worker Tax Rates

(c) Individual and Sales Tax Rates

(d) Corporate and Sales Tax Rates



Notes: Panel (a) plots state government direct expenditure against model-based tax revenue in 2007. Data are drawn from Census Government Finances. Panel (b) plots the statutory state corporate keep rate, as measured by $1 - t_n^{corp}$, against the combined federal and state effective individual income keep rate, which is estimated using NBER's tax simulator TAXSIM. For each state, we compute average federal and state tax liabilities and divide their sum by average Adjusted Gross Income (AGI) in that state. Then, we account for the impact of sales taxes on individuals' purchasing power by dividing the raw keep rate by $1 + t_n^c$. Panel (c) shows the correlation between the combined federal and state individual income keep rate and the statutory state sales keep rate, as measured by $1 - t_n^c$. We estimate the former using NBER's tax simulator TAXSIM. For each state, we compute average federal and state tax liabilities and divide their sum by average Adjusted Gross Income (AGI) in that state. Panel (d) plots the statutory state corporate keep rate against the statutory state sales keep rate. In panels (b), (c), and (d), the vertical and horizontal grey lines denote population-weighted averages of the variables on the x- and y-axis, respectively. Observations are weighted by state population.

A.2 Bilateral Trade Shares and State Corporate Taxation

According to our model, using (A.3), (A.4), and (A.5) and aggregating across firms, inter-state trade flows take the form:

$$\ln X_{ni} = \beta_1 \ln \frac{\sigma}{\sigma - \tilde{t}_{ni}} + \beta_2 \ln \tau_{ni} + \psi_i + \psi_n + \varepsilon_{in},$$

where ψ_i and ψ_n are respectively origin and destination fixed effects. As shown in (A.3), $\tilde{t}_{ni}$ is a function of the matrix of trade flows and corporate taxes and therefore we instrument for this term using corporate taxes in the destination only.

Table A.4: Bilateral Trade Shares and Trade-Dispersion Cost

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) 2SLS	(6) 2SLS	(7) 2SLS	(8) 2SLS
$\ln \frac{\sigma}{\sigma-\tilde{t}}$	-4.265*	-3.414	-2.250	-2.948**	-9.513***	-3.993	-2.631	-2.590*
	(2.204)	(2.111)	(2.154)	(1.289)	(2.660)	(2.448)	(2.491)	(1.390)
Observations	10,512	10,512	10,512	10,272	10,512	10,512	10,512	10,272
R-squared	0.457	0.474	0.474	0.826	0.456	0.474	0.474	0.826
Year FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Dest GDP Control	No	No	Yes	Yes	No	No	Yes	Yes
Distance Control	No	No	No	Yes	No	No	No	Yes

NOTES: The panel consists of the 48 contiguous states in 1993, 1997, 2002, 2007, and 2012. Each observation is an origin-destination-year triplet. In all specifications, the dependent variable is log bilateral trade share, which is defined as $s_{in} = \frac{x_{in}}{\sum_i x_{in}}$, where x_{in} denotes sales from state n to state i. All models allow for origin and destination state fixed effects. Observations are weighted by destination state population. Columns 1-4 show the association between $\ln \frac{\sigma}{\sigma-\tilde{t}}$ and bilateral trade share, allowing for year fixed effects (Column 2), and controlling for destination state GDP (Column 3) and distance between state pairs (Column 4). In Column 5, $\ln \frac{\sigma}{\sigma-\tilde{t}}$ is instrumented with destination t^x. In Column 6, this specification is augmented with year fixed effects. Columns 7 and 8 also control for destination state GDP and distance between state pairs, respectively. Robust standard errors are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

B Appendix to Section 4

B.1 Firm Maximization

We characterize here the problem in (20) for a firm j located in i whose productivity is z. When a firm j located in state i sets its price p^j_{ni} in state n, the quantity exported to state n is $q^j_{ni} = Q_n(p^j_{ni}/P_n)^{-\sigma}$. The first-order condition of profits (20) with respect the quantity sold to n is:

$$\frac{\partial \pi^j_i}{\partial q^j_{ni}} = (1 - \bar{t}^j_i)\frac{\partial \tilde{\pi}^j_i}{\partial q^j_{ni}} - \frac{\partial \bar{t}^j_i}{\partial q^j_{ni}} \tilde{\pi}^j_i = 0, \tag{A.1}$$

where $\tilde{\pi}^j_i \equiv \sum_{n=1}^{N} x^j_{ni} - (\tau_{ni} c_i/z) q^j_{ni}$ are pre-tax profits, and where:

$$\frac{\partial \tilde{\pi}^j_i}{\partial q^j_{ni}} = \frac{\sigma-1}{\sigma} E_n^{1/\sigma} P_n^{1-1/\sigma} \left(q^j_{ni}\right)^{-1/\sigma} - c_i \frac{\tau_{ni}}{z},$$

$$\frac{\partial \bar{t}^j_i}{\partial q^j_{ni}} = \frac{\sigma-1}{\sigma} \left(t^x_n - \sum_{n'} t^x_{n'} s^j_{n'i} \right) \frac{p^j_{ni}}{x^j_i}.$$

Combining the last two expressions with (A.1) yields:

$$p_{ni}^j = \frac{1}{1 - \tilde{t}_{ni}^j \left(\tilde{\pi}_i^j / x_i^j\right)} \frac{\sigma}{\sigma - 1} \frac{\tau_{ni}}{z} c_i, \tag{A.2}$$

where

$$\tilde{t}_{ni}^j \equiv \frac{t_n^x - \sum_{n'} t_{n'}^x s_{n'i}^j}{1 - \bar{t}_i}. \tag{A.3}$$

Expressing pre-tax profits as

$$\tilde{\pi}_i^j \equiv \sum_{n=1}^{N} x_{ni}^j \left(1 - \frac{\tau_{ni}}{z} \frac{c_i}{p_{ni}^j}\right),$$

introducing this expression in (A.2) and using that $\sum_i s_{ni}^j \tilde{t}_{ni}^j = 0$ yields $\tilde{\pi}_i^j = x_i^j / \sigma$. This implies that

$$p_{ni}^j = \frac{\sigma}{\sigma - \tilde{t}_{ni}^j} \frac{\sigma}{\sigma - 1} \frac{\tau_{ni}}{z}. \tag{A.4}$$

Finally, note that export shares are independent of productivity, z_i^j:

$$s_{ni}^j = \frac{E_n \left(p_{ni}^j\right)^{1-\sigma}}{\sum_{n'=1}^{N} E_{n'} \left(p_{n'i}^j\right)^{1-\sigma}} = \frac{E_n \left(\frac{\sigma - \tilde{t}_{ni}^j}{\tau_{ni}}\right)^{\sigma - 1}}{\sum_{n'=1}^{N} E_{n'} \left(\frac{\sigma - \tilde{t}_{n'i}^j}{\tau_{n'i}}\right)^{1-\sigma}}. \tag{A.5}$$

Equations (A.3) and (A.5) for $n = 1, .., N$ define a system for $\left\{\tilde{t}_{ni}^j\right\}$ and $\left\{s_{ni}^j\right\}$ whose solution is independent of the firm's productivity z. Therefore, $\tilde{t}_{ni}^j = \tilde{t}_{ni}$ and $s_{ni}^j = s_{ni}$ for all firms j located in state i.

B.2 Additional State-Level Variables

In this section, we let χ^{FE} be an indicator variable that equals 1 when we assume free entry of homogeneous firms and zero when we assume free mobility of heterogeneous firms.

Factor Payments From the Cobb-Douglas technologies and CES demand, in addition to the free-entry condition when $\chi^{FE} = 1$, it follows that payments to intermediate inputs, labor and fixed factors in state i can be expressed as fractions of sales X_i:

$$P_i I_i = \left(1 + \chi^{FE} \frac{1 - \bar{t}_i}{\sigma - 1}\right) (1 - \gamma_i) \frac{\sigma - 1}{\sigma} X_i, \tag{A.6}$$

$$w_i L_i^E = \left(1 + \chi^{FE} \frac{1 - \bar{t}_i}{\sigma - 1}\right) (1 - \beta_i) \gamma_i \frac{\sigma - 1}{\sigma} X_i, \tag{A.7}$$

$$r_i H_i = \left(1 + \chi^{FE} \frac{1 - \bar{t}_i}{\sigma - 1}\right) \beta_i \gamma_i \frac{\sigma - 1}{\sigma} X_i. \tag{A.8}$$

In each of these expressions, the term multiplied by χ^{FE} reflects the resources devoted to pay for entry costs. In the second equation, L_i^E are the total efficiency units of labor demanded in state i, in equilibrium these efficiency units equal $L_i h_i E_i[z]$, where h_i are the hours worked by a worker with productivity z in state i in (13).

Aggregate pre-tax profits $\tilde{\Pi}_i$ are:

$$\tilde{\Pi}_i = \frac{X_i}{\sigma}, \tag{A.9}$$

After-tax profits, gross of entry costs when $\chi^{FE} = 1$, are:

$$\Pi_i = \left(1 - \bar{t}_n\right) \frac{X_i}{\sigma}. \tag{A.10}$$

Expenditure and Sales Shares The share of aggregate expenditures in state n on goods produced in state i is

$$\lambda_{ni} = M_i^{1+\frac{1-\chi^{FE}}{\varepsilon_F}(1-\sigma)} \left(\frac{\sigma}{\sigma - \tilde{t}_{ni}} \frac{\sigma}{\sigma - 1} \frac{\tau_{ni} c_i}{z_i^0} \frac{1}{P_n} \right)^{1-\sigma}. \tag{A.11}$$

Under free entry ($\chi^{FE} = 1$), the congestion effect from entry on productivity described in Section 4.4 is absent. We construct the sales shares s_{ni}, which are necessary to compute the corporate tax rate $\bar{t}_i$ in (22) and the pricing distortion $\tilde{t}_{ni}$ in (24), using the identity $s_{ni} = \lambda_{ni} P_n Q_n / X_i$, where $P_n Q_n$ is the aggregate expenditure on final goods in state n.

Real GDP Adding up (A.7), (A.8), and (A.9), in the case with ex-ante heterogeneous firms, real GDP in state n is

$$\frac{GDP_n}{P_n} = \frac{1 + \gamma_n (\sigma - 1) \left(1 - (1 - \beta_n) t_{fed}^w / \left(1 + t_{fed}^w\right)\right)}{\sigma} \frac{X_n}{P_n}. \tag{A.12}$$

Aggregate real GDP is defined as $GDP^{real} = \sum_n (GDP_n / P_n)$.

Consumption The aggregate personal consumption expenditure in state n is $P_n C_n = P_n C_n^W + P_n C_n^K$, where C_n^W is the aggregate real consumption of workers and C_n^K is the consumption of capital owners. Taking into account the taxes paid to each level of government, these aggregates are:

$$P_n C_n^W = \mathbb{E}_n \left[\frac{1 - T_n^y (w_n h_n z)}{1 + t_n^c} w_n h_n z \right] L_n \tag{A.13}$$

$$P_n C_n^K = \frac{\left(1 - \chi^{FE}\right) \tilde{\Pi} + R - T^{corp} - \left(\overline{t_n^y} + \overline{t_{n,fed}^y} \left(1 - \overline{t_n^y}\right)\right) \left(\left(1 - \chi^{FE}\right) \Pi + R\right)}{1 + t_n^c} \omega_n, \tag{A.14}$$

where $\overline{t_n^y}$ and $\overline{t_{n,fed}^y}$ are the top average state and federal personal income tax rates, $\Pi = \sum_i \Pi_i$, $\tilde{\Pi} = \sum_i \tilde{\Pi}_i$ and $R = \sum_i r_i H_i$ are national after-tax profits, pre-tax profits and returns to land and structures, respectively, and T^{corp} are the national corporate tax payments.

State Tax Revenue By Type of Tax State government revenue from corporate, sales, and income taxes, is, respectively,

$$R_n^{corp} = t_n^x \sum_{n'} s_{nn'} \tilde{\Pi}_{n'} + t_n^l \tilde{\Pi}_n, \tag{A.15}$$

$$R_n^y = \mathbb{E}\left[t_n^y (w_n h_n z) w_n h_n z\right] L_n + \overline{t_n^y} \omega_n \left(\left(1 - \chi^{FE}\right) \Pi + R\right), \tag{A.16}$$

$$R_n^c = t_n^c P_n C_n. \tag{A.17}$$

The base for corporate tax revenues are the pre-tax profits from every state, defined in (A.9), adjusted by the proper apportionment weights. Equation (A.16) shows that the base for state income taxes is the income of both workers and capital-owners who reside in n net of federal income taxes. Income tax revenue from workers results from aggregating tax payments over the distribution of individual productivity. Capital owners are at the highest rate, $\overline{t_n^y}$. Under free entry, profits after corporate taxes equal the entry costs and therefore there are no dividends; in that case, capital owners only obtain income from land. The base for the sales tax in (A.17) is the total personal consumption expenditure of workers and capital owners defined in the previous section.

Trade Imbalances Three reasons give rise to differences between aggregate expenditures $P_n Q_n$ and sales X_n of state n, and therefore create trade imbalances. First, differences in the ownership rates ω_n lead to differences between the gross domestic product of state n, GDP_n, and the gross income of residents of state n, GSI_n. Second, differences in ownership rates ω_n and in sales-apportioned corporate taxes t_n^x across states create differences between the corporate tax revenue raised by state n's government (R_n^{corp}) and the corporate taxes paid by residents of state n (TP_n^{corp}). Third, there may be differences between taxes paid by residents of state n to the federal government ($T_{n,fed}$) and the expenditures made by the federal government in state n in either transfers to the state government in n ($T_n^{fed\to st}$) or purchases of the final good produced in state n ($G_{n,fed}$). As a result, the trade imbalance in state n, defined as difference between expenditures and sales in that state, can be written as follows:[1]

$$P_nQ_n - X_n = (GSI_n - GDP_n) + (R_n^{corp} - TP_n^{corp}) + \left(P_nG_{n,fed} + T_n^{fed\to st} - T_{n,fed}\right). \tag{A.18}$$

Letting $R = \sum_n r_nH_n$ and $\tilde{\Pi} = \sum_n \tilde{\Pi}_n$ be the pre-tax returns to the national portfolio of fixed factors and firms, we can rewrite some of the components of (A.18) as follows:[2]

$$GSI_n - GDP_n = \left(1 - \chi^{FE}\right)\omega_n\left(\tilde{\Pi} - \tilde{\Pi}_n\right) + \omega_nR - r_nH_n, \tag{A.19}$$

$$R_n^{corp} = \frac{1}{\sigma}\left(t_n^x\frac{P_nQ_n}{X_n} + t_n^l\right)X_n, \tag{A.20}$$

$$TP_n^{corp} = b_n\sum_{n'}\left(\bar{t}_{n'} - t_{fed}^{corp}\right)\tilde{\Pi}_{n'}. \tag{A.21}$$

Replacing (A.19) to (A.21) into (A.18), and using (A.8) and (A.9) to express land payments and pre-tax profits as function of sales, after some manipulations we obtain:

$$\frac{P_nQ_n}{X_n} = \frac{1}{\sigma - t_n^x}\left((\sigma-1)(1-\beta_n\gamma_n) + t_n^l + \frac{P_nG_{n,fed} + T_n^{fed\to st} - T_{n,fed}}{\tilde{\Pi}_n}\right) + \frac{1}{\sigma - t_n^x}\left(\chi^{FE}\left(1 - \beta_n\gamma_n\left(1-\bar{t}_n\right)\right) + \frac{\omega_n}{\tilde{\Pi}_n/\left(\Pi + R + \left(t_{fed}^{corp} - \chi^{FE}\right)\tilde{\Pi}\right)}\right) \tag{A.22}$$

Expression (A.22) is used in the calibration to back out the ownership shares $\{\omega_n\}$ from observed data on trade imbalances. To implement it, we assume that transfers from the federal government to the state government in n are entirely financed with federal taxes paid by residents of state n. Then, the ownership shares can be expressed as a function of other parameters and observables as follows:

$$\omega_n = \frac{\tilde{\Pi}_n}{\Pi + R + \left(t_{fed}^{corp} - \chi^{FE}\right)\tilde{\Pi}}\left[(\sigma - t_n^x)\left(\frac{P_nQ_n}{X_n}\right) - (\sigma-1)(1-\beta_n\gamma_n) - t_n^l - \chi^{FE}\left(1-\beta_n\gamma_n\left(1-\bar{t}_n\right)\right)\right]. \tag{A.23}$$

B.3 General Equilibrium Conditions

We note that, using the definition of import shares in (A.11), imposing expression (17) for final good prices in every state is equivalent to imposing that expenditures shares in every state add up to 1.

$$\sum_n \lambda_{in} = 1 \text{ for all } i. \tag{A.24}$$

Additionally, by definition, aggregate sales by firms located in state i are:

$$X_i = \sum_n \lambda_{ni}P_nQ_n. \tag{A.25}$$

[1] To reach this relationship, first impose goods market clearing (18) to obtain $P_nQ_n = P_n\left(C_n + G_{n,fed} + G_n + I_n\right)$. Then, note that personal-consumption expenditures can be written as $P_nC_n = GSI_n - (R_n^y + R_n^c + TP_n^{corp}) - T_{n,fed}$, where the terms between parentheses are tax payments made by residents of state n to state governments and $T_{n,fed}$ are taxes paid to the federal government. Combining these two expressions and using the state's government budget constraint (28) gives $P_nQ_n = (GDP_n + P_nI_n) + (GSI_n - GDP_n) + (R_n^{corp} - TP_n^{corp}) + \left(P_nG_{n,fed} + T_n^{fed\to st} - T_{n,fed}\right)$. Adding and subtracting GDP_n and noting that by definition $GDP_n = X_n - P_nI_n$ gives (A.18).

