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WHO BENEFITS FROM STATE CORPORATE TAX CUTS? A LOCAL LABOR MARKETS APPROACH WITH HETEROGENEOUS FIRMS

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ABSTRACT

This paper estimates the incidence of state corporate taxes on workers, landowners, and firm owners in a spatial equilibrium model in which corporate taxes affect the location choices of both firms and workers. Heterogeneous, location-specific productivities and preferences determine the mobility of firms and workers, respectively. Owners of monopolistically competitive firms receive economic profits and may bear the incidence of corporate taxes as heterogeneous productivity can make them inframarginal in their location choices. We derive a simple expression for equilibrium incidence as a function of a few estimable parameters. Using variation in state corporate tax rates and apportionment rules, we estimate the reduced-form effects of tax changes on firm and worker location decisions, wages, and rental costs. We then use minimum distance methods to recover the parameters that determine equilibrium incidence as a function of these reduced-form effects. In contrast to previous assumptions of infinitely mobile firms and perfectly immobile workers, we find that firms are only approximately twice as mobile as workers over a ten-year period. This fact, along with equilibrium impacts on the housing market, implies that firm owners bear roughly 40% of the incidence, while workers and land owners bear 35% and 25%, respectively. Finally, we derive revenue-maximizing state corporate tax rates and discuss interactions with other local taxes and apportionment formulae.

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> If you're a business owner in Illinois, I want to express my admiration for your ability to survive in an environment that, intentionally or not, is designed for you to fail. [...] There is an escape route to economic freedom... a route to Texas.
>
> —Texas Governor Rick Perry (6/1/2013)

Policymakers often use local economic development policies, such as corporate tax policy, to encourage businesses to locate in their jurisdictions.[1] For instance, the governors of Kansas, Nebraska, and Louisiana have recently advocated for large state corporate income tax cuts.[2] This paper evaluates the welfare effects of cutting corporate income taxes on business owners, workers, and landowners.[3] We make three contributions. We provide new empirical evidence of the effects of tax cuts on business location, a new framework for evaluating the welfare effects of corporate tax cuts, and a new assessment of corporate tax incidence and efficiency that is useful for policymakers.[4]

In the standard open economy model of corporate tax incidence, immobile workers bear the full incidence of corporate taxes as capital flees high tax locations (Kotlikoff and Summers, 1987; Gordon and Hines, 2002).[5] As a result, the conventional wisdom among economists and policymakers is that corporate taxation in an open economy is unattractive on both efficiency and equity grounds; it distorts the location and scale of economic activity and falls on the shoulders of workers. The standard model, however, neither incorporates the location decisions of firms, which increasingly drive policymakers' decisions on corporate tax policy, nor the possibility that a firm's productivity can differ across locations.

This paper enhances the standard model by allowing the location decisions of monopolistically competitive and heterogeneously productive firms to determine the level and spatial distribution of capital, employment, and production. Accounting for these realistic features

[1] "As Companies Seek Tax Deals, Governments Pay High Price" *The New York Times* 1/1/2012. For the Perry quote, see "Perry Ad Campain Targets Illinois Businesses" *The Texas Tribune* 4/15/2013.

[2] "Republican Governors Push Taxes on Sales, Not Income" *The New York Times* 1/24/2013.

[3] In this paper, we analyze the effects of state corporate income tax cuts and increases and the use the terminology of tax cuts throughout the paper.

[4] While some research on the incidence of local corporate tax cuts exists, to our knowledge, there are no empirical analyses that incorporate local equilibrium effects of these tax changes to guide policymakers and voters. See McLure Jr. (1977) for an early analysis, Feldstein and Vaillant (1998) for evidence that mobility reduces states' ability to redistribute income, Gyourko and Tracy (1989) for the effects of local tax policy on inter-city wage differentials, Goolsbee and Maydew (2000) on the effects of corporate tax rules on manufacturing employment, Duranton et al. (2011), Bartik (1985), and Holmes (1998) on the location decisions of businesses. Fuest et al. (2013) use employer-firm linked data to assess the effects of corporate taxes on wages in Germany and Desai et al. (2007) analyze international variation in corporate tax rates using data from American multinationals.

[5] Gravelle and Smetters (2006) show how imperfect product substitution can alter this conclusion.

has substantial implications for the incidence and efficiency of corporate taxation.[6] If a firm is especially productive in a given location, it can be inframarginal in its location choice. That is, tax and factor price increases may not offset productivity advantages enough to make relocation profitable. For example, if California were to increase corporate tax rates modestly, both new and existing technology firms may still find Silicon Valley the most profitable place in the world for them to locate.[7] Thus, if firms' productivities are heterogeneous across locations, the location decisions of firms will be less responsive to corporate tax changes and firm owners will bear some of the burden of corporate taxes. Furthermore, this lower responsiveness decreases the efficiency cost of raising revenue through corporate income taxation. Assessing the equity and efficiency of state corporate income taxes requires quantifying the extent to which location-specific productivity limits firm mobility.

Our analysis proceeds in three steps. We first present reduced-form evidence on the effects of taxes on business location. We then develop a model of spatial equilibrium with firm location to interpret these effects and characterize the welfare impacts on business owners, workers, and landowners. Finally, we estimate the parameters that govern this model and quantify these welfare effects. The variation in our empirical analysis comes from changes to state corporate tax rates and apportionment rules, which are state-specific rules that govern how national profits of multi-state firms are allocated for tax purposes. We implement these state corporate tax system rules using matched firm-establishment data and construct a measure of the average tax rate that businesses pay in a local area.[8] This approach not only closely approximates actual taxes paid by businesses, but it also provides multiple sources of identifying variation from changes in state tax rates, apportionment formulae, and the rate and rule changes of other states.

We begin our empirical analysis by quantifying the responsiveness of establishments to local business tax changes and document the validity of this variation through a number of robustness checks. If every establishment compares the profits that they would earn across locations (based on local taxes, local factor prices, and their local productivity), then counting the number of establishments in a given area (and measuring how these counts change following tax changes)

[6]While many recent papers have documented large and persistent productivity differences across countries (Hall and Jones, 1999), sectors (Levchenko and Zhang, 2012), businesses (Syverson, 2011), and local labor markets (Moretti, 2011), the corporate tax literature has not accounted for the role that heterogeneous productivities may have in determining equilibrium incidence.

[7]In this paper, existing and new firms can be inframarginal due to heterogeneous productivities. This idea is conceptually distinct from the taxation of "old" capital as discussed by Auerbach (2006).

[8]To our knowledge, our paper with Zoe Cullen, Cullen et al. (2014), is the first paper to implement these formulae at the firm level and we follow their approach to compute the average effective tax for each local area.

will reveal information about the relative importance of taxes, factor prices, and productivities for business location. We find that a 1% cut in local business taxes increases the number of local establishments by 3 to 4% over a ten year period. This estimate is unrelated to other changes in policy that would otherwise bias our results, including changes in per-capita government spending and changes in the corporate tax base such as investment tax credits. To rule out the possibility that business tax changes occur in response to abnormal economic conditions, we analyze the typical dynamics of establishment growth in the years before and after business tax cuts. We also directly control for a common measure of changes in local labor demand from Bartik (1991). Finally, we estimate the effects of external tax changes of *other locations* on local establishment growth and find symmetric effects of business tax changes on establishment growth. These symmetric effects corroborate the robustness of our reduced-form result of business tax changes on establishment growth.

To interpret this reduced-form effect and determine its welfare implications, we develop a local labor markets model with heterogeneously productive and monopolistically competitive firms. Our model expands recent frameworks in the local labor markets literature (e.g., Kline and Moretti (2013)) by incorporating modeling features popular in trade models. Adding these features enables us to model firms' location and scale decisions, to incorporate the possibility that individual firms have location-specific productivities, and to derive a simple expression that relates these features to local labor demand. Developing the demand side of local labor markets is important because our framework allows firm owners to bear some of the incidence of local economic development policies and can be used to assess the incidence implications of productivity shocks as well as many other place-based policies.

Our framework models how business owners, workers, and landowners benefit from a local corporate tax cut. The incidence on these three groups depends on the equilibrium impacts on profits, real wages, and housing costs, respectively. A corporate tax cut affects labor, housing, and product markets as well as the location and scale of economic activity. A tax cut mechanically reduces the tax liability and the cost of capital of local establishments, attracts establishments, and increases local labor demand. This increase in labor demand leads firms to offer higher wages, encourages migration of workers, and increases the cost of housing. Our model characterizes the new spatial equilibrium following a business tax cut and relates the changes in wages, rents, and profits to features of the labor, housing, and product markets. We show that the incidence on wages depends on the degree to which establishment location decisions respond to tax changes, an effective labor supply elasticity that depends on housing market conditions, and a macro labor demand elasticity that depends on location and scale decisions of establishments. Having determined the incidence on wages, the incidence on profits is straightforward; it combines the mechanical effects of lower corporate taxes and the impact of higher wages on production costs. Our model delivers simple expressions for the incidence calculations in terms of a few estimable parameters.[9]

In the third part of the analysis, we estimate these parameters and test overidentifying restrictions of the model and find that they are satisfied. In particular, we minimize the distance between the predicted equilibrium effects of business tax cuts from our model and the estimated reduced-form effects of tax cuts on local establishment growth, as well as similar effects on population, wage, and rental cost growth. The structural parameters are precisely estimated.

Our main finding is that, over a ten-year period, firm owners bear a substantial portion of the incidence of a corporate tax change, while land owners and workers split the remaining burden. Our estimates place approximately 40% of the burden on firm owners, 25% on landowners and 35% on workers; the finding that firms bear a substantial portion of the burden is robust across a variety of specifications and estimating assumptions. The result that firm owners may bear the incidence of local policies starkly contrasts with existing results in the corporate tax literature (e.g. Fullerton and Metcalf (2002)) and is a novel result in the local labor markets literature (e.g. Moretti (2011)).

In the last section of the paper, we analyze the efficiency costs of state corporate income taxes and discuss the implications of our results for the revenue-maximizing tax rate. While business location decisions are not particularly sensitive to tax changes, there are important tax interactions with other revenue sources and apportionment tax rules that affect revenue-maximizing tax rates. Business mobility is an often-cited justification in proposals to lower states' corporate tax rates. However, we find that business location distortions per se do not lead to a low revenue-maximizing rate. Based solely on the responsiveness of establishment location to tax changes, corporate tax revenue-maximizing rates would be nearly 40%. This rate greatly exceeds average state corporate tax rates, which were 7% on average in 2010. We explore how interactions with other sources of state tax revenue and apportionment tax rules affect this conclusion. We find that corporate tax cuts have large fiscal externalities by

[9]These parameters are the dispersion of firm productivity across locations, the dispersion of worker preferences across locations, the elasticity of substitution across varieties of consumption goods, the elasticity of housing supply, and the output elasticity of labor.

distorting the location of individuals. This additional consideration implies substantially lower revenue-maximizing state corporate tax rates than the 40% rate based only on establishment mobility.[10] Nonetheless, the revenue-maximizing tax rate also depends on state apportionment rules. We find that states can increase corporate tax rates if these increases are accompanied by other changes to states' tax rules. In particular, by apportioning on the basis of sales activity, policymakers can decrease the importance of firms' location decisions in the determination of their tax liabilities and thus lower the distortionary effects of corporate taxes.[11]

We make a number of simplifying assumptions that may limit some of our analysis. First, we abstract from issues of endogenous agglomerations that may result from changes in corporate taxes.[12] Second, we do not allow firms to bear the cost of rising real estate costs. This feature could be added in a model with a real estate market that integrates the residential and commercial sectors. However, given that firm's cost shares on real estate are small, this addition would likely not change our main result and would come at the cost of additional complexity. Third, our model abstracts from the entrepreneurship margin.[13] Abstracting from this margin is unlikely to affect our incidence calculations to the extent that the entrepreneurship margin is small relative to the number of firms and aggregate employment. In particular, the magnitude of this margin depends on the effect of one state's tax changes on the total number of businesses in the United States. Fourth, many of the factors in our incidence formulae are likely to be geographically heterogeneous. A more general model that accounts for differences in housing markets, sectoral compositions, and skill-group compositions may result in a better approximation to the incidence in specific locations and is an interesting area for future work.

We discuss how this paper contributes to the business location, public finance, labor, and urban economics literatures in Section 1, describe the data and U.S. state corporate tax apportionment rules in Section 2, and present reduced form evidence that state business tax cuts increase the number of establishments over a sustained period in Section 3. In Section 4, we

[10] These rates ranges from 0% to 28% depending on the relative importance of the personal sales and income tax revenues to corporate tax revenues (see Table 8 for more detail on these rates).

[11] Switching to sales-only apportionment is attractive since it makes tax liabilities independent of location decisions (in the absence of trade costs). As a result, switching to sales-only apportionment eliminates the fiscal externality on personal income and sales tax revenue and allows for higher corporate tax rates. In addition, this policy usually does not require transition relief, which has limited the attractiveness of comparable corporate tax reforms at the national level (e.g. Altig et al. (2001), Auerbach (2010)).

[12] Incorporating agglomeration into spatial equilibrium models with heterogeneous firms is an interesting area for future research. See Kline and Moretti (2014) for a model of agglomeration with a representative firm and Diamond (2012) for amenity-related agglomerations.

[13] See Gentry and Hubbard (2000) and Scheuer (2012) for such an analysis.

develop a spatial equilibrium model and derive simple expressions for the incidence of state corporate tax changes in Section 5. In Section 6, we estimate the structural parameters governing incidence and show that firm owners bear a large portion of the incidence. In Section 7, we use our model and estimates to evaluate policy implications. Finally, we conclude in Section 8.

1 Relation to Previous Literature

This paper contributes to the literatures on business location, local labor markets, local public finance, and, most importantly, corporate taxation.

Hines (1997) highlights literature from the 1980s and early 1990s on state taxes on business location decisions. Newman (1983), Bartik (1985), Helms (1985), and Papke (1987, 1991) provide evidence supporting the idea that taxes meaningfully affect business location decisions. In his influential review of the literature, Bartik (1991) highlights methodological and econometric issues in some of the earlier literature that found mixed results of the effects of taxes on business location and notes that many more recent and careful studies find supportive evidence that corporate taxes and other aspects of fiscal policy affect business location decisions.[14] In terms of worker location decisions, Bakija and Slemrod (2004) find modest but negative effects while Kleven et al. (2013) and Kleven et al. (2014) find somewhat larger effects among high income earners in Denmark and European soccer players, respectively. Our paper embeds the location decisions of businesses and workers in a spatial equilibrium model, which allows for the evaluation of the welfare effects of corporate tax changes.

Additionally, our paper builds on urban and local labor market literatures (e.g., Rosen (1979), Roback (1982), Topel (1986), Glaeser (2008), Moretti (2011)) by incorporating heterogeneous firms. We contribute to this often underdeveloped aspect of local labor market models by incorporating insights developed mostly for models of international trade and macroeconomics. Indeed, our model in Section 4 uses insights from models developed by Hopenhayn

[14]See Wasylenko (1997) and Bradbury et al. (1997) for more detailed reviews of this literature. More recently,Goolsbee and Maydew (2000) and Holmes (1998) find that state policies have sizable effects on manufacturing location decisions. Rothenberg (2012) shows how government-provided infrastructure improvements affect the location choices of manufactures in Indonesia and reviews relevant business location literature on market access. Using micro-data from France, Rathelot and Sillard (2008) show that high corporate taxes tend to discourage firms from locating in a given area, but that these effects are weak. Chirinko and Wilson (2008) compare manufacturing establishment counts across state borders and find significant but economically small effects of tax differentials on establishment location. Devereux and Griffith (1998) provide cross-country evidence using panel data on U.S. multinationals. Duranton et al. (2011) also find little effect on entry, but show important impacts of local taxes on local labor market outcomes.

(1992), Krugman (1979), and Melitz (2003).[15] In this paper, the role of firm heterogeneity is crucial for firms to have imperfect mobility as well as equilibrium profits.[16] More generally, this renewed focus on the firm coincides with recent work on the important role of firms in determining labor market outcomes (see, *e.g.*, Card (2011), and Card et al. (2013)).

We follow Gyourko and Tracy (1989), Bartik (1991), Haughwout and Inman (2001), Duranton et al. (2011), and many others (recently surveyed by Glaeser (2012)) in focusing on the fiscal effects on local economic conditions. Of particular relevance to our paper is a recent literature studying incidence in local labor markets (Busso et al., 2013; Diamond, 2012; Kline, 2010; Notowidigdo, 2013; Suárez Serrato and Wingender, 2011).[17] One finding from this set of papers that differentiates them from previous work is the possibility that workers may be inframarginal in their location decisions. This feature allows workers to bear the benefit or cost of local policies (Kline and Moretti, 2013). Analogously, our paper allows firms to be inframarginal in their location decisions and thus may also bear the cost or benefit of local policies—a feature that was previously absent in models of local labor markets.

The main contribution of this paper is a new assessment of the incidence of corporate taxation. The existing corporate tax literature provides a wide range of conclusions about the corporate tax burden on workers. In the seminal paper of this literature, Harberger (1962) finds that under reasonable parameter values, capital bears the burden of a tax in a closed economy model in which all the adjustment has to be through factor prices. However, different capital mobility assumptions, namely perfect capital mobility in an open economy, can completely reverse Harberger's conclusion (Kotlikoff and Summers, 1987).[18] Gravelle (2010) reviews more recent theoretical papers in this literature and shows how conclusions from various studies hinge on their modeling assumptions, while Fullerton and Metcalf (2002) note that "few of the stan-

[15]Recent papers that have also analyzed this aspect of models of spatial equilibrium include Baldwin and Okubo (2005).

[16]Note, however, that the choice to model economic profits as arising from monopolistically competitive firms is not crucial for our results. In a previous version of this paper, which is available upon request, we show that many of our conclusions hold when profits arise from a decreasing returns to scale production function. In addition, see Liu and Altshuler (2013) and Cronin et al. (2013) for incidence papers that allow for imperfect competition and supernormal economic profits, respectively.

[17]Related literatures analyzing the incidence of tax policies at the national level include Rothstein (2010). Similarly, a large body of work analyzes the effects of international immigration on the wages of native workers. See, *e.g.*, Card (2001), Borjas et al. (1997), and Ottaviano and Peri (2012).

[18]See Desai et al. (2007) for estimates that suggest the incidence of corporate taxes is partly shared by workers and owner's of capital. Heterogeneous experiments, settings, and data explain some of this variation while complexities relating to dynamics, corporate financial policy, investment incentives and other factors often complicate incidence analyses (Auerbach, 2006).

dard assumptions about tax incidence have been tested and confirmed." Gravelle (2011) and Clausing (2013) critically review some of the existing empirical work on corporate tax incidence. We contribute to both the theoretical and empirical corporate tax literature by developing a new theoretical approach and connecting this theory directly to the data.[19] Doing so not only allows the data govern the relative mobility of firms and workers, but also enables us to conduct inference on the resulting incidence calculations.

2 Data and Institutional Details of State Corporate Taxes

Our paper uses yearly and decadal data from different sources to analyze the short-run dynamics as well as the long-run effects of changes in states' corporate tax rules. This section first describes the outcome data that we use and then turns to the state tax data and institutional setting.

Following Suárez Serrato and Wingender (2011), we analyze data at the level of consistent public-use micro-data areas (PUMAs) as developed by Ruggles et al. (2010). This level of aggregation is the smallest geographical level that can be consistently identified in Census and American Community Survey (ACS) datasets and has a number of advantages for our purposes.[20]

2.1 Data on Economic Outcomes

2.1.1 Yearly Data on Local Establishment Counts and Population

We use annual county-level data from 1980-2012 for over 3,000 counties to create a panel of tax changes for 490 county-groups. We aggregate the number of establishments in a given county

[19] We use state corporate tax apportionment rules to quantify mobility responses and assess the incidence of state corporate tax changes. Previous studies have focused on the theoretical distortions that apportionment formulae have on the geographical location of capital and labor (see, e.g., McLure Jr. (1982) and Gordon and Wilson (1986)). Empirically, several studies have used variation in apportionment rules (e.g., Goolsbee and Maydew (2000)). In the international tax literature Hines (2009) and Devereux and Loretz (2007) have analyzed how these tax distortions affect the location of economic activity.

[20] First, this geographical definition depends on county boundaries that are geographically consistent since 1980. This fact allows us to generate data series at a yearly frequency using data for individual counties. Moreover, it allows us to use micro-data from the U.S. census to create wage, rental cost, and home value indexes for geographically consistent areas across censuses. Second, the level of aggregation does not straddle state lines, in contrast to other definitions of local economies. This feature is beneficial since some of the policies we analyze, namely changes in statutory corporate tax rates, vary at the state level. Since local areas vary in industrial composition, apportionment rules create within state variation in the taxes businesses pay. To our knowledge, this paper is the first to use apportionment rules to compute the average tax rates businesses pay across different locations in the United States. Finally, this level of aggregation enables us to maximize statistical power and to exploit and measure variation in prices in local labor and housing markets, which vary considerably within states.

to the PUMA county-groups using data from the Census Bureau's County Business Patterns (CBP). To measure the responsiveness of business location to tax changes, we use changes in the number of establishments across U.S. county-groups. We analogously calculate population changes using Bureau of Economic Analysis (BEA) data.

2.1.2 Decadal Data on Local Wages and Housing Costs

To measure longer-term effects and price changes in local economies, this paper also uses individual-level data from Census Bureau surveys. We use data from the 1980, 1990, and 2000 U.S. censuses and the 2009 ACS to create a balanced panel of 490 county groups with indices of wages, rental costs, and housing values.

When comparing wages and housing values, it is important that our comparisons refer to workers and housing units with similar characteristics. As is standard in the literature on local labor markets (see, e.g., Albouy (2009); Busso et al. (2013); Kline (2010); Notowidigdo (2013)), we create indices of changes in wage rates and rental rates that are adjusted to eliminate the effects of changes in the compositions of workers and housing units in any given area. We create these composition-adjusted values as follows. First, we limit our sample to the non-farm, non-institutional population of adults between the ages of 18 and 64. Second, we partial out the observable characteristics of workers and housing units from wages and rental costs to create a constant reference group across locations and years. We do this adjustment to ensure that changes in the prices we analyze are not driven by changes in the composition of observable characteristics of workers and housing units. Additional details regarding our sample selection and the creation of composition-adjusted outcomes are available in Appendix A. Finally, we construct a "Bartik" local labor demand shock that we use to supplement our tax change measure and enhance the precision of labor supply parameters.[21]

[21] Many other papers in the local labor markets literature use Bartik shocks, e.g., Bartik (1991), Notowidigdo (2013), Diamond (2012). This approach weights national industry-level employment shocks by the initial industrial composition of each local area to construct a measure of local labor demand shocks:

$$Bartik_{c,t} \equiv \sum_{Ind} \text{EmpShare}_{Ind,t-10,c} \times \Delta\text{Emp}_{Ind,t,\text{National}}$$

where $\text{EmpShare}_{Ind,t-10,c}$ is the share of employment in a given industry at the start of the decade and $\Delta\text{Emp}_{Ind,t,\text{National}}$ is the national percentage change in employment in that industry.[22] We use this measure as a proxy of local productivity changes that have exogenous effects on local labor demand. Variation in this measure does not result from idiosyncratic local labor market conditions since the variation comes from national shocks to employment.

2.2 Tax Data

Businesses pay two types of income taxes. C-corporations pay state corporate taxes and many other types of businesses, such as S-corporations and partnerships, pay individual income taxes. We construct a dataset of state tax rules that determine these tax rates using a number of sources including the *Book of the States* (1976-2011), *Significant Features of Fiscal Federalism* (1976-1995), the *Statistical Abstract of the United States* (1993-2012), Tax Foundation (2013), and NBER's TAXSIM model (Feenberg and Coutts, 1993).[23] In Subsection 2.2.1, we describe how we use this tax data to measure the average tax rate C-corporations pay and how we exploit the complexities of state corporate tax rules to generate local tax-rule based variation in taxes. We then briefly describe our measure of state personal income tax rates in Subsection 2.2.2. In Subsection 2.2.3, we combine these measures to calculate an average business tax rate for every local area in the U.S. from 1980 to 2010.

2.2.1 State Corporate Tax Data and Institutional Details

The tax rate we aim to obtain in this subsection is the effective average tax rate paid by establishments of C-corporations in a given location from 1980 to 2010. In order to define the data required to measure the tax rates C-corporations pay and to show sources of variation in taxes, consider briefly how the state corporate income tax system works.