[2] Equations (A.19) and (A.21) hold by definition. For (A.20), combine (A.15) with (A.25) and (A.9).

This is equivalent to imposing that sales shares from every state add up to 1:

$$\sum_i s_{in} = 1 \text{ for all } n. \tag{A.26}$$

After several manipulations of the equilibrium conditions (available upon request), these shares can be expressed as functions of employment shares, wages, aggregate variables, and parameters as follows:

$$\lambda_{in} = A_{in} \left(\frac{w_n}{\bar{\pi}}\right)^{1-\kappa_1} \left(L_n h_n E_n[z]\right)^{1-\kappa_{2n}} \left(\frac{w_i}{\bar{\pi}}\right)^{\sigma-1} \left(L_i h_i E_i[z]\right)^{-\kappa_{3i}}, \tag{A.27}$$

$$s_{in} = \lambda_{in} \frac{P_i Q_i}{X_n}, \tag{A.28}$$

where A_{in} is given by

$$A_{in} = \Theta_n \left(\frac{z_n^A}{\tau_{in}^A} \left(\frac{Z_i u_i^A}{v}\right)^{\frac{1}{1-\alpha_{W,i}}} \left(\frac{Z_n u_n^A}{v}\right)^{\frac{1-\gamma}{1-\alpha_{W,n}}\left(\frac{(\sigma-1)\alpha_F \chi_F - 1}{\sigma-1}\chi^{FE} - 1\right)} \right)^{\sigma-1}, \tag{A.29}$$

where $\{z_n^A, \tau_{in}^A, u_n^A\}$ are defined in (30) to (32) in the text, where Z_n summarizes the impact of hours worked and skill heterogeneity,

$$Z_n = \frac{\zeta_n}{\zeta_n - (1-b_n)(1-\alpha_{W,n})} \left(\frac{\zeta_n}{\zeta_n - 1} z_{L,n}\right)^{1/\varepsilon_W + \alpha_{W,n}\chi_W} h_n^{(1-b_n)(1-\alpha_{W,n})} e^{-\alpha_h \frac{h_n^{1+1/\eta}}{1+1/\eta}},$$

and where Θ_n is a state-specific constant,

$$\Theta_n \equiv \left(1 + t_{fed}^w\right)^{1-(\sigma-1)\left(\frac{1-\chi^{FE}}{\varepsilon_F} + \alpha_F \chi_F\right) + \gamma\left(-(\sigma-1) + ((\sigma-1)\alpha_F \chi_F - 1)\chi^{FE}\right)}$$
$$* \left(\frac{1-\beta}{\beta} H_n\right)^{\beta\gamma\left((\sigma-1) - [(\sigma-1)\alpha_F \chi_F - 1]\chi^{FE}\right)} \left(\frac{f_{E,n}^{\chi^{FE}\left(\alpha_F - \frac{1}{\sigma-1}\right)\frac{\sigma-1}{\sigma}}}{\left((1-\beta)\gamma\right)^{\frac{1}{\sigma-1} - \frac{1-\chi^{FE}}{\varepsilon_F} - \alpha_F \chi_F}} \right)^{\sigma-1}.$$

The parameters $\{\kappa_1, \kappa_{2n}, \kappa_3\}$ in (A.27) and (A.28) are given by:

$$\kappa_1 = (\sigma-1)\left(1 + \alpha_F \chi_F + \frac{1-\chi^{FE}}{\varepsilon_F}\right) - ((\sigma-1)\alpha_F \chi_F - 1)\chi^{FE}, \tag{A.30}$$

$$\kappa_{2n} = (\sigma-1)\left(\frac{1-\chi^{FE}}{\varepsilon_F} + \alpha_F \chi_F + \gamma\beta - \frac{1+\varepsilon_W \chi_W \alpha_{W,n}}{\varepsilon_W (1-\alpha_{W,n})}(1-\gamma_n)\right)$$
$$- \chi^{FE}\left(\gamma\beta((\sigma-1)\alpha_F \chi_F - 1) - \frac{1+\varepsilon_W \chi_W \alpha_{W,n}}{\varepsilon_W} \frac{1-\gamma}{1-\alpha_{W,n}}((\sigma-1)\alpha_F \chi_F - 1)\right), \tag{A.31}$$

$$\kappa_{3i} = (\sigma-1)\frac{1+\varepsilon_W \chi_W \alpha_{W,i}}{\varepsilon_W (1-\alpha_{W,i})}. \tag{A.32}$$

As in the previous sections of this appendix, we let χ^{FE} be an indicator variable that equals 1 when we assume free entry of homogeneous firms and zero when we assume free mobility of heterogeneous firms.

Equations (A.24) to (A.29), together with (8) and (A.22), give the solution for import shares $\{\lambda_{in}\}$, export shares $\{s_{in}\}$, employment shares $\{L_n\}$, wages relative to average profits $\{w_n/\bar{\pi}\}$, government sizes $\{P_n G_n\}$, relative trade imbalances $\{P_n Q_n / X_n\}$, and utility v. The endogenous variables not included in this system can be recovered using the remaining equilibrium equations of the model.

B.4 Uniqueness in a Special Case

Consider a special case of baseline the model with a fixed mass of ex-ante heterogeneous firms (i.e. $\chi^{FE} = 0$) in which there is no dispersion in sales-apportioned corporate taxes across states ($t_n^x = t^x$ for all n), no cross-ownership of assets across states, and same preference for government spending across states ($\alpha_{W,n} = \alpha_W$). In this case, the adjusted amenities and productivities u_n^A and z_n^A defined in (32) and (30) become exogenous functions of fundamentals and own-state taxes. It is then possible to show that Conditions 1 to 3 and 4' of Allen et al. (2014) are satisfied (proof available upon request) and that, applying their Corollary 2, a sufficient uniqueness condition for the system of equations in $\{L_n, w_n/\bar{\pi}, v\}$ in (A.24) to (A.26) is

$$\frac{\sigma - (1-\kappa_3)}{\sigma(1-\kappa_2) - (1-\kappa_3)(1-\kappa_1)} > 1, \tag{A.33}$$

$$\frac{\kappa_1 - \kappa_2}{\sigma(1-\kappa_2) - (1-\kappa_3)(1-\kappa_1)} > 1, \tag{A.34}$$

where κ_1 to κ_3 are defined in (A.30) to (A.32).

B.5 General Equilibrium in Relative Changes

To perform counterfactuals, we solve for the changes in model outcomes as function of changes in taxes. Consider computing the effect of moving from the current distribution of state taxes, $\left\{t_n^y, t_n^c, t_n^x, t_n^l\right\}_{n=1}^N$ to a new distribution $\{(t_n^y)', (t_n^c)', (t_n^x)', (t_n^l)'\}_{n=1}^N$. As we discussed in Section 4.8, implementing counterfactuals in our framework requires simultaneously accounting for a mapping from changes in adjusted fundamentals to changes in outcomes and for a mapping from changes in taxes and in general-equilibrium outcomes to changes in adjusted fundamentals. The first mapping is given by (A.35) to (A.42) below, and the second is given by (A.43) to (A.45).

Defining $\hat{x} = x'/x$ as the counterfactual value of x relative to its initial value, we have that the changes in import shares, export shares, number of workers, and wage per efficiency unit $\left\{\hat{\lambda}_{in}, \hat{s}_{in}, \hat{L}_n, \hat{w_n}\right\}$, as well as the welfare change of workers $\hat{v}$ must be such that conditions (A.24) and (A.26) hold:

$$\sum_n \lambda_{in}\hat{\lambda_{in}} = 1 \text{ for all } i, \tag{A.35}$$

$$\sum_i s_{in}\hat{s_{in}} = 1 \text{ for all } n, \tag{A.36}$$

where, using (A.27) and (A.28),

$$\hat{\lambda_{in}} = \hat{A_{in}} \left(\frac{\hat{w_n}}{\bar{\pi}}\right)^{1-\kappa_1} \left(\hat{h_n}\hat{L_n}\right)^{1-\kappa_{2n}} \left(\frac{\hat{w_i}}{\bar{\pi}}\right)^{\sigma-1} \left(\hat{h_i}\hat{L_i}\right)^{-\kappa_{3i}}, \tag{A.37}$$

$$\hat{s_{in}} = \hat{\lambda_{in}} \left(\frac{\widehat{P_i Q_i}}{X_i}\right) \frac{\hat{X_i}}{\hat{X_n}}, \tag{A.38}$$

where using (A.29),

$$\hat{A}_{in} = \left(\frac{\hat{z_n^A}}{\hat{\tau_{in}^A}} \left(\frac{\hat{Z_i}\hat{u_i^A}}{\hat{v}}\right)^{\frac{1}{1-\alpha_{W,i}}} \left(\frac{\hat{Z_n}\hat{u_n^A}}{\hat{v}}\right)^{\frac{1-\gamma_n}{1-\alpha_{W,n}}\left(\frac{(\sigma-1)\alpha_F\chi_F - 1}{\sigma-1}\chi^{FE}-1\right)}\right)^{\sigma-1}, \tag{A.39}$$

where the impact of changes in hours worked and the skill distribution within each state is captured by

$$\hat{Z_n} = \left(\left(\hat{h_n}\right)^{1-\left(b_n^y\right)'} e^{-\frac{b_n^y - \left(b_n^y\right)'}{1+1/\eta}}\right)^{1-\alpha_{W,n}} \left(h_n^{b_n^y - \left(b_n^y\right)'}\right)^{1-\alpha_{W,n}} \frac{\zeta_n - (1-b_n^y)(1-\alpha_{W,n})}{\zeta_n - \left(1-(b_n^y)'\right)(1-\alpha_{W,n})} \tag{A.40}$$

and where, from (13), the change in the number of hours worked is

$$\hat{h_n} = \left(\frac{1-(b_n^y)'}{1-b_n^y}\right)^{\frac{1}{1+1/\eta}}. \tag{A.41}$$

Additionally, labor shares must add up to 1 :

$$\sum L_n\hat{L_n} = 1. \tag{A.42}$$

From (30) to (32), the changes in the adjusted fundamentals are

$$\hat{\tau_{in}^A} = \frac{\sigma - \tilde{t}_{in}}{\sigma - \left(\tilde{t}_{in}\right)'}, \tag{A.43}$$

$$\hat{z_n^A} = \left(\frac{\left(1 - (\bar{t}_n)'\right) / \left(\sigma - 1 + \chi^{FE}\left(1 - (\bar{t}_n)'\right)\right)}{\left(1 - \bar{t}_n\right) / \left(\sigma - 1 + \chi^{FE}\left(1 - \bar{t}_n\right)\right)}\right)^{\frac{1}{\sigma-1} - \left(\frac{1-\chi^{FE}}{\varepsilon_F} + \alpha_F \chi_F\right)} \hat{G_n}^{\alpha_F}, \tag{A.44}$$

$$\hat{u_n^A} = \left(\frac{1 - T_n'\left(w_n z_n^L \hat{w_n}\right)}{1 - T_n\left(w_n z_n^L\right)} \frac{1 + t_n^c}{1 + (t_n^c)'}\right)^{1-\alpha_W} \left(\hat{G_n}\right)^{\alpha_{W,n}}. \tag{A.45}$$

where

$$\frac{1 - T_n'\left(w_n z_n^L \hat{w_n}\right)}{1 - T_n\left(w_n z_n^L\right)} = \hat{a_n^y} \frac{1 + t_n^c}{1 + (t_n^c)'} \hat{w_n}^{-\left(b_n^y\right)'} \left(w_n z_n^L\right)^{-\left(\left(b_n^y\right)' - b_n^y\right)}. \tag{A.46}$$

The variables $\left\{\frac{\hat{P_n Q_n}}{X_n}, \hat{G_n}, T_n', (\bar{t}_n)', \left(\tilde{t}_{in}\right)'\right\}_{n=1}^N$ entering in (A.43) to (A.45) can be expressed as function of the original taxes $\left\{t_n^y, t_n^c, t_n^x, t_n^l\right\}_{n=1}^N$, the new tax distribution $\{(t_n^y)', (t_n^c)', (t_n^x)', \left(t_n^l\right)'\}_{n=1}^N$, and the new export shares $\{\hat{s_{in}} s_{in}\}_{n,i=1}^N$ using (9), (22), (24), (A.22), and (28). Hence, these equations, together with (A.35) to (A.42), give the solution for $\left\{\hat{\lambda}_{in}, \hat{s}_{in}, \hat{L}_n, \hat{w_n}\right\}$ and $\hat{v}$. The new government sizes and trade deficits also depend on the new values of $\tilde{\Pi}$ and $\Pi + R$; these variables can be expressed as a function of initial conditions and changes in the endogenous variables.

C Appendix to Section 5

Proof of Proposition 1 Under the assumptions in the proposition, the efficient allocations follow from optimization of the following Lagrangian:

$$\begin{aligned} \mathcal{L} = v &- \sum_n \lambda_{1n} \left[v - U_n\left(\frac{C_n^L}{L_n}, G_n\right)\right] - \sum_n \lambda_{2n} \left[v_n^K - U_n^K\left(\frac{C_n^K}{K_n}, G_n\right)\right] \\ &- \lambda_3 \left(\sum_n C_n^L + \sum_n C_n^K + \sum_n G_n + \sum_n I_n - \sum_n F_n\left(L_n, I_n\right)\right) \\ &- \lambda_4 \left(\sum L_n - 1\right). \end{aligned} \tag{A.47}$$

The efficient allocations result from maximizing the welfare of workers v given arbitrary levels of welfare of capital owners, v_n^K. The first term in square brackets in the first line is the spatial mobility constraint, where $U_n(c, g)$ is the direct utility function defined in (2) under the assumption of no disutility from labor, and where $U_n^K(c, g)$ is the utility of each capital owner in n. The second line shows the goods feasibility constraint, where

$$F_n\left(L_n, I_n\right) = z_n^0 \left[\frac{1}{\gamma_n}\left(\frac{H_n}{\beta_n}\right)^{\beta_n}\left(\frac{L_n}{1-\beta_n}\right)^{1-\beta_n}\right]^{\gamma_n} \left(\frac{I_n}{1-\gamma_n}\right)^{1-\gamma_n}$$

is the production technology. The last line of (A.47) is national labor market clearing. Except for the existence of intermediates, the arbitrary many regions, and the immobile capital owners, (A.47) is the same optimization problem considered in Flatters et al. (1974) and Wildasin (1980). Letting $U_{nc} \equiv \partial U_n(c, g)/\partial c$ and $F_{nL} \equiv \partial F_n/\partial L_n$, taking the first order condition over L_n and C_n we obtain

$$\begin{aligned} &[L_n] && \lambda_3 F_{nL} = \lambda_4 + \frac{C_n^L}{L_n} \lambda_{1n} \frac{U_{nc}^L}{L_n}, \\ &\left[C_n^L\right] && \lambda_{1n} \frac{U_{nc}^L}{L_n} = \lambda_3. \end{aligned}$$

Combining these two conditions we obtain $F_{nL} - C_n^L/L_n = \lambda_4/\lambda_3$. Under $t_{fed}^w = 0$ the market allocation gives $w_n = F_{nL}$. Absent compensating differentials, mobility of workers implies that C_n^L/L_n is constant across locations, which gives part i) of the proposition. More generally, we have that $w_n - C_n^L/L_n$, which equals tax payments in the decentralized equilibrium, is equalized across locations, which gives part ii).

Proof of Proposition 2 Consider a tax structure with only state sales and income taxes. Assume no trade costs ($\tau_{in} = 1$ for all i, n), perfect substitutability across varieties ($\sigma \to \infty$), homogeneous firms ($\varepsilon_F \to \infty$), and constant labor supply ($\zeta_n \to \infty$ and h_n constant). Because goods are perfect substitutes ($\sigma \to \infty$) and there are no trade costs ($\tau_{in} = 1$) the production cost c_n must be equalized across regions, and normalized to 1. This must also be the price of the final good produced everywhere. Because firms are homogeneous ($\varepsilon_F \to \infty$), it follows from (27) that the summary statistic of the productivity distribution in n equals the common component of productivity, $\tilde{z}_n = z_n^0$. Using (A.6), total production in region n is

$$\left(\frac{z_n^0}{\gamma_n}\right)^{1/\gamma_n} \left(\frac{H_n}{\beta_n}\right)^{\beta_n} \left(\frac{L_n}{1-\beta_n}\right)^{1-\beta_n}. \tag{A.48}$$

From (4), state-specific appeal is:

$$v_n = u_n \left(\frac{G_n}{L_n^{\chi_W}}\right)^{\alpha_{W,n}} \left(\left(1-T_n\right) w_n\right)^{1-\alpha_{W,n}}. \tag{A.49}$$

From (A.7), labor demand in state n is given by the condition that labor costs equal the marginal product of labor, $w_n = MPL_n$, given by

$$MPL_n = Z_{n,0} L_n^{-\beta_n}, \tag{A.50}$$

where $Z_{n,0} = \left(1-\beta_n\right)^{\beta_n} \beta_n^{-\beta_n} \left(z_n^0/\gamma_n\right)^{1/\gamma_n} H_n^{\beta_n}$. Labor supply in n follows from (7). Equating local labor demand and local labor supply gives the solution for employment in n,

$$L_n^*\left(v\right) = \left(\frac{\left(Z_n\left(1-T_n\right)\right)^{1-\alpha_{W n}}}{v}\right)^{\frac{1}{1/\varepsilon_W + \alpha_{W,n}\chi_W + \left(1-\alpha_{W,n}\right)\beta_n}} \tag{A.51}$$

where $Z_n = Z_{n,0}\left(u_n G_n^{\alpha_W}\right)^{\frac{1}{1-\alpha_W}}$. National labor-market clearing then gives the solution for worker welfare v as the value where $H^*\left(v\right) \equiv \sum_{n=1}^N L_n^*\left(v\right) = 1$. $H^*\left(v\right)$ is decreasing in v so that there can only be a unique solution for v. Assume now that $\alpha_{W,n} = \alpha_W$ for all n. Then, letting

$$\zeta = \frac{1-\alpha_W}{1/\varepsilon_W + \alpha_W \chi_W + \left(1-\alpha_W\right)\beta} > 0,$$

the solution for worker welfare is:

$$v = \left(\sum_n \left(Z_n\left(1-T_n\right)\right)^{\zeta}\right)^{\frac{1-\alpha_W}{\zeta}}. \tag{A.52}$$

Let v' be welfare under a distribution of taxes where every tax rate is brought to the mean of the initial distribution, $T_n' = N^{-1}\sum T_n$ for all n. Then, $v' > v$ if and only if

$$E[Z_n^{\zeta}](E[1-T_n])^{\zeta} > cov[Z_n^{\zeta}, (1-T_n)^{\zeta}] + E[Z_n^{\zeta}]E[(1-T_n)]^{\zeta} \tag{A.53}$$

where E and cov denote the sample mean and covariance. This expression can be rearranged to reach

$$\frac{\mathbb{E}\left[1-T_n\right]^{\zeta} - \mathbb{E}\left[\left(1-T_n\right)^{\zeta}\right]}{sd\left(\left(1-T_n\right)^{\zeta}\right)} > cv\left(Z_n^{\zeta}\right) corr\left[Z_n^{\zeta}, \left(1-T_n\right)^{\zeta}\right] \tag{A.54}$$

where cv and sd denote the coefficient of variation and the standard deviation. Therefore, $v' > v$ if $corr[Z_n^{\zeta}, (1-T_n)]^{\zeta}$ is low enough, and $v' > v$ if $corr[Z_n^{\zeta}, (1-T_n)]^{\zeta}$ is large enough. Part i) follows from the fact that $\zeta = 1/\beta$ when $\varepsilon_W \to \infty$ and $\chi_W = 0$. Part ii) follows from the example in the body of the text.

D Appendix to Section 6

D.1 Model-implied Fundamentals

This section shows the composite term A_{in}, is related to measures of local amenities and market access. We recover measures of the composite terms A_{in} from observed data and estimated parameters using equation (A.27). Then, we relate the composite terms A_{in} to its determinants in the model. We focus on testing the predictions of equation (A.29) for the relationship between A_{in} and observable exogenous determinants of trade costs τ_{in}^A and amenities in states i and n, u_i^A and u_n^A by estimating regressions of the form

$$\ln A_{in} = b_0 + b_1 \ln \tau_{in}^A + b_2 u_i^A + b_3 u_n^A + e_{in},$$

where we use distance as our proxy for trade costs τ_{in}^A and data on measures of temperature and air quality in a state as our proxy for u_i^A and u_n^A. Table A.5 reports the results of these regressions. We find three main results: First, there is a negative relation between distance between states and the composite term A_{in}. Second, there is a positive relation between A_{in} and observable covariates that increase state i's exogenous amenity level u_i^A (and vice versa). Column 2 shows that states with a higher minimum temperature, and with lower maximum temperatures and precipitation have higher values of A_{in}. We also find that states with a lower number of toxic sites have higher values of A_{in}, but this relation, as well as the relations with measures of air quality, are not statistically significant. Finally, there is a negative relation between A_{in} and observable covariates that increase state n exogenous amenity level u_n^A (and vice versa). Column 3 shows that destination states with more amenable weather (higher minimum temperature, lower maximum temperatures, and less precipitation) have lower values of A_{in}. These relationships are consistent with (A.29). The only relation that contradicts the prediction of the model is that of particulate matter in destination states, which may reflect other factors like the level of economic activity. Overall, these results provide evidence that the model-implied fundamentals have sensible empirical foundations.

Table A.5: Regressions of $\ln(A_{in})$ on Own-State and Other-State Amenities

	(1)	(2)	(3)	(4)
Log Distance in Miles	-1.467***	-1.296***	-1.506***	-1.298***
	(0.292)	(0.170)	(0.313)	(0.174)
Min Temp (Origin)		1.422***		1.418***
		(0.481)		(0.483)
Max Temp (Origin)		-0.988**		-0.985**
		(0.379)		(0.380)
Precipitation (Origin)		-0.003*		-0.003*
		(0.002)		(0.002)
Toxic Site (Origin)		-0.269		-0.268
		(0.538)		(0.539)
Particulate Matter (Origin)		0.354		0.352
		(0.285)		(0.286)
Ozone Days (Origin)		0.069		0.070
		(0.059)		(0.060)
Min Temp (Destination)			-0.203***	-0.096***
			(0.014)	(0.031)
Max Temp (Destination)			0.070***	-0.010
			(0.006)	(0.018)
Precipitation (Destination)			0.001***	0.001***
			(0.000)	(0.000)
Toxic Site (Destination)			0.075***	0.044**
			(0.015)	(0.021)
Particulate Matter (Destination)			-0.103***	-0.061**
			(0.028)	(0.024)
Ozone Days (Destination)			0.035***	0.034***
			(0.005)	(0.007)
Observations	2122	2099	2114	2091

NOTES: The table reports results of a regression of the form: $\ln A_{in} = b_0 + b_1 \ln distance_{in} + b_2 u_i^A + b_3 u_n^A + e_{in}$, where A_{in} is constructed from the data using equation (A.27), and where u_i^A and u_n^A are measures of amenities in origin and destination states. We estimate these regressions using a cross-section of data, where data on amenities comes from Couture et al. (2018). Amenity data are population-weighted averages at the state level. All models allow for clustered standard errors by the origin state and the destination state. Standard errors are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

D.2 Appendix to Section 6.2

D.2.1 Construction of Covariates in Worker and Firm Mobility Equation

We first describe how we construct the variable $z_n^L w_{nt}$ entering the covariate $\tilde{y}_{nt}$ in (34) and, through (A.46), the system of equilibrium equations in changes used for counterfactuals. In the model, the hourly wage of a worker l in state n is $w_n^h(l) = z_n^l w_n$, where w_n is the wage per efficiency unit. Given the assumption that distribution of efficiency units within each state is Pareto with parameters $\left(z_n^L, \zeta_n\right)$, average hourly income per worker in state n is $\mathbb{E}_n\left[w_n^h(l)\right] = z_n^L \frac{\zeta_n}{\zeta_n - 1} w_n$. Assuming that the shape of the Pareto distribution ζ_n is constant over time, we obtain

$$z_n^L w_{nt} = \mathbb{E}_n\left[w_{nt}^h(l)\right] \frac{\zeta_n - 1}{\zeta_n}, \tag{A.55}$$

where $\mathbb{E}_n\left[w_{nt}^h(l)\right]$ is empirically measured as the average hourly wage across individuals living in state n in year t. Using again the assumption that the distribution of efficiency units across workers within a state is Pareto, the shape parameter ζ_n can be estimated using information on the average and variance of the distribution of hourly wages across workers living in state n:

$$(\zeta_n - 2)\zeta_n = \frac{\mathbb{E}_n\left[w_{nt}\left(l\right)\right]^2}{\mathbb{V}_n\left[w_{nt}\left(l\right)\right]}. \tag{A.56}$$

For each state n and period t, we construct A^S_{nt} using the information on the estimated ζ_n and estimated progressivity parameter b^y_{nt}. See Appendix F.1 for detailed information about the construction of income tax schedule parameters.

To construct measures of after-tax real earnings $\tilde{y}_{nt}$, market potential MP_{nt}, real government services $\tilde{R}_{nt}$, and unit costs c_{nt}, we need data on prices. We use the consumer price index from the Bureau of Labor Statistics. This is the same price data that is used in the estimation of the labor equation to construct measures of real government spending and real wages.

Constructing unit costs also requires data on the price of structures r_{nt}, which is is not available at an annual frequency. To avoid this shortcoming in the data, we construct an annual series of unit costs by setting the local price of structures to equal the local price index, resulting in the following measure of unit costs: $c_{nt} = (w^{1-\beta_n}_{nt} P^{\beta_n}_{nt})^{\gamma_n} P^{1-\gamma_n}_{nt}$.[3]

To construct measures of $\{\bar{t}_{nt}\}^N_{n=1}$ and $\{\tilde{t}_{n'nt}\}^{N,N}_{n=1,n'=1}$ (which enters the market potential MP_{nt}), we need information on the share of total sales generated in state n that accrue to state n'. Annual data on trade flows across U.S. states does not exist. To overcome this data limitation, we set export shares in any period t equal to the average of the recorded export shares for the years 1993 and 1997, i.e., $s_{int} = 0.5 \times (s_{in,1993} + s_{in,1997})$. We also use the same information on export shares to construct a proxy for the term $\{\tau_{n'nt}\}^{N,N}_{n=1,n'=1}$ entering the expression for $\{MP_{nt}\}^N_{n=1}$. Specifically, we set $\tau_{n'nt} = dist^{\zeta}_{n'n}$, where $\zeta = 0.8/(\sigma - 1)$ and 0.8 is the point estimate of the elasticity of cross-state export shares with respect to distance, controlling for year, exporter and importer fixed effects.

We also need information on total state expenditures $\{P_{nt}Q_{nt}\}^N_{n=1}$ to a measure for $\{MP_{nt}\}^N_{n=1}$. Since expenditures are not observed in every year, we follow the predictions of the model and construct a proxy for $P_{nt}Q_{nt}$ for every state $n$as a function of state n's GDP by combining (A.7), (A.12), and (A.22) to obtain

$$P_{nt}Q_{nt} = \frac{(\sigma - 1)\left(1 - \beta_n\gamma_n\right) + a_{nt} + t^l_n}{\sigma - t^x_n} \frac{\sigma}{\gamma_n\left(\sigma - 1\right) + 1} GDP_{nt}, \tag{A.57}$$

where $a_{nt} \equiv b_n(\Pi + R + t^{corp}_{fed}\tilde{\Pi})(\tilde{\Pi}_n)^{-1}$. State GDP is observed in every year, but a_{nt} is not. Hence, to compute a yearly measure of $P_{nt}Q_{nt}$, we set its value to that observed in the calibration: $a_{nt} = a_{n,2007}$ for all t.[4]

D.3 Construction of Instrument for Market Potential

We define the instrument MP^*_{nt} as a variable that has a similar structure to market potential MP_{nt} in (41) but that differs from it in that we substitute the components E_{nt}, P_{nt}, and $\tilde{t}_{n'nt}$ that might potentially be correlated with ν^M_{nt} with functions of exogenous covariates that we respectively denote as E^*_{nt}, P^*_{nt}, and $\tilde{t}^*_{n'nt}$:

$$MP^*_{nt} = \sum_{n' \neq n} E^*_{n't} \left(\frac{\tau_{n'nt}}{P^*_{n't}} \frac{\sigma}{\sigma - \tilde{t}^*_{n'nt}} \frac{\sigma}{\sigma - 1} \right)^{1-\sigma}. \tag{A.58}$$

To implement this expression, we need to construct measures of the variables E^*_{nt}, P^*_{nt}, and $\tilde{t}^*_{n'nt}$. We construct E^*_{nt} using (A.57) with lagged GDP instead of period $t's$ GDP:

$$E^*_{nt} = \frac{(\sigma - 1)\left(1 - \beta_n\gamma_n\right) + a_{nt} + t^l_n}{\sigma - t^x_n} \frac{\sigma}{\gamma_n\left(\sigma - 1\right) + 1} GDP_{n,t-1}$$

We set $P^*_{n,t} = 1 + t^c_{n,t}$. We construct $\tilde{t}^*_{n'nt}$ using the expression for $\tilde{t}_{ni}$ in (24) evaluated at hypothetical export shares defined as relative inverse log distances:

[3] Projecting the decadal data on rental prices r_{nt} on wages and local price indices, w_{nt} and P_{nt}, and using the projection estimates in combination with annual data on w_{nt} and P_{nt} to compute predicted rental prices, $\hat{r}_{nt}$, and predicted unit costs, $c_{nt} = (w^{1-\beta_n}_{nt} \hat{r}^{\beta_n}_{nt})^{\gamma_n} P^{1-\gamma_n}_{nt}$, produces similar estimates of the structural parameters ε_F and α_F.

[4] Using an alternate definition of $P_{nt}Q_{nt}$, i.e., $P_{nt}Q_{nt} = constant{*}GDP_{nt}$ where the constant is an OLS estimate of the derivative of total expenditures with respect to GDP in those years in which we observe both components, yields very similar results.

$$s^*_{int} = \frac{\ln(dist_{in})^{-1}}{\sum_{i\neq n}\ln(dist_{in})^{-1}+1} \quad \forall t, i \neq n \qquad \text{and} \qquad s^*_{iit} = \frac{1}{\sum_{i\neq n}\ln(dist_{in})^{-1}+1} \quad \forall t.$$

D.4 Robustness Checks: Labor Supply

This section presents a series of robustness checks that address a number of potential concerns about our instrument choice and labor supply specification. Table A.6 presents GMM estimates for structural parameters when government spending is measured using actual, as opposed to model-based, tax revenue. Table A.7 reports estimates from a specification in which we use a wage Bartik instrument instead of a payroll Bartik instrument. In Table A.8 we estimate structural parameters in the case of no unobserved worker heterogeneity. In Table A.9 we ignore the intensive margin of labor supply.

First, Table A.6 reports GMM estimates for structural parameters of the labor supply equation when government spending $\tilde{R}_{nt}$ is measured using actual, as opposed to model-based, tax revenue.