Firms can generate earnings from activity in many states. State authorities have to determine how much activity occurred in state s for every firm i. They often use a weighted average of sales, payroll, and property activity. The weights, called apportionment weights, determine the relative importance tax authorities place on these three measures of in-state activity. Apportionment weights are important because they define each firm's tax base in a state and shape how their total national tax liability changes when they alter their spatial distribution of production.[24]

The tax liability in state s of firm i is comprised of three parts: taxes due on apportioned

[23] In addition to the sources listed above, we also rely on data collected by the authors of the following papers: Seegert (2012) , Bernthal et al. (2012), and Chirinko and Wilson (2008). In particular, Seegert (2012) generously shared data on corporate tax rates and Bernthal et al. (2012) provided data on apportionment formulae. In both cases we cross-checked our newly digitized data with those used by these authors. Chirinko and Wilson (2008) provided us with data on investment tax credits to analyze the concomitance of changes in corporate tax rates and the corporate tax base.

[24] Goolsbee and Maydew (2000) use variation in apportionment weights on payroll activity to show that reducing the payroll apportionment weight from 33% to 25% leads to an increase in manufacturing employment of roughly one percent on average.

national profit based on sales activity, payroll activity, and property activity in state s:

$$\text{State Tax Liability}_{is} = \underbrace{(\tau_s^c \theta_s^x a_{is}^x)\Pi_i^p}_{\text{Tax from Sales Activity}} + \underbrace{(\tau_s^c \theta_s^w a_{is}^w)\Pi_i^p}_{\text{Tax from Payroll Activity}} + \underbrace{(\tau_s^c \theta_s^\rho a_{is}^\rho)\Pi_i^p}_{\text{Tax from Property Activity}} .$$

where τ_s^c is the corporate tax rate in state s, $0 \leq \theta_s^x \leq 1$ is the sales apportionment weight in state s, $a_{is}^x \equiv \frac{S_{is}}{S_i}$ is the share of the firm's total sales activity that occurs in state s, and Π^p is total pretax profits for the entire firm across all of it's establishments in the U.S. Payroll and property activity in state s are defined similarly and the weights sum to one for each state, i.e., $\theta_s^x + \theta_s^p + \theta_s^\rho = 1 \; \forall s$. Summing tax liabilities across states results in the following firm-specific "apportioned" tax rate:

$$\tau_i^A = \sum_s \left((\tau_s^c \theta_s^x a_{is}^x) + (\tau_s^c \theta_s^w a_{is}^w) + (\tau_s^c \theta_s^r a_{is}^\rho) \right) \tag{1}$$

where τ_i^A is the firm-specific tax rate for all of it's establishments across the U.S. This expression shows that the effective tax rate of a given establishment depends on (1) apportionment weights θ_s in every state, (2) the corporate rate τ_s^c in every state, and (3) the distribution of it's payroll, property, and sales activity across states: a_{is}^w,a_{is}^ρ and a_{is}^x, respectively, for all s. Finally, note that while the activity weights of payroll and capital are source-based (i.e. where goods are produced), the activity weights of revenue are destination-based (i.e., where goods are consumed). This distinction has important efficiency implications, which we discuss in Section 7.

Equation 1 shows that the tax rate corporations pay depends on own-state and other states tax rates and rules. To ensure that a decrease in tax rates can be interpreted as an in increase in the attractiveness of any given location, we decompose τ_i^A into three components: one that depends on own-state "domestic" tax rates and rules, an "external" component that depends on the statutory rates and rules in other states, and a sales component.

$$\underbrace{\tau_i^A}_{\text{Apportioned Rate}} = \underbrace{(\tau_s^c \theta_s^w a_{is}^w) + (\tau_s^c \theta_s^r a_{is}^\rho)}_{\text{Domestic Component}} + \underbrace{\sum_{s' \neq s} (\tau_{s'}^c \theta_{s'}^w a_{is'}^w) + (\tau_s^c \theta_{s'}^r a_{is'}^\rho)}_{\text{External Component}} + \underbrace{\sum_s (\tau_s^c \theta_s^x a_{is}^x)}_{\text{Sales Component}}$$

We then define the domestic tax rate that excludes the external component of tax changes, i.e. $\tau_i^D \equiv (\tau_s^c \theta_s^w a_{is}^w) + (\tau_s^c \theta_s^r a_{is}^\rho) + \sum_s (\tau_s^c \theta_s^x a_{is}^x)$, and the external rate as the difference between the apportionment rate and the domestic rate: $\tau_i^E \equiv \tau_i^A - \tau_i^D$.

In order to implement these tax rates, we follow Cullen et al. (2014) by using linked establishment-firm data to compute the activity weights for each establishment in the U.S. We use the Reference USA dataset from Infogroup for years 1997-2010 to compute the geographic distribution of employment at the firm level and complement these data with salary data from the QCEW series described above.[25] These data allow us to compute the payroll activity weight for each location. Due to the lack of information on the geographic distribution of property in the Reference USA dataset, we make the simplifying assumption that capital activity weights equal the payroll weights. Finally, since the apportionment of sales is destination-based, we use state GDP data for ten broad industry groups from the BEA to apportion sales to states based on their share of national GDP.[26]

Using the estimates of activity weights for each establishment in the U.S., we then compute an average tax rate $\bar{\tau}_c^A$ for all establishments in each location since 1980 as well as the average domestic and external rates, $\bar{\tau}_c^D$ and $\bar{\tau}_c^E$. Due to the way we use RefUSA data, note that variation in the main measures of 10 year changes in tax rates come driven solely by changes in statutory rates and formulae and not by changes in the distribution of firms' economic activity. Computing domestic and external rates yields three benefits. First, creating the domestic rate ensures that a decrease in tax rates can be interpreted as an in increase in the attractiveness of any given location. Second, it maximizes the variation we can use from changes in apportionment formulae and tax rates by giving them the same scale as changes in the effective tax rate. Finally, the external rate represents an index of the importance of changes in every other state's tax and yields a source of variation that is likely exogenous to local economic conditions and that we use to compare to the effects of tax changes driven by own-state changes.

Figure 1 shows that apart from a few states that have never taxed corporate income, most states have changed their rates at least 3 times since 1979. States in the south made fewer changes while states in the midwest and rust belt changed rates more frequently. This figure shows that changes in state corporate tax rates did not come form a particular region of the U.S. The top rate is 12% in Iowa and 75% of the states have rates above 6%.

States also vary in the apportionment rates that they use. Table 2 provides summary statistics of apportionment weights. Since the late 1970s, apportionment weights generally

[25] We use the spatial distribution of establishment-firm ownership and payroll activity in 1997 for years prior to 1997 due to data availability constraints on micro establishment-firm linked data in prior years. Since we hold the spatial distribution of establishment-firm ownership and payroll activity weights constant at 1997 values, variation in our tax measure τ_i^A comes from variation in state apportionment rules, variation in state corporate tax rules, and initial conditions, which determine the sensitivity of each firm's tax rate τ_i^A to changes in corporate rates and apportionment weights.

[26] This assumption corresponds to the case where all goods are perfectly traded, as in our model. We use broad industry groups in order to link SIC and NAICS codes when calculating GDP by state-industry-year.

placed equal weight on payroll, property, and sales activity, setting $\theta_s^w = \theta_s^\rho = \theta_s^x = \frac{1}{3}$. For instance, 80% of states used an equal-weighting scheme in 1980. However, many states have increased their sales weights over the past few decades as shown in Figure 2. In 2010, the average sales weight is two-thirds and less than 25% of states still maintain sales apportionment weights of 33%.

2.2.2 Personal Income Tax Rate Data

To calculate state personal income tax changes, we use the NBER Tax Simulator TAXSIM, which calculates individual tax liabilities for every annual tax schedule and stores a large sample of actual tax returns. Similar to Zidar (2013), we construct a measure of synthetic tax changes by comparing each individual's income tax liabilities in the year preceding a tax change to what their tax liabilities would have been if the new tax schedule had been applied, while holding other tax-relevant factors such as income and deductions constant.[27]

2.2.3 Local Business Tax Rate Data

We combine our measures of state personal income tax rates and local effective corporate tax rates that account for apportionment to construct a measure of the change in average taxes that local businesses pay:

$$\begin{aligned}\Delta \ln(1-\tau^b)_{c,t,t-h} \equiv & \underbrace{f^{SC}_{c,t-h}\Delta \ln(1-\tau^c)_{c,t,t-h} + f^{MC}_{c,t-h}\Delta \ln(1-\bar{\tau}^D)_{c,t,t-h}}_{\text{Corporate}} \\ & + \underbrace{(1 - f^{SC}_{c,t-h} - f^{MC}_{c,t,t-h})\Delta \ln(1-\tau^i)_{c,t,t-h}}_{\text{Personal}} \end{aligned} \tag{2}$$

where $h \in \{1, 10\}$ is the number years over which the difference is measured, $f^{SC}_{c,t}$ is the fraction of local establishments that are single-state C-corporations, and $f^{MC}_{c,t}$ is the fraction of local establishments that are multi-state C-corporations. We use the County Business Patterns and

[27]For example, suppose there was a state tax change in 1993. This measure subtracts how much a taxpayer paid in 1992 from how much she would have paid in 1992 if the 1993 tax schedule had been in place. We then use these measures to calculate effective state personal income tax changes. This process has the benefit that it mechanically ignores the effects of taxes on economic behavior, which might be related to unobservable factors driving our outcomes of interest. Before using these data in our empirical work in Section 3, we first crosscheck these simulated changes with actual statutory changes to top and bottom marginal rates for each state to ensure that the variation we observe is actually driven by statutory changes. Note that when calculating tax liabilities, TAXSIM takes into account each individual's deductions and credits and their specific implications for state personal income tax liabilities. See Zidar (2013) for more detail on the construction of this measure of income tax changes.

RefUSA to obtain these fractions.[28] Overall, changes in corporate tax rates, apportionment weights, and personal income tax rates generate considerable variation in effective tax rates across time and space. The bottom of Table 2 provides summary statistics of a few different measures of corporate tax changes over 10 year periods. The average log change over 10 years in corporate taxes due only to statutory corporate rates $\Delta \ln(1-\tau^c)_{c,t,t-10}$ is near zero and varies less than measures based on business taxes that incorporate the complexities of apportionment changes. Business tax changes $\Delta \ln(1-\tau^b)_{c,t,t-10}$ are slightly more negative on average over a ten year period. The minimum and maximum values are less disperse than the measure based on statuary rates since sales apportionment reduces location specific changes in effective corporate tax rates.

3 Reduced-Form Results

This section presents our main reduced-form result that a one percent cut in the effective tax rate that local businesses pay increases the number of local establishments by three to four percent over a ten year period. This result indicates that the responsiveness of establishments to changes in tax rates is much smaller than the conventional wisdom implies.[29]

There are a number of potential concerns that would caution the causal interpretation of this result. These include reverse causality of current or expected local economic conditions on tax changes, concomitant changes in other policies, and interactions with other state taxes. We explore the validity of this result in three ways. First, we document the annual effects of local changes in business taxes on local establishment growth and test for pre-trends in Subsection 3.1. We find that local economic conditions do not drive changes in corporate taxes. Second, we show in Subsections 3.2 and 3.3 that the establishment growth result is robust to changes in government spending, local productivity shocks, and changes to the corporate tax base. As described in the previous section, apportionment rules provide two measures of tax changes: those from domestic tax changes and those from the tax changes of other states. Additional evidence that our main effect is not spurious comes from tax changes from other states. We

[28] In 2010, C-corporations accounted for roughly half of employment and one-third of establishments in the U.S. Yagan (2013a) notes that switching between corporate types is rare empirically.

[29] The standard model effectively implies that establishments will be infinitely responsive to business tax changes over the long-run in the sense that higher corporate taxes cause capital to flee following small changes in corporate tax rates (Kotlikoff and Summers, 1987). This result is due, in part, to assumptions about the existence of a representative firm in each location and the (lack of) dispersion of firm productivity across locations. See Section 4 for more development of this idea.

show that the main effect is not only robust to including both measures of tax changes, but the effects from the two measures are also symmetric.

3.1 Annual Effects of Business Tax Cuts on Establishment Growth

We begin by documenting the effect of annual changes in corporate taxes on establishment growth. One potential concern is tax changes may be related to local economic conditions and bias our main result. We measure the effects of local business tax cuts on the growth in the number of local establishments using the following specification:

$$\ln E_{c,t} - \ln E_{c,t-1} = \sum_{h=\underline{h}}^{\overline{h}} \beta_h [\ln(1-\tau^b_{c,t-h}) - \ln(1-\tau^b_{c,t-1-h})] + \mathbf{D}'_{s,t}\mathbf{\Psi}_{s,t} + e_{c,t} \tag{3}$$

where $\ln E_{c,t} - \ln E_{c,t-1}$ is the annual log change in local establishments, $\ln(1-\tau^b_{c,t-h}) - \ln(1-\tau^b_{c,t-1-h})$ is the annual log change in the net-of-business-tax rate for different time horizons indexed by h, $\mathbf{D}_{s,t}$ is a vector with year dummies as well as state dummies for states in the industrial midwest in the 1980s. The specification relates changes in establishment growth to leads and lags of annual changes in business taxes, differences out time invariant local characteristics and adjusts for average national establishment growth and abnormal conditions in rust belt states in the 1980s.

This specification allows for lags that can show the dynamic impacts of tax changes and leads that can detect pre-trends. The baseline specification includes five lags and no leads, i.e. $\overline{h} = 5$ and $\underline{h} = 0$. In this baseline, we relate business tax changes over the past five years to establishment growth. Summing up the coefficients for each lag provides an estimate of the cumulative effect of a change in business taxes. For example, a state tax change in 2000 has its initial impact β_0 in 2000, its first year impact β_1 in 2001, the second year impact in 2002, etc. The number of local establishments in 2005 reflects the impact of each of these lagged effects, which sum to the cumulative effect $\sum_{h=0}^{5} \beta_h$. We also include leads in some specifications. Including leads, i.e. $\underline{h} < 0$, enables the detection of abnormal average establishment growth preceding tax changes.

Table 3 shows results for different combinations of leads and lags. Column (1) shows that a one percent cut in business taxes increases establishment growth by roughly 1.5% over a five year period. This increase in average growth tends to occur two and three years after the cut. Columns (2) sets $\underline{h} = -2$ and Column (3) sets $\underline{h} = -5$. The estimates of each of the leads in

Column (2) indicate that average establishment growth in the two years preceding a business tax cut are not statistically different from zero. The same applies for the specification with 5 leads in Column (3). In addition, the p-value of the joint test that all leads are zero is quite large for both cs. Columns (4) through (7) show similar results with 10 lags and up to 10 leads. Figure 3 and Figure 4 help visualize the resulting estimates from the ten leads and lags.

Figure 3 shows the cumulative effects of the estimates in Column (4). It shows that establishment growth increases following a one percent cut in business taxes, especially two to four years after a tax cut. The cumulative effect after ten years is roughly three percent, which amounts to roughly one fifth of a standard deviation in establishment growth over a ten year period. Controlling for 10 lags makes the estimates less precise, but the cumulative effect after 10 years is statistically significant at the 90% level. Figure 4 shows the analogous information using the estimates in column (7), which come from a specification with 10 leads and lags. This figure with leads shows a modest dip in average establishment growth in the years before business tax changes occur. However, this decline is statistically indistinguishable from zero. The figure also shows the cumulative effects of the lags if the leads were set to zero. The two cumulative effects with and without leads are quite similar. Overall, the evidence based on annual changes in establishment growth and business taxes suggests that (1) business tax cuts tend to increase establishment growth over a five-to-ten year period and (2) business tax changes do not occur in response to abnormally good or bad local economic conditions.

3.2 Long Differences

We analyze the effect of changes in business taxes on establishment growth between census years, which provides a summary measure and will be useful in the structural analysis that uses census data available each decade on wages and rental costs. The long difference estimates are similar to and more precise than the cumulative ten year effects from the previous section and are robust to accounting for changes in state investment tax credits, changes in per-capita government spending, and Bartik productivity shocks.

The long difference specification is:

$$\ln E_{c,t} - \ln E_{c,t-10} = \beta^E[\ln(1 - \tau^b_{c,t}) - \ln(1 - \tau^b_{c,t-10})] + \mathbf{D}'_{s,t}\mathbf{\Psi}^{LD}_{s,t} + u_{c,t} \tag{4}$$

where $\ln E_{c,t} - \ln E_{c,t-10}$ is approximately establishment growth over ten years and $[\ln(1-\tau^b_{c,t}) - \ln(1 - \tau^b_{c,t-10})]$ is growth in the net-of-business-tax-rate over ten years. In particular, this regression measures the degree to which larger tax cuts are associated with greater establishment growth. The validity of the reduced-form estimate β^E depends on the relationship between 10 year business tax cuts and the residual term $u_{c,t}$, which contains a number of potential confounding elements such 10 year changes in a the tax base, government spending, and productivity shocks.

Table 4 provides results of long differences specifications that account for these concerns. Column (1) shows a one percent cut in business taxes causes a 4.07% increase in establishment growth increase over a ten year period. To the extent that cuts in corporate taxes are not fully self-financing, states may have to adjust other policies when they cut corporate taxes.[30] Column (2) controls for changes in state investment tax credits and Column (3) changes in per capita government spending. There is no evidence that either confound the reduced form estimate $\hat{\beta}^E$. Column (4) controls for other measures of labor demand shocks. The point estimate declines slightly, but χ^2 tests indicate that $\hat{\beta}^E$ estimates are not statistically different than the estimate in Column (1). Column (5) uses variation in the external tax rates from changes in other states' tax rates and rules, $[\ln(1-\tau^E_{c,t}) - \ln(1-\tau^E_{c,t-10})]$. This specification has three interesting results. First, the point estimate of changes in business taxes is 3.9%, which is close to the estimate of $\hat{\beta}^E$ without controls in Column (1). Second, the point estimate from external tax changes is roughly equal and opposite of the estimates of $\hat{\beta}^E$. This symmetry in effects indicates that external tax shocks based on state apportionment rules have comparable effects to domestic business tax changes.[31] Third, one potential concern for our main result is that firms do not appear responsive to tax changes because they expect other states to match tax cuts as might be expected in tax competition models. By holding other state changes constant, we find no evidence that expectations of future tax cuts lower establishment mobility. Column (6) controls for all of these potentially confounding elements simultaneously. The point estimate of β^E is robust to including all of these controls.

Figure 4 shows that the long difference estimate is very similar to the cumulative effect discussed in the previous section. Moreover, this relationship holds even when adjusting for 10 years of prior economic activity.

[30] We explore the tax revenue implications of corporate tax changes in Section 7.

[31] χ^2 tests indicate that the effect from domestic and external business tax changes are statistically indistinguishable (in absolute value).

3.3 Tax Base Changes

One concern is that concomitant tax base changes might confound the effects of state corporate tax changes in ways that are not detectable in the long difference specification. To address this concern, we use data generously provided by Chirinko and Wilson (2008) and find that there is no relationship between long-run tax changes and investment tax credit changes. Figure 5 shows how the average tax rate change varies for different bins of investment credit changes. The best fit line is fairly flat, the estimated slope is 0.026 (se=.06), which is quite modest and not statistically different from zero.

Overall, these reduced form results suggest that the establishment growth increases by roughly 3% to 4% following a one percent cut in business taxes.

4 A Spatial Equilibrium Model with Heterogeneous Firms

> You have to start this conversation with the philosophy that businesses have more choices than they ever have before. And if you don't believe that, you say taxes don't matter. But if you do believe that, which I do, it's one of those things, along with quality of life, quality of education, quality of infrastructure, cost of labor, it's one of those things that matter.
>
> —Delaware Governor Jack Markell (11/3/2013)

This section presents a spatial equilibrium model of workers, landowners, and establishments that provides a framework for understanding these reduced-form results and for estimating the incidence of corporate tax changes.[32] We combine simple ingredients from the local labor markets, public finance, macro and trade literatures to allow workers, land owners, and firm owners to bear the incidence of corporate taxes. In the model, local housing market characteristics and worker and establishment decisions determine the equilibrium outcomes of local labor and housing markets. Corporate tax changes affect the spatial equilibrium in terms of the location decisions of firms and workers as well as the prices that determine their decisions. Before formally describing the model, we briefly provide a graphical overview. We then describe the setup of the model, the household problem, the land owner problem, and the establishment problem.

4.1 Graphical Overview of the Model

Panel I of Figure 6 depicts the three main effects of state corporate tax cuts on local establishments. Cutting corporate taxes reduces the tax liability of each local establishment, mechani-

[32] For Markell quote, see "Low wages 'arent what it's about anymore': Delaware's governor on bringing jobs home," *The Washington Post* 11/3/2013.

cally increasing their after-tax profits. Since returns to equity holders are not tax deductible, lowering corporate taxes also reduces the cost of capital. Effects 1 and 2 illustrate how these two simultaneous mechanical effects increase profits. Lower taxes and higher profits attract new establishments. However, choosing a location for tax purposes may require locating somewhere where the establishment will be less productive.[33] Therefore, the dispersion of each establishment's productivity across locations is crucially important in evaluating the effects of corporate tax cuts since productivity differences ultimately determine the magnitude of establishment inflows and the scale of economic activity. For instance, if an establishment's productivity is similar in all locations, it's location decision will be more responsive to tax changes. Effect 3 shows the consequences of a given amount of establishment entry. Entry bids up local wages, increases marginal costs, and reduces profits. The cumulative effect of local corporate taxes on after tax profits depends on how much wages increase, which is determined in the local labor market.[34]

Panel II of Figure 6 depicts the effect of a corporate tax cut in the local labor market. The graph describes the local labor market equilibrium over the long-run; where workers' migration and housing market characteristics determine local labor supply, and establishment migration and the scale of production determine local labor demand. As discussed above, local corporate tax cuts increase the after-tax profits of establishments and cause an inflow of establishments. Establishment entry creates an excess demand for labor $L_1 - L_0$. Since the marginal product of workers for new establishments exceeds the initial wage w_0, new establishments offer higher wages and attract workers from other cities.[35] Increased numbers of workers and establishments cause the local labor market to re-equilibrate.[36] The magnitude of worker inflows depends on the dispersion of workers' idiosyncratic location-specific preferences and local housing market characteristics.

The incidence on workers is then given by the increase in wages from w_0 to w^* and depends on three factors familiar to any incidence calculation: the slope of the local labor supply and

[33]In terms of Figure 6, higher productivity corresponds to lower marginal costs since factor requirements for a given level of output are lower.

[34]Note that there are different effects in the graphs to help provide intuition. However, the formal model does not have dynamics. Instead, the model involves an initial steady state, an exogenous corporate tax shock, and a new steady state, which corresponds to the outcome after effect 3 in Figure 6.

[35]Our analysis abstracts from the decisions of workers to become entrepreneurs, which may be sensitive to tax policy. See Gentry and Hubbard (2000) and Scheuer (2012) for such an analysis.

[36]Blanchard and Katz (1992) discuss the central importance of regional migration in the re-equilibrating process of local labor markets. Cadena and Kovak (2013) and Yagan (2013b) provide more recent evidence from the Great Recession on the importance of regional migration in this re-equilibration process.

local labor demand functions as well as the size of the shift in labor demand in response to changes in corporate taxes. While this intuition is simple, characterizing the interactions of inter-regional labor supply, housing supply, and the location, scale, and hiring decisions of establishments in spatial equilibrium is more complex. Our model determines each of these effects as functions of five parameters that govern the location decisions of firms, the location decisions of workers, and housing market characteristics. Moreover, these five parameters - the dispersion of establishment productivity across locations, the dispersion of worker preferences across locations, the elasticity of substitution across varieties, the elasticity of housing supply, and the output elasticity of labor - are sufficient to characterize the equilibrium incidence on workers, land owners, and firm owners.

4.2 Model Setup

We follow the exposition in Kline (2010) and Moretti (2011) as well as recent papers in the literature. We consider a small location c in an open economy with many other locations. There are three types of agents: households, establishment owners, and land owners. There are N_c households in location c, E_c establishments in each location c, and representative land owners in each location.[37] In terms of market structure, capital and goods markets are global and labor and housing markets are local. We compare outcomes in spatial equilibrium before and after a corporate tax cut and do not model the transition between pre-tax and post-tax equilibria.[38]

4.3 Household Problem

In a given location c with amenities A, households maximize Cobb-Douglas utility over housing h and a composite X of non-housing goods x_j while facing a wage w, rent r, and non-housing good prices p_j as follows:

$$\max_{h,X} \; \ln A + \alpha \ln h + (1-\alpha)\ln X \;\; s.t. \;\; rh + \int_{j\in J} p_j x_j dj = w, \;\; \text{where } X = \left(\int_{j\in J} x_j^{\frac{\varepsilon^{PD}+1}{\varepsilon^{PD}}} dj \right)^{\frac{\varepsilon^{PD}}{\varepsilon^{PD}+1}},$$

[37]Note that having a representative landowner simples exposition but is not an essential feature of this model. See Busso et al. (2013) for a model in which landowners face heterogeneous costs of supplying local housing.

[38]We abstract from transition dynamics, which can have important incidence implications (Auerbach, 2006) and are an interesting area for future research.

$\varepsilon^{PD} < -1$ is elasticity of substitution for product demand, and P is a national CES price index that is normalized to one.[39] Workers inelastically provide a unit of labor.[40] Demand from each household for variety j, $x_j = (1-\alpha)wp_j^{\varepsilon^{PD}}$, depends on the non-housing expenditure, the price of variety j, and the product demand elasticity. Overall, households spend a share of their income $\alpha = \frac{rh}{w}$ on housing and a share $(1-\alpha) = \frac{X}{w}$ on non-housing goods.

4.3.1 Household Location Choice

Wages, rental costs, and amenities vary across locations. The indirect utility of household n from their choice of location c is then

$$V_{nc}^{W} = a_0 + \ln w_c - \alpha \ln r_c + \ln A_{nc}$$

where a_0 is a constant. Notice that indirect utility is more responsive to wages than to rents since the expenditure share on housing α is less than one. Households compare their indirect utility across locations as well as the value of location-specific amenities $\ln A_{nc}$, which are comprised of a common location specific term $\bar{A}_c$ and location specific idiosyncratic preference ξ_{nc}:[41]

$$\max_c \quad \underbrace{a_0 + \ln w_c - \alpha \ln r_c + \bar{A}_c}_{\equiv u_c} + \xi_{nc}.$$

Household n's indirect utility depends not only on common terms u_c but also on ξ_{nc}, which is distributed i.i.d. type I extreme value. This household specific component is important because it allows workers to bear some of the incidence of labor demand shocks (Kline and Moretti, 2013). Households will locate in location c if their indirect utility there is higher there than in any other location c'. The share of households for whom that is true determines local population N_c:

$$N_c = P\left(V_{nc}^{W} = \max_{c'}\{V_{nc'}^{W}\}\right) = \frac{\exp \frac{u_c}{\sigma^W}}{\sum_{c'} \exp \frac{u_{c'}}{\sigma^W}} \tag{5}$$

[39] One could incorporate personal income taxes into this framework by replacing w with after tax income $w(1-\tau^i)$. One could also incorporate local property taxes by replacing r analogously. The intuition for having a product demand elasticity $\varepsilon^{PD} < -1$ reflects the idea that the demand elasticity for a broad category of goods, such as food or transportation, is typically thought to be closer to -1. Since there are many varieties, this representation is a simplified way of capturing the idea that price changes result in substitution within and across categories of goods. In addition, note that this price index is $P = \left(\int_{j \in J} (p_j)^{1+\varepsilon^{PD}} dj\right)^{\frac{1}{1+\varepsilon^{PD}}} = 1$.

[40] Inelastically supplied labor is a common assumption in local labor markets models such as Rosen (1979)-Roback (1982), and Moretti (2011) and is consistent with modestly-sized estimates of individual labor supply elasticities in Saez et al. (2012).

[41] We assume fixed amenities for simplicity. See Diamond (2012) for an analysis with endogenous amenities.

where σ^W is the dispersion of the location specific idiosyncratic preference ξ_{nc}. Note that the probability that indirect utility is highest in city c depends on the difference between indirect utility in city c and indirect utility in all other cities c'. If $u_c = u'_c \ \forall c'$, then every location will have equal population.

4.3.2 Local Labor Supply

Taking logs of equation 5 yields the (log) local labor supply curve:

$$\ln N_c(w_c, r_c; \bar{A}_c) = \frac{\ln w_c}{\sigma^W} - \frac{\alpha}{\sigma^W} \ln r_c + \frac{\bar{A}_c}{\sigma^W} \tag{6}$$

Local labor supply is increasing in wages w_c, decreasing in rents r_c, and increasing in log amenities $\bar{A}_c$. If workers have similar tastes for cities, then σ^W will be low and local labor supply will be fairly responsive to real wage and amenity changes.

4.4 Housing Market

4.4.1 Housing Supply

Housing supply is upward sloping and varies across locations. The local supply of housing $H_c^S = G(r_c; B_c^H)$ is increasing in rental price r_c and exogenous local housing productivity B_c^H. This relationship allows landowners to benefit from higher rental prices and implies that the marginal land owner supplies housing at cost $r_c = G^{-1}(H_c^S; B_c^H)$. For tractability, let $G(r_c; B_c^H) \equiv (B_c^H r_c)^{\eta_c}$, so higher local rental prices r_c and higher local housing productivity B_c^H increase the supply of housing where the local housing supply elasticity $\eta_c > 0$ governs the strength of the response.[42]

4.4.2 Housing Demand

Since all households in location c spend $r_c h_c = \alpha w_c$ on housing, local housing demand from households is given by: $H_c^D = \frac{N_c \alpha w_c}{r_c}$. It is easy to see that demand is increasing in local population, expenditure shares on housing, and local after tax wages and is decreasing in local rental costs.

[42] Notowidigdo (2013) discusses the incidence implications of non-linear housing supply functions as in Glaeser and Gyourko (2005).

4.4.3 Housing Market Equilibrium

The housing market clearing condition, $H_c^S = H_c^D$, implies that the (log) price of housing r_c in location c is given by the following expression.

$$\ln r_c = \frac{1}{1+\eta_c} \ln N_c + \frac{1}{1+\eta_c} \ln w_c - \frac{\eta_c}{1+\eta_c} B_c^H + a_1 \tag{7}$$

where a_1 is a constant.[43] This expression shows that local population growth and wage growth increase rental costs.[44] For small values of η_c, which correspond to highly inelastic housing supply, rents will essentially go up one for one with population and wage increases.

4.5 Establishment Problem

When making location decisions, firm owners primarily tradeoff three characteristics: factor prices, taxes, and productivity. The relative importance of these three characteristics is crucially important for determining the incidence on firm owners. If an establishment is only marginally more productive in a particular location, small changes in factor prices or taxes can make locating elsewhere more profitable. However, if establishments are substantially more productive in a given location, they will be inframarginal in terms of location decisions following tax and factor price changes but will likely reduce the scale of production. This section formalizes the establishment location and scale decisions and uses them to derive a novel and tractable expression for local labor demand.

Establishments j are monopolistically competitive and have productivity B_{jc} that varies across locations.[45] Monopolistic competition allows firm owners to make economic profits. Establishments combine labor l_{jc}, capital k_{jc}, and a bundle of intermediate goods M_{jc} to produce output y_{jc} with the following technology:

$$y_{jc} = B_{jc} l_{jc}^{\gamma} k_{jc}^{\delta} M_{jc}^{1-\gamma-\delta} \tag{8}$$

where $M_{jc} \equiv \left(\int\limits_{v \in J} (x_{v,jc})^{\frac{\varepsilon^{PD}+1}{\varepsilon^{PD}}} dv \right)^{\frac{\varepsilon^{PD}}{\varepsilon^{PD}+1}}$ is establishment j's bundle of goods of varieties v. Goods of all varieties can serve as either final goods for household consumption or as intermediate inputs for establishment production. The bundle of intermediate goods M_{jc} is defined identically

[43] Note that $a_1 \equiv \frac{1}{1+\eta_c} \ln \alpha$.

[44] The expression also shows that housing productivity improvements decrease housing costs ceteris paribus.

[45] To simplify exposition, we describe the case in which firms are single-plant establishments in the main text, but fully characterize the more general firm problem and its complex interaction with apportionment rules in Appendix B.

the consumption bundle X in the household problem so that demand for the establishment's variety j has CES demand as in Basu (1995).[46] We incorporate intermediate inputs since they represent a considerable portion of gross output in practice and are important to consider when evaluating production technology parameter values empirically.[47]

In a given location c, establishments maximize profits over inputs and prices p_{jc} while facing a local wage w_c, national rental rates ρ, national prices p_v of each variety v, and local business taxes τ_c^b subject to the production technology in Equation 8:

$$\pi_{jc} = \max_{l_{jc}, k_{jk}, x_{v,jc}, p_{jc}} (1-\tau_c^b)\left(p_{jc}y_{jc} - w_c l_{jc} - \int_{v\in J} p_v x_{v,jc} dv\right) - \rho k_{jc} \tag{9}$$

where the local business tax is the effective tax from locating in location c.[48] An important feature of the establishment problem is the tax treatment of the returns to equity holders. Since returns to equity holders are not tax deductible, the corporate tax affects the cost of capital (Auerbach, 2002).[49]

After solving this establishment problem (see Appendix B.1 and Appendix B.2), we can express economic profits in terms of of local taxes, factor prices, and local productivity:

$$\pi_{jc} = (1-\tau_c^b) w_c^{\gamma(\varepsilon^{PD}+1)} \rho_c^{\delta(\varepsilon^{PD}+1)} B_c^{-(\varepsilon^{PD}+1)} \kappa \tag{10}$$

where the local tax rate is τ_c^b, local factor prices are w_c and $\rho_c = \frac{\rho}{1-\tau_c^b}$, the establishment's local productivity is B_c, and κ is a constant term across locations.[50]

[46] We use the same elasticity of substitution ε^{PD} for establishments and consumers to maintain CES demand overall. This characterization is not an essential aspect of the model. An alternative characterization is that intermediate inputs are imported at global prices from a location outside the United States. In addition, note that the production technology simplifies to the standard production technology when $\gamma + \delta = 1$.

[47] Accounting for intermediate goods also makes assumptions about trade costs important. We assume zero trade costs to simplify the model. To evaluate this assumption and its importance for our incidence results, consider the opposite extreme in which there is no trade and suppose that locations that have heterogeneous incomes. In this case, locating in a high income location will be very attractive and may make establishments inframarginal in their location decisions. For instance, many firms would not want to leave New York if wages or taxes increased modestly. An intermediate case of non-zero but finite trade costs is operative in practice. Due to the possibility that these market access concerns can also make establishments inframarginal in their location decisions, we believe that the incidence implications in models with non-zero trade costs will be consistent with those in this paper. See Fajgelbaum et al. (2014) for a closely related model that incorporates trade costs.

[48] See Appendix B.1 for the establishment problem in the more general case with apportionment.

[49] Establishments are equity financed in the model. We view this as a reasonable characterization given non-tax costs of debt and firm optimization.

[50] See Appendix B.2 for a derivation. Note that equation 33 is the more general version of equation 10.

4.5.1 Establishment Location Choice

When choosing location, firm owners maximize after tax profits π_{jc} of their establishment's across locations c. To derive the establishment's value function for each location, suppose that the log of establishment j's productivity B_{jc} in location c equals $\bar{B}_c + \zeta_{jc}$ where $\bar{B}_c$ is a common location specific level of productivity and ζ_{jc} is an idiosyncratic establishment and location-specific term that is i.i.d. type I extreme value. Establishments may be idiosyncratically more productive for a variety of reasons, including match-quality, sensitivity to transportation costs, factor or input market requirements, sector-specific concentration and agglomeration.[51]

Define an establishment j's *value function* V^F_{jc} in location c:[52]

$$V^F_{jc} = \underbrace{\frac{\ln(1-\tau^b_s)}{-(\varepsilon^{PD}+1)} + \bar{B}_c - \gamma \ln w_c - \delta \ln \rho_c + \frac{\ln \kappa_1}{-(\varepsilon^{PD}+1)}}_{\equiv v_c} + \zeta_{jc}. \tag{11}$$

This value function is a positive monotonic transformation of log profits.[53] Notice that a decrease in log wages by one unit increases the value of a location by the labor production technology parameter $\gamma < 1$, which is less valuable than a one unit increase in productivity since increases in productivity reduce *both* labor and capital costs for a given level of output. The model implies similar tradeoffs for taxes, which depend on the magnitude of product demand elasticities and hence net markups $\mu - 1 \equiv \frac{1}{-(\varepsilon^{PD}+1)}$. In particular, Equation 11 shows that corporate taxes matter more for location decisions when net markups (and thus profits) are large. Similar to the household location problem, establishments will locate in location c if their value function there is higher there than in any other location c'. The share of establishments for which that is true determines local establishment share E_c:

$$E_c = P\left(V_{jc} = \max_{c'}\{V_{jc'}\}\right) = \frac{\exp \frac{v_c}{\sigma^F}}{\sum_{c'} \exp \frac{v_{c'}}{\sigma^F}} \tag{12}$$

where σ^F is the dispersion of the location specific idiosyncratic establishment productivity ζ_{jc}.[54]

[51] Allowing for endogenous agglomeration, i.e. making B_{jc} a function of local population, is beyond the scope of this paper, but is an interesting area for future research. See Kline and Moretti (2014) for a related model of agglomeration with a representative firm and Diamond (2012) for amenity-related agglomerations.

[52] In practice, establishment j is owned by firm i, which determines j's tax rate and thus pays a firm location specific rate τ^b_{is} rather than τ^b_s due to apportionment rules. See Apprendix B.1 for the firm problem under apportionment.

[53] The transformation divides log profits by $-(\varepsilon^{PD}+1) \geq 1$, where log profits are the non-tax shifting portion of log profits, i.e. $\ln \pi_{jc} = \ln(1-\tau^A_i) + \gamma(\varepsilon^{PD}+1)\ln w_c + \delta(\varepsilon^{PD}+1)\ln \rho_c - (\varepsilon^{PD}+1)\ln \bar{B}_c + \ln \kappa_1$, which closely approximates the exact expression for log profits as shown in Appendix B.2.2. Note that the constant $\kappa_1 = \tilde{\mu}_{ic}\kappa$ in the firm problem under apportionment. Note that $-(\epsilon^{PD}+1)^{-1} = \mu - 1$, which the net-markup. We use the two terms interchangeably in the rest of the paper.

[54] It can be shown that incorporating firm specific differences in the corporate tax term results in the same expression for v_c where τ^A_c is replaced by an establishment ownership size weighted average of τ^A_{ic}.

Note that the probability that the value function is highest in city c depends on the difference between profits in city c and profits in all other cities c'. If $v_c = v_c' \;\; \forall c'$, then every location will have equal shares of establishments.

4.5.2 Local Labor Demand

Local labor demand in c depends on the share of establishments that choose to locate in E_c and how much these establishments want to hire on average: $\mathbb{E}_\zeta[l^*_{jc}(\zeta_{jc})|c = \underset{c'}{\text{argmax}}\{V_{jc'}\}]$. Changes in wages will result in changes along both of these margins, resulting in a macro elasticity and a micro elasticity that collectively determine the slope of aggregate labor demand in a location L_c^D. By macro elasticity, we mean how much aggregate local labor demand changes following wage changes for both existing firms on the intensive margin and new entrants on the extensive margin. By micro elasticity, we mean how much labor demand changes due to intensive margin changes of only existing firms.

Local labor demand for a given type of corporation is given by the following expression:

$$L_c^D = \mathbb{E}_\zeta[l^*_{jc}(\zeta_{jc})|c = \underset{c'}{\text{argmax}}\{V_{jc'}\}]E_c$$

Using the law of large numbers to simplify expressions and rearranging terms yields labor demand in location c for a given type of corporation.[55]

$$L_c^D = \underbrace{\left(\frac{1}{C\bar{\pi}}\exp\left(\frac{v_c}{\sigma^F}\right)\right)}_{\text{Extensive margin}} \times \underbrace{w_c^{(\gamma\epsilon^{PD}+\gamma-1)}\rho_c^{(1+\epsilon^{PD})\delta}\kappa_0\left(e^{\bar{B}_c(-\epsilon^{PD}-1)}\right)z_c}_{\text{Intensive margin}} \tag{13}$$

where C is the number of cities, $\bar{\pi} \equiv \frac{1}{C}\sum_{c'}\exp(\frac{v_{c'}}{\sigma^F})$ is closely related to average profits in all other locations, κ_0 is a common term across locations, and z_c is a term increasing in the idiosyncratic productivity draw ζ_{jc}.

There are three things to note about this expression for labor demand regarding the overall share of global labor demand, the extensive margin, and the intensive margin. The first term $\frac{1}{C\bar{\pi}}$ shows that the global share of labor demand is smaller when the number of cities is higher and when average profits in other cities are higher. The second part of the extensive margin term shows that locations with an attractive combination of taxes, wages, and common productivity will have a larger share of global labor demand. This attractiveness is scaled by the importance

[55] Given a large number of cities C, we can follow Hopenhayn (1992) and use the law of large numbers to simplify the denominator of E_c and express the share $E_c = \left(\frac{\exp\frac{v_c}{\sigma^F}}{C\bar{\pi}}\right)$ as a function of average location specific profits in all other locations $\bar{\pi} \equiv \frac{1}{C}\sum_{c'}\exp(\frac{v_{c'}}{\sigma^F})$.

of idiosyncratic productivity σ^F. Finally, the intensive margin portion shows how much labor the average establishment will hire, which is increasing in local productivity $\bar{B}_c$ and the idiosyncratic local productivity draw ζ_{jc}, but is decreasing in prices of labor w_c and capital ρ_c.

The key object of interest is the elasticity of local labor demand:

$$\frac{\partial \ln L_c^D}{\partial \ln w_c} = \underbrace{\gamma - 1}_{\text{Substitution}} + \underbrace{\gamma \epsilon^{PD}}_{\text{Scale}} - \underbrace{\frac{\gamma}{\sigma^F}}_{\text{Firm-Location}} \equiv \varepsilon^{LD} \tag{14}$$

where γ is the output elasticity of labor, ϵ^{PD} is the product demand elasticity, and σ^F is the dispersion of idiosyncratic productivity.[56] This expression is composed of three effects: the substation effect $\gamma - 1$, the scale effect $\gamma \epsilon^{PD}$, and the firm-location effect $\frac{-\gamma}{\sigma^F}$. Since $\sigma^F > 0$, $\epsilon^{PD} < -1$, and $\gamma \in (0, 1)$, each of these three effects contributes to the negative slope of the labor demand curve represented by the macro elasticity ε^{LD}. By considering the location decisions of establishments, we introduce a new feature to models of local labor markets: a decomposition of labor demand into an extensive margin (related to firm entry and exit) and an intensive margin (related to factor costs).[57] If $\sigma^F = \infty$, which corresponds to the case in which establishments are not mobile (due to enormous productivity draws that trump local factor prices and taxes), then the labor demand elasticity is simply the intensive margin micro elasticity: $\gamma - 1 + \gamma \epsilon^{PD}$.

5 The Incidence of Local Corporate Tax Cuts

We now characterize the incidence of corporate taxes on wages, rents, and profits and relate these effects to the welfare of workers, landowners, and firms. We focus on the welfare of local residents as the policies we study are determined by policymakers with the objective of maximizing local welfare.[58]

5.1 Local Incidence on Prices and Profits

Assuming full labor force participation, i.e. $L_c^S = N_c$, clearing in the housing, labor, capital, and goods markets gives the following labor market equilibrium:[59]

$$N_c(w_c, r_c; \bar{A}_c, \eta_c) = L_c^D(w_c, \bar{\pi}; \rho_c, \tau_c^c, \theta, \tau_c^i, \bar{B}_c, z_c).$$

[56] Note that the full expression for (log) labor demand is Equation 34 in Appendix B.3.

[57] Landais et al. (2010) and Chetty et al. (2012) discuss the relation between micro and macro elasticities in the contexts of unemployment insurance and labor supply, respectively.

[58] We also discuss how decisions based on local objectives affect outcomes in other locations in Appendix C.1.

[59] See Busso et al. (2013) for a generalization that allows for non-participation in the labor market.

This expression implicitly defines equilibrium wages w_c.[60] Let $\dot{w}_c = \frac{\partial \ln w_c}{\partial \ln(1-\tau_c^b)}$ and define $\dot{r}_c$ analogously. The effect of a local corporate tax cut on local wages is given by the following expression:

$$\dot{w}_c = \frac{\frac{(\mu-1)f_c^C}{\sigma^F}}{\underbrace{\left(\frac{1+\eta_c-\alpha}{\sigma^W(1+\eta_c)+\alpha}\right) - \gamma\left(\epsilon^{PD}+1-\frac{1}{\sigma^F}\right)+1}_{\varepsilon^{\mathrm{LS}}-\varepsilon^{\mathrm{LD}}>0}}. \tag{15}$$

This expression for wage growth has an intuitive economic interpretation that translates the forces in our spatial equilibrium model to those in a basic supply and demand diagram, as in Figure 6. The numerator captures the shift in labor demand following the tax cut: $\frac{(\mu-1)f_c^C}{\sigma^F}$, where $(\mu-1)$ is the net markup and f_c^C is the share of establishments subject to the corporate tax. Since this shift in demand is due to establishment entry, the numerator is a function of the location decisions of establishments. Profit taxes matter more for location decisions when markups (and thus profits) are large, but matter less when productivity is more heterogeneous across locations. The denominator is the difference between an effective labor supply elasticity and a macro labor demand elasticity. The effective elasticity of labor supply $\varepsilon^{LS} \equiv \left(\frac{1+\eta_c-\alpha}{\sigma^W(1+\eta_c)+\alpha}\right)$ incorporates indirect housing market impacts. As $\frac{\partial\varepsilon^{LS}}{\partial\eta_c} > 0$, the effect of corporate taxes on wages will be smaller, the larger the elasticity of housing supply. A simple intuition for this is that if η is large, workers do not need to be compensated as much to be willing to live there. As discussed in the previous section, the macro elasticity of housing supply depends on both location and scale decisions of firms.

Similarly, the effect on rents is given by the following expression:

$$\dot{r}_c = \left(\frac{1+\varepsilon^{LS}}{1+\eta_c}\right)\dot{w}_c, \tag{16}$$

where the quantity $1+\varepsilon^{LS}$ captures the effects of higher wages on housing consumption through both a direct effect of higher income and an indirect effect on the location of workers. The magnitude of the rent increase depends on the elasticity of housing supply η_c and the strength of the inflow of establishments through its effect on $\dot{w}_c$ as in Equation 15.[61]

As illustrated in Figure 6, the effect of a corporate tax cut on establishment profits when

[60] Appendix B.4 derives the expressions for equilibrium wages, rents, and population.

[61] Note that the change in local population is given by $\dot{N}_c = \varepsilon^{LS}\dot{w}$ and the change in real wages is $\sigma^W\varepsilon^{LS}\dot{w}$.

apportionment effects are suppressed is given by the following expression:[62]

$$\dot{\pi}_c = 1 \quad \underbrace{-\delta(\varepsilon^{PD}+1)}_{\text{Reducing Capital Wedge}} \quad + \underbrace{\gamma(\varepsilon^{PD}+1)\dot{w}_c}_{\text{Higher Labor Costs}}, \tag{17}$$

where $\dot{\pi}_c$ is the percentage change in after-tax profits, δ is the output elasticity of capital, ε^{PD} is the product demand elasticity, γ is the output elasticity of labor, and $\dot{w}_c$ is the percentage change in wages following a corporate tax cut. Establishment profits mechanically increase by one percent following a corporate tax cut of one percent. They are also affected by effects on factor prices. The middle term reflects increased profitability due to a reduction in the effective cost of capital and the last term diminishes profits due to increases in local wages.

5.2 Local Incidence on Welfare

Having derived the incidence of corporate taxes on local prices and profits, we now explore how these price changes affect the welfare of workers, landowners, and firm owners.[63] A potential problem in assessing the effects of price changes on welfare is that agents might change their behavior in response to price changes. However, envelope-theorem logic implies that, to a first-order approximation, the effect of price changes on agents' welfare does not depend on their behavioral response.

In order to see this, define the welfare of workers as $\mathcal{V}^W \equiv \mathbb{E}[\max_c\{u_c + \xi_{nc}\}]$. Since the distribution of idiosyncratic preferences is type I extreme value, the welfare of workers can be written as:

$$\mathcal{V}^W = \sigma^W \log\left(\sum_c \exp\left(\frac{u_c}{\sigma^W}\right)\right),$$

as in McFadden (1978) and Kline and Moretti (2013).[64] It then follows that the effect of a tax cut in location c on the welfare of workers is given by:

$$\frac{d\mathcal{V}^W}{d\ln(1-\tau_c^c)} = N_c(\dot{w}_c - \alpha\dot{r}_c). \tag{18}$$

That is, the effect of a tax cut on welfare is simply a transfer to workers in location c equivalent to a percentage change in the real wage given by: $(\dot{w}_c - \alpha\dot{r}_c)$. One very useful aspect of this formula

[62] Without suppressing apportionment effects, $\dot{\pi}_c = 1 + \gamma(\varepsilon^{PD}+1)(\dot{w}_c + \dot{\omega}_w) + \delta(\varepsilon^{PD}+1)\dot{\omega}_\rho + \dot{\tilde{\mu}}_c$

[63] See Appendix C.1 for a consideration the effects on agents in other locations in a global incidence calculation.

[64] Euler's constant, which is $\approx .577$, is suppressed relative to the expression in (McFadden, 1978). In other words, $\mathcal{V}^W$ defined here less Euler's constant is the correct value for $\mathcal{V}^W$. This constant does not affect the welfare change calculations below.

is that it does not depend on the effect of tax changes on the location decisions of workers in the sense that there are no $\dot{N}_c$ terms in this expression (Busso et al., 2013).[65] This expression assumes $\mathcal{V}^W = \mathcal{V}_c^W$, that is, tax changes in location c have no effect on wages and rental costs in other locations, consistent with the perspective of a local official. In Appendix C.1, we relax this assumption and consider the effects on global welfare.