Second, Table A.7 reports GMM estimates that differ from the baseline ones in Section 6.2 in that $\boldsymbol{Z}^B_{nt}$ contains a wage Bartik instrument instead of a payroll Bartik instrument:

$$\text{BtkW}_{nt} = \sum_k \frac{L_{kn,1974}}{L_{n,1974}} \frac{w_{kt} - w_{k,t-10}}{w_{k,t-10}},$$

where w denotes real hourly wages.

Third, we consider a specification in which we do not account for unobserved worker heterogeneity. Specifically, Table A.8 shows GMM estimates from the following model:

$$\ln L_{nt} = a_{0,n} \ln \tilde{y}_{nt} + b_{0,n} \ln \tilde{R}_{nt} + \psi^L_t + \xi^L_n + \nu^L_{nt},$$

where the shape parameter of the distribution of efficiency units, $\zeta_{n,}$ is set to 1 and, as a consequence, the hourly wage adjusted for efficiency units is equal to the raw wage observed in the Current Population Survey (CPS).

Finally, Table A.9 reports worker parameter estimates from a specification in which we do not account for the intensive margin of labor supply. This implies that real after-tax earnings are defined as:

$$\tilde{y}_{nt} \equiv \frac{a^y_{nt}}{1+t^c_{nt}} \frac{1}{P_{nt}} \left(h_{nt} w^z_{nt}\right)^{1-b^y_{nt}}.$$

Table A.6: GMM Estimates of Worker Parameters: Tax Revenue Robustness

Instruments	Restrictions on $\alpha_{W,n}$	ε_W		α_W	
		$\chi_W = 0$	$\chi_W = 1$	$\chi_W = 0$	$\chi_W = 1$
$\boldsymbol{Z}_{nt}^T$	$\alpha_{W,n} = \alpha_W$	1.23***	1.96**	.3**	.3**
		(.33)	(.96)	(.12)	(.12)
$\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = \alpha_W$	1.81***	3.54**	.27**	.27**
		(.48)	(1.78)	(.12)	(.12)
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = \alpha_W$	1.26***	1.81***	.24**	.24**
		(.28)	(.69)	(.11)	(.11)
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = \frac{R_n}{GDP_n}$	.72***	1.4***		
		(.23)	(.33)		
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_W = 0.04 = \text{Mean} \frac{R_n}{GDP_n}$	1.1***	1.15***		
		(.31)	(.34)		
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_W = 0$	1.03***	1.03***		
		(.3)	(.3)		

Notes: This table shows the GMM estimates for structural parameters entering the labor mobility equation (33). The data are at the state-year level. Each column has 712 observations. Every specification includes state and year fixed effects. Observations are weighted using state population. The instrument vectors used to compute the estimates in each row are indicated under the heading "Instruments". Similarly, restrictions on $\alpha_{W,n}$ are described under the heading "Restrictions on $\alpha_{W,n}$". Robust standard errors are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

Table A.7: GMM Estimates of Worker Parameters: Labor Market Bartik IV Robustness

Instruments	Restrictions on $\alpha_{W,n}$	ε_W		α_W	
		$\chi_W = 0$	$\chi_W = 1$	$\chi_W = 0$	$\chi_W = 1$
$\boldsymbol{Z}_{nt}^T$	$\alpha_{W,n} = \alpha_W$	1.42***	2.1***	.23***	.23***
		(.36)	(.8)	(.07)	(.07)
$\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = \alpha_W$	.86*	1.05	.21*	.21*
		(.47)	(.65)	(.13)	(.13)
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = \alpha_W$	1.17***	1.47***	.18***	.18***
		(.31)	(.5)	(.07)	(.07)
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = \frac{R_n}{GDP_n}$	.47*	1.3***		
		(.25)	(.33)		
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_W = 0.04 = \text{Mean} \frac{R_n}{GDP_n}$	.99***	1.03***		
		(.3)	(.32)		
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_W = 0$	.83***	.83***		
		(.27)	(.27)		

Notes: This table shows the GMM estimates for structural parameters entering the labor mobility equation (33). The data are at the state-year level. Each column has 712 observations. Every specification includes state and year fixed effects. Observations are weighted using state population. The instrument vectors used to compute the estimates in each row are indicated under the heading "Instruments". Similarly, restrictions on $\alpha_{W,n}$ are described under the heading "Restrictions on $\alpha_{W,n}$". Robust standard errors are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

Table A.8: GMM Estimates of Worker Parameters: No Unobserved Worker Heterogeneity

Instruments	Restrictions on $\alpha_{W,n}$	ε_W		α_W	
		$\chi_W = 0$	$\chi_W = 1$	$\chi_W = 0$	$\chi_W = 1$
$\boldsymbol{Z}_{nt}^T$	$\alpha_{W,n} = \alpha_W$	1.42***	2.09***	.23***	.23***
		(.36)	(.79)	(.07)	(.07)
$\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = \alpha_W$	1.79***	2.25**	.11*	.11*
		(.63)	(.93)	(.06)	(.06)
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = \alpha_W$	1.35***	1.72***	.16***	.16***
		(.3)	(.52)	(.06)	(.06)
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = \frac{R_n}{GDP_n}$	.74***	1.48***		
		(.23)	(.33)		
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_W = 0.04 = \text{Mean}\frac{R_n}{GDP_n}$	1.19***	1.25***		
		(.32)	(.35)		
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_W = 0$	1.04***	1.04***		
		(.3)	(.3)		

NOTES: This table shows the GMM estimates for structural parameters entering the labor mobility equation (33) when $\ln A_n^S = 0$ and $w_n^z = w_n^{CPS}$, i.e., there is no unobserved worker heterogeneity. The data are at the state-year level. Each column has 712 observations. Every specification includes state and year fixed effects. Observations are weighted using state population. The instrument vectors used to compute the estimates in each row are indicated under the heading "Instruments". Similarly, restrictions on $\alpha_{W,n}$ are described under the heading "Restrictions on $\alpha_{W,n}$". Robust standard errors are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

Table A.9: GMM Estimates of Worker Parameters: No Intensive Margin of Labor Supply

Instruments	Restrictions on $\alpha_{W,n}$	ε_W		α_W	
		$\chi_W = 0$	$\chi_W = 1$	$\chi_W = 0$	$\chi_W = 1$
$\boldsymbol{Z}_{nt}^T$	$\alpha_{W,n} = \alpha_W$	1.48***	2.24***	.23***	.23***
		(.37)	(.86)	(.06)	(.06)
$\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = \alpha_W$	1.81***	2.3**	.12*	.12*
		(.64)	(.95)	(.06)	(.06)
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = \alpha_W$	1.39***	1.8***	.16***	.16***
		(.31)	(.54)	(.06)	(.06)
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_{W,n} = \frac{R_n}{GDP_n}$	.8***	1.39***		
		(.25)	(.29)		
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_W = 0.04 = \text{Mean}\frac{R_n}{GDP_n}$	1.2***	1.26***		
		(.32)	(.36)		
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_W = 0$	1.03***	1.03***		
		(.3)	(.3)		

NOTES: This table shows the GMM estimates for structural parameters entering the labor mobility equation (33) when $\eta \to 0$, i.e., the labor supply has no intensive margin responses. The data are at the state-year level. Each column has 712 observations. Every specification includes state and year fixed effects. Observations are weighted using state population. The instrument vectors used to compute the estimates in each row are indicated under the heading "Instruments". Similarly, restrictions on $\alpha_{W,n}$ are described under the heading "Restrictions on $\alpha_{W,n}$". Robust standard errors are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

D.5 Robustness Checks: Firm Mobility

Table A.10 presents a robustness check for the firm mobility equation. Using the baseline model in Section 6.2, we measure government spending $\tilde{R}_{nt}$ using model-based, as opposed to actual, tax revenue.

Table A.10: GMM Estimates of Firm Parameters: Tax Revenue Robustness

Instruments	Restrictions on α_F	ε_F		α_F	
		$\chi_F = 0$	$\chi_F = 1$	$\chi_F = 0$	$\chi_F = 1$
$\boldsymbol{Z}_{nt}^T$	None	2.5***	2.15***	-.06*	-.06*
		(.28)	(.27)	(.04)	(.04)
$\boldsymbol{Z}_{nt}^B$	None	2.74***	2.66***	-.01	-.01
		(.32)	(.33)	(.03)	(.03)
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	None	2.46***	2.3***	-.03	-.03
		(.26)	(.27)	(.03)	(.03)
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_F = 0.04 = \text{Mean}\frac{R_n}{GDP_n}$	2.29***	2.53***		
		(.25)	(.31)		
$\boldsymbol{Z}_{nt}^T$, $\boldsymbol{Z}_{nt}^B$	$\alpha_F = 0$	2.45***	2.45***		
		(.26)	(.26)		

Notes: This table shows GMM estimates for structural parameters entering the firm mobility equation (40). Data are at the state-year level. Each column has 587 observations, which is lower than the worker estimation due to data requirements for constructing a measure of the market potential and unit costs terms (see Appendix D.3 for details). Every specification includes state and year fixed effects. The instrument vectors used to compute the estimates in each row are indicated under the heading "Instruments". Similarly, restrictions on α_F are described under the heading "Restrictions on α_F". Robust standard errors are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

D.6 Supplemental: 2SLS Estimates of Worker Parameters

This section presents both Ordinary Least Squares (OLS) and Two-Stage Least Squares (2SLS) estimates for the auxiliary parameters a_0 and a_1 in (33). To implement a 2SLS estimator, we consider the simplified case in which there is no unobserved worker heterogeneity (i.e., the case in which $\ln A_n^S = 0$ and thus $w_n^z = w_n^{CPS}$). Appendix Table A.8 shows that the estimates in this case are nearly identical to the baseline estimates. When computing this 2SLS estimator, we use the two instrument vectors described in Section 6.2, $\boldsymbol{Z}_{nt}^T$ and $\boldsymbol{Z}_{nt}^B$, first separately and then jointly.

Table A.11 provides the estimates of the first-stage regression corresponding to the 2SLS estimation of a_0 and a_1. Column (1) shows the estimates of a regression of after-tax real wages on the instrument vector $\boldsymbol{Z}_{nt}^T$ and state and year fixed effects. Column (4) does the same for real government services $\tilde{R}_{nt}$. The coefficients on external taxes indicate that being "close" to high sales tax (and high sales-apportioned corporate tax) states tends to be associated with lower after-tax real wages. Real government services tend to be lower when the state is "close" to high income tax states. Columns (2) and (5) show the results using the Bartik instruments $\boldsymbol{Z}_{nt}^B$. Initial state-industry specific shares weighted national industry-specific payroll changes and initial state-type of tax specific shares weighted national tax revenue shocks tend to be associated with higher state earnings and government service provision. The first stage for earnings is a bit underpowered in the Bartik IV specification, whereas the state tax revenue first stage is fairly strong. Columns (3) and (6) show the first stage results when both sets of instruments are included. The F-statistics of joint significance of the instruments conditional on state and year fixed effects are 8.6 in column (3) and 13.4 in column (6). Additionally, the Cragg-Donald Wald F-statistic is 9.9 and the Kleibergen-Paap Wald F-statistic is 7.8.

As mentioned in the main text, our model predicts that OLS estimates of a_0 and a_1 are asymptotically biased due to the dependence of after-tax real earnings and government spending on unobserved amenities or government efficiency accounted for in the term ν_{nt}^L. Specifically, our model predicts that amenities in a state are negatively correlated with its after-tax real earnings and positively correlated with its real government spending. Intuitively, higher amenities in a state attract workers, shift out the labor supply curve, and lower wages. This increase in the number of workers also raises the tax revenue and thus increases government spending. Our model thus predicts that the OLS estimate of a_0 is biased downwards, and the OLS estimate of a_1 is biased upwards. Therefore, if our

Table A.11: First Stage of Labor-Supply Equation

	(1)	(2)	(3)	(4)	(5)	(6)
		$\ln \tilde{y}_{nt}$			$\ln \tilde{R}_{nt}$	
	$\boldsymbol{Z}_{nt}^T$	$\boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^T, \boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^T$	$\boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^T, \boldsymbol{Z}_{nt}^B$
t_{nt}^{*x}	-0.39		-0.40	0.80		0.36
	(0.25)		(0.25)	(0.74)		(0.70)
t_{nt}^{*c}	3.28***		3.19***	0.13		0.37
	(0.55)		(0.55)	(1.93)		(1.77)
t_{nt}^{*y}	0.48		0.53	-8.11***		-6.40***
	(0.45)		(0.46)	(1.40)		(1.37)
$BtkP_{nt}$		0.06**	0.06**		0.01	-0.01
		(0.03)	(0.02)		(0.07)	(0.07)
$BtkTR_{nt}$		-0.03	-0.01		1.05***	0.90***
		(0.04)	(0.04)		(0.19)	(0.20)
R-squared	0.946	0.944	0.947	0.992	0.992	0.993
F-stat	12.1	3.4	8.6	12.6	15.3	13.4

NOTES: This table shows first-stage estimates for the labor mobility equation (33) when $\ln A_n^S = 0$ and $w_n^z = w_n^{CPS}$, i.e., there is no unobserved worker heterogeneity. The dependent variables are after-tax real earnings and real government expenditures in columns 1-3 and 4-6, respectively. Data are at the state-year level. Every specification includes state and year fixed effects. Each column has 712 observations. F-statistics refer to specifications that do not control for state and year dummies. Robust standard errors are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

instrument vectors were to be valid, we should should obtain 2SLS estimates of a_0 and a_1 that are, respectively, higher and lower than their OLS counterparts.

Table A.12 presents OLS and 2SLS estimates of a_0 and a_1. Column (1) shows the OLS estimates. Columns (2)-(4) show the 2SLS estimates. Compared to the 2SLS estimates, the OLS estimates imply a lower elasticity of labor supply with respect to after-tax real earnings and a larger one with respect to real government spending. This difference between the OLS and the 2SLS estimates is consistent with our model's predictions. In addition, the 2SLS estimates that rely on different instrument vectors are quite similar. The implications of these reduced-form estimates of a_0 and a_1 for our structural parameters are shown at the bottom of the table.

Table A.12: OLS and 2SLS Estimates of Local Labor Supply Parameters

	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS
		$\boldsymbol{Z}^T_{nt}$	$\boldsymbol{Z}^B_{nt}$	$\boldsymbol{Z}^T_{nt}, \boldsymbol{Z}^B_{nt}$
$\ln \tilde{y}_{nt}$	0.28***	1.36***	1.58***	1.35***
	(0.06)	(0.34)	(0.61)	(0.30)
$\ln \tilde{R}_{nt}$	0.44***	0.32***	0.20*	0.23**
	(0.03)	(0.12)	(0.11)	(0.10)
Structural Parameters				
ε_W for $\chi_W = 0$	.72***	1.67***	1.79***	1.59***
	(.07)	(.39)	(.63)	(.34)
ε_W for $\chi_W = 1$	1.28***	2.45***	2.25**	2.07***
	(.17)	(.9)	(.93)	(.61)
α_W	0.60***	0.19***	0.11*	0.15***
	(.06)	(.06)	(.06)	(.05)

NOTES: This table shows TSLS estimates for the labor mobility equation (33) when $\ln A^S_n = 0$ and $w^z_n = w^{CPS}_n$, i.e., there is no unobserved worker heterogeneity. The data are at the state-year level. Each column has 712 observations. The Cragg-Donald Wald F-statistic is 9.9 and the Kleibergen-Paap Wald F-statistic is 7.8 for the 2SLS specification in column (4). Every specification includes state and year fixed effects. Robust standard errors are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

D.7 Supplemental: 2SLS Estimates of Firm Parameters

This section presents both OLS and 2SLS estimates of the auxiliary parameters b_0, b_1, and b_2 in equation (40). When computing 2SLS estimates, we instrument for after-tax market potential, unit costs, and real government services using either the instrument vector of external tax rates $\boldsymbol{Z}^T_{nt} = (t^{*c}_{nt}, t^{*x}_{nt}, t^{*y}_{nt})$ and MP^*_{nt}, the vector of Bartik instruments $\boldsymbol{Z}^B_{nt} \equiv (\text{BtkP}_{nt}, \text{BtkTR}_{nt})$ and MP^*_{nt}, or all of these instruments combined.

As mentioned in the main text, our model predicts that OLS estimates of b_0, b_1, and b_2 are asymptotically biased due to the dependence of after-tax market potential, costs, and government spending in state n and year t on unobserved productivity or government efficiency in the same state and year, which are accounted for in the term ν^M_{nt}.