Similarly, defining the welfare of firm owners as:[66]

$$\mathcal{V}^F \equiv \mathbb{E}[\max_c\{v_c + \zeta_{jc}\}] \times -(\varepsilon^{PD} + 1)$$

yields an analogous expression for the effect of corporate taxes on domestic firm owner welfare, which is given by:

$$\frac{d\mathcal{V}^F}{d\ln(1-\tau_c^c)} = E_c\dot{\pi}_c. \tag{19}$$

Finally, consider the effect on landowner welfare in location c. Landowner welfare in each location is the difference between housing expenditures and the costs associated with supplying that level of housing. This difference can be expressed as follows:[67]

$$\mathcal{V}^L = N_c\alpha w_c - \int_0^{N_c\alpha w_c/r_c} G^{-1}(q; Z_c^h)dq = \frac{1}{1+\eta_c}N_c\alpha w_c,$$

and is proportional to housing expenditures. The effect of a corporate tax cut on the welfare of domestic landowners is then given by:

$$\frac{d\mathcal{V}^L}{d\ln(1-\tau_c^c)} = \frac{\dot{N}_c + \dot{w}_c}{1+\eta_c}. \tag{20}$$

After turning to the data to estimate parameters in Section 6, we evaluate Equations 18, 19, and 20 and discuss how the total gains are distributed between these agents empirically in Section 7.1 .

[65] This result follows Busso et al. (2013), who additionally show that this logic holds for an arbitrary distribution of idiosyncratic preferences. Note that this expression differs from that in (Busso et al., 2013) by including the percentage changes in prices as opposed to the price changes in levels. This deviation is a result of having Cobb-Douglas preferences and normalizing by the marginal utility of income as in Suárez Serrato and Wingender (2011).

[66] The firm owner term is multiplied by $-(\varepsilon^{PD} + 1) > 0$ to undo the monotonic transformation that was applied when defining the establishment value function V_{jc}^F. In addition, this formulation treats firm owners and landlords as distinct from workers for conceptual clarity. Moreover, the log formulation implicitly assumes that firm owners and landlords have no other income. One could add a term for average wages inside the log to adjust for the lack of wage income.

[67] Note that, in contrast to workers and firm owners, this formulation of the utility of the representative landlord assumes constant marginal utility of income.

6 Empirical Implementation

This section describes how we connect the theory to the data and implement the incidence formulae from the previous section. We proceed in a few steps. First, in Section 6.1, we characterize the equilibrium effects of a tax cut on population, establishment, wage, and rent growth in a simultaneous equations model (SEM) and relate them to reduced-form effects of these four outcomes. Second, in Section 6.2, we show that our incidence formulae are point-identified by these four reduced-form effects. Third, in Section 6.3 we estimate the parameters of the model using classical minimum distance (CMD) methods. This structural approach allows us to implement the incidence formulae for wages, rental costs, and profits; even when the latter is not observed in the data. In Appendix E.1, we provide a complementary approach that recovers the parameters of the model from separate, single equation estimations of the labor supply, housing supply, and establishment location equations from the previous section.[68] We estimate our model in reduced form and then solve for structural parameters instead of estimating it in structural form directly via 3SLS with cross-equation restrictions because the former approach is somewhat more transparent and better connected to Section 3.

6.1 Deriving Exact Reduced-Form Effects of Business Tax Changes

In order to derive the equilibrium predictions of our model, we stack the decision of the agents in our model from Equations 6, 7, the log of Equation 12, as well as the log of the local labor demand expression in Equation 13. This yields the structural form of the model:

$$\mathbb{A}\mathbf{Y}_{c,t} = -\mathbb{B}\mathbf{Z}_{c,t} + \mathbf{e}_{c,t}, \tag{21}$$

where $\mathbf{Y}_{c,t}$ is a vector of the four endogenous variables: population growth, wage growth, rental cost growth, and establishment growth, $\mathbf{Z}_{c,t}$ is a vector of tax shocks, $\mathbb{A}$ is a matrix that characterizes the inter-dependence among the endogenous variables, $\mathbb{B}$ is a matrix that measures the direct effects of the tax shocks on each endogenous variable,[69] and $\mathbf{e}_{c,t}$ is a structural error term.[70] Explicitly, these elements are given by:

[68] Moreover, in Appendix E.2 we propose an alternative instrumental variables strategy based on work by Albouy (2009) that provides a relative labor supply shock. This strategy allows us to identify firm's extensive and intensive margin responses to tax changes and provides similar results as those in this section.

[69] We first implement this approach first by only using variation from tax changes. We then supplement this approach with additional variation from the Bartik local labor demand shock to increase the precision of our estimates.

[70] We control for changes in personal income taxes in the population growth regression to account for the fact that personal income taxes directly affect both worker and firm location. We provide evidence that alternative

$$
\mathbf{Y}_{c,t} = \begin{bmatrix} \Delta \ln w_{c,t} \\ \Delta \ln N_{c,t} \\ \Delta \ln r_{c,t} \\ \Delta \ln E_{c,t} \end{bmatrix}, \qquad \mathbb{A} = \begin{bmatrix} -\frac{1}{\varepsilon^{LD}} & 1 & 0 & 0 \\ 1 & -\frac{1}{\sigma^W} & +\frac{\alpha}{\sigma^W} & 0 \\ -\frac{1}{1+\eta_c} & -\frac{1}{1+\eta_c} & 1 & 0 \\ 0 & \frac{\gamma}{\sigma^F} & 0 & 1 \end{bmatrix},
$$

$$
\mathbb{B} = \begin{bmatrix} \frac{1}{\varepsilon^{LD}\sigma^F(\varepsilon^{PD}+1)} \\ 0 \\ 0 \\ \frac{1}{-\sigma^F(\varepsilon^{PD}+1)} \end{bmatrix}, \quad \text{and} \qquad \mathbf{Z}_{c,t} = \begin{bmatrix} \Delta \ln(1-\tau^b_{c,t}) \\ \vdots \\ \Delta \ln(1-\tau^b_{c,t}) \end{bmatrix}.
$$

We convert the structural form to the reduced form to derive the equilibrium predictions of our model. Pre-multiplying by the inverse of the matrix of structural coefficients $\mathbb{A}$ gives the reduced form:

$$
\mathbf{Y}_{c,t} = \underbrace{-\mathbb{A}^{-1}\mathbb{B}}_{\equiv \mathbb{C}} \mathbf{Z}_{c,t} + \mathbb{A}^{-1}\mathbf{e}_{c,t} \tag{22}
$$

where $\mathbb{C} = \left[\boldsymbol{\beta}^{\text{Business Tax}}\right]$ is a vector of reduced-form estimates of business tax changes on population growth, wage growth, rental cost growth, and establishment growth, respectively.[71] The elements of $\mathbb{C}$ have intuitive economic interpretations that show how changes in business taxes relate to population growth, wage growth, rental cost growth, and establishment growth in terms of structural parameters.

To see this intuitive interpretation, consider first the wage equation:

$$
\Delta \ln w_{c,t} = \underbrace{(\dot{w})}_{=\beta^W} \Delta \ln(1-\tau^b_{c,t}) + \mathbf{D}'_{s,t}\boldsymbol{\Psi}^1_{s,t} + u^1_{c,t}, \tag{23}
$$

where $\mathbf{D}_{s,t} = \left[\mathrm{I}(t=1990) \quad \dots \quad \mathrm{I}(t=2010) \quad \mathrm{I}(Midwest1990)_{s,t}\right]'$ is a vector with year dummies as well as state dummies for states in the industrial midwest in the 1980s, as in Section 3. This equation relates the empirical incidence on wages β^W to the formula derived in Equation 15.

The labor supply equation has a similarly intuitive interpretation:

$$
\Delta \ln N_{c,t} = \underbrace{(\dot{w}\varepsilon^{LS})}_{=\beta^N} \Delta \ln(1-\tau^b_{c,t}) + \mathbf{D}'_{s,t}\boldsymbol{\Psi}^2_{s,t} + u^2_{c,t}, \tag{24}
$$

where the coefficient on changes in taxes $\dot{w}\varepsilon^{LS}$ describes the equilibrium growth in population. The magnitude of the wage increase $\dot{w}$ and the effective labor supply ε^{LS} determine the responsiveness of population growth to business tax changes. Equations 23 and 24 can be interpreted

approaches yield similar parameter estimates in Appendix E.

[71] In the implementation of the model we separate the error term $\mathbb{A}^{-1}\mathbf{e}_{c,t}$ into a vector of year dummies and state fixed effects for the industrial midwest as in Section 3, and a structural error term $\mathbf{u}_{c,t}$.

in an instrumental variables framework where Equation 23 acts as the first stage and Equation 24 as the reduced-form equation for an IV regression of labor supply on wages where wages are instrumented by corporate tax changes.[72]

Similarly, the equilibrium effect on rental costs follows the equation:

$$\Delta \ln r_{c,t} = \underbrace{\left(\frac{1+\varepsilon^{LS}}{1+\eta_c}\dot{w}\right)}_{=\beta^R} \Delta \ln(1-\tau^b_{c,t}) + \mathbf{D}'_{s,t}\mathbf{\Psi}^3_{s,t} + u^3_{c,t}. \tag{25}$$

As discussed in Section 5, the incidence on rents β^R is determined by the factor $\frac{1}{1+\eta_c}$ times the increase in wage plus the increase in population, given by $\dot{w}(1+\varepsilon^{LS})$. As in the case of the labor supply equation, we can interpret Equation 25 as a reduced-form of an instrumental variables regression of rents on wages where the first stage is given by Equation 23.

Finally, the last equation of the exact reduced form is given by:

$$\Delta \ln E_{c,t} = \underbrace{\left(\frac{\mu-1}{\sigma^F} - \frac{\gamma}{\sigma^F}\dot{w}\right)}_{=\beta^E} \Delta \ln(1-\tau^b_{c,t}) + \mathbf{D}'_{s,t}\mathbf{\Psi}^4_{s,t} + u^4_{c,t} \tag{26}$$

where the coefficient on tax changes β^E is the same as the one in Equation 28. The model prediction for β^E combines a direct effect through higher after-tax profits, $(\mu-1)$, and an indirect effect through higher wages, which lowers profits by $\gamma\dot{w}$, both of which are modulated by the inverse elasticity of firm mobility σ^F. Notice also that Equation 26 corresponds exactly to the reduced-form regression in Equation 4. One of the contributions of this paper is to provide an economic interpretation for this reduced-form relationship by linking it to the location decisions of establishments (as described by Equation 11).

6.2 Identification of Parameters and Incidence Formulae

This section shows that the four reduced-form moments of the data, $\boldsymbol{\beta}^{\text{Business Tax}} = \left[\beta^W, \beta^N, \beta^R, \beta^E\right]'$, are sufficient to identify the formulae describing the incidence on the welfare of each of our agents. Table 1 reproduces the incidence formulae for the welfare of each of our agents. The formulae for workers and landowners are identified by the direct effects of taxes on disposable income $(\hat{\beta}^W - \alpha\hat{\beta}^R)$ and the direct effects on rents $\hat{\beta}^R$, respectively. The expression for firm owners depends on the equilibrium effect on profits, which are not directly observed empirically. Table

[72]Indeed, a well-known result is that one can formulate and IV regression as a special case of the CMD approach. See Appendix E for an instrumental variables estimation of the worker location and rental market equations. See also Figure A2 for a comparison of the OLS and the IV estimates of the worker location equation

Table 1: Identification of Local Incidence on Welfare

Stakeholder (Benefit)	Incidence	Identified By
Workers (Disposable Income)	$\dot{w} - \alpha \dot{r}$	$\hat{\beta}^W - \alpha \hat{\beta}^R$
Landowners (Housing Costs)	$\dot{r}$	$\hat{\beta}^R$
Firm Owners (After-tax Profit)	$1 + \gamma(\varepsilon^{PD} + 1)(\dot{w}_c - \frac{\delta}{\gamma})$	$1 + \left(\frac{\hat{\beta}^N - \hat{\beta}^E}{\hat{\beta}^W} + 1 \right) (\hat{\beta}^W - \frac{\delta}{\gamma})$

NOTES: This table shows how reduced-form estimates $\hat{\boldsymbol{\beta}}^{\text{Business Tax}} = [\hat{\beta}^W, \hat{\beta}^N, \hat{\beta}^R, \hat{\beta}^E]'$ map to the incidence on welfare of workers, landowners, and firm-owners at the local level. Note that we calibrate the housing expenditure share (α) and the ratio of the capita to labor output elasticities (δ/γ).

1 shows that the formula for the incidence on after-tax profits includes the term $\gamma(\varepsilon^{PD} + 1)$. This term measures the decrease in profits from a 1-percent increase in wages normalized by the firm's net-markup.[73] To identify this term, first fix two empirical quantities: (1) the elasticity of labor supply, which is identified by the ratio of Equations 24 and 23 so that $\varepsilon^{LS} = \hat{\beta}^N / \hat{\beta}^W$, and (2) the shift in the labor demand, which is the numerator of the wage incidence formula. Given these two quantities, the term $\gamma(\varepsilon^{PD} + 1)$ can be obtained from the wage incidence equation by decomposing the elasticity of labor demand into the extensive margin (related to firm location) and the intensive margin (related to scale and substitution effects) as shown in Equation 14.

To see this, recall the wage incidence equation:

$$\hat{\beta}^W = \dot{w} = \frac{-\frac{1}{(\varepsilon^{PD}+1)\sigma^F}}{\underbrace{\left(\frac{1 + \eta_c - \alpha}{\sigma^W (1 + \eta_c) + \alpha} \right)}_{\varepsilon^{\text{LS}}} \underbrace{- \gamma \left(\epsilon^{PD} + 1 - \frac{1}{\sigma^F} \right) + 1}_{\varepsilon^{\text{LD}}}}.$$

Rearranging Equation 26, the establishment location equation, we obtain an empirical version of the numerator in this equation:

$$\frac{1}{-\sigma^F (\varepsilon^{PD} + 1)} = \hat{\beta}^E + \frac{\gamma}{\sigma^F} \hat{\beta}^W.$$

[73] Recall that $(\varepsilon^{PD} + 1) = \frac{-1}{\mu - 1}$, where μ is the markup.

We can thus re-write the wage incidence formula as a function of reduced-form parameters:

$$\hat{\beta}^W = \frac{\hat{\beta}^E + \frac{\gamma}{\sigma^F}\hat{\beta}^W}{\underbrace{\frac{\hat{\beta}^N}{\hat{\beta}^W} - \gamma\left(\epsilon^{PD} + 1 - \frac{1}{\sigma^F}\right) + 1}_{\varepsilon^{\mathrm{LD}}}}.$$

Solving this equation for the term $\gamma(\varepsilon^{PD}+1)$ shows that

$$\gamma(\varepsilon^{PD}+1) = \left(\frac{\hat{\beta}^N - \hat{\beta}^E}{\hat{\beta}^W} + 1\right).$$

The intuition behind this derivation is that, given estimates of the equilibrium change in wages, employment, and the slope of labor supply, we can decompose the elasticity of labor demand into the extensive component, using the equilibrium change in establishments, and the intensive margin $\gamma(\epsilon^{PD}+1)-1$. Given our specification of the firm problem, this micro-elasticity of labor demand also reveals the effect of a wage increase on profits, which determines the incidence on firm owners.

A few remarks are worth highlighting about this identification argument. First, note that the welfare effects are point identified even if we cannot identify all of the parameters of the model independently. In particular, even though we cannot separately identify γ and ε^{PD}, identifying the product $\gamma(\varepsilon^{PD}+1)$ is sufficient to characterize the effect of a corporate tax cut on profits. Second, we can further identify additional primitives of the model including σ^W and η_c by manipulating the identification of the elasticity of labor supply and the incidence on rents. Finally, this identification argument shows the relationship between the theory and reduced-form estimates, providing a transparent way to evaluate how sensitive our ultimate incidence estimates are to changes in the four reduced-form estimates.

6.3 Minimum Distance Estimation of Structural Parameters

There are two steps in our classical minimum distance (CMD) estimation. The first step is the estimation of the reduced-form effects $\boldsymbol{\beta}$ of business tax changes on our four outcomes as in Equation 22.[74] The second step is to find the parameters of the model that match these reduced-form moments of the data. We use this CMD procedure in three ways. In Section 6.3.1 we focus on the establishment location equation as this is a central component of the paper. In Section 6.3.2 we jointly estimate the parameters in the simultaneous equations model. We

[74]These effects are estimated using a system OLS regression.

initially use only variation from tax changes and then supplement this approach with additional variation from the Bartik local labor demand shock to increase the precision of our estimates. The supplemental variation from labor demand shocks provides over-identifying restrictions that enable us to test the goodness-of-fit and evaluate the predictions of our model.

To set up the CMD estimate, we collect the four exact reduced forms of the simultaneous equation model derived in Section 6.1. This defines a vector of four predicted moments $\mathbf{m}(\boldsymbol{\theta})$ where $\boldsymbol{\theta}$ is vector of the five structural parameters: the dispersion of firm productivity across locations σ^F, the dispersion of worker preferences across locations σ^W, the elasticity of substitution across varieties ε^{PD}, the elasticity of housing supply η, and the output elasticity of labor γ. We proceed by using a classical minimum distance estimator to find the parameters that best match the moments $\mathbf{m}(\boldsymbol{\theta})$ to the vector of reduced form effects $\hat{\boldsymbol{\beta}}$. Formally, we find an estimate of $\boldsymbol{\theta}$ by solving the problem:

$$\hat{\boldsymbol{\theta}} = \arg\min_{\boldsymbol{\theta}\in\boldsymbol{\Theta}} \; [\hat{\boldsymbol{\beta}} - \mathbf{m}(\boldsymbol{\theta})]'\hat{\mathbf{V}}^{-1}[\hat{\boldsymbol{\beta}} - \mathbf{m}(\boldsymbol{\theta})] \tag{27}$$

where $\hat{\mathbf{V}}$ is the inverse variance of the OLS estimate, $\mathbf{m}(\boldsymbol{\theta})$ is the moment predicted by our model.

6.3.1 CMD Estimation of the Establishment Location Equation

In the previous section we describe the general procedure to recover structural parameters from our four equilibrium outcomes. Before proceeding to the system estimation, we first focus on one outcome – establishment location – and do so for three reasons: to elucidate the relationship between the reduced-form estimates in Section 3 and the parameters of the model, to illustrate the mechanics of the CMD, and to highlight a conceptual innovation in the estimation of local labor demand. Estimating labor demand functions in models of local labor markets has been limited by the lack of plausibly exogenous labor supply shocks that may trace the slope of the demand function.[75] Instead, this equation exploits the empirical tradeoff firms make among productivity, corporate taxes, and factor prices to recover the parameters governing labor demand and the incidence on firm profits.

Recall from Section 6.1 that the exact reduced-form of the establishment location equation

[75]Recent papers have used structural approaches to ensuring a downward sloping labor demand curve (*e.g.*, Notowidigdo (2013)) or have emphasized the role of local amenities in driving relative demand for skilled and unskilled workers (*e.g.*, Suárez Serrato and Wingender (2011) and Diamond (2012)).

is given by:

$$\Delta \ln E_{c,t} = \underbrace{\left(\frac{\mu - 1}{\sigma^F} - \frac{\gamma}{\sigma^F}\dot{w}\right)}_{\beta^E} \Delta \ln(1 - \tau^b_{c,t}) + \mathbf{D}'_{s,t}\mathbf{\Psi}^4_{s,t} + u^4_{c,t}.$$

While we derived this equation from the SEM, this equation can also be obtained by log differencing Equation 12. We can decompose the parameter β^E into two forces: the increased desirability of a location through lower taxes and the countervailing force of higher wages:

$$m(\boldsymbol{\theta}) \equiv \underbrace{\frac{1}{-(\varepsilon^{PD} + 1)\sigma^F}}_{\text{LowerTaxes}} \underbrace{- \left(\frac{\gamma}{\sigma^F}\right)\dot{w}(\boldsymbol{\theta})}_{\text{Higher Wages}} \tag{28}$$

where $\dot{w}(\boldsymbol{\theta})$ is given in Equation 15 and $\boldsymbol{\theta}$ is the vector of parameters of the model. Thus, given the parameters of the model $\eta, \sigma^W, \varepsilon^{PD}$, and γ and an estimated $\hat{\beta}^E$, one can recover an estimate of the productivity dispersion parameter σ^F.

Formally, we recover the estimate of σ^F via classical minimum distance. We first estimate β^E via OLS. Using the parameter $\hat{\beta}^E$ as an empirical moment of the data along with its respective variance $\hat{\mathbf{V}}$, the classical minimum distance estimator is the solution to Equation 27 where $m(\boldsymbol{\theta})$ is as in Equation 28. This approach takes calibrated values of the parameters $\eta, \sigma^W, \varepsilon^{PD}$, and γ, finds the value $\hat{\sigma}^F$ that solves Equation 27 and computes its variance.

In order to implement this strategy, we use assumed values of the parameters governing the housing and labor supply equations and calibrate some of the parameters that can be approximated based on external data and other literature.[76] We calculate γ based on data from the U.S. Internal Revenue Service's Statistics of Income data on corporate tax returns and from the Bureau of Economic Analysis. The IRS data indicate that labor's share of revenues is roughly 10% of sales and is roughly 13% of costs. These data also show that costs of goods sold are substantially larger than labor costs.[77] BEA data on gross output for private industries show similar patterns but report labor shares that are roughly twice as large as those based on IRS data. We present results for calibrations for wide ranges of γ and choose a baseline that is in between the IRS and BEA numbers and close to other values used in the local labor markets literature (e.g., Kline and Moretti (2014)). Estimates of product demand elasticity often are not used in the local labor markets literature due to the lack of focus on firms (Card,

[76]See Appendix E.1 for single equation estimates of these other parameters.

[77]The IRS data are from the most recent year available 2003 and can be downloaded here http://www.irs.gov/uac/SOI-Tax-Stats-Integrated-Business-Data. Results based on revenue and cost shares from earlier years available are similar.

2011). In other literatures, the estimates vary widely. For our baseline, we use estimates that are slightly lower that in the macro and trade literatures (e.g., Coibion et al. (2012); Arkolakis et al. (2013)) in order to obtain local labor demand elasticities that are similar to those used in the labor literature (Hamermesh, 1993). However, we will also provide results for a wide range of product demand elasticities and estimate this elasticity directly in Section 6.3.2.

Figure 7 shows estimates for σ^F from the CMD estimation using the values for calibrated parameters discussed above. The graph plots the mean values of log changes in the number of establishments for different bins of log changes in the net of business tax rate. The red line plots the relation between changes in taxes and firm mobility that is implied by the CMD estimation. The parameter estimate in this case is $\hat{\sigma}^F = 0.1(SE = 0.058)$, which is statistically significant. The black line plots the same relationship when we use an implied value of σ^F from an OLS regression that ignores the indirect effect of tax cuts on firm location through higher wages. The red line is steeper than the black line, which makes firms look more mobile than they would appear in the OLS specification and is consistent with the fact that the CMD estimate is three times smaller than the implied value from the OLS regression.[78] However, if we consider the conventional wisdom of perfect mobility as given by the vertical green line, we see that even a small value of productivity dispersion σ^F yields estimates of firm mobility that are far smaller than that implied by the conventional wisdom.

6.3.2 CMD Estimation of the Simultaneous Equation Model

In order to implement the incidence formulae, we now estimate the parameters of the model using a system CMD approach. We first conduct this estimation using only the four moments implied by the effects of taxes on the four equilibrium outcomes. In a second approach, we add the Bartik local labor demand shock to increase the provision of our estimates.

Consider first estimating the model's parameters using only tax variation. In this case, since we have four moments and five parameters, we calibrate some of the parameters that can be approximated based on external data and other literature as discussed above. In particular, we calibrate the output elasticity of labor γ and the product demand elasticity ε^{PD}. In later specifications, we also estimate the parameter ε^{PD}.

The results of this estimation procedure are presented in Panel (a) of Table 5 for different values of the calibrated parameters γ and ε^{PD}. Our baseline specification in Column (1), using

[78]The results of these regressions are also presented in table form in Table A1.

the values $\gamma = 0.15$ and $\varepsilon^{PD} = -2.5$, finds an estimate for the productivity dispersion $\hat{\sigma}^F = 0.11 (SE = 0.069)$. This estimate has a similar magnitude as the value from the single-equation approach reported in Figure 7. The estimate for preference dispersion $\hat{\sigma}^W = 0.469 (SE = 0.360)$ is statistically significant and implies a labor mobility elasticity of 2.13. The elasticity of housing supply is $\hat{\eta} = 2.244 (SE = 3.163)$ is statistically insignificant. However, recall that the effect of an increase in wages or an increase in population on rents is given by $\frac{1}{1+\eta} \approx 0.31$, which is statistically significant. Columns (2)-(7) explore the effect of different calibrate values of γ and ε^{PD} on the parameter estimates. These columns show that increase γ from 0.1 to 0.3 or decreasing ε^{PD} from -2.5 to -3.5 yields smaller estimates of productivity dispersion $\hat{\sigma}^F$. In both cases, these parameter changes increase the elasticity of labor demand for which the estimator compensates with a smaller $\hat{\sigma}^F$. In contrast, the estimates for $\hat{\sigma}^W$ and $\hat{\eta}$ are relatively stable.

In order to improve the precision of these estimates, we use additional information on the structure of the labor and housing markets by using variation from the Bartik local labor demand shock. We interpret this shock as a proxy for changes in local productivity and estimate auxiliary parameters that project this proxy onto the local productivity measures in our model as follows:

$$\Delta B_{c,t} = \varphi Bartik_{c,t} + v_{c,t}$$
$$\Delta B^H_{c,t} = \varphi^h Bartik_{c,t} + v^h_{c,t}$$
$$\Delta z_{c,t} = \varphi^z Bartik_{c,t} + v^z_{c,t}.$$

With these productivity measures, we define a new reduced form that relates the matrix of tax and Bartik shocks:

$$\mathbf{Z}_{c,t} = \begin{bmatrix} \Delta \ln(1-\tau^b_{c,t}) & Bartik_{c,t} \\ \vdots & \vdots \end{bmatrix},$$

to the same vector of outcomes $\mathbf{Y}_{c,t}$. The matrix $\mathbb{A}$ remains unchanged and the matrix $\mathbb{B}$ in Equation 22 is now given by:

$$\mathbb{B} = \begin{bmatrix} \frac{1}{\varepsilon^{LD}\sigma^F(\varepsilon^{PD}+1)} & \frac{\left(\varepsilon^{PD}+1-\frac{1}{\sigma^F}\right)\varphi-\varphi^z}{\varepsilon^{LD}} \\ 0 & 0 \\ 0 & \frac{-\eta_c\varphi^h}{1+\eta_c} \\ \frac{1}{-\sigma^F(\varepsilon^{PD}+1)} & \frac{\varphi}{\sigma^F} \end{bmatrix}.$$

The matrix of reduced form moments $\mathbb{C}$ now includes the effects of taxes and the effects of productivity shocks

$$\mathbb{C} = \begin{bmatrix} \boldsymbol{\beta}^{\text{Business Tax}} & \boldsymbol{\beta}^{\text{Bartik}} \end{bmatrix}.$$

This gives us a total of 8 reduced-form effects. The predicted moments from our model have similar intuitive interpretations as those above and are listed in Appendix B.4.1.

The results of this estimation are presented in Panel (b) of Table 5. Our baseline case in Column (1), where $\gamma = 0.15$ and $\varepsilon^{PD} = -2.5$, results in similar estimates of the parameter σ^F as in Panel (a) but they are more precisely estimated due to the additional variation in the Bartik shocks. Columns (2)-(4) show similar estimates for different values of γ. Columns (5)-(7) presents results for specifications in which we estimate rather than calibrate ε^{PD}. However, this parameter is not estimated very precisely. The point estimates range from roughly -10 to -4, which corresponds to values used in the macro and trade literatures (Coibion et al., 2012; Arkolakis et al., 2013). As the calibrated value of γ increases, the estimated value of ε^{PD} declines.[79] However, as discussed in Section 6.2, the combination of parameters $\gamma(\varepsilon^{PD} + 1)$ is point identified and is sufficient to determine the incident on firm owners. In the next section, we discuss this relation between parameters in the context of our incidence calculation and how these parameters influence the elasticity of labor demand.

Before discussing the implications of these estimates for our incidence calculations, we first evaluate the fit of our model by comparing the estimated reduced-form effects to the predictions of our model. Table 6 presents the estimated reduced-form effects along with the predicted moments based on the estimated parameters for three cases. Panel (a) shows the model for the case where only taxes are used in estimation and corresponds to Column (1) in Panel (a) of Table 5. In all four cases, the model matches the reduced-form estimates well. However, most of of the effects are not precisely estimated, with the exception of the effect of taxes on establishment growth. This estimation has three parameters and four moments, which allows us to conduct a test of over identifying restrictions. The last line of Panel (a) reports the results of this test and shows that this restriction is not rejected by the data. Panels (b) and (c) report similar results models corresponding to Columns (1) and (5) of Panel (b) of Table 5, respectively. In both cases the models fit the reduced-form estimates well and do not reject the over identification restriction. The benefit of using the additional variation in the Bartik shock is evident in these panels as the corresponding moments are more precisely estimated than those in Panel (a).

[79]This relationship is illustrated in more detail in Appendix Figure A3.

7 Welfare Effects and Policy Implications

This section computes equilibrium incidence for a variety of values of the calibrated parameters. We then use our estimates to calculate the revenue-maximizing tax rates implied by our estimates.

7.1 Welfare Effects

We use the estimates of the structural parameters described in the previous section to implement the incidence formulae for wages, rents, and profits. The resulting estimates are displayed in Table 7 for the three different classical minimum distance estimators.

Panel (a) shows the effects of a one percent business tax cut on wage growth, rental cost growth, real wage growth, and profit growth. Column (1) in Panel (a) shows the incidence results for the CMD estimator with just the tax shock.[80] A 1% cut in business taxes increases wages by approximately 1.4% over a ten-year period. Business tax cuts also increase rental costs. On average, rental costs increase by roughly 1.2%. As a result, real wages go up by roughly 25% less than the increase in wages. The last element of Column (1) in Panel (a) shows that profits increase by nearly one percent. Column (4) shows what these four estimates imply for the share of incidence accruing to landowners, workers, and firm owners. In contrast to the conventional view that 100% of the burden of corporate taxation falls on workers in an open economy, the estimated share of the burden for workers is only roughly 35%. Column (2) presents the incidence calculations for the baseline parameters of the CMD estimator with tax and Bartik shocks, which corresponds to Column (1) of Panel (b) of Table 5, and yields similar results with more statistical precision. The effect on wages and rents decline slightly and the profit estimate increases modestly. Column (5) shows that these estimates indicate that firm owners bear roughly 35% of the burden.

In order to assess the effect of different values of the calibrated parameters γ and ε^{PD} on our results, we calculate the share of total incidence accruing to firm owners for a wide range of values of each of these parameters. Figure 8 Part A plots these results and shows that our baseline values of $\gamma = 0.15$ and $\varepsilon^{PD} = -2.5$ give a conservative share of the incidence to firm owners. Part A shows that using calibrations with more elastic product demand elasticities, while holding the output elasticity of labor constant at $\gamma = 0.15$, does not change the result that

[80] Note that this column corresponds to the parameter estimates in Column (1) of Panel (a) of Table 5.

the share to firm owners is between 35 and 40%. Increasing the calibrated output elasticity of labor generally increases the share accruing to firm owners. Part A indicates that larger product demand elasticities ε^{PD} and/or larger output elasticities of labor γ result in larger burdens on firm owners.

Column (3) of Panel (a) shows the incidence results for the CMD estimator that also estimates ε^{PD}, the product demand elasticity. These results show slightly lower effects on wages and rents, while showing larger impacts on profits. The share of incidence results in Column (6) indicate that firm owners bear roughly 40% and landowners bear 23% of the burden, leaving workers with substantially less than 100% of the burden. As discussed in Section 6.2, the incidence formulae on welfare and profits are point-identified even when the individual parameters γ and ϵ^{PD} are not themselves point-identified. This identification result is this responsible for the fact that these shares are independent of the calibrated value of γ as shown by Part B of Figure 8.[81]

Figure 6 and the discussion in Section 5 show that the effective labor supply and labor demand curves are crucial determinants of the incidence on wages. Panel (b) Table 7 shows the estimated supply and demand elasticities corresponding to the three CMD estimators. On the supply side, Column (1) shows the labor supply elasticity without housing market effects is roughly two percent. Incorporating housing market interactions lowers the effective elasticity of labor supply. This estimate of a labor supply is close to other estimates in the literature. Based in a calibrated model of population flows, Albouy and Stuart (2013) estimate that the labor supply elasticity is 1.98. Empirical estimates are comparable if not modestly larger. The ranges cited by Bartik (1991) and Notowidigdo (2013) are roughly 2 to 4. Importantly, this shows that our estimates are conservative with respect to our bottom line results since other labor supply elastics would imply lower incidence on wages and, consequently, more incidence on firm owners.

On the demand side, Panel (b) also provides estimates of the micro elasticity of labor demand, which measures the intensive margin responses of establishments' labor demand to wage changes, and the macro elasticity, which also incorporates extensive margin effects of establishment entry and exit from the local labor market. The first two CMD estimators in Column (1) and (2) show micro elasticities of labor demand of -1.2 and macro elasticities of roughly -2. While there are

[81] Appendix Figure A3 shows the relationship between calibration values and estimates as well as their implications for markups.

few estimates of the average slope of local labor demand, perhaps as a consequence of common assumptions of a representative firm (Card, 2011) and its implied infinite labor demand elasticity (Kline, 2010), our result in consistent with values cited in the literature. In particular, based on estimates from Hamermesh (1993), Kline and Moretti (2014) use a macro elasticity of local labor demand of -1.5. Column (3) shows estimates for the CMD estimator that estimates product demand elasticities ε^{PD}. Column (3) shows a much larger macro labor demand elasticity of -24.5 that is remarkably close to the estimate from Albouy and Stuart (2013), who obtains a calibration-based elasticity of -22.79 when using quality-of-life changes and -24.7 when using housing-productivity changes. However, this macro labor demand elasticity is estimated very imprecisely. Importantly, the incidence results with this elastic labor demand did not imply a small share of the burden on firm owners. The intuition for this result is that the parameters consistent with a highly elastic labor demand curve also imply large shifts in labor demand.

Overall, these results in Table 7 show that workers do not bear 100% percent of state corporate taxes. Landowners often bear some of the increase in wages, which many empirical analyses of corporate tax incidence attribute as gains to workers. However, the total impacts of corporate taxes exceed the sum of incidence on workers and landowners. The primary empirical contribution of this paper pertains to the incidence on firm owners. We find that the incidence on firm owners in Columns 1 through 3 as well as for a wide variety of reasonable calibration values is statistically significant and economically important. The bottom line of these results is that firm owners bear a substantial burden of the incidence of U.S. state corporate taxes.

Finally, it is important to note that we document average effects, but there is likely heterogeneity in the effects of corporate tax cuts across regions.[82] For instance, housing markets vary considerably, which affects the incidence of local corporate tax cuts. Our results should be interpreted as national averages but location-specific considerations can alter local incidence and the structure of optimal local corporate tax policy.

[82]For example, places like Houston, which have real estate markets that can accommodate large inflows of people without large housing costs increases, have more elastic effective labor supply curves ε^{LS}. Corporate tax cuts in these places will tend to result in more adjustment in population than in prices. Consequently, location decision distortions, and thus efficiency costs, are likely to be larger in these areas. This statement applies in the absence of other market failures affecting these areas. In terms of equity, lower adjustment in prices means less incidence on workers. Lower adjustments in prices, however, benefits firm owners since labor costs won't increase by as much as they would in places like San Francisco where housing markets are less elastic. Based on this reasoning, the efficiency and equity consequences of corporate tax cuts will be bigger in places like Texas. In locations like San Francisco, the efficiency costs are likely less stark and corporate tax cuts will result in more non-firm incidence on landowners.

7.2 Discussion & Tax Revenue Implications

Firm mobility is an often-cited justification in proposals to lower states' corporate tax rates. In this section, we explore whether firm mobility is a compelling reason to lower or eliminate state corporate taxes. Additionally, we consider how interactions with other state tax revenues, such as personal income taxes, and with features of apportionment rules affect this conclusion.

Consider first the effect of a corporate tax cut solely on the corporate tax income revenues of a given state. In Appendix D, we show that the corporate-tax-revenue-maximizing corporate tax rate equals the following expression.

$$\tau_c^* = \frac{1}{\dot{\bar{\pi}}_c + \dot{E}_c}.$$

This expression shows that the revenue-maximizing corporate tax rate is inversely related to the effects of corporate tax changes on average establishment profitability and on establishment mobility. Recall that $\dot{\bar{\pi}}_c$ denotes average percentage change in after-tax profit and $\dot{E}_c$ is the percentage change in establishments in location c. Based on our estimates of average national parameters, we find that establishment mobility on its own does not justify a low maximal tax rate. In particular, using estimates from Table 7, Panel (a), Column (3), we calculate the maximal tax rate and report the results in Table 8 for selected states. This rate is roughly 40%, substantially above current state corporate tax rates.[83]

However, this calculation does not account for fiscal externalities on other aspects of local public finance that are quantitatively important. For instance, one can show that the *total state tax revenue* maximizing corporate rate equals the following expression:

$$\tau_c^{**} = \frac{1}{\dot{\bar{\pi}}_c + \dot{E}_c + (\text{revshare}_c^{\text{pers}}/\text{revshare}_c^{C})(\dot{w}_c + \dot{N}_c)},$$

where $\text{revshare}_c^{\text{pers}}/\text{revshare}_c^{C}$ is the relative share of personal tax revenues and corporate tax revenues. This additional term in the denominator reflects revenue externalities from reduced personal income and sales tax revenue due to worker mobility. Since state personal income and state sales tax revenue comprise a larger share of total tax revenue for almost all states,

[83] Note that this measure varies slightly across states due to differences state size. A corporate tax cut in large states like California affects more local areas simultaneously, which slightly diminishes the effect of a tax cut to an extent that depends on the state's establishment share (as shown in Appendix D). We adjust our estimates of the percent change in local establishments $\dot{E}_c$ by state to account for this simultaneous impact based on state size. The first corporate-revenue-maximizing tax rate, $\tau_s^* = \frac{1}{\dot{E}_s + \dot{\bar{\pi}}_c}$, is a function of this state-size adjusted establishment response $\dot{E}_s$ and the estimate of national average change in profits $\dot{\bar{\pi}}_c$ from Table 7, Panel (a), Column (3).

including this extra term in the denominator lowers the revenue-maximizing corporate tax rate all else equal.[84] We present these revenue shares for a few selected states in Table 8 and provide these statistics for all states in Appendix D. In California, for example, the personal to corporate revenue share in 2010 was 9. Based on national averages of the percentage change in wages $\dot{\hat{w}}_c$ and the percentage change in population $\dot{\hat{N}}_c$, the revenue-maximizing rate absent fiscal externalities $\tau^*_{CA} = 39\%$ exceed the revenue-maximizing rate with fiscal externalities $\tau^{**}_{CA} = 3.9\%$ by a factor of 10. This difference in revenue-maximizing rates is smaller in states that raise a relatively smaller share of their revenue from personal income taxes and sales taxes.

In addition to fiscal externalities, there are also important and interesting complexities in determining the revenue-maximizing rate due to apportionment. The relevant rate that incorporates apportionment is $\frac{\tau_c^{**}}{1-\theta_s^x}$. This rate scales up τ_c^{**} since only a portion of state corporate taxes, namely the payroll and property components, distort location decisions.[85] Since sales apportionment is destination based, it does not distort location decisions (absent trade costs) and allows for higher revenue-maximizing tax rates. Reducing the location dependence of corporate taxes increases the revenue-maximizing rate since it alleviates the costs of fiscal externalities mentioned above. We present calculations of $\frac{\tau_c^{**}}{1-\theta_s^x}$ for a few selected states in the last Column of Table 8. A comparison of New Mexico and Arizona illustrates the importance of apportionment considerations. As shown in Table 8, New Mexico's statutory corporate tax rate τ^c_{NM} was 7.6% in 2010 and Arizona's rate τ^c_{AZ} was 7.0%. New Mexico used an equal-weighted apportionment formula with $\theta^w_{NM} = \theta^\rho_{NM} = \theta^x_{NM} = 33\%$ in 2010. Arizona, however, put much more weight on sales as $\theta^x_{AZ} = 80\%$. As a result, New Mexico's revenue-maximizing rate was roughly four times smaller than that of Arizona despite only a 0.6 percentage point difference in their statutory corporate rates. In particular, $\frac{\tau^{**}_{NM}}{1-\theta^x_{NM}} = 2.2\%$ and $\frac{\tau^{**}_{AZ}}{1-\theta^x_{AZ}} = 8.6\%$. Perhaps for this reason, we've seen more states shift more weight towards the sales factor θ^x_s as shown in Figure 2. Overall, other tax factors, including apportionment formulae and differences in the reliance on other sources of tax revenue, account for the large geographic variation in the total revenue-maximizing state corporate tax rates that range from 0.7% to 42%.

[84] In addition, this calculation abstracts from the welfare, productivity, and amenity enhancing effects of prudent government spending.

[85] This statement applies in models without trade costs. See Fajgelbaum et al. (2014) for a closely related model that incorporates trade costs.

8 Conclusion

This paper evaluates the welfare effects of cutting corporate income taxes on business owners, workers, and landowners. This question is important for three reasons. First, the conventional view among many economists and policy makers – that workers fully bear the incidence of corporate taxes in an open economy – is based on fairly abstract arguments and less than fully convincing evidence. Second, evaluating the welfare effect of corporate taxes also highlights efficiency consequences of corporate taxation and has direct implications for revenue-maximizing rates. Third, the welfare impacts of corporate tax cuts closely relate to the welfare impacts of a broad class of local economic development policies that aim to entice businesses to locate in their jurisdictions.

We estimate the incidence of corporate taxes in four steps. First, we use state corporate tax apportionment rules and matched establishment-firm data to construct a new measure of the effective tax rate that businesses pay at the local level. Second, we relate changes in these effective rates to local outcomes and show that a one percent cut in business taxes increases establishment growth by 3 to 4% over a ten-year period. Third, we develop novel local labor markets framework with heterogeneously productive and monopolistically competitive firms. This framework not only enables us to characterize the incidence on workers, firms, and landowners in terms of a few parameters, but it also can be used to answer other important questions such as the welfare impacts of business location subsidies for individual companies, optimal local tax policy, and the incidence of technological change. Fourth, and most importantly, we combine these three components – a new measure of business taxes, new reduced form effects of business taxes, and a new framework – to estimate the incidence of corporate taxes on firm owners, workers, and landowners.

Our main result is that firm owners bear a substantial portion of the incidence of corporate taxes in an open economy. The intuition for this result is that non-tax considerations, namely heterogeneous productivity, can limit the mobility of businesses. If a business is especially productive in a given location, small changes in taxes won't have large enough impacts on profitability to make changing locations attractive. For instance, technology firms may still find it optimal to locate in Silicon Valley, even if corporate tax rates were increased modestly. Consequently, firm owners bear a substantial portion of the incidence of corporate tax changes; a result that starkly contrasts with the conventional wisdom.

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Table 2: Summary Statistics

Variable	Mean	S.D.	Min	Max	N
Annual Outcome Data from BEA and CBP					
Year	1995	8.9	1980	2010	15190
Log Population: $\ln N_{c,t}$	13.8	1.1	10.9	16.1	15190
Log Employment: $\ln L_{c,t}$	13.2	1.2	9.4	15.6	15190
Log Establishments: $\ln E_{c,t}$	10.0	1.2	6.5	12.4	15190
Annual Data on Apportionment Rules and Corporate, Personal, and Business Tax Rates					
State Corporate Tax Apportionment Parameters					
Payroll Apportionment Weight: $\theta^{w}_{s,t}$	22.7	11.6	0.0	33.3	15190
Property Apportionment Weight: $\theta^{\rho}_{s,t}$	22.8	11.6	0.0	33.3	15190
Sales Apportionment Weight: $\theta^{x}_{s,t}$	54.5	23.2	25	100	15190
Corporate Income					
Rate: $\tau^{c}_{s,t}$	6.6	3.0	0.0	12.3	15190
% Change in Net-of-Rate: $\Delta \ln (1-\tau^{c})_{s,t,t-1}$	-0.01	0.4	-5.4	3.8	15190
Personal Income					
Effective Rate: $\tau^{i}_{s,t}$	2.6	1.7	0.0	7.4	15190
% Change in Net-of-Rate: $\Delta \ln (1-\tau^{i})_{s,t,t-1}$	0.03	0.2	-3.3	2.5	15190
Business Income					
Rate: $\tau^{b}_{c,t}$	3.1	1.1	0.3	5.4	15190
% Change in Net-of-Rate: $\Delta \ln (1-\tau^{b})_{c,t,t-1}$	-0.01	0.2	-1.8	1.2	15190
Decadal Data					
Year	2000	8.2	1990	2010	1470
% Change in Population: $\Delta \ln N_{c,t,t-10}$	11.2	10.4	-16.6	76.1	1470
% Change in Establishments: $\Delta \ln E_{c,t,t-10}$	15.2	16.5	-23	126.2	1470
% Change in Adjusted Wages: $\Delta \ln w_{c,t,t-10}$	-2.8	7.2	-31.2	14.9	1470
% Change in Adjusted Rents: $\Delta \ln r_{c,t,t-10}$	8.5	12.0	-41.4	43.4	1470
% Change in Net-of-Corp.-Rate: $\Delta \ln (1-\tau^{c})_{s,t,t-10}$	-0.1	1.1	-5.4	4.5	1470
% Change in Net-of-Pers.-Rate: $\Delta \ln (1-\tau^{i})_{s,t,t-10}$	-1.3	1.1	-5.3	1.3	1470
% Change in Net-of-Bus.-Rate: $\Delta \ln (1-\tau^{b})_{c,t,t-10}$	-0.8	0.6	-2.8	1.3	1470
% Change in Gov. Expend./Capita: $\Delta \ln G_{c,t,t-10}$	0.0	0.6	-13.3	11.6	1470
Bartik Shock: $\text{Bartik}_{c,t,t-10}$	7.8	4.8	-15.2	26.0	1470

SOURCES: BEA, CBP, Zidar (2013), Suárez Serrato and Wingender (2011). Corporate tax sources in Section 2.