Table A.13 provides the estimates of the first-stage regression corresponding to the 2SLS estimation of b_0, b_1, and b_2. The table shows how after-tax market potential, unit costs, and real government spending relate to the instruments. Column (1) shows the estimates of a regression of after-tax market potential on the instrument vector $\boldsymbol{Z}^T_{nt}$, the leave-out market potential term, and state and year fixed effects. Column (2) replaces with $\boldsymbol{Z}^B_{nt}$, and column (3) uses both instrument vectors. These three columns show that the leave-out market potential term is highly correlated with after-tax market potential. Columns (4)-(6) show similar specifications for unit costs, which tend to be lower when the state is close to high sales tax and low market potential neighbors. Columns (7)-(9) show similar results for real tax revenues, which tend to be high when leave-out market potential is high and when the that state's main tax revenue source is high nationally.

To increase power and mimic the variation used to estimate ε_F in those cases in which we calibrate the value of α_F, Table A.14 reports first-stage estimates for the combinations of after-tax market potential, unit costs, and real government spending used to identify ε_F in these cases. Specifically, in the case in which we assume that $\alpha_F = 0.04$, we can write the right hand side of equation (40) as $b_0 \times RHS_{nt}$, where $RHS_{nt} \equiv \ln((1-\bar{t}_{nt})MP_{nt}) - (\sigma-1)\ln c_{nt} + 0.05(\sigma-1)\ln \tilde{R}_{nt}$, and σ is calibrated to equal 4. Similarly, in the case in which we assume that $\alpha_F = 0$, we can write the right-hand side of equation (40) as $b_0 \times RHS_{nt}$, where $RHS_{nt} \equiv \ln((1-\bar{t}_{nt})MP_{nt}) - (\sigma-1)\ln c_{nt}$. Columns (1)-(3) and (4)-(6) report the first stage estimates for RHS_{nt} for these two possible calibrations of the parameter α_F, respectively. The composite term tends to be positively correlated with nearby state tax rates and leave-out market potential.

Table A.13: First Stage of Firm-Location Equation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	$\ln((1-\bar{t}_{nt})MP_{nt})$			$\ln c_{nt}$			$\ln \tilde{R}_{nt}$		
	$\boldsymbol{Z}_{nt}^T$	$\boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^T, \boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^T$	$\boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^T, \boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^T$	$\boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^T, \boldsymbol{Z}_{nt}^B$
t_{nt}^{*x}	2.30**		2.34**	0.31		0.30	-1.02		-1.10*
	(0.96)		(0.96)	(0.22)		(0.22)	(0.64)		(0.63)
t_{nt}^{*y}	3.39**		3.26**	0.17		0.21	-1.24		-0.94
	(1.59)		(1.62)	(0.41)		(0.42)	(1.52)		(1.45)
t_{nt}^{*c}	0.60		0.60	-1.32***		-1.31***	1.79		1.85
	(1.97)		(1.98)	(0.46)		(0.46)	(1.65)		(1.65)
$\ln MP_{!n,t}$	2.72***	2.48***	2.72***	0.26***	0.28***	0.26***	0.90***	0.93***	0.91***
	(0.40)	(0.40)	(0.40)	(0.08)	(0.08)	(0.08)	(0.26)	(0.26)	(0.26)
$BtkW_{nt}$		0.01	0.01		0.00	0.00		0.00	0.00
		(0.01)	(0.01)		(0.00)	(0.00)		(0.01)	(0.01)
$BtkTR_{nt}$		-0.10	-0.09		0.03	0.03		0.19	0.20
		(0.18)	(0.17)		(0.06)	(0.06)		(0.16)	(0.15)
R-squared	0.996	0.996	0.996	0.993	0.993	0.993	0.995	0.995	0.995
F-stat	12.6	13.5	8.7	7.7	4.6	5.1	4.7	4.7	3.3

Notes: This table shows first stage estimates for the firm mobility equation (40). The dependent variables are after-tax market potential in columns 1-3, unit cost in columns 4-6, and real government expenditures in columns 7-9. The data are at the state-year level. Every specification includes state and year fixed effects. Each row has 587 observations. Observations are weighted by state population. Robust standard errors are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

Table A.14: First Stage of Firm-Location Equation

	(1)	(2)	(3)	(4)	(5)	(6)
	RHS with $\alpha_F = .04$			RHS with $\alpha_F = 0$		
	$\boldsymbol{Z}_{nt}^T$	$\boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^T, \boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^T$	$\boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^T, \boldsymbol{Z}_{nt}^B$
t_{nt}^{*x}	1.25**		1.31**	1.37***		1.44***
	(0.57)		(0.57)	(0.53)		(0.53)
t_{nt}^{*y}	2.74**		2.52**	2.88***		2.63**
	(1.11)		(1.12)	(1.08)		(1.08)
t_{nt}^{*c}	4.79***		4.76***	4.57***		4.53***
	(1.52)		(1.53)	(1.41)		(1.43)
$\ln MP_{!n,t}$	2.06***	1.76***	2.06***	1.95***	1.65***	1.95***
	(0.29)	(0.32)	(0.29)	(0.27)	(0.30)	(0.27)
$BtkW_{nt}$		0.00	0.01		0.00	0.01
		(0.01)	(0.01)		(0.01)	(0.01)
$BtkTR_{nt}$		-0.16	-0.15		-0.19	-0.17
		(0.16)	(0.15)		(0.15)	(0.14)
R-squared	0.996	0.995	0.996	0.995	0.995	0.995
F-stat	16.2	11.2	11.1	17.3	11.5	12

Notes: This table shows first stage estimates for the firm mobility equation (40). The dependent variables are two versions of the variable $RHS = \ln((1-\bar{t}_{nt})MP_{nt}) - (\sigma-1)\ln c_{nt} + \alpha_F(\sigma-1)\ln \tilde{R}_{nt}$. Columns 1-3 show estimates for the sum of after-tax market potential, $(\sigma-1) = 3$ times unit costs, and $\alpha_F \times (\sigma-1) = .04 \times 3$ times real government expenditures (which results in common coefficients in the model). Similiarly, columns 4-6 correspond to columns 1-3 with $\alpha_F = 0$, so the sum is just of after-tax market potential and 3 times unit costs. Observations are weighted by state population. Robust standard errors are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

Table A.15 presents OLS and 2SLS estimates of b_0, b_1, and b_2. Columns (1)-(3) present OLS estimates and (4)-(12) present 2SLS estimates. Column (1) shows that higher after-tax market potential and real government services tend to attract firms and that higher costs are unattractive. Recall that $(\varepsilon_F, \alpha_F)$ are over-identified, but that the ratio of $-b_2/b_1$ identifies α_F. Intuitively, firm location is $0.42/0.14 = 3$ times as responsive to unit costs as to real government spending, and $\alpha_F = 1/3 = .34$ reflects the inverse of this relative responsiveness. Columns (2) and (3) show the OLS estimate of b_0 in the cases in which we either assume that α_F is equal to the cross-state average R_n/GDP_n or we set it to 0; the resulting estimate of b_0 is similar to that in column (1). Our model predicts that these OLS estimates are asymptotically biased estimates of the parameters b_0, b_1, and b_2, the reason being that after-tax market potential, production costs and real government services are likely correlated with unobserved state productivity and government efficiency.

Column (4) in Table A.15 shows that the 2SLS estimates are larger than the OLS estimates for the coefficients on after-tax market potential and real government services and smaller than the corresponding OLS estimate for the coefficient on unit costs. The coefficient on real government services is estimated imprecisely: this shows that the identification of the structural parameters ε_F and α_F in our GMM estimation approach comes mainly from the auxiliary parameters b_0 and b_1. Furthermore, as columns (5) and (6) illustrate, conditional on calibrated values of α_F, the 2SLS estimate of parameter ε_F is estimated with a high degree of precision. Specifically, columns (11)-(12) show an estimate of 0.7 for the 2SLS estimate of the parameter b_0. Given that $b_0 \equiv (\varepsilon_F / (\sigma - 1)) / (1 + \chi_F \alpha_F \varepsilon_F)$, an estimate of 0.7 for b_0 implies that $\hat{\varepsilon}_F = ((\sigma - 1)(\hat{b}_0))/(1 - \chi_F \alpha_F (\sigma - 1)) = (3 \times .7)/(1 - .7 \times .04 \times 3) = 2.29$. This estimate of $\hat{\varepsilon}_F = 2.29$ is precise. Similarly, the 2SLS estimate of $\hat{\varepsilon}_F$ under the assumption that $\alpha_F = 0$ is also precisely estimated. Moreover, the estimates in columns (11) and (12) are not affected by weak instrument problems. The Cragg-Donald Wald F-statistic is 16.7 and the Kleibergen-Paap Wald F-statistic is 11.1 for the 2SLS specification in column (11) and 17.6 and 12.0, respectively, for the specification in column (12).

Table A.15: OLS and 2SLS Estimates of Firm-Location Parameters

	(1) OLS	(2) OLS	(3) OLS	(4) 2SLS	(5) 2SLS	(6) 2SLS	(7) 2SLS	(8) 2SLS	(9) 2SLS	(10) 2SLS	(11) 2SLS	(12) 2SLS
				$\boldsymbol{Z}_{nt}^T$	$\boldsymbol{Z}_{nt}^T$	$\boldsymbol{Z}_{nt}^T$	$\boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^T, \boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^T, \boldsymbol{Z}_{nt}^B$	$\boldsymbol{Z}_{nt}^T, \boldsymbol{Z}_{nt}^B$
$\ln(1-\bar{t}_{nt})MP_{nt}$	0.34***			0.78***			0.25			0.71***		
	(0.04)			(0.14)			(0.82)			(0.13)		
$\ln c_{nt}$	-0.42***			-3.00***			4.80			-2.64***		
	(0.11)			(0.72)			(7.64)			(0.71)		
$\ln \tilde{R}_{nt}$	0.14***			0.01			-0.91			0.13		
	(0.04)			(0.26)			(1.82)			(0.22)		
RHS with $\alpha_F = .04$		0.39***			0.69***			0.62***			0.68***	
		(0.03)			(0.07)			(0.08)			(0.07)	
RHS with $\alpha_F = 0$			0.40***			0.72***			0.65***			0.70***
			(0.03)			(0.07)			(0.09)			(0.08)
Structural Parameters												
ε_F for $\chi_F = 0$	1.03***			2.33***			.75			2.12***		
	(.11)			(.41)			(2.46)			(.38)		
ε_F for $\chi_F = 1$	1.59***			2.34***			.88			2.28***		
	(.26)			(.33)			(3.58)			(.29)		
α_F	0.34**			0.00			0.19			.05		
	(.17)			(.09)			(.35)			(.09)		

NOTES: This table shows OLS and 2SLS estimates. The dependent variable in each column is log of the number of establishments $\ln M_{nt}$. The data are at the state-year level. Each column has 587 observations. The dependent variables are after-tax market potential, unit cost, and real government expenditures. RHS is $\ln((1-\bar{t}_{nt})MP_{nt}) - (\sigma-1)\ln c_{nt} + \alpha_F(\sigma-1)\ln\tilde{R}_{nt}$. Every specification includes state and year fixed effects. Robust standard errors are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

D.8 Supplemental: Dynamic Panel Data Elasticities

The model described in Section 4 is a static model, and thus assumes that workers and firms can move across locations freely, without any need to pay a fixed costs of moving. Consequently, the equilibrium equations used to estimate the structural elasticities of labor and firm mobility with respect to changes in taxes, economic variables and public spending (i.e. (33) and (40) in the main text) predict that the share of workers and firms located in each state in any given year t depends exclusively on the period t values of different covariates. In a more general model with fixed costs of mobility, the population or firm share in a location in a period t will depend on the corresponding share in every location in period $t-1$. Furthermore, in this general model, a permanent change in any of the economic determinants of workers' and firms' locations in a period t will have a different impact on the short run (i.e. in the same period t) and on the long run (i.e., infinite periods ahead).

In this Appendix section, we explore how the static panel data elasticities that we estimate following the procedure in Section 6.2 compare to the short-run and long-run elasticities generated by a dynamic panel data model with multiple locations. Specifically, for a set of locations $i = 1, \ldots, 50$ and time periods $t = 1, \ldots, 1000$, we simulate the following statistical model:

$$l_{it} = \beta\rho_l l_{it-1} + (1-\beta)\rho_l (N-1)^{-1} \sum_{n \neq i} l_{nt-1} + x_{it} + \varepsilon_{l,it} \tag{A.59}$$

$$x_{it} = \alpha_{0,i} + \rho_x x_{it-1} + \varepsilon_{x,it} \tag{A.60}$$

$$\varepsilon_{l,it} \sim \mathbb{N}(0,1) \qquad \text{and independent across } i \text{ and } t,$$

$$\varepsilon_{x,it} \sim \mathbb{N}(0,1) \qquad \text{and independent across } i \text{ and } t, \tag{A.61}$$

$$\alpha_{0,i} \sim \mathbb{N}(0,1) \qquad \text{and independent across } i, \tag{A.62}$$

$$(l_{i0}, x_{i0}) = (0,0). \tag{A.63}$$

According to (A.59), (log) population (or firms or workers) in a location i in a period t, l_{it}, depends both on the population in every state in period $t-1$, $\{l_{it-1}\}_{i=1}^{50}$, and on the regressor x_{it}. The coefficient on x_{it} is assumed to be equal to one. As reflected in (A.59), the parameter vector ρ_l indicates the degree to which the (log) population in any location i is affected by the distribution of population across locations in period $t-1$. Specifically, if $\rho_l = 0$, then(A.59) is static and, thus, there is no serial correlation in population. The opposite is true if ρ_l is close to one. Given a value of ρ_l, the parameter β indicates the degree to which population in a location i is affected by past population in the same location i. If $\beta = 1$, equation (A.59) implies there is no migration across regions. The opposite is true when β is equal to zero.

Equation (A.60) indicates the time evolution of x_{it}. Specifically, the parameter ρ_x modulates the degree of persistence in x_{it}. The variable x_{it} plays the role of after-tax real wages or real government spending in the labor mobility equation in (33), and the role of market potential, unit cost or real government spending in the firm mobility equation in (40).

For each combination of the following parameter values

$$\rho_l \in \{0, 0.1, 0.5, 0.9\}, \tag{A.64}$$

$$\rho_x \in \{0.5, 0.9\}, \tag{A.65}$$

$$\beta \in \{0.5, 0.9\}, \tag{A.66}$$

we simulate 1000 different longitudinal datasets using (A.59) to (A.63).

For each of the 1000 simulated datasets corresponding to a particular parameter vector (ρ_l, ρ_x, β), we form an estimation sample by keeping the information on the simulated values of l_{it} and x_{it} for the last 25 periods we simulate and for all the 50 locations in our simulated dataset. Our choice of the number of periods and locations in the simulated estimation sample aims to replicate the dimensions of the sample that we use for estimation in Section 6.2. By keeping only the last 25 periods of the simulated dataset, we make sure that the observations that we keep in our simulated estimation sample are unaffected by the initial conditions (l_{i0}, x_{i0}).

For each of the 1000 generated estimation samples corresponding to a particular parameter vector (ρ_l, ρ_x, β), we use Ordinary Least Squares (OLS) to estimate a static linear panel data model analogous to that in(33) and (40):

$$l_{it} = \gamma_i + \gamma_t + \gamma_l x_{it} + u_{it},$$

where γ_i denotes a location i fixed effect, γ_t denotes a period t fixed effect, and u_{it} is an unobserved residual.

For each parameter vector (ρ_l, ρ_x, β) that we explore in our simulation, Table A.16 reports: (a) the mean and standard deviation of the OLS estimates $\hat{\gamma}_l$ that we obtain in our 1000 generated estimation samples; (b) the true short-run and long-run impact on the dependent variable l_i for a permanent change in one unit in x_i.