Table 3: Annual Effects of Business Tax Cuts on Establishment Growth

Establishment Growth	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δ Log Net-of-Business-Tax$_t$	0.11	0.16	-0.04	0.19	0.42	0.20	0.27
	(0.16)	(0.21)	(0.24)	(0.18)	(0.26)	(0.30)	(0.38)
Δ Log Net-of-Business-Tax$_{t-1}$	0.14	0.36	0.36	0.14	0.47*	0.54**	0.59
	(0.13)	(0.22)	(0.23)	(0.14)	(0.27)	(0.27)	(0.39)
Δ Log Net-of-Business-Tax$_{t-2}$	0.48***	0.50**	0.51**	0.52**	0.54**	0.61**	0.63
	(0.17)	(0.20)	(0.24)	(0.20)	(0.25)	(0.29)	(0.38)
Δ Log Net-of-Business-Tax$_{t-3}$	0.57***	0.55**	0.58**	0.57**	0.55*	0.62*	0.50
	(0.20)	(0.23)	(0.25)	(0.22)	(0.28)	(0.31)	(0.34)
Δ Log Net-of-Business-Tax$_{t-4}$	0.20	0.19	0.17	0.15	0.16	0.17	0.13
	(0.13)	(0.13)	(0.16)	(0.25)	(0.30)	(0.34)	(0.37)
Δ Log Net-of-Business-Tax$_{t-5}$	0.02	0.03	-0.00	0.19	0.25	0.25	0.21
	(0.25)	(0.26)	(0.26)	(0.32)	(0.37)	(0.38)	(0.41)
Δ Log Net-of-Business-Tax$_{t-6}$				0.18	0.22	0.26	0.30
				(0.25)	(0.31)	(0.31)	(0.36)
Δ Log Net-of-Business-Tax$_{t-7}$				0.34**	0.43*	0.33	0.46*
				(0.16)	(0.23)	(0.23)	(0.26)
Δ Log Net-of-Business-Tax$_{t-8}$				0.21	0.21	0.15	0.26
				(0.13)	(0.17)	(0.18)	(0.18)
Δ Log Net-of-Business-Tax$_{t-9}$				0.03	0.01	0.04	0.02
				(0.14)	(0.15)	(0.16)	(0.17)
Δ Log Net-of-Business-Tax$_{t-10}$				0.26	0.25	0.32*	0.31*
				(0.16)	(0.16)	(0.16)	(0.18)
Δ Log Net-of-Business-Tax$_{t+1}$		0.10	0.03		0.13	0.20	0.02
		(0.20)	(0.20)		(0.22)	(0.23)	(0.30)
Δ Log Net-of-Business-Tax$_{t+2}$		-0.02	0.22		-0.06	0.30	0.08
		(0.16)	(0.20)		(0.18)	(0.23)	(0.31)
Δ Log Net-of-Business-Tax$_{t+3}$			-0.10			0.04	-0.05
			(0.32)			(0.33)	(0.40)
Δ Log Net-of-Business-Tax$_{t+4}$			-0.33			-0.36	-0.30
			(0.22)			(0.25)	(0.45)
Δ Log Net-of-Business-Tax$_{t+5}$			-0.33			-0.39	-0.28
			(0.23)			(0.27)	(0.42)
Δ Log Net-of-Business-Tax$_{t+6}$							-0.15
							(0.33)
Δ Log Net-of-Business-Tax$_{t+7}$							-0.30
							(0.38)
Δ Log Net-of-Business-Tax$_{t+8}$							-0.30
							(0.33)
Δ Log Net-of-Business-Tax$_{t+9}$							-0.05
							(0.11)
Δ Log Net-of-Business-Tax$_{t+10}$							-0.11
							(0.13)
Observations	13,230	12,250	10,780	10,780	9,800	8,330	5,880
R-squared	0.225	0.143	0.099	0.197	0.106	0.054	0.120
Cumulative Effect over 5 Years	1.51**	1.80*	1.59	1.77*	2.38	2.39	2.34
	(0.75)	(1.02)	(1.14)	(1.03)	(1.58)	(1.72)	(2.10)
Cumulative Effect over 10 Years				2.79*	3.49	3.49	3.70
				(1.51)	(2.27)	(2.36)	(2.81)
P-value of All Lags=0:	0.003	0.012	0.051	0.000	0.002	0.037	0.036
P-value of All Leads=0:		0.74	0.40		0.66	0.46	0.92

NOTES: This table shows the effects of annual local business tax cuts on local establishment growth. Data are for 490 county-groups. See Section 2 for sources. Cumulative effects and F-stats of joint tests that all leads and lags are zero indicate that tax cuts increase local establishment growth and do not exhibit statistically non-zero pre-trends. Regressions use initial population as weights and include year fixed effects and dummies for states in the industrial midwest in the 1980s. Standard errors clustered by state are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Effects of Business Tax Cuts on Establishment Growth over 10 Years

Establishment Growth	(1)	(2)	(3)	(4)	(5)	(6)
Δ ln Net-of-Business-Tax Rate	4.07**	4.14**	4.06**	3.35**	3.91**	3.24**
	(1.82)	(1.80)	(1.83)	(1.43)	(1.78)	(1.41)
Δ State ITC		-0.46				-0.17
		(0.32)				(0.30)
Δ ln Gov. Expend./Capita			-0.01			-0.01
			(0.01)			(0.01)
Bartik				0.59***		0.57***
				(0.19)		(0.18)
Change in Other States' Taxes					-4.66***	-4.18***
					(1.60)	(1.43)
Observations	1,470	1,470	1,470	1,470	1,470	1,470
R-squared	0.472	0.475	0.472	0.491	0.481	0.500

NOTES: This table shows the effects of local business tax changes over ten years on local establishment growth. The data are decade changes from 1980-1990, 1990-2000, and 2000-2010 for 490 county-groups. See Section 2 for data sources. Col (2)-(6) show that the effect of business taxes is robust to controlling for state investment tax credit changes in Col (2), per capita government spending changes in Col (3), Bartik shocks in Col (4), external tax shocks due to changes in tax rules of other states in Col (5), and all of these controls in Col (6). χ^2 tests indicate that the coefficient in Col (1) and Col (4) are not statistically different. Similarly, the negative effect from tax cuts in other states is not statistically different than the positive effect of tax cuts. Regressions use initial population as weights and include year fixed effects and dummies for states in the industrial midwest in the 1980s. Standard errors clustered by state are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Minimum Distance Estimates of Structural Parameters

Panel (a) Tax Shock Only

Calibrated Parameters	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Output Elasticity γ	0.15	0.1	0.2	0.3	0.1	0.2	0.3
Elasticity of Product Demand ε^{PD}	-2.5	-2.5	-2.5	-2.5	-3.5	-3.5	-3.5
Estimated Parameters							
Idiosyncratic Location	0.110	0.128*	0.094	0.067	0.063	0.035	0.016
Productivity Dispersion σ^F	(0.069)	(0.069)	(0.070)	(0.074)	(0.042)	(0.045)	(0.051)
Idiosyncratic Location	0.469	0.476	0.462	0.444	0.467	0.437	0.405
Preference Dispersion σ^W	(0.360)	(0.362)	(0.358)	(0.352)	(0.360)	(0.350)	(0.334)
Elasticity of Housing	2.244	2.194	2.313	2.511	2.265	2.595	3.163
Supply η	(3.163)	(3.033)	(3.338)	(3.834)	(3.216)	(4.049)	(5.610)

Panel (b) Bartik and Tax Shock

Calibrated Parameters	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Output Elasticity γ	0.15	0.1	0.2	0.3	0.1	0.2	0.3
Elasticity of Product Demand ε^{PD}	-2.5	-2.5	-2.5	-2.5	Estimated below		
Estimated Parameters							
Idiosyncratic Location	0.174*	0.200*	0.151	0.110	0.004	0.009	0.013
Productivity Dispersion σ^F	(0.103)	(0.106)	(0.102)	(0.100)	(0.052)	(0.106)	(0.155)
Idiosyncratic Location	0.765**	0.770**	0.759**	0.749**	0.725**	0.726**	0.725**
Preference Dispersion σ^W	(0.313)	(0.317)	(0.310)	(0.304)	(0.304)	(0.304)	(0.304)
Elasticity of Housing	2.467	2.483	2.473	2.544	3.154	3.145	3.155
Supply η	(5.099)	(5.127)	(5.148)	(5.456)	(8.813)	(8.763)	(8.816)
Elasticity of Product					-9.778	-5.344	-3.926
Demand ε^{PD}					(15.506)	(7.715)	(5.169)

NOTES: This table shows the estimated parameters of our model. The data are decade changes from 1980-1990, 1990-2000, and 2000-2010 for 490 county-groups. See Section 2 for data sources. Panel (a) presents estimates from models with only the tax shock relying on 4 moments to estimate 3 parameters for a variety of assumed values of γ and ε^{PD}. Panel (b) presents estimates from models with both the Bartik shock and the tax shock. The first four columns calibrate the parameters γ and ε^{PD} while the last three columns calibrate only γ and present estimates of ε^{PD}. Section 6 for more details on the estimation. Regressions use initial population as weights and include year fixed effects and dummies for states in the industrial midwest in the 1980s. Standard errors clustered by state are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Empirical and Predicted Moments from Structural Model

Panel (a) Tax Shock Only ($\gamma = .15, \varepsilon^{PD} = -2.5$)				
	Population	Wage	Rent	Establishments
Empirical Moments				
Business Tax	2.331	1.451	1.172	4.074**
	(1.51)	(0.94)	(1.44)	(1.82)
Predicted Moments				
Business Tax	2.323	1.438	1.159	4.084
$\chi^2(1)$ Stat	0.001	χ^2 P-Value	0.979	

Panel (b) Bartik and Tax Shock ($\gamma = .15, \varepsilon^{PD} = -2.5$)				
	Population	Wage	Rent	Establishments
Empirical Moments				
Business Tax	1.792	0.777	0.323	3.354**
	(1.33)	(0.82)	(1.37)	(1.43)
Bartik	0.445**	0.557***	0.702**	0.595***
	(0.18)	(0.08)	(0.27)	(0.19)
Predicted Moments				
Business Tax	1.300	1.211	0.724	2.783
Bartik	0.453	0.568	0.740	0.542
$\chi^2(2)$ Stat	0.569	χ^2 P-Value	0.752	

Panel (c) Bartik and Tax Shock ($\gamma = .15$) and estimated ε^{PD}				
	Population	Wage	Rent	Establishments
Empirical Moments				
Business Tax	1.792	0.777	0.323	3.354**
	(1.33)	(0.82)	(1.37)	(1.43)
Bartik	0.445**	0.557***	0.702**	0.595***
	(0.18)	(0.08)	(0.27)	(0.19)
Predicted Moments				
Business Tax	1.168	1.004	0.523	3.054
Bartik	0.471	0.562	0.732	0.574
$\chi^2(1)$ Stat	0.288	χ^2 P-Value	0.592	

NOTES: This table shows the estimated reduced forms used in our minimum distance estimation as well as the models predicted by our model.The reduced forms are estimated via a system OLS. The data are decade changes from 1980-1990, 1990-2000, and 2000-2010 for 490 county-groups. See Section 2 for data sources. Panel (a) presents estimates of the model using only the tax shock for parameters ($\gamma = .15, \varepsilon^{PD} = -2.5$); panel (b) uses the Bartik shock and the tax shock for parameters ($\gamma = .15, \varepsilon^{PD} = -2.5$); and Panel (c) uses both shocks, calibrates $\gamma = .15$ and estimates ε^{PD}. Results of the χ^2 test of over identifying restrictions are below each model. Section 6 for more details on the estimation. Regressions use initial population as weights and include year fixed effects and dummies for states in the industrial midwest in the 1980s. Standard errors clustered by state are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Estimates of Economic Incidence

Panel (a) Incidence

	Incidence			Shares of Incidence		
	(1)	(2)	(3)	(4)	(5)	(6)
	Tax Only	Tax & Bartik		Tax Only	Tax & Bartik	
Output Elasticity γ	0.15	0.15	0.15	0.15	0.15	0.15
Elasticity of Product	-2.500	-2.500	-6.852	-2.500	-2.500	-6.852
Demand ε^{PD}			(10.337)			(10.337)
Wages $\dot{w}$	1.438*	1.211**	1.004			
	(0.798)	(0.592)	(0.708)			
Landowners $\dot{r}$	1.159	0.724	0.523	0.371	0.273	0.230
	(1.329)	(1.241)	(1.298)	(0.251)	(0.338)	(0.463)
Workers $\dot{w} - \alpha\dot{r}$	1.090**	0.994***	0.847**	0.348***	0.375***	0.372**
	(0.476)	(0.316)	(0.419)	(0.105)	(0.145)	(0.152)
Firm Owners $\dot{\pi}$	0.879***	0.930***	0.908*	0.281	0.351	0.399
	(0.180)	(0.133)	(0.512)	(0.191)	(0.220)	(0.405)

Panel (b) Demand and Supply Elasticities

	(1)	(2)	(3)
	Tax Only	Tax & Bartik	
Output Elasticity γ	0.150	0.15	0.15
Elasticity of Product	-2.500	-2.500	-6.852
Demand ε^{PD}			(10.337)
Labor Mobility	2.130	1.308**	1.379**
$\frac{1}{\sigma^W}$	(1.636)	(0.535)	(0.578)
Elasticity of	1.615	1.073**	1.163*
Labor Supply	(1.305)	(0.541)	(0.659)
Micro Elasticity	-1.225	-1.225	-1.878
of Labor Demand			(1.551)
Macro Elasticity	-2.584***	-2.086***	-24.509
of Labor Demand	(0.850)	(0.510)	(266.914)

NOTES: This table shows the estimates of economic incidence from our model. Col (1)-(3) of Panel (a) show the estimates of tax changes from our three minimum distance models: using only taxes, using both taxes and Bartik, and using both shocks and estimating ε^{PD}. See Table 5 for details about the estimation of the related structural models. Col (4)-(6) of Panel (a) present the shares of total economic gains to each agent. Panel (b) presents the associated elasticities of labor mobility, effective labor supply, and micro- and macro-elasticities of labor demand for each model. Standard errors clustered by state are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

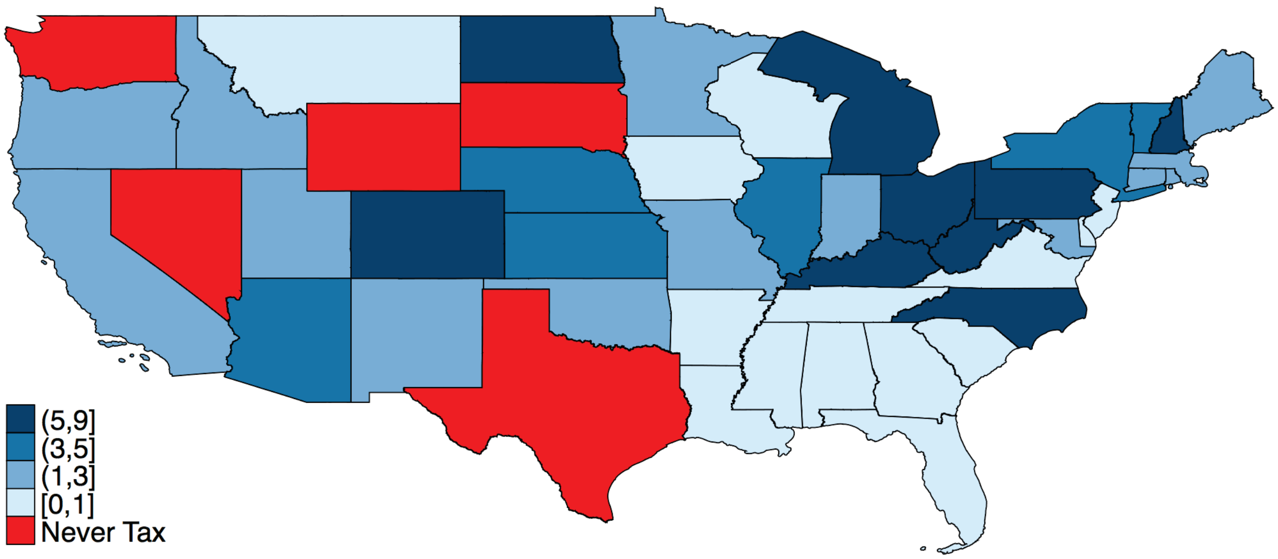
Table 8: Revenue-Maximizing Corporate Tax Rates for Selected States

State	Establishment Share E_s	Revenue Ratio $\text{rev}_s^{\text{pers}}/\text{rev}_s^C$	Sales Apport. Weight θ_s^x	Corporate Tax Rate τ_s	Revenue Max. Corp. Rate τ_s^*	τ_s^{**}	$\tau_s^{**}/(1-\theta_s^x)$
Kansas	1.0	16	33	7.1	36.9	2.3	3.5
New Mexico	0.6	26	33	7.6	39.1	1.5	2.2
California	11.7	9	50	8.8	39.0	3.9	7.8
Virginia	1.5	18	50	6.0	36.0	2.0	4.1
Arizona	1.8	22	80	7.0	36.0	1.7	8.6
Indiana	2.0	21	90	8.5	40.3	1.8	18.4
Texas	7.2		100	0.0	36.4		
U.S. State Average	2.0	21.7	66.1	6.7	38.8	3.0	7.5
U.S. State Median	1.4	17.1	50.0	7.1	38.3	2.2	4.6
U.S. State Min	0.3	0.4	33.3	0.0	33.8	0.3	0.7
U.S. State Max	11.7	141.5	100.0	12.0	46.6	28.1	42.1

NOTES: This table shows the corporate tax revenue-maximizing corporate tax rate τ_s^* and the total tax revenue-maximizing corporate tax rate τ_s^{**}, which accounts for fiscal externalities on personal income sources, for a few selected states (see Appendix Table A3 for the full list of states). These calculations are based on 2010 data and **average national parameter estimates** and do not incorporate heterogeneous housing markets. We use three state statistics to calculate state revenue-maximizing rates discussed in Section 7 and presented in the last columns of the table. These three statistics are the state's share of establishments, the state's ratio of revenue that comes from personal income, i.e. sales and personal income taxes, to their state corporate tax revenue, and their sales apportionment weight. The second column shows each state's share of national establishments in 2010. A corporate tax cut in large states like California affects more local areas simultaneously, which slightly diminishes the effect of a tax cut to an extent that depends on the state's establishment share (as shown in appendix D). We adjust our estimates of the percent change in local establishments $\dot{E}_c$ by state to account for this simultaneous impact based on state size. The first corporate revenue-maximizing tax rate, $\tau_s^* = \frac{1}{\dot{E}_s + \dot{\pi}_c}$, is a function of this state-size adjusted establishment response $\dot{E}_s$ and the estimate of national average change in pre-tax profits $\dot{\pi}_c$ from Table 7, panel (a), column (3). This rate is much higher than τ_s^{**} which accounts for fiscal externalities. The size of fiscal externalities from corporate tax changes vary based on the importance of other revenue sources. We measure the state-specific importance of population dependent revenue sources $\text{rev}_s^{\text{pers}}/\text{rev}_s^C$ with the ratio of (1) total state tax revenue from sales and personal income taxes to (2) total state revenue from corporate income taxes. The product of this state-specific revenue share term and national average responsiveness of wages and population is added to the denominator following the formula presented in Section 7 and Section D. These rates are much lower on average. However, in models without trade costs, location distortions result from payroll and property apportionment but not from sales apportionment. The right-most column divides the total state tax revenue-maximizing state corporate tax rate τ_s^{**} by the apportionment factors that distort establishment location, i.e. $(1-\theta_s^s)$. Since sales is destination based, it does not distort location decisions (absent trade costs) and allows for higher revenue-maximizing tax rates. See Section 7 and Section D in the appendix for more details. Sources: U.S. Census Annual Survey of Governments and the other sources listed in Section 2.

Figure 1: State Corporate Tax Rates

A. Number of Corporate Tax Changes by State since 1979



B. Corporate Tax Rates by State in 2012

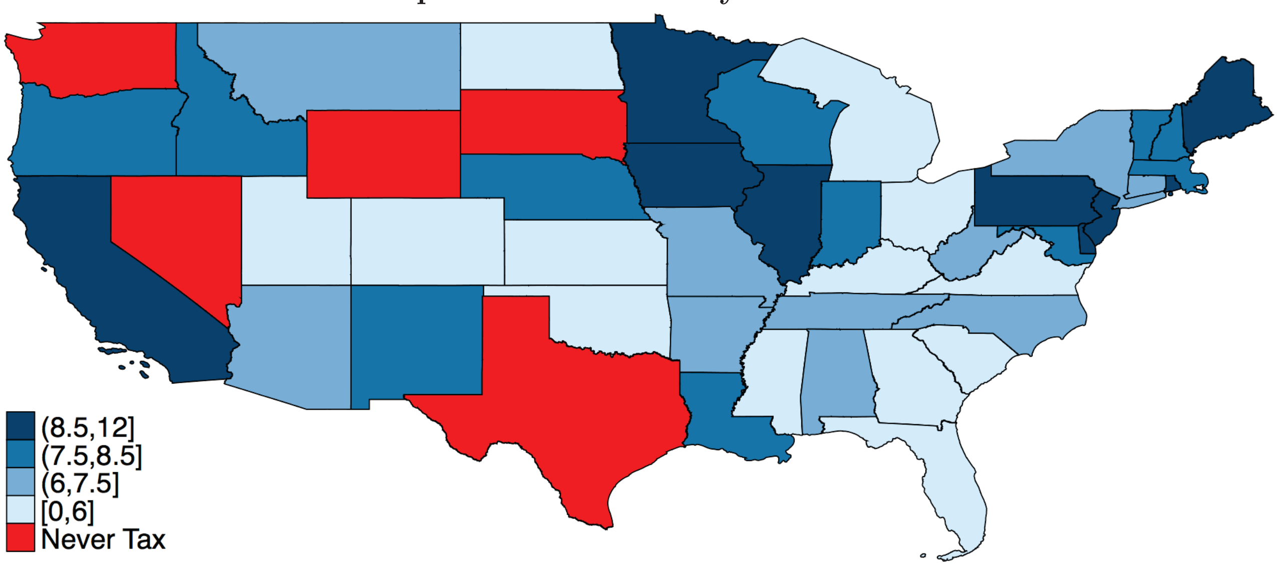
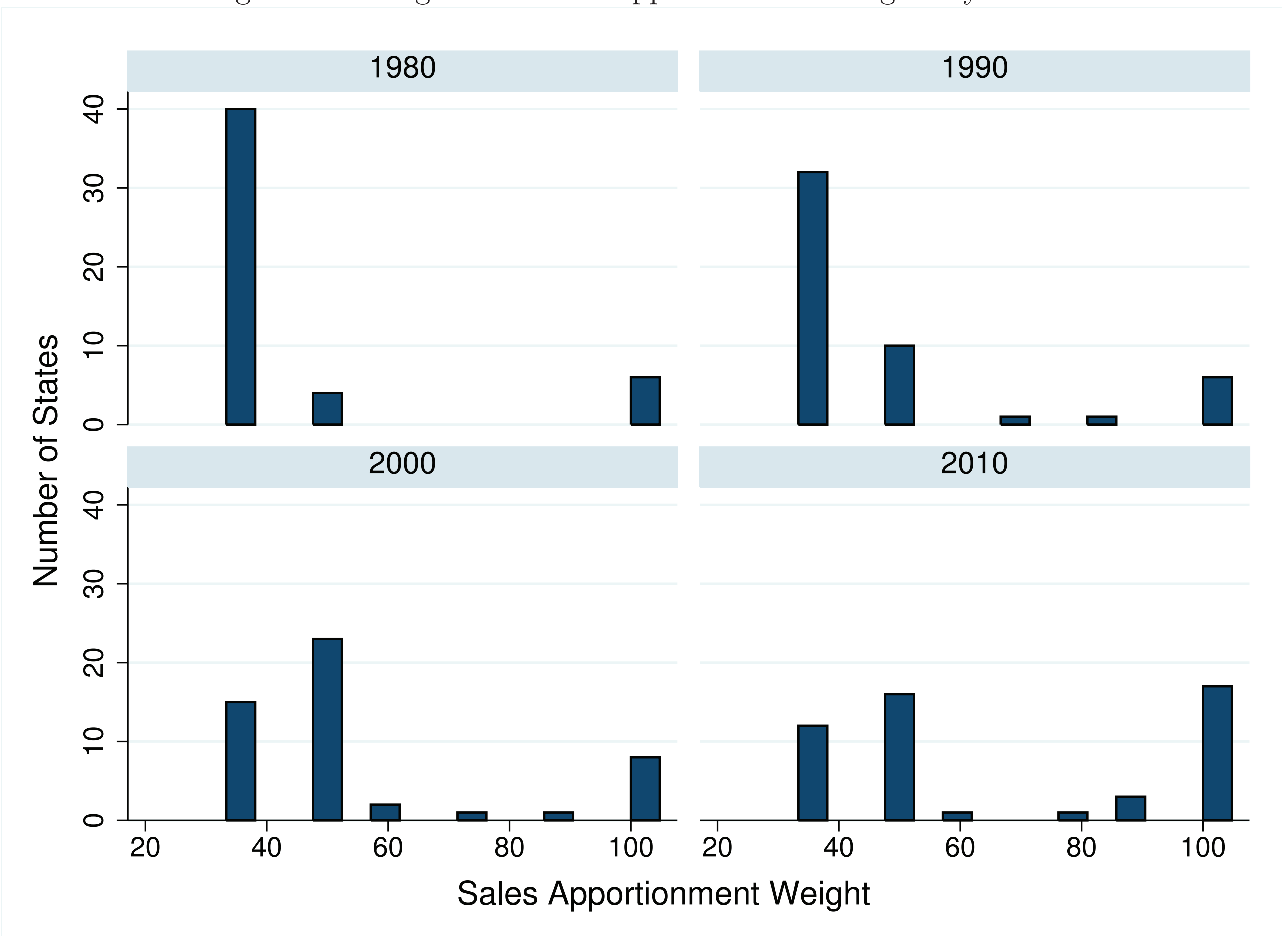
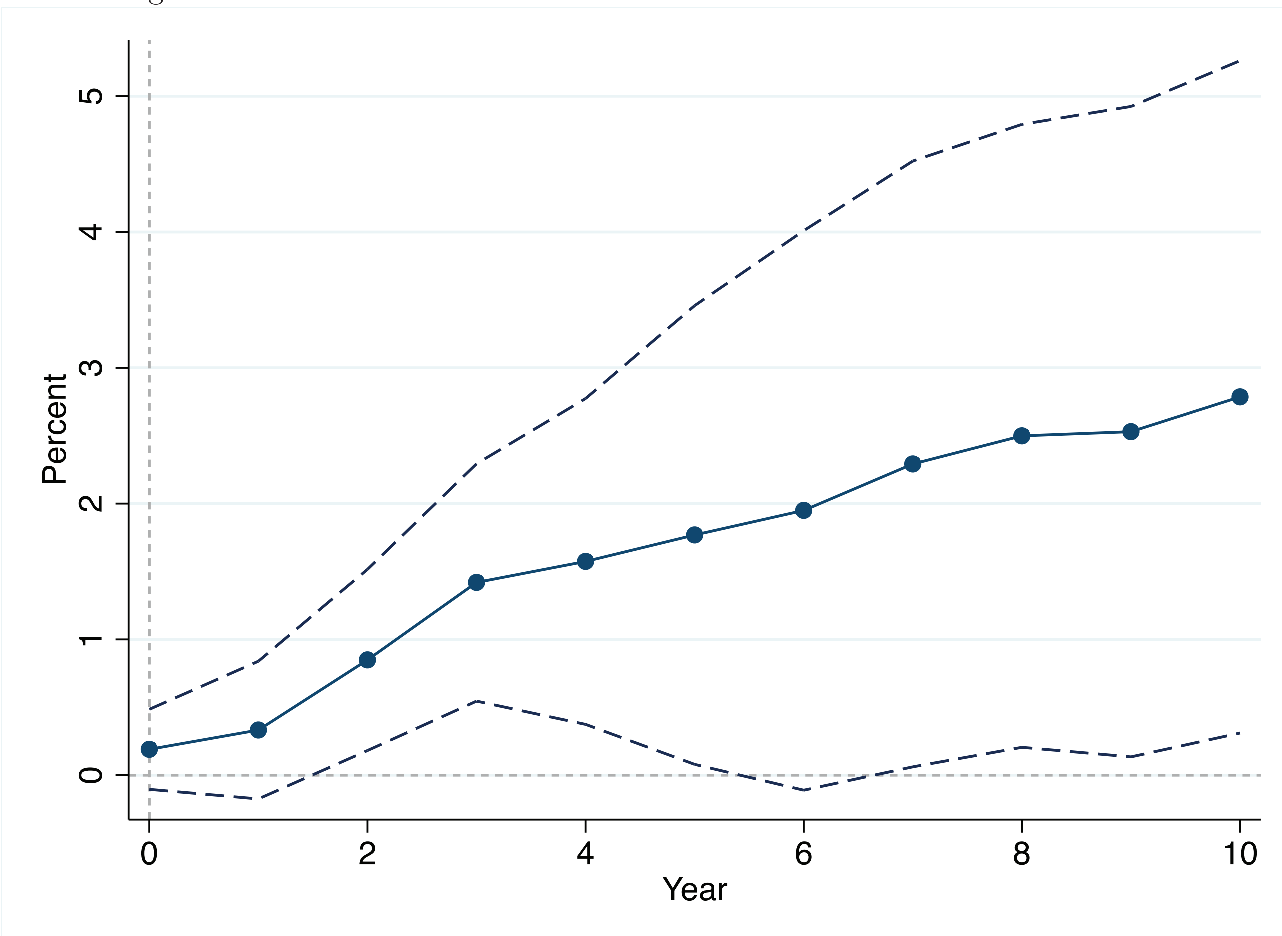


Figure 2: Histogram of Sales Apportionment Weights by Decade



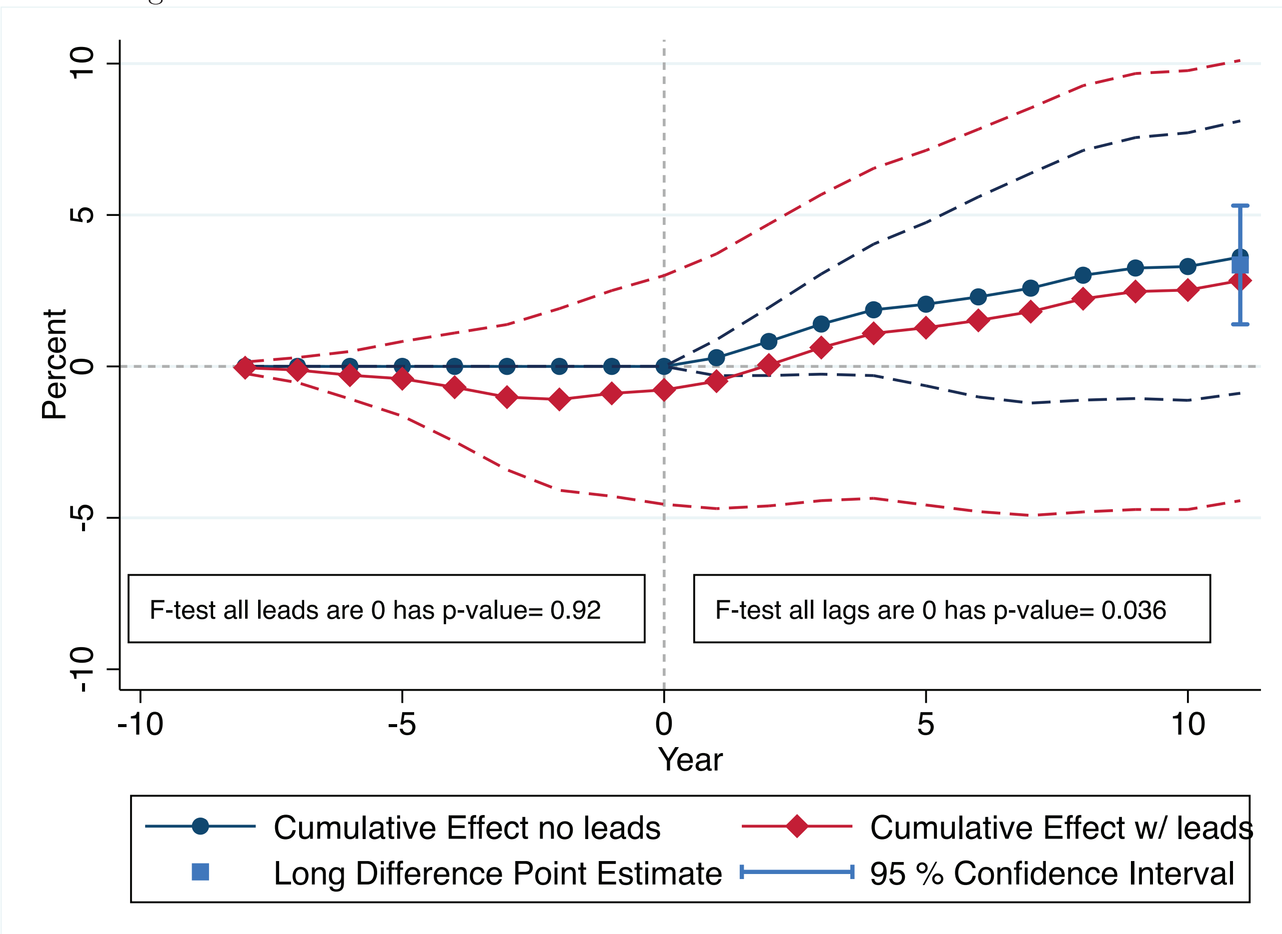
Notes: This figure shows a histogram of the weight on sales activity that states use to apportion the national profits of multi-state firms for tax purposes. Many states have increased their sales apportionment weights in recent decades. Forty states used a one-third weight in 1980. As of 2010, more states put half or full 100% weight on sales activity than the number that still uses the traditional one-third weight. See Section 2.2.1 for a detailed description of state corporate tax apportionment rules.

Figure 3: Cumulative Effects of Business Tax Cuts on Establishment Growth



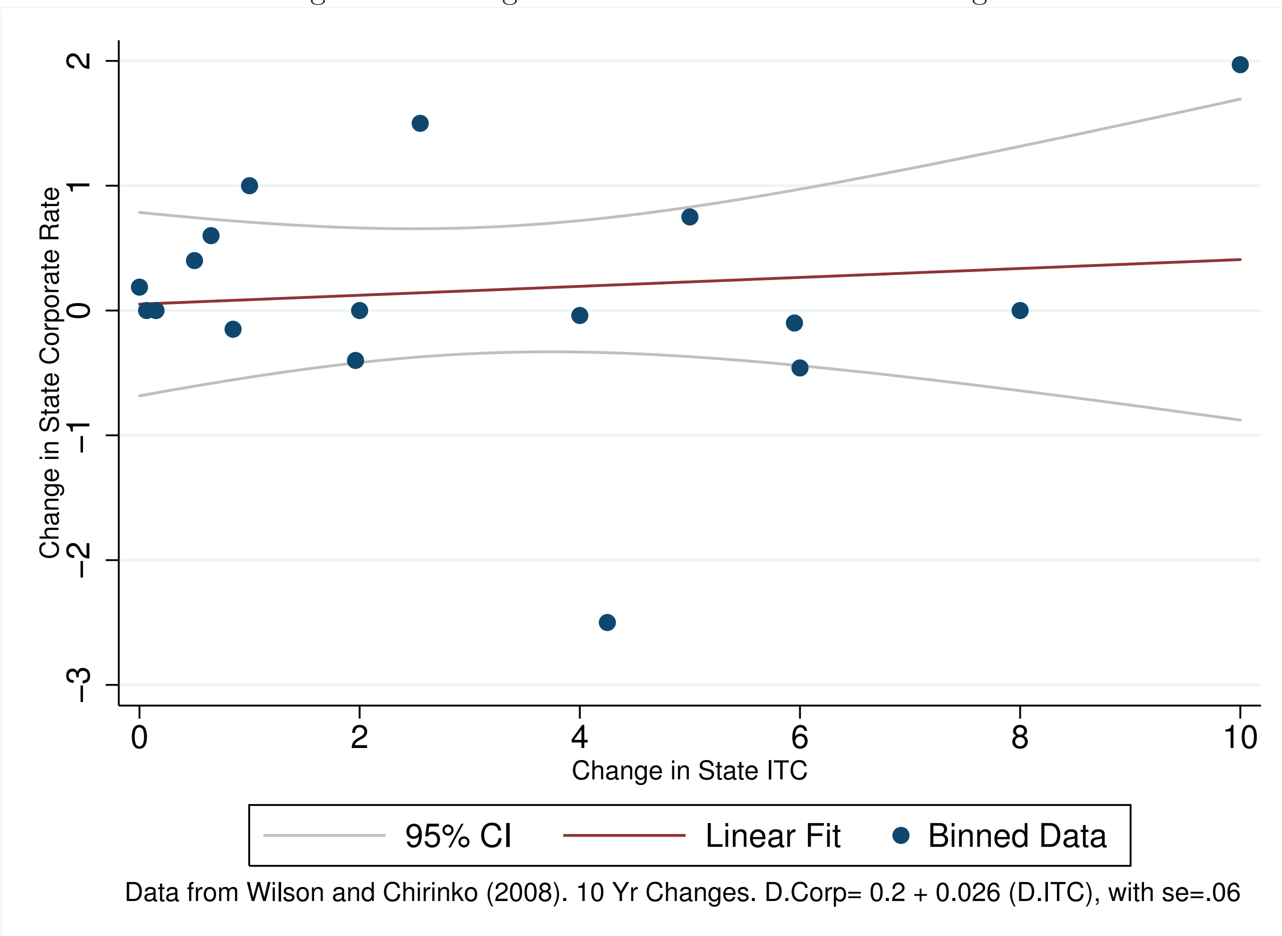
NOTES: This figure shows the cumulative annual effects of local business tax cuts on local establishment growth over different time horizons. It plots the sum of the point estimates in Col (4) of Table 3 and 90% confidence interval for each time horizon. For example, the cumulative effect for year 4 corresponds to the following sum of point estimates: $\hat{\beta}_0 + \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3 + \hat{\beta}_4$. See Section 2 for data sources, Section 3 for estimation details, Appendix Figure 4 for a version of this figure that shows the cumulative effects including pre-trends.

Figure 4: Cumulative Effects of Business Tax Cuts on Establishment Growth



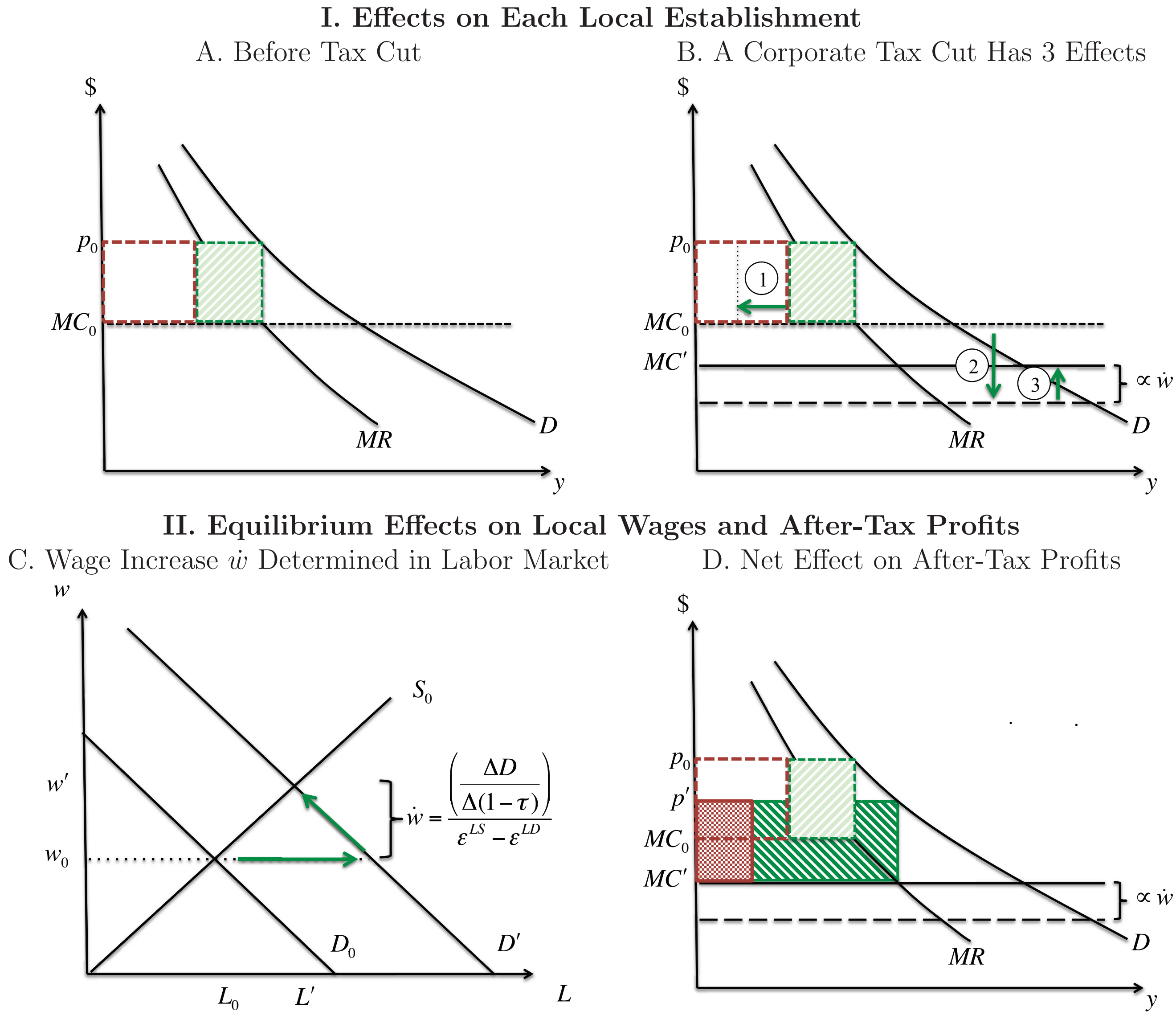
Notes: This figure shows the cumulative annual effects of local business tax cuts on local establishment growth over different time horizons with pre-trends. It plots the sum of the point estimates in Col (7) of Table 3 and 90% confidence interval for each time horizon starting with the greatest lead. In addition, it reports the p-values for the F-test that all leads and lags are jointly equal to zero, which is also reported in Col 7 of Table 3. The square shows the point estimate and 95% confidence interval for the long-run effect of a one percent businesses tax cut on establishment growth, which corresponds to the estimate reported in Col 4 of Table 4. See Section 2 for data sources and Section 3 for estimation details.

Figure 5: Testing for Concomitant Tax Base Changes



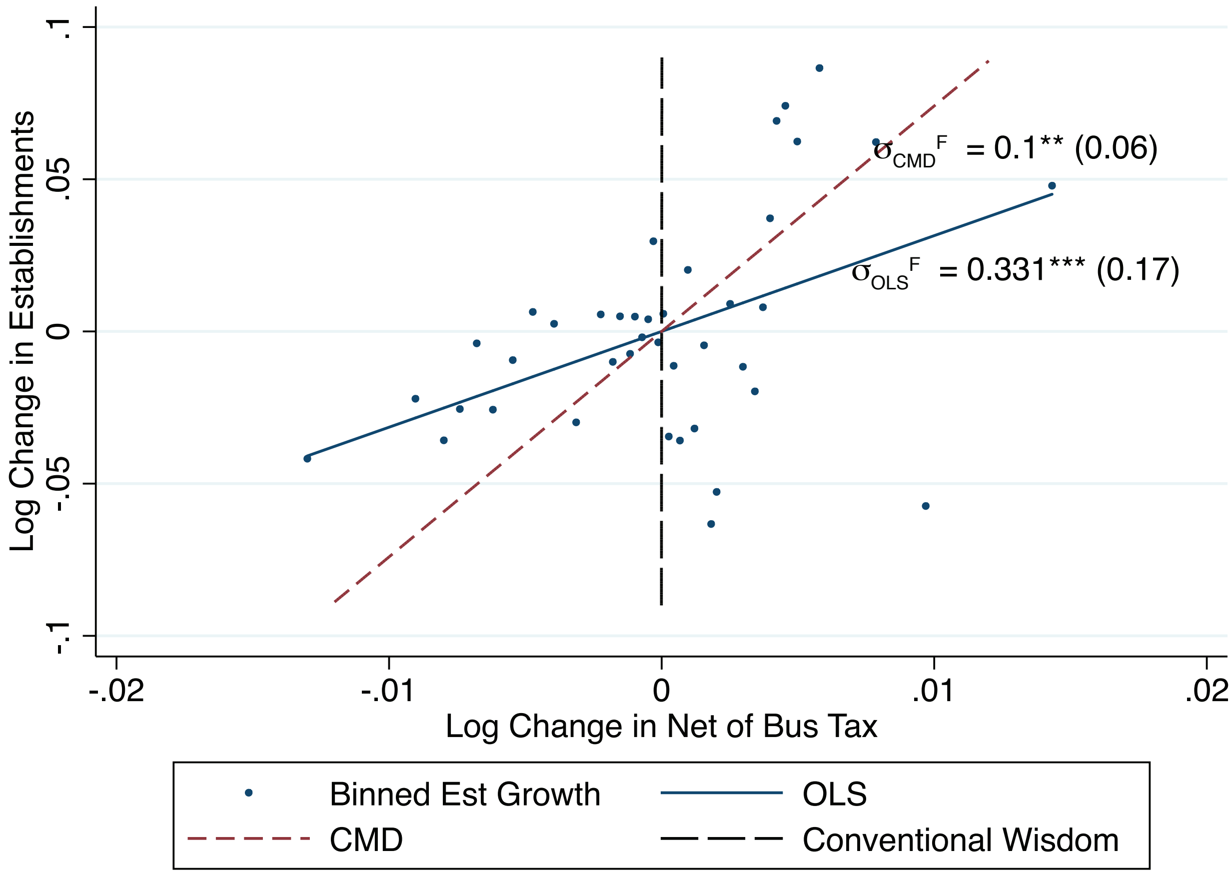
NOTES: This figure, which uses data generously provided by Chirinko and Wilson (2008), illustrates that there is no detectable relationship between corporate tax rate changes and investment tax credit changes. It shows the average state corporate tax rate change for different bins of state investment credit changes. The estimated relationship is $\Delta\tau^c_{s,t} = 0.2 + 0.026\Delta ITC_{s,t}$, with se=0.06 and $R^2 = .001$. Changes are measured over ten year periods.

Figure 6: The Impact of a Corporate Tax Cut on Workers and Firm Owners



Notes: **A**. Monopolistically competitive establishments earn profits, which are divided into taxes and after-tax profits. **B**. Cutting corporate taxes has three effects on local establishments: a corporate tax cut reduces the establishment's (1) tax liability and (2) capital wedge mechanically. (3) Establishments enter the local area and bid up wages by $\dot{w}$ percent. **C**. Wage increases are determined in the local labor market as workers move in, house prices increase, each establishment hires fewer workers, and some marginal establishments leave. **D**. The cumulative percentage increase on profits $\dot{\pi}$ depends on the magnitude of wage increases. We derive the change in local labor demand, ε^{LS}, and ε^{LD} from microfoundations and express them in terms of a few estimable parameters in Section 4. Empirical estimates of these parameters, which govern the three effects above are provided in Tables A1 and 5 and discussed in Section 7. Note that these effects are enumerated to help provide intuition, but the formal model does not include dynamics. The model shows how the spatial equilibrium changes when states cut corporate taxes.

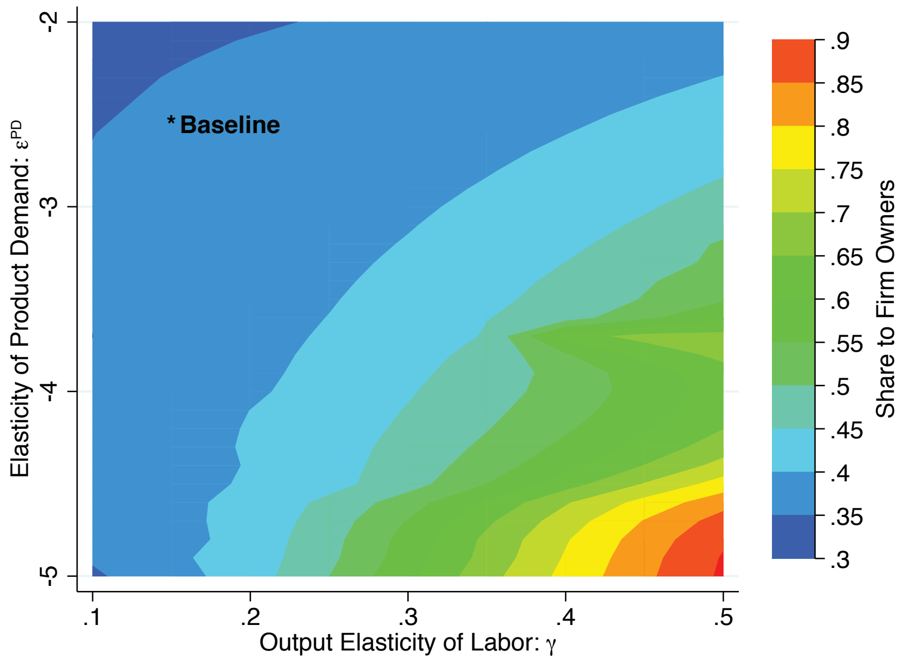
Figure 7: Estimates of Establishment Location Equation



Notes: This figure illustrates how establishment location choices relate to business taxes. The conventional view on corporate taxation in an open economy, which is based on models that neither incorporate the location decisions of business nor the possibility that a business's productivity can differ across locations, effectively implies that business location will be very responsive to tax differentials over the long-run (Gordon and Hines, 2002). This figure shows how this conventional wisdom on responsiveness compares to the empirical responsiveness of location decisions to business tax changes over a ten-year period. In particular, it shows the mean log change in establishments by bin of log change in the net-of-business-tax rate. The fitted lines plot the associated estimates via OLS and classical minimum distance (CMD) from Table A1 Col. 5 and 6, respectively (see Section 6.3.1 for more detail). The OLS line shows the relationship between log changes in net-of-business-taxes and establishment growth. The positive slope indicates that tax cuts increase the number of local establishments over a ten-year period. However, ignoring equilibrium effects of tax changes on wages attenuates the effects of business tax changes on establishment growth. The CMD line shows that accounting for these impacts increases estimated responsiveness. Nonetheless, accounting for equilibrium impacts still yields substantially lower responsiveness to tax changes than the conventional wisdom implies. Section 5 quantifies how lower responsiveness affects the incidence and efficiency of corporate taxation. Standard errors clustered by state are in parentheses and *** p<0.01, ** p<0.05, * p<0.1. See Appendix Figure A2 for the analogous figure for worker location.

Figure 8: Robustness of Economic Incidence

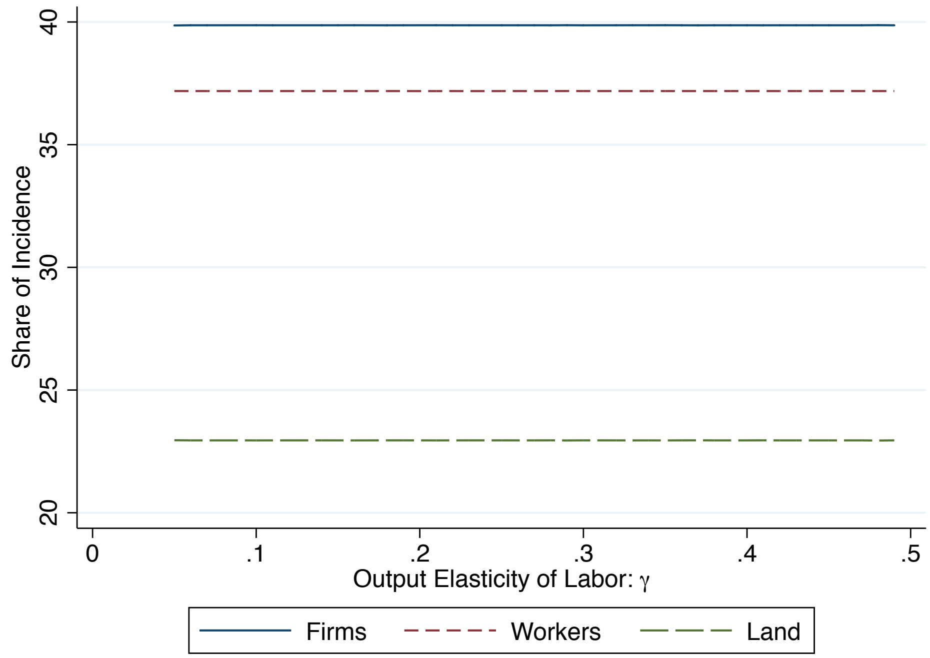
A. Firm Owner's Share of Incidence for Calibrated Values of γ and ε^{PD}



Notes: This figure shows that our baseline empirical result – that firm owners bear a substantial share of incidence – is robust to using a wide range of calibrated parameter values. The figure plots firm owner incidence shares for a variety of parameter values and illustrates that our baseline parameters values of $\gamma = 0.15$ and $\varepsilon^{PD} = -2.5$ give a conservative share of the incidence to firm owners. Using calibrations with more elastic product demand elasticities, while holding the output elasticity of labor constant at $\gamma = 0.15$, does not change the result that the share to firm owners ranges between 35 and 40%. Increasing the calibrated output elasticity of labor generally increases the share accruing to firm owners. Overall, larger product demand elasticities ε^{PD} and/or larger output elasticities of labor γ result in larger burdens on firm owners. See Section 6 for more detail.