Table A.16: Elasticity Simulation Estimates

	$\rho_l = 0$				$\rho_l = 0.1$			
	$\rho_x = 0.5$		$\rho_x = 0.9$		$\rho_x = 0.5$		$\rho_x = 0.9$	
	$\beta = 0.5$	$\beta = 0.9$	$\beta = 0.5$	$\beta = 0.9$	$\beta = 0.5$	$\beta = 0.9$	$\beta = 0.5$	$\beta = 0.9$
$\bar{\hat{\gamma}}_l$	1	1	1	1	1.02	1.04	1.04	1.08
$s.d.(\hat{\gamma}_l)$	(0.03)	(0.05)	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
Long-Run Impact	1	1	1	1	1.05	1.10	1.05	1.10
Short-Run Impact	1	1	1	1	1	1	1	1
	$\rho_l = 0.5$				$\rho_l = 0.9$			
	$\rho_x = 0.5$		$\rho_x = 0.9$		$\rho_x = 0.5$		$\rho_x = 0.9$	
	$\beta = 0.5$	$\beta = 0.9$	$\beta = 0.5$	$\beta = 0.9$	$\beta = 0.5$	$\beta = 0.9$	$\beta = 0.5$	$\beta = 0.9$
$\bar{\hat{\gamma}}_l$	1.13	1.25	1.27	1.62	1.25	1.48	1.65	3.23
$s.d.(\hat{\gamma}_l)$	(0.03)	(0.05)	(0.03)	(0.07)	(0.08)	(0.23)	(0.35)	(0.66)
Long-Run Impact	1.34	1.82	1.34	1.82	1.95	5.31	1.95	5.31
Short-Run Impact	1	1	1	1	1	1	1	1

The results in Table A.16 illustrate that, no matter the value of the parameters ρ_l, ρ_x, and β, our estimates tend to be between the short-run and the long-run impact parameters. Furthermore, the quantitative difference between our point estimates and the true long-run impact increases in the value of the three parameters, reaching its maximum when $\rho_l = \rho_x = \beta = 0.9$.

The OLS estimate of the coefficient of each of the regressors entering either the labor mobility or the firm mobility equations on their own respective lag is always close to 0.9. Therefore, the relevant value of ρ_x is close to 0.9. It is reasonable to expect that the population of a state in a year t depends significantly more on the lag population of the same state than on the lag population in other states, so the actual value of β is probably larger or equal than 0.5. Similarly, the actual value of the parameter ρ_l is also likely larger or equal than 0.5, reflecting a significant amount of persistence in each state's population. Looking at the relevant cells of Table \ref{tab: simul}, one can conclude that, given the value of ρ_x close to 0.9: (a) if either β or ρ_l are close to 0.5, then the estimate $\hat{\gamma}_l$ will likely be very close to the long-run impact of the regressor on the dependent variable; (b) only if both β and ρ_l are very close to 0.9, the estimate $\hat{\gamma}_l$ will likely be half-way between the short-run and the long-run impact of the regressor on the dependent variable.

D.9 Comparison with Existing Estimates

Researchers have previously estimated regressions similar to (33) and (40) using sources of variation different from ours to identify the labor and firm mobility elasticities. Table A.17 compares our estimates of ε_W, α_W, ε_F, and α_F to those that we would have constructed if we had used estimates of the elasticity of labor and firms with respect to after-tax wages and public expenditure from six recent studies. The parameter that is most often estimated is the elasticity of labor with respect to real wages; this previous literature implies estimates of ε_W with mean value of 1.81. Our numbers of $\varepsilon_W = 1.36$ ($\chi_W = 0$) and $\varepsilon_W = 1.73$ ($\chi_W = 1$) reported in Table 1 are within the range of these estimates. Our estimate of ε_F is between the firm-mobility parameters reported in Suárez Serrato and Zidar (2016) and Giroud and Rauh (2015).

Concerning α_W and α_F, there is substantial evidence that public expenditures have amenity and productivity value for workers and firms, respectively, which is consistent with $\alpha_W > 0$ and $\alpha_F > 0$. Some studies infer positive amenity value for government spending from land rents,[5] while others focus on the productivity effects of large investment projects.[6] However, very few papers estimate specifications similar to (33) and (40). The estimates of the effects of variation in federal spending at the local level from Suárez Serrato and Wingender (2016) imply $\alpha_F = 0.10$ and $\alpha_W = 0.26$.

Of course, all these comparisons are imperfect due to differences in the source of variation, geography, and time dimension; for example, all of these studies use smaller geographic units than states. Additionally, not all specifications include the same covariates as in (33) and (40). These differences notwithstanding, our structural parameters are close to those in the literature.

[5]E.g., Bradbury et al. (2001) show that local areas in Massachusetts with lower increases in government spending had lower house prices, and Cellini et al. (2010) show that public infrastructure spending on school facilities raised local housing values in California. Their estimates imply a willingness to pay \$1.50 or more for each dollar of capital spending. Chay and Greenstone (2005) and Black (1999) also provide evidence of amenity value from government regulations on air quality and from school quality, respectively.

[6]Kline and Moretti (2014) find that infrastructure investments in by the Tennessee Valley Authority resulted in large and direct productivity increases, yielding benefits that exceeded the costs of the program. Fernald (1999) also provides evidence that road-building increases productivity, especially in vehicle-intensive industries. Haughwout (2002) shows evidence from a large sample of U.S. cities that "public capital provides significant productivity and consumption benefits" for both firms and workers.

Table A.17: Structural Parameters Implied by Similar Studies

Paper	Estimates	Implied Values of				Source of Variation	Level of Variation
		ε_W	α_W	ε_F	α_F	(Shock)	
Bound and Holzer (2000)	$a_0 = 1.20$[7]	1.16				Bartik	MSA (1980's)
Notowidigdo (2013)	$a_0 = 3.47$[8]	2.49				Bartik	MSA (1980-2000)
Suárez Serrato and Wingender (2016)	$a_0 = 1.58$[9]	1.45				Bartik and Census Instrument	County Group (1980-2009)
	$a_0 = 2.9$, $a_1 = 1.02$, $b_1 = 0.26$[10]	1.94	0.26		0.10		
Diamond (2016)	$a_0 = 3.10$[11]	2.32				Bartik	MSA (1980-2000)
Suárez Serrato and Zidar (2016)	$a_0 = 1.28$[12]	1.23				Bartik	County Group (1980-2009)
	$a_0 = 2.63$, $b_0 = 3.35$[13]	2.09		5.26		Business Tax	
Giroud and Rauh (2015)	$b_0 = 0.40$[14]			1.31		Corporate Tax	Firm-Level (1977-2011)

NOTES: This table reports the values of our structural parameters implied by estimates of specifications similar to (33) and (40) found in the previous literature. Whenever needed, we assume the values used in our baseline parametrization of $\sigma = 4$, $\chi_W = 1$, $\chi_F = 1$, $\alpha_F = 0.03$, and $\alpha_W = 0.16$ in recovering structural parameters. When the effects are only reported separately for skilled and unskilled workers we use a share of skilled workers of 33% to average the effects.

[7] For both college and non-college groups, we first construct a_0 from Table 3 in Bound and Holzer (2000) by taking the ratio of the effects on Population and Total Hours. We then average the effect by the college share above.

[8] This parameter comes from Table 3 in Notowidigdo (2013) and results from taking the ratio of columns (1) and (6). Note that these specifications also control for quadratic effects. We employ marginal effects around 0.

[9] This number is directly reported in Suárez Serrato and Wingender (2016) in Table 9.

[10] The parameters a_0 and a_1 come from Table 10 in Suárez Serrato and Wingender (2016) by manipulating the structural parameters as follows: $a_0 = 1/\sigma^i$ and $a_0 = \psi^i/\sigma^i$ for each skill group. The parameter b_1 comes from using the effect of spending on firm location and by noting that this effect is equal to $1 - (\kappa_i^{GS} + (1 - \kappa_i^{GS})/(1 - \alpha_i))\frac{\partial W^i}{\partial F}$ in Suárez Serrato and Wingender (2016). The parameters α^i,κ_i^{GS}, and $\frac{\partial W^i}{\partial F}$ are reported in Tables 9 and 10 by skill group in Suárez Serrato and Wingender (2016). We then average these effects by the college share above.

[11] Diamond (2016) reports the effect on wage on population by skill group in Table 3. We then average these effects by the college share above. Note that Diamond (2016) also controls for state of origin which leads to a larger effect of population on wages than in other similar papers, especially for the low skill population.

[12] We construct a_0 from Table 6, Panel (c) in Suárez Serrato and Zidar (2016) by taking the ratio of the effects on Population and Wages.

[13] We construct a_0 from Table 6, Panel (c) in Suárez Serrato and Zidar (2016) by taking the ratio of the effects on Population and Wages. b_0 is reported in Table 6, Panel (c).

[14] Giroud and Rauh (2015) report an elasticity of number of establishment with respect to corporate taxes of 0.4.

E Appendix to Section 7

E.1 Consumption-Equivalent Welfare Change

The change in indirect utility $\hat{v}$ in (45) follows from assuming that an individual l located in n receives utility $v_n \epsilon_n^l$. Assume that, instead of $v_n \epsilon_n^l$, the indirect utility received by an individual l in n was $W\left(v_n \epsilon_n^l\right)$ where $W(\cdot)$ is an increasing function. We continue to assume that the ϵ_n^l are i.i.d normalized Fréchet, with CDF $H(x) = \Pr\left(\epsilon_n^l < x\right) = e^{-x^{-\varepsilon}}$. This monotone transformation does not impact the choice probabilities. As we show below, in this case the expected indirect utility of a worker is

$$V = \mathbb{E}\left[W\left(v\epsilon\right)\right] \equiv \int_{\epsilon} W\left(v\epsilon\right) dH\left(\epsilon\right), \tag{A.67}$$

where v is defined in (8) and the expectation is over the Fréchet draw ϵ. Therefore, in any counterfactual the relative change in indirect utility is

$$\hat{V} = \frac{\mathbb{E}\left[W\left(v\hat{v}\epsilon\right)\right]}{\mathbb{E}\left[W\left(v\epsilon\right)\right]}, \tag{A.68}$$

implying that any change in private or public consumption that leads to a relative change $\hat{v}$ is equivalent to the actual welfare change experienced by workers under any monotone function $W(\cdot)$. For example, the counterfactual change in welfare $\hat{v}$ is equivalent to the change in welfare that would arise if the relative consumption of both the public and the private goods were to change in every state by an amount equal to $\hat{v}$.

To derive (A.67), by definition of V we have:

$$V = \sum_n \int_{\epsilon} \Pr\left[v_{n'}\epsilon_{n'} \leq v_n \epsilon, \forall n' \neq n\right] W\left(v_n \epsilon\right) H'\left(\epsilon\right) d\epsilon. \tag{A.69}$$

Since the shocks are i.i.d, we have $\Pr\left[v_{n'}\epsilon_{n'} \leq v_n \epsilon, \forall n' \neq n\right] = \prod_{n' \neq n} H\left(c_n \epsilon / c_{n'}\right)$. Using this expression, the definition of $H(x)$ and the change of variable $z_n \equiv v_n \epsilon$ we get:

$$V = \sum_n \int_{z_n} \prod_{\forall n'} H\left(\frac{z_n}{v_{n'}}\right) W\left(z_n\right) \varepsilon \left(\frac{z_n}{v_n}\right)^{-\varepsilon - 1} \frac{1}{v_n} dz_n. \tag{A.70}$$

We also have that $\prod_{\forall n'} H\left(z_n / c_{n'}\right) = H\left(z_n / v\right)$ for v defined in (8). Using this property and the change of variable $Z_n = z_n / v$ we get

$$V = \sum_n \int_{Z_n} W\left(vZ_n\right) \varepsilon \left(\frac{Z_n}{v_n} v\right)^{-\varepsilon - 1} \frac{v}{v_n} H\left(Z_n\right) dZ_n, \tag{A.71}$$

which, using the definition of $H'(x)$, gives:

$$V = \sum_n \left(\frac{v_n}{v}\right)^{\varepsilon} \int_{Z_n} W\left(vZ_n\right) dH\left(Z_n\right). \tag{A.72}$$

Using the fact that $\sum_n \left(v_n / v\right)^{\varepsilon} = 1$ gives (A.67).

E.2 Derivation of Equation (46)

It follows from (7) and (8) that, in any counterfactual, the first-order approximation to the change in v is:

$$d \ln v = \sum L_n d \ln v_n. \tag{A.73}$$

In what follows, we consider a special case with no trade costs ($\tau_{in} = 1$ for all i, n), perfect substitutability across varieties ($\sigma \to \infty$), homogeneous firms ($\varepsilon_F \to \infty$), constant labor supply (h_n constant), and identical preferences for government spending across states ($\alpha_{W,n} = \alpha_W$). In addition, we also consider a tax structure with only state sales and income taxes. These assumptions are more general than the restrictions in Proposition 1, in that we do not impose non-rival public goods and we allow for dispersion in preference draws, $\varepsilon_W < \infty$, and in individual productivity draws, $\zeta_n < \infty$. In addition, we assume that state income and sales taxes are the only taxes, and that income taxes are constant. As a result, the tax distribution is characterized by the keep rate $1-T_n = (1-t_n^y)/(1+t_n^c)$ of each state.

Then, because we have assumed constant intensive margin of labor supply, we have:

$$d \ln v_n = (1-\alpha_W)\, d \ln \left(\frac{C_n^L}{L_n}\right) + \alpha_W d \ln \frac{G_n}{L_n} + \alpha_W \left(1-\chi_W\right) d \ln L_n, \tag{A.74}$$

where C_n^L is the aggregate consumption of workers. Because firms make zero profits, (A.8) implies that the payments to capital owners are a fraction β of the GDP of state n, GDP_n. Therefore, the final consumption of capital owners is $C_n^K = (1-T_n)\, \beta GDP_n$. In addition, under our assumptions, government spending is $G_n = T_n GDP_n$. Combining these last two expressions with the fact that $C_n^W + C_n^K + G_n = GDP_n$, aggregate consumption of workers can be written: $C_n^L = (1-\beta)\left(GDP_n - G_n\right)$. This las expression in turn implies:

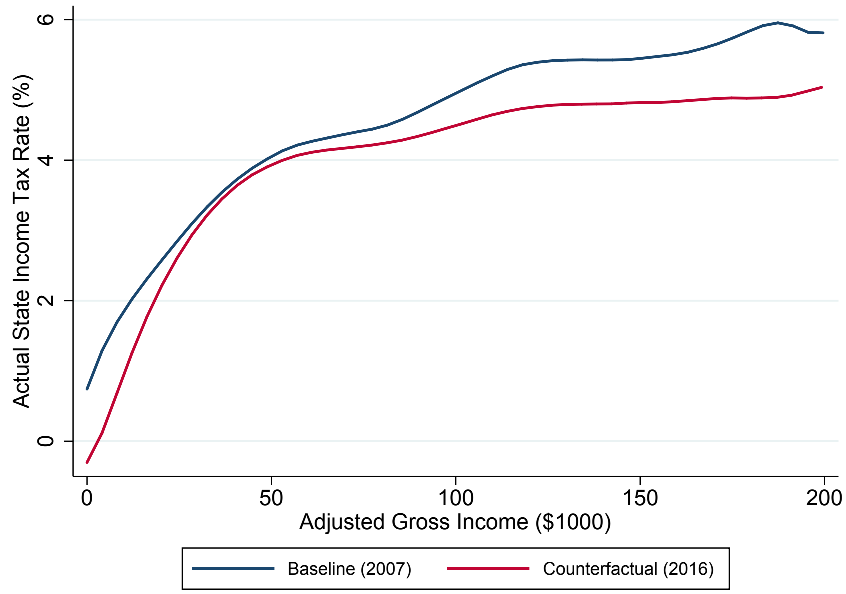
$$d \ln \frac{C_n^L}{L_n} = \frac{d \ln \frac{GDP_n}{L_n} - \frac{G_n}{GDP_n} d \ln \frac{G_n}{L_n}}{1 - \frac{G_n}{GDP_n}}. \tag{A.75}$$

Combining (A.73), (A.74) and (A.75), assuming $\alpha_{W,n} = \alpha_W$ and from the labor market clearing condition that $\sum L_n dL_n = 0$ gives (46).

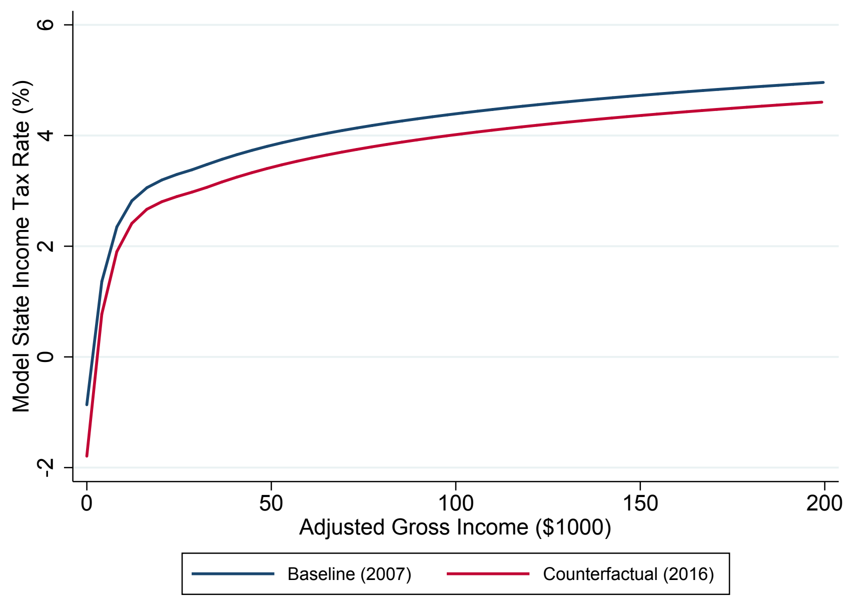
E.3 Appendix Figures to Section 7.1

Figure A.3: The North Carolina Income Tax Cuts: Actual and Estimated Income Tax Schedules Before and After the Reform

(a) Actual Income Tax Rates



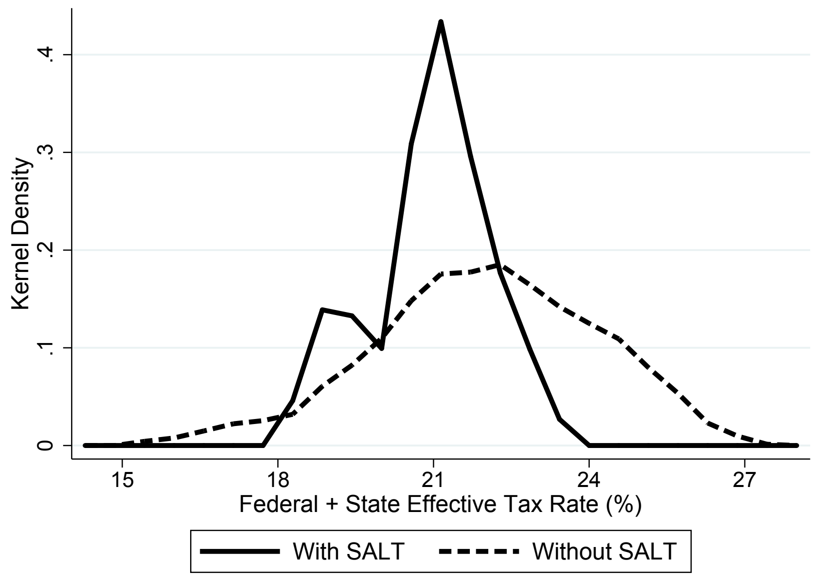
(b) Model Income Tax Rates



Notes: This figure plots actual and model-based income tax rates in North Carolina before and after the 2014-2016 reform.

E.4 Appendix to Section 7.3

Figure A.4: Dispersion in Federal and State Income Taxes with and without SALT



Notes: This figure shows dispersion in effective tax rates when State and Local Taxes (SALT) can or cannot be deducted from federal income. Tax rates are computed using a sample of individual tax returns from the Statistics of Income (SOI) Public Use Files and NBER's tax simulator TAXSIM. Individual returns with negative Adjusted Gross Income (AGI) are dropped and the remaining observations are winsorized by their effective federal and state income tax rate at the 1st and 99th percentiles. The figure displays the kernel density of federal and state income tax rates in 2007.

Table A.18: Income Tax Parameters and Effective Rates with and without SALT

State	With SALT		Without SALT		Rates with SALT if AGI is				Rates without SALT if AGI is			
	a_n^y	b_n^y	a_n^y	b_n^y	25K	50K	100K	200K	25K	50K	100K	200K
AL	1.273	0.044	1.218	0.039	14.8	18.1	22.9	25.2	14.7	17.6	21.9	24.0
AK	1.243	0.039	1.368	0.049	13.1	16.2	20.6	22.7	12.7	16.5	22.0	24.6
AZ	1.336	0.047	1.537	0.061	13.4	17.0	22.2	24.7	12.0	16.8	23.5	26.6
AR	1.352	0.049	1.437	0.053	14.1	17.9	23.3	25.9	12.2	16.4	22.3	25.1
CA	1.365	0.049	1.522	0.060	13.4	17.2	22.7	25.3	12.7	17.4	24.0	27.1
CO	1.322	0.047	1.372	0.053	14.2	17.8	23.0	25.5	15.6	19.6	25.3	27.9
CT	1.346	0.049	1.425	0.056	13.9	17.7	23.0	25.6	15.2	19.4	25.5	28.3
DE	1.323	0.047	1.487	0.058	14.0	17.6	22.8	25.2	12.7	17.2	23.6	26.6
FL	1.243	0.039	1.209	0.035	13.1	16.2	20.6	22.7	12.7	15.5	19.5	21.5
GA	1.400	0.053	1.859	0.079	13.8	17.9	23.7	26.4	10.6	16.8	25.5	29.5
HI	1.405	0.053	1.676	0.072	14.1	18.2	24.1	26.8	13.7	19.2	26.9	30.5
ID	1.440	0.055	1.648	0.068	13.6	17.9	24.0	26.8	12.1	17.5	24.9	28.4
IL	1.266	0.042	1.250	0.043	14.3	17.6	22.3	24.6	15.5	18.7	23.4	25.6
IN	1.266	0.043	1.332	0.049	15.0	18.3	23.1	25.3	15.5	19.3	24.6	27.2
IA	1.388	0.052	1.493	0.061	14.2	18.2	23.9	26.6	14.5	19.1	25.6	28.7
KS	1.322	0.047	1.238	0.043	14.5	18.1	23.3	25.8	17.0	20.3	24.9	27.1
KY	1.327	0.048	1.382	0.053	14.7	18.4	23.6	26.1	14.9	18.9	24.6	27.3
LA	1.341	0.048	1.794	0.075	14.0	17.7	23.0	25.5	10.4	16.4	24.7	28.5
ME	1.400	0.053	1.507	0.062	14.1	18.2	24.0	26.8	15.1	19.8	26.4	29.5
MD	1.308	0.046	1.272	0.046	14.4	17.9	23.0	25.4	17.0	20.5	25.4	27.8
MA	1.308	0.047	1.212	0.044	15.1	18.7	23.8	26.2	18.8	22.0	26.5	28.7
MI	1.302	0.046	1.468	0.057	14.4	17.9	22.9	25.3	13.3	17.8	24.0	27.0
MN	1.372	0.051	1.392	0.056	14.3	18.2	23.8	26.5	16.6	20.8	26.6	29.4
MS	1.255	0.041	1.052	0.022	14.3	17.5	22.1	24.3	13.9	15.6	18.2	19.4
MO	1.321	0.047	1.384	0.052	14.2	17.8	23.0	25.4	13.9	17.9	23.6	26.3
MT	1.354	0.049	1.440	0.054	14.1	17.9	23.3	25.9	12.5	16.7	22.7	25.6
NE	1.373	0.051	1.380	0.054	13.8	17.7	23.3	25.9	16.0	20.0	25.8	28.5
NV	1.243	0.039	1.371	0.049	13.1	16.2	20.6	22.7	12.7	16.5	22.0	24.6
NH	1.244	0.039	1.076	0.028	13.2	16.3	20.7	22.8	17.2	19.3	22.4	23.9
NJ	1.307	0.045	1.214	0.041	13.8	17.3	22.4	24.8	17.0	20.1	24.5	26.7
NM	1.462	0.056	2.053	0.088	12.5	16.8	23.0	25.9	8.4	15.5	25.1	29.6
NY	1.361	0.050	1.361	0.054	14.3	18.1	23.6	26.2	17.1	21.1	26.7	29.4
NC	1.309	0.047	1.384	0.053	15.2	18.8	23.9	26.4	14.7	18.7	24.4	27.1
ND	1.305	0.045	1.349	0.048	13.5	17.0	22.0	24.4	13.5	17.3	22.6	25.2
OH	1.316	0.046	1.317	0.048	14.1	17.7	22.8	25.2	15.2	18.8	24.0	26.5
OK	1.418	0.054	1.625	0.069	13.7	17.9	23.8	26.6	13.6	18.8	26.2	29.6
OR	1.370	0.052	1.449	0.059	15.4	19.4	25.0	27.7	15.9	20.3	26.6	29.5
PA	1.298	0.045	1.388	0.053	14.4	17.9	22.9	25.3	14.8	18.8	24.5	27.3
RI	1.356	0.049	1.419	0.056	13.8	17.6	23.0	25.6	15.0	19.2	25.2	28.1
SC	1.327	0.047	1.353	0.048	14.1	17.7	22.9	25.4	13.2	17.0	22.4	24.9
SD	1.243	0.039	1.216	0.038	13.1	16.2	20.6	22.7	14.7	17.6	21.9	24.0
TN	1.244	0.039	1.222	0.037	13.2	16.3	20.7	22.8	12.8	15.7	19.9	21.9
TX	1.243	0.039	1.381	0.049	13.1	16.2	20.6	22.7	12.0	15.8	21.3	23.9
UT	1.347	0.049	1.339	0.048	14.3	18.1	23.5	26.0	14.0	17.7	23.0	25.5
VT	1.454	0.055	1.679	0.072	12.8	17.1	23.2	26.1	13.5	19.0	26.7	30.3
VA	1.334	0.048	1.382	0.054	14.4	18.1	23.4	25.9	15.8	19.8	25.6	28.3
WA	1.243	0.039	1.307	0.045	13.1	16.2	20.6	22.7	13.6	17.1	22.1	24.5
WV	1.317	0.047	1.350	0.049	14.8	18.4	23.5	26.0	14.2	18.0	23.4	25.9
WI	1.345	0.049	1.346	0.051	14.6	18.4	23.8	26.4	16.1	19.9	25.4	28.1
WY	1.243	0.039	1.356	0.050	13.1	16.2	20.6	22.7	14.2	18.1	23.5	26.1

NOTES: This table shows combined federal and state income tax parameters in 2007 with and without the deduction of State and Local Taxes (SALT) from federal taxable income. The table also shows effective tax rates for different levels of Adjusted Gross Income (AGI). Federal taxation includes individual income taxes and the employee portion of payroll (FICA) taxes.

E.5 Appendix to Section 7.4

Table A.19: State Tax Rates in 1980

State	t_n^y	t_n^c	t_n^{corp}	t_n^x
AL	2.4	4	5	1.7
AZ	2.9	4	10	3.3
AR	2.5	3	6	2
CA	3.1	4.8	9.6	3.2
CO	2.2	3	5	1.7
CT	.4	7.5	10	3.3
DE	4.9	0	8.7	2.9
FL	0	4	5	2.5
GA	2.8	3	6	2
HI	4.8	4	6.4	2.1
ID	3.2	3	6.5	2.2
IL	2.2	4	4	1.3
IN	1.6	4	3	1
IA	3.1	3	10	10
KS	2.1	3	6.8	2.3
KY	3.1	5	5.8	1.9
LA	.8	3	8	2.7
ME	2.5	5	6.9	2.3
MD	3.2	5	7	2.3
MA	4.6	5	9.5	4.7
MI	3.4	4	2.3	.8
MN	5.7	4	12	4
MS	1.2	5	4	1.3
MO	1.9	3.1	5	1.7
MT	3.2	0	6.8	2.3
NE	2	3	4.7	1.6
NV	0	3	0	0
NH	.4	0	8	2.7
NJ	1.9	5	7.5	2.5
NM	1.6	3.8	5	1.7
NY	5.1	4	10	5
NC	4	3	6	2
ND	1.5	3	8.5	2.8
OH	1.5	4	8	2.7
OK	2.2	2	4	1.3
OR	4.7	0	7.5	2.5
PA	2.2	6	10.5	3.5
RI	2.8	6	8	2.7
SC	3.5	4	6	2
SD	0	5	0	0
TN	.4	4.5	6	2
TX	0	4	0	0
UT	3	4	4	1.3
VT	3.1	3	7.5	2.5
VA	3.1	3	6	2
WA	0	4.5	0	0
WV	2.5	3	6	2
WI	4.4	4	7.9	4
WY	0	3	0	0

NOTES: This table shows state tax rates in 1980 for individual income (t_n^y), general sales (t_n^c), corporate (t_n^{corp}), and sales-apportioned corporate (t_n^x) taxes, which is the product of the statutory corporate tax rate and the state's sales apportionment weight.

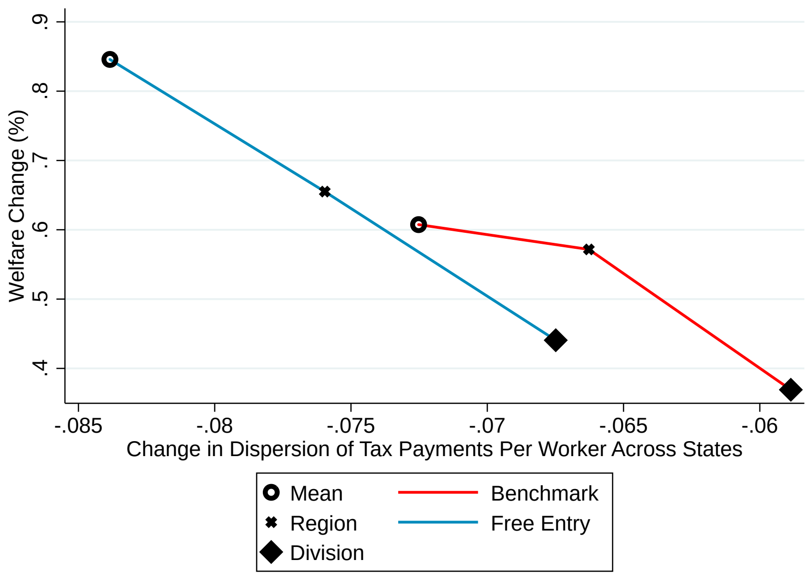
Table A.20: State Income Tax Parameters and Effective Tax Rates in 1980

State	$a_{n,state}$	$b_{n,state}$	State tax rates if AGI is				Overall tax rates if AGI is			
			25K	50K	100K	200K	25K	50K	100K	200K
AL	1.025	0.005	2.0	2.4	3.1	3.4	14.8	18.1	22.9	25.2
AK	1.000	0.000	0.0	0.0	0.0	0.0	13.1	16.2	20.6	22.7
AZ	1.078	0.008	0.2	1.0	2.2	2.7	13.4	17.0	22.2	24.7
AR	1.092	0.011	1.2	2.1	3.6	4.3	14.1	17.9	23.3	25.9
CA	1.102	0.011	0.3	1.3	2.7	3.5	13.4	17.2	22.7	25.3
CO	1.066	0.008	1.3	2.0	3.2	3.7	14.2	17.8	23.0	25.5
CT	1.087	0.010	0.9	1.8	3.2	3.9	13.9	17.7	23.0	25.6
DE	1.067	0.008	1.0	1.7	2.9	3.4	14.0	17.6	22.8	25.2
FL	1.000	0.000	0.0	0.0	0.0	0.0	13.1	16.2	20.6	22.7
GA	1.132	0.014	0.8	2.1	4.0	5.0	13.8	17.9	23.7	26.4
HI	1.136	0.015	1.2	2.5	4.5	5.5	14.1	18.2	24.1	26.8
ID	1.166	0.017	0.5	2.1	4.4	5.5	13.6	17.9	24.0	26.8
IL	1.019	0.004	1.4	1.8	2.3	2.5	14.3	17.6	22.3	24.6
IN	1.019	0.004	2.2	2.6	3.2	3.5	15.0	18.3	23.1	25.3
IA	1.122	0.014	1.2	2.5	4.3	5.2	14.2	18.2	23.9	26.6
KS	1.066	0.009	1.6	2.4	3.6	4.2	14.5	18.1	23.3	25.8
KY	1.070	0.009	1.9	2.7	4.0	4.6	14.7	18.4	23.6	26.1
LA	1.082	0.010	1.0	1.9	3.2	3.8	14.0	17.7	23.0	25.5
ME	1.131	0.015	1.2	2.5	4.5	5.5	14.1	18.2	24.0	26.8
MD	1.055	0.007	1.5	2.2	3.2	3.7	14.4	17.9	23.0	25.4
MA	1.055	0.008	2.4	3.1	4.2	4.8	15.1	18.7	23.8	26.2
MI	1.049	0.007	1.5	2.1	3.1	3.5	14.4	17.9	22.9	25.3
MN	1.108	0.013	1.4	2.5	4.2	5.1	14.3	18.2	23.8	26.5
MS	1.010	0.003	1.4	1.6	1.9	2.1	14.3	17.5	22.1	24.3
MO	1.065	0.008	1.3	2.0	3.1	3.7	14.2	17.8	23.0	25.4
MT	1.093	0.011	1.1	2.1	3.6	4.3	14.1	17.9	23.3	25.9
NE	1.109	0.012	0.8	1.9	3.6	4.4	13.8	17.7	23.3	25.9
NV	1.000	0.000	0.0	0.0	0.0	0.0	13.1	16.2	20.6	22.7
NH	1.000	0.000	0.1	0.1	0.1	0.1	13.2	16.3	20.7	22.8
NJ	1.054	0.007	0.8	1.4	2.3	2.8	13.8	17.3	22.4	24.8
NM	1.183	0.017	-0.8	0.8	3.1	4.3	12.5	16.8	23.0	25.9
NY	1.099	0.012	1.3	2.4	4.0	4.7	14.3	18.1	23.6	26.2
NC	1.055	0.009	2.5	3.2	4.4	5.0	15.2	18.8	23.9	26.4
ND	1.052	0.006	0.5	1.0	1.8	2.2	13.5	17.0	22.0	24.4
OH	1.061	0.008	1.2	1.9	2.9	3.4	14.1	17.7	22.8	25.2
OK	1.146	0.016	0.7	2.1	4.2	5.2	13.7	17.9	23.8	26.6
OR	1.107	0.014	2.7	4.0	5.8	6.7	15.4	19.4	25.0	27.7
PA	1.046	0.007	1.5	2.1	3.0	3.5	14.4	17.9	22.9	25.3
RI	1.095	0.011	0.8	1.7	3.2	3.9	13.8	17.6	23.0	25.6
SC	1.071	0.009	1.1	1.9	3.0	3.6	14.1	17.7	22.9	25.4
SD	1.000	0.000	0.0	0.0	0.0	0.0	13.1	16.2	20.6	22.7
TN	1.001	0.000	0.1	0.1	0.2	0.2	13.2	16.3	20.7	22.8
TX	1.000	0.000	0.0	0.0	0.0	0.0	13.1	16.2	20.6	22.7
UT	1.087	0.011	1.4	2.3	3.8	4.5	14.3	18.1	23.5	26.0
VT	1.177	0.017	-0.5	1.1	3.4	4.6	12.8	17.1	23.2	26.1
VA	1.076	0.010	1.6	2.4	3.7	4.4	14.4	18.1	23.4	25.9
WA	1.000	0.000	0.0	0.0	0.0	0.0	13.1	16.2	20.6	22.7
WV	1.062	0.009	1.9	2.7	3.9	4.4	14.8	18.4	23.5	26.0
WI	1.086	0.011	1.8	2.8	4.2	4.9	14.6	18.4	23.8	26.4
WY	1.000	0.000	0.0	0.0	0.0	0.0	13.1	16.2	20.6	22.7

NOTES: This table shows state income tax parameters in 1980 as well as effective tax rates for different levels of Adjusted Gross Income (AGI). Tax rates reported in columns 4-7 are state-only, while tax rates in columns 8-11 combine federal and state taxation. Federal taxation includes individual income taxes and the employee portion of payroll (FICA) taxes.

E.6 Appendix Figures to Section 7.6

Figure A.5: Welfare Change and Dispersion of Tax Payments Under Free Entry



NOTES: This figure plots the change in welfare against the change in dispersion of tax liabilities per worker associated with tax harmonization to the national, region, and division means under free entry ($\chi_{FE} = 1$).

F Data Sources

In this section we describe the data used in sections 3.1, 6, and 7.

F.1 Government Finances

- State revenue from sales, income and corporate taxes taxes (R_n^c, R_n^y, R_n^{corp}): Source: U.S. Census Bureau – Governments Division; Dataset: Historical State Tax Collections; Variables: corporate, individual, and general sales taxes, which are CorpNetIncomeTaxT41, IndividualIncomeTaxT40, TotalGenSalesTaxT09. We also collect information from the variable TotalTaxes, which include the three types we measure as well as fuels taxes, select sales taxes, and a few other miscellaneous and minor sources of tax revenue.

- State direct expenditures: Source: U.S. Census Bureau – Governments Division; Dataset: State Government Finances; Variable: direct expenditures.

- Effective state individual income tax rate t_n^y. Source: SOI Public Use Tax Files (PUFs). Dataset construction: we draw individual taxpayer data from SOI Public Use Tax Files (PUFs) and use NBER's TAXSIM to simulate federal and state individual income tax liabilities under each year's tax law. We drop observations with negative Adjusted Gross Income (AGI) and winsorize observations by their effective state and federal tax rate at the 1st and 99th percentile. We compute t_n^y as the state-year ratio of average AGI over average state income tax liabilities.

- State sales tax rate t_n^c: Source: Book of the States; Dataset: Table 7.10 State Excise Tax Rates; Variable: general sales and gross receipts tax (percent).

- State corporate tax rate and apportionment data for t_n^x and t_n^l: Source: Suárez Serrato and Zidar (2016).

- Effective federal corporate tax rate t_{fed}^{corp}: Source: IRS, Statistics of Income; Dataset: Corporation Income Tax Returns (historical); Variable: effective corporate tax rate = total income tax/ net income (less Deficit); i.e., the effective rate is row 83 divided by row 77.

- Federal individual income tax rate t_{fed}^y: Source: NBER TAXSIM; Dataset: Marginal and Average Tax Rates and Elasticities for the U.S., using a fixed 1984 (but in/deflated) sample of taxpayers; Variable: average effective federal tax rate on income, "fed_avg", by state and year.

- Federal payroll tax rate t_{fed}^w: Source: Congressional Budget Office; Dataset: Average Federal Tax Rates in 2007; Variable: average payroll tax rates. See Table A.2 for the average in 2007 and additional details in the table notes.

- Income tax schedule parameters a_n^y and b_n^y. Source: SOI Public Use Tax Files (PUFs). Dataset construction: we draw individual taxpayer data from SOI Public Use Tax Files (PUFs). In order to abstract from changes in the income distribution over time, we choose 2007 as base year and deflate or inflate nominal variables using the Personal Consumption Expenditure (PCE) index. Then, we use NBER's TAXSIM to simulate state and federal individual income tax liabilities under each year's tax law. We compute individual t_{fed}^y and $t_{n,state}^y$ by dividing federal and state income tax liabilities by Adjusted Gross Income, respectively. We drop observations with negative AGI and winsorize observations by their effective state and federal tax rate at the 1st and 99th percentile. Then, we fit the following models: $1 - t_{fed}^y = a_{fed}^y y^{-b_{fed}^y}$ and $1 - t_{n,state}^y = a_{n,state}^y y^{-b_{n,state}^y}$. In order to estimate $a_{n,state}^y$ and $b_{n,state}^y$, we use OLS to estimate γ and λ in the regression $\ln(1 - t_{i(n),state,t}^y) = \gamma - \lambda \ln \mathrm{AGI}_{i(n),t} + \varepsilon_{i(n),t}$ for each state-year pair, where $i(n)$ denotes taxpayer i residing in state n, and then compute $a_{n,state}^y = e^\gamma$ and $b_{n,state}^y = \lambda$. In order to estimate a_{fed}^y and b_{fed}^y, we pool states and follow a similar procedure. Finally, we compute $a_n^y = a_{fed}^y (a_{n,state}^y)^{1-b_{fed}^y}$ and $b_n^y = b_{n,state}^y + b_{fed}^y - b_{n,state}^y b_{fed}^y$.

- Income tax schedule parameters a_n^y and b_n^y when state and local taxes are not deductible from federal taxable income. Source: SOI Public Use Tax Files (PUFs). Dataset construction: we draw individual taxpayer data from SOI Public Use Tax Files (PUFs) and set to 0 three variables associated with state and local tax deductions (*i.e., data50, data51, data52*, which are state and local income taxes, sales taxes, and real estate deductions, respectively). In order to abstract from changes in the income distribution over time, we choose 2007 as base year and deflate or inflate nominal variables using the Personal Consumption Expenditure (PCE) index. Then, we use NBER's TAXSIM to simulate state and federal individual income tax liabilities under each year's tax law. We compute individual t_{fed}^y and $t_{n,state}^y$ by dividing federal and state income tax liabilities by Adjusted Gross Income, respectively. We drop observations with negative AGI and winsorize observations by their effective state and federal tax rate at the 1st and 99th percentile. Because of the non-deductibility of state taxes, we fit the following model: $1 - t_{fed}^y - t_{n,state}^y = a_n^y y^{-b_n^y}$. We use OLS to estimate γ and λ in the regression $\ln(1 - t_{i(n),fed,t}^y - t_{i(n),state,t}^y) = \gamma - \lambda \ln \text{AGI}_{i(n),t} + \varepsilon_{i(n),t}$ for each state-year pair, where $i(n)$ denotes taxpayer i residing in state n, and then compute $a_n^y = e^\gamma$ and $b_n^y = \lambda$.

- Ratio of state and local to state tax revenue for income, sales, and corporate taxes; i.e. $\frac{R_n^{StandLocal,j}}{R_n^{State,j}}$ $\forall j \in \{y, c, corp\}$, respectively. Source: U.S. Census Bureau – Governments Division; Dataset: State and Local Government Finances; Variable: State and Local Revenue; State Revenue (Note that sales taxes uses the general sales tax category)

- We derive the following variables from the sources listed above (for Figure A.1):
  - State and local corporate tax rate: $t_n^{corp,s+l} = t_n^{corp} \times \frac{R_n^{StandLocal,corp}}{R_n^{State,corp}}$.
  - State and local sales tax rate $t_n^{c,s+l} = t_n^c \times \frac{R_n^{StandLocal,c}}{R_n^{State,c}}$.
  - State and local income tax rate $t_n^{y,s+l} = t_n^y \times \frac{R_n^{StandLocal,y}}{R_n^{State,y}}$.

F.2 Calibration (Section 6.1) and Over-Identification Checks (Section 6.4)

Given the model elasticities and taxes, implementing the counterfactuals in equations (A.24)-(A.46) requires data on $\left\{s_{in}, \lambda_{in}, L_n, M_n, w_n z_n^L, h_n, P_n Q_n, X_n\right\}$. We describe here how each of these variables is constructed, alongside other measures used at other states of the quantification.

- Number of Workers L_n: Source: 2007 Economic Census of the United States; Dataset: EC0700A1 - All sectors: Geographic Area Series: Economy-Wide Key Statistics: 2007; Variable: Number of paid employees for pay period including March 12

- Annual Hours worked h_n: Source: IPUMS; Dataset: March Current Population Survey (CPS); Variable Construction: the number of weeks worked (*wkswork1*) is multiplied by the usual number of hours worked per week (*uhrsworkly*). Sample: our sample is restricted to civilian adults between the ages of 18 and 64. In order to be included in our sample, an individual had to be working at least 35 weeks in the calendar year and with a usual work week of at least 30 hours per week. We also drop individuals who report earning business or farm income.

- State average Hourly Wages $w_{nt}^h(i)$: Source: IPUMS; Dataset: March Current Population Survey (CPS); Variable Construction: annual wage income (*incwage*) is divided by annual hours worked. Sample: the sample for this variable is the same as the one we used to compute state-year average annual hours worked. Top-coded values for years prior to and including 1995 are multiplied by 1.5. These wages are used to construct the variable entering in the quantification $z_n^L w_n$ using equation A.55 and the same steps described in Section D.2.1.

- Total sales X_n^{Total}: Source: 2007 Economic Census of the United States; Dataset: EC0700A1 - All sectors: Geographic Area Series: Economy-Wide Key Statistics: 2007; Variable: Employer value of sales, shipments, receipts, revenue, or business done. The source of county-level sales is the U.S. Census Bureau - 2007 Survey of Business Owners and Self-Employed Persons (SBO); Variable: Sales and Receipts, Firms with Paid Employees.

- International Exports $Exports_t^{ROW}$: Source: U.S. Department of Commerce International Trade Administration; Dataset: TradeStats Express - State Export Data; Variable: Exports of NAICS Total All Merchandise to World

- Consumption expenditures P_nC_n: Source: U.S. Department of Commerce – Bureau of Economic Analysis (BEA) Regional Data; Dataset: Personal Consumption Expenditures by State; Variable: Personal consumption expenditures

- State GDP GDP_n: Source: U.S. Department of Commerce – Bureau of Economic Analysis (BEA) Regional Data; Dataset: GSP NAICS ALL and and GSP SIC ALL; Variable: Gross Domestic Product by State

- Value of Bilateral Trade flow X_{ni}: Source: U.S. Census Bureau; Dataset: Commodity Flow Survey; Variable: Value. County-level bilateral trade flows are imputed using weighted shares of state flows, where weights correspond to county shares of state payroll.

- Number of Establishments M_n: Source: 2007 Economic Census of the United States; Dataset: EC0700A1 - All sectors: Geographic Area Series: Economy-Wide Key Statistics: 2007; Variable: Number of employer establishments

- We derive the following variables from the primary sources listed above:

  - Value of Intermediate Inputs: $P_nI_n = X_n - GDP_n$
  - Total state spending and revenue: $P_nG_n = R_n = T_n^c + T_n^y + R_n^{corp}$.
  - Total expenditures: $P_nQ_n = P_nG_n + P_nI_n + P_nC_n$
  - Sales from state n: $X_n = X_n^{Total} - Exports_n^{ROW}$.
  - Sales to the own state: $X_{ii} = X_i - \sum_n X_{ni}$.
  - Share of sales from n to state i: $s_{in} = \frac{X_{in}}{\sum_{i'} X_{i'n}}$.
  - Share of expenditures in i from state n: $\lambda_{in} = \frac{X_{in}}{\sum_{n'} X_{in'}}$.

F.3 Estimation (Section 6.2)

The variables used for estimation are different from those used for the calibration due to data availability. In computing both the calibrated parameters and the counterfactuals, we use the Economic Census measures for wages and employment; the reason being that we collect the sales data from the Economic Census as well. However, the Economic Census is available less frequently than the following data sources, which we use for estimation.

- Number of Workers L_n: Source: U.S. Census Bureau; Dataset: County Business Patterns (CBP); Variable: Total Mid-March Employees with Noise; Data cleaning: implemented David Dorn's fixed-point algorithm to impute employment counts in industry-county-year cells that withheld information for confidentiality reasons, and then summed county-level observations by state and year.

- Annual Payroll: Source: U.S. Census Bureau; Dataset: County Business Patterns (CBP); Variable: Annual Payroll

- Number of Establishments M_n: Source: U.S. Census Bureau; Dataset: County Business Patterns (CBP); Variable: Total Number of Establishments

- Annual Hours worked h_n: Source: IPUMS; Dataset: March Current Population Survey (CPS); Variable Construction: the number of weeks worked (*wkswork1*) is multiplied by the usual number of hours worked per week (*uhrsworkly*). Sample: our sample is restricted to civilian adults between the ages of 18 and 64. In order to be included in our sample, an individual had to be working at least 35 weeks in the calendar year and with a usual work week of at least 30 hours per week. We also drop individuals who report earning business or farm income.

- Wages from CPS w_n^{CPS}: Source: IPUMS; Dataset: March Current Population Survey (CPS); Variable Construction: annual wage income (*incwage*) is divided by annual hours worked. Sample: the sample for this variable is the same as the one we used to compute state-year average annual hours worked. Top-coded values for years prior to and including 1995 are multiplied by 1.5.

- Rental prices r_n: Source: IPUMS; Dataset: American Community Survey (ACS); Variable: Mean rent; Sample: Adjusted for top coding by multiplying by 1.5 where appropriate

- Price Index $P_n = P_n^{BLS}$; Source: Bureau of Labor Statistics (BLS); Dataset: Consumer Price Index; Variable: Consumer Price Index - All Urban Consumers; Note: Not available for all states. We used population data to allocate city price indexes in cases when a state contained multiple cities with CPI data (e.g., LA and San Francisco for CA's price index)