Figure 8: Robustness of Economic Incidence

B. Share of Incidence for Calibrated Values of γ and Estimated ε^{PD}



Notes: This figure shows that the shares of incidence to firm owners, workers, and landowners are independent of the calibrated values for the output elasticity of labor γ. As discussed in Section 6.2, the incidence formulae on welfare and profits are point-identified even when the individual parameters of the model are not themselves point-identified. Similar to Part A of Figure 8, it indicates that our baseline empirical result – that firm owners bear a substantial share of incidence – is robust to using a variety of calibrated parameter values. Appendix Figure A3 shows the relationship between calibration values and estimates as well as their implications for markups. See Section 6 for more detail.

Appendices

A Data

This appendix describes in detail the construction of the skill-specific, county group outcomes using micro-data from the IPUMS samples of the 1980, 1990, and 2000 Censuses and the 2009 American Community Survey (Ruggles et al. (2010)). The data created using this process was first used in Suárez Serrato and Wingender (2011) and this data appendix is a reproduction of an identical appendix in that paper. Our sample is restricted to adults between the ages of 18 and 64 that are not institutionalized and that are not in the farm sector. We define an individual as skilled if they have a college degree.[86]

A number of observations in the data have imputed values. We remove these values from the following variables: employment status, weeks worked, hours worked, earnings, income, employment status, rent, home value, number of rooms, number of bedrooms, and building age. Top-coded values for earnings, total income, rents, and home values are multiplied by 1.5. Since the 2009 ACS does not include a variable with continuous weeks worked, we recode the binned variable for 2009 with the middle of each bin's range.

Our measure of individual wages is computed by dividing earnings income by the estimate of total hours worked in a year given by multiplying of average hours worked and average weeks worked. Aggregate levels of income, earnings, employment, and population at the county group level are computed using person survey weights. Average values of log-wages are also computed using person survey weights while log-rents and log-housing values are computed using housing unit survey weights and restricting to the head of the household to avoid double-counting.

We create composition-adjusted values of mean wages, rents, and housing values in order to adjust for changes in the characteristics of the population of a given county group. First, we de-mean the outcomes and the personal and household characteristics relative to the whole sample to create a constant reference group across states and years. We then estimate the coefficients of the following linear regression model

$$\dot{y}_{ctsi} = \dot{X}_{ctsi}\Gamma^{s,\tau} + \nu_c + \mu_{c,\tau} + \varepsilon_{ctsi},$$

[86] For the 1980 Census there is no college degree code. We code those with less than 4 years of college education as not having a college degree. This corresponds to detailed education codes less than 100.

where $\dot{y}_{ctsi}$ is observations i's de-meaned log-price in county group c, year t and state group s. $\dot{X}_{ctsi}$ is observations i's de-meaned characteristics, ν_c is a county group fixed effect, and $\mu_{c,\tau}$ is a county group-year fixed effect. Allowing $\Gamma^{s,\tau}$ to vary by state and year allows for heterogeneous impacts of individual characteristics on outcomes.

We run this regression for every state group and for years $\tau = 1990, 2000$, and 2010.[87] For each regression we include observations for years $t = \tau, \tau - 10$ so that the county group-year fixed effect corresponds to the average change in the price of interest for the reference population. Our analysis of adjusted prices uses the set of fixed effects $\{\mu_{c,t}\}$ as outcome variables.

The regressions on wage outcomes use individual survey weights while the regressions on housing outcomes use housing survey weights and restrict to the head of the household. The wage regressions include the following covariates: a quartic in age and dummies for hispanic, black, other race, female, married, veteran, currently in school, some college, college graduate, and graduate degree status. The housing regressions included the following covariates: a quadratic in number of rooms, a quadratic in the number of bedrooms, an interaction between number of rooms and number of bedroom, a dummy for building age (every 10 years), interactions of the number of room with building age dummies, and interactions of the number of bedroom with building age dummies.

B Model Details

B.1 Establishment Problem with Apportionment

In a given location c, establishments maximize profits over inputs and prices p_{ijc} while facing a local wage w_c, national rental rates ρ, national prices p_v of each variety v, local corporate taxes τ_s^c, and local apportionment weights θ_s subject to the production technology in Equation 8:

$$\pi_{ijc} = \max_{l_{ijc}, k_{ijk}, x_{v,ijc}, p_{ijc}} (1 - \tau_i^A) \left(p_{ijc} y_{ijc} - w_c l_{ijc} - \int_{v \in J} p_v x_{v,ijc} dv \right) - \rho k_{ijc} - (\tau_i^A - \tau_{i/j}^A) \Pi_{i/j}^p \quad (29)$$

where $\tau_i^A = \left(\sum_{s'} ((\tau_{s'}^c \theta_{s'}^x a_{is'}^x) + (\tau_{s'}^c \theta_{s'}^w a_{is'}^w) + (\tau_{s'}^c \theta_{s'}^\rho a_{is'}^\rho)) \right)$ is the effective "apportioned" corporate tax rate with activity weights for sales a_{is}^x, payroll a_{is}^w, and property a_{is}^ρ, where $a_{is}^w \equiv \frac{w_c l_{ijc}}{W_i}$ is

[87] As a technical note, before every regression was computed, an algorithm checked that no variables would be automatically excluded by the software program in order to avoid problems with cross-equation comparisons.

the local share of national payroll, W_i, for firm i.[88] Sales and property activity weights are defined similarly.[89] In addition, $\tau^A_{i/j}$ and $\Pi^p_{i/j}$ are the effective apportioned corporate tax rate and pre-tax profit respectively for firm i without any production from establishment j.

State tax laws, which apportion *firm* profits based on *firm* activity to determine tax liabilities, have two important effects on establishments. First, the effective apportioned corporate tax rate τ^A of an establishment operating in location c can be quite different than τ^c_c, the statutory state corporate rate, due to apportionment and activity weights. Second, increasing production at a given establishment affects the *firm*'s tax liability by the product of the change in the firm's effective apportioned tax rate (due to establishment production) and the firm's pretax profits: $(\tau^A_i - \tau^A_{i/j})\Pi^p_{i/j}$. Thus, including this additional term incorporates the ultimate effects on firm i's profitability due to the location and production decisions at establishment j.

One can show that demand takes the following form:[90]

$$y_{ijc} = I\left(\frac{p_{ijc}}{P}\right)^{\varepsilon^{PD}}$$

where I is the sum of national real income not spent on housing and intermediate good demand from establishments and P is the price level, which was normalized to 1 in the prior section.Using this demand expression to substitute for price gives the following expression for establishment j's economic profits.

$$\pi_{ijc} = (1-\tau^A_i)\left(y_{ijc}^{\frac{1}{\mu}} I^{\left(\frac{1}{\varepsilon^{PD}}\right)} - w_c l_{ijc} - \int_{v\in J} p_v x_{v,ijc} dv\right) - \rho k_{ijc} - (\tau^A_i - \tau^A_{i/j})\Pi^p_{i/j}$$

where the markup $\mu \equiv \left[\frac{1}{\varepsilon^{PD}} + 1\right]^{-1}$ is constant due to CES demand.

Firms maximize this establishment profit function and set the optimal choices of labor, capital, and intermediate inputs. These, in turn, determine the scale in production in each establishment. However, as first noted McLure Jr. (1977), the effective tax rate faced by a given firm is affected by changes in the geographical distribution of payroll and capital.[91] Thus, when firms optimize this profit function, they take this effect into consideration thus creating a wedge

[88] Given the typical structure of state corporate tax schedules, one can think of τ^A_i as both the marginal and average tax rate of establishments owned by firm i.

[89] For apportionment purposes, property is measured as the sum of land and capital expenditures.

[90] See the appendix of Basu (1995) for a derivation where I is analogous to the sum of intermediate goods and final goods in Equation (A6) of his paper.

[91] McLure Jr. (1977) assumed that the corporate rate of all other states was zero, so the term in brackets simplifies to a simpler factor wedge, e.g. $\tau^c_s \theta^w_{is}(1-a^w_{is})$.

between the marginal product of factors and their respective marginal costs. These wedges are evident in the firm's first-order conditions for labor and capital: [92]

$$\frac{y_{ijc}^{\frac{1}{\mu}}}{\mu}\frac{\gamma}{l_{ijc}}I^{\left(\frac{1}{\varepsilon^{PD}}\right)} = \underbrace{w_c\left(\frac{1-\tau_i^A+\frac{\Pi_i^p}{W_i}\left[\tau_s^c\theta_{is}^w-\sum_{s'}a_{is'}^w\tau_{s'}^c\theta_{is'}^w\right]}{1-\tau_i^A}\right)}_{\equiv\tilde{w}_c} \tag{30}$$

$$\frac{y_{ijc}^{\frac{1}{\mu}}}{\mu}\frac{\delta}{k_{ijc}}I^{\left(\frac{1}{\varepsilon^{PD}}\right)} = \underbrace{\rho\left(\frac{1+\frac{\Pi_i^p}{R_i}\left[\tau_s^c\theta_{is}^\rho-\sum_{s'}a_{is'}^\rho\tau_{s'}^c\theta_{is'}^\rho\right]}{1-\tau_i^A}\right)}_{\equiv\tilde{\rho}_c} \tag{31}$$

We denote the effective wage and capital rental rates $\tilde{w}_c$ and $\tilde{\rho}_c$ respectively. Note that capital owners supply capital perfectly elastically at the national rate, so local capital wedges result in lower levels of local capital.[93] These conditions and the input demand for the bundle of intermediate goods yield an expression for firm revenues and costs that takes the form:[94]

$$y_{ijc}^{\frac{1}{\mu}}I^{\left(\frac{1}{\varepsilon^{PD}}\right)} = y_{ijc}\mu\underbrace{\frac{1}{B_{ijc}}\left[\tilde{w}^\gamma\tilde{\rho}^\delta\gamma^{-\gamma}\delta^{-\delta}(1-\gamma-\delta)^{-(1-\gamma-\delta)}\right]}_{\equiv c_{ijc}} \tag{32}$$

This equation shows that revenues are a markup μ over costs, i.e. $p_{ijc}y_{ijc} = \mu y_{ijc}c_{ijc}$, indicating that prices are a markup over marginal costs c_{ijc}.

B.2 Deriving the Profit Expression

Taking a ratios of the first order conditions (Equation 30 and 31) and the analogous expression for the intermediate good bundle yields an expression for the capital to labor and intermediate good to labor ratios:

$$\frac{k_{ijc}}{l_{ijc}} = \frac{\tilde{w}_c}{\tilde{\rho}_c}\frac{\delta}{\gamma} \qquad \frac{M_{ijc}}{l_{ijc}} = \frac{\tilde{w}_c}{1}\frac{1-\gamma-\delta}{\gamma}$$

[92]Note the following auxiliary derivative $\frac{\partial\tau_i^A}{\partial l_{ijc}} = \frac{\tau_s^c\theta_{is}^w}{W_i}w_c - \sum_{s'}\frac{\tau_{s'}^c\theta_{is'}^w W_{is'}}{W_i^2}w_c = \frac{w_c}{W_i}\left[\tau_s^c\theta_{is}^w - \sum_{s'}a_{is'}^w\tau_{s'}^c\theta_{is'}^w\right]$ where the second equality exploits the assumption that all of a firms activity in a given state is done by one establishment.

[93]Given the setup of the establishment problem, we effectively abstract from consequences of state corporate tax changes on capital structure choices. See Heider and Ljungqvist (2012) for such an analysis.

[94]See Appendix B.2 for the derivation. Note that the price of the intermediate good bundle is 1.

Plugging these expressions into the production function yields expressions for input demand:

$$y_{ijc} = B_{ijc} l_{ijc}^{\gamma} k_{ijc}^{\delta} \left(\frac{\tilde{w}_c}{1} \frac{1-\gamma-\delta}{\gamma} l_{ijc} \right)^{1-\gamma-\delta} \Rightarrow l_{ijc} = \frac{y_{ijc}}{B_{ijc}} \left[\tilde{w}_c^{\gamma-1} (\tilde{\rho}_c)^{\delta} \gamma^{1-\gamma} \delta^{-\delta} (1-\gamma-\delta)^{-(1-\gamma-\delta)} \right]$$

$$\Rightarrow k_{ijc} = \frac{y_{ijc}}{B_{ijc}} \left[\tilde{w}_c^{\gamma} (\tilde{\rho}_c)^{\delta-1} \gamma^{-\gamma} \delta^{1-\delta} (1-\gamma-\delta)^{-(1-\gamma-\delta)} \right]$$

$$\Rightarrow M_{ijc} = \frac{y_{ijc}}{B_{ijc}} \left[\tilde{w}^{\gamma} (\tilde{\rho}_c)^{\delta} \gamma^{-\gamma} \delta^{-\delta} (1-\gamma-\delta)^{(\gamma+\delta)} \right]$$

Substituting the expression for labor into Equation 30 and rearranging terms yields the markup expression in Equation 32. With these expressions for establishment factor demand, we can now derive the expression for profits in Equation 10.

B.2.1 Profits

Begin with the following expression for profits in terms of factors:

$$\pi_{ijc} = (1-\tau_i^A) \left(p_{ijc} y_{ijc} - w_c l_{ijc} - \int_{v \in J} p_v x_{v,ijc} dv \right) - \rho k_{ijc} - (\tau_i^A - \tau_{i/j}^A) \Pi_{i/j}^p$$

In terms of after wedge wages and interest rates, we can use the capital to labor ratio, the intermediate good to labor ratio, and the implication of Equation 32 that price is a markup over marginal costs to express profits as follows:

$$\pi_{ijc} = (1-\tau_i^A) \tilde{w}_c l_{ijc} \left[\frac{\mu}{\gamma} - \frac{1}{\omega_w} - \frac{1-\gamma-\delta}{\gamma} - \frac{(1-\tau_i^A)}{\omega_\rho} \frac{\delta}{\gamma} \right] - (\tau_i^A - \tau_{i/j}^A) \Pi_{i/j}^p$$

where $\omega_w \equiv \left(\frac{1-\tau_i^e + \frac{\Pi_i^p}{W_i} \left[\tau_s^c \theta_{is}^w - \sum_{s'} a_{is'}^w \tau_{s'}^c \theta_{is'}^w \right]}{1-\tau_i^A} \right)$, and $\omega_\rho \equiv \left(\frac{1 + \frac{\Pi_i^p}{R_i} \left[\tau_s^c \theta_{is}^r - \sum_{s'} a_{is'}^\rho \tau_{s'}^c \theta_{is'}^\rho \right]}{1-\tau_i^e} \right)$. Substituting for labor and using the definition of product demand yields:

$$\pi_{ijc} = (1-\tau_i^A) I \mu^{\varepsilon^{PD}} c_{ijc}^{\varepsilon^{PD}+1} \left[\mu - \frac{\gamma}{\omega_w} - \frac{1-\gamma-\delta}{1} - \frac{(1-\tau_i^A)\delta}{\omega_\rho} \right] - (\tau_i^A - \tau_{i/j}^A) \Pi_{i/j}^p$$

Notice that in the standard case in which there are no apportionment wedges, the term in brackets would be $\mu - 1$, indicating that profits are a mark up over costs where $\mu \geq 1$. Substituting for c_{ijc}, we can express profits as a function of local factor prices, local productivity, and taxes.

$$\pi_{ijc} = (1-\tau_i^A) \tilde{w}_c^{\gamma(\varepsilon^{PD}+1)} \tilde{\rho}_c^{\delta(\varepsilon^{PD}+1)} B_c^{-(\varepsilon^{PD}+1)} \tilde{\mu}_{ic} \kappa - (\tau_i^A - \tau_{i/j}^A) \Pi_{i/j}^p \tag{33}$$

where $\tilde{\mu}_{ic}$ is an apportionment adjusted mark-up term and κ is a constant term across locations.[95]

[95] $\kappa \equiv I \mu^{\varepsilon^{PD}} \left(\gamma^{-\gamma} \delta^{-\delta} (1-\gamma-\delta)^{-(1-\gamma-\delta)} \right)^{\varepsilon^{PD}+1}$ and $\tilde{\mu}_{ic} \equiv \left[\mu - \frac{\gamma}{\omega_w} - \frac{1-\gamma-\delta}{1} - \frac{(1-\tau_i^A)\delta}{\omega_\rho} \right]$.

Equation 33 shows that apportionment creates an externality between the after-tax profits within multi-state firms. In practice, this tax shifting term is empirically small relative to the other components of establishment profitability. The intuition for this result is that the potential change in the firm's apportionment tax rates $(\tau_i^A - \tau_{i/j}^A)$ is small and declines at a rate faster than the impact of increasing establishment on profits. Appendix B.2.2 quantifies this argument explicitly.

B.2.2 Quantifying the Tax Shifting Term

In this section, we show that log profits can be closely approximated by $\ln \pi_{ijc} = \ln(1-\tau_i^A) + \gamma(\varepsilon^{PD}+1)\ln \tilde{w} + (1-\gamma)(\varepsilon^{PD}+1)\ln \tilde{\rho} - (\varepsilon^{PD}+1)\ln B + \tilde{\mu}_{ic} + \ln \kappa$. To illustrate this point, let $\bar{\pi}$ be the average profit of the existing N establishments and assume that the establishments in all states are of the same size. In this case, we can write the change in firm profits from opening the new establishment as:

$$\pi = (1-\tau^A)\bar{\pi} - \phi N \bar{\pi}(\tau^A - \tau_0^A)$$

where ϕ is a factor of relative profitability of the old establishments and τ_0^A is the pre-existing effective corporate tax rate. It then follows that the share of new establishment profits as a fraction of the total change in profit is given by:

$$\frac{1-\tau^A}{1-\tau^A - \phi N(\tau^A - \tau_0^A)}$$

From this equation we observe that the fraction is close to 1 when the change in taxes is small, i.e., $(\tau^A - \tau_0^A) \approx 0$ and is decreasing in the size of the firm N. Note that $(\tau^A - \tau_0^A) \approx (\frac{1}{N+1} - \frac{1}{N})$. Related to a point raised by Bradford (1978), one may be concerned that small activity weight changes are associated with large profits, i.e. $N\bar{\pi}$, so the product of activity weight changes and profits may still be large. However, the product is small in this setting. To see this, note that the product of the change in activity weights and profits is roughly:

$$\underbrace{(\frac{1}{N+1} - \frac{1}{N})}_{\text{Activity weight change}} \underbrace{\phi N \bar{\pi}}_{\text{profits}}$$

As $N \to \infty$, this product goes to zero regardless of the size of $\phi\bar{\pi}$. Since most employment in the U.S. happens at firms that are located in more that 10 states, we believe that ignoring the tax shifting part of the firm's decision problem does not significantly bias our estimates.

B.3 Local Labor Demand

$$L_c^D(w_c; Z_c, \tau_s^b) = \mathbb{E}_\zeta[n^*(\zeta_{ijc})|c = \underset{c'}{\text{argmax}}\{V_{ijc'}\}]E_c$$

To determine local labor demand, we first solve for the intensive labor demand term.

B.3.1 Intensive Margin

$$\begin{aligned}
l_{ijc} &= \frac{y_{ijc}}{B_{ijc}}\left[\tilde{w}_c^{\gamma-1}(\tilde{\rho}_c)^\delta \gamma^{1-\gamma}\delta^{-\delta}(1-\gamma-\delta)^{-(1-\gamma-\delta)}\right] \\
l_{ijc} &= B_{ijc}^{-(\epsilon^{PD}+1)}\tilde{w}_c^{(\gamma\epsilon^{PD}+\gamma-1)}\tilde{\rho}_c^{(1+\epsilon^{PD})\delta}\kappa_0
\end{aligned}$$

where $\kappa_0 = I\mu^{\epsilon^{PD}}\gamma^{-\gamma(\epsilon^{PD}+2)+1}\delta^{-\delta(\epsilon^{PD}+2)}(1-\gamma-\delta)^{-(1-\gamma-\delta)(\epsilon^{PD}+2)}$. Thus, we can express $\mathbb{E}_\zeta[l_{ijc}^*(\zeta_{ijc})|c = \underset{c'}{\text{argmax}}\{V_{ijc'}\}]$ as follows:

$$\mathbb{E}_\zeta[n^*(\zeta_c^j)|c] = \tilde{w}_c^{(\gamma\epsilon^{PD}+\gamma-1)}\tilde{\rho}_c^{(1+\epsilon^{PD})\delta}\kappa_0\mathbb{E}_\zeta[B_{ijc}^{-(\epsilon^{PD}+1)}]$$

where $\mathbb{E}_\zeta[B_{ijc}^{-(\epsilon^{PD}+1)}] = \exp\left((-\epsilon^{PD}-1)\bar{B}_c\right)\underbrace{\mathbb{E}_\zeta[\exp\left((-\epsilon^{PD}-1)\zeta_{ijc}\right)|c]}_{\equiv z_c}$.

B.3.2 Growth in Local Labor Demand

We can now combine this intensive labor demand expression with the expression for aggregate location decisions to determine local labor demand.

$$L_c^D = \mathbb{E}_\zeta[l_{ijc}^*(\zeta_{ijc})|c = \underset{c'}{\text{argmax}}\{V_{ijc'}\}]E_c$$

Taking logs yields (log) labor demand:

$$\begin{aligned}
\ln L_c^D = &\ln\left(\tilde{w}_c^{(\gamma\epsilon^{PD}+\gamma-1)}\tilde{\rho}_c^{(1+\epsilon^{PD})\delta}\kappa_0\exp\left(\bar{B}_c(-\epsilon^{PD}-1)\right)z_c\right) + \\
&+\frac{\bar{B}_c}{\sigma^F} - \frac{\gamma}{\sigma^F}\ln\tilde{w}_c - \frac{\delta}{\sigma^F}\ln\tilde{\rho}_c - \frac{\ln\tilde{\mu}_{ic}}{(\varepsilon^{PD}+1)\sigma^F} - \frac{\ln(1-\bar{\tau}_{is}^A)}{(\varepsilon^{PD}+1)\sigma^F} - \ln(C) - \ln(\bar{\pi})
\end{aligned}$$

Simplifying this expression yields the (log) local labor demand curve.[96]

$$\begin{aligned}
\ln L_c^D = &\kappa_2 - \frac{\ln(1-\tau_c^b)}{(\varepsilon^{PD}+1)\sigma^F} - \ln\bar{\pi} + \left(\gamma(\epsilon^{PD}+1-\frac{1}{\sigma^F})-1\right)\ln\tilde{w}_c - \frac{\ln\tilde{\mu}_{ic}}{(\varepsilon^{PD}+1)\sigma^F} \\
&+\left(\delta(\epsilon^{PD}+1-\frac{1}{\sigma^F})\right)\ln\tilde{\rho}_c + \left(-(\epsilon^{PD}+1)+(\frac{1}{\sigma^F})\right)\bar{B}_c + z_c \qquad (34)
\end{aligned}$$

[96] In the model, we treat all establishments as C-corporations but some labor is demanded by other types of firms. We assume that C-corporations and non C-corporations are the same in all other dimensions and, for analytical tractability, that corporate status is fixed. As a result, we can replace the apportioned rate with the corporate form weighted average business tax rate that was introduced in Section 2.

where κ_2 is a common term across locations and $\bar{\pi}$ is a sufficient statistic for tax, factor price, and productivity changes in all other cities.[97]

B.4 Equilibrium and Incidence Expressions

Spatial equilibrium c depends market clearing in factor markets, housing markets, and output markets and can be expressed in terms of the expressions for labor supply 6, housing market clearing 7, and labor demand 34 as follows:

$$\begin{bmatrix} -\frac{\bar{A}_c}{\sigma^W} \\ -B_c^H \\ -\left(\ln\kappa_2 - \frac{\ln(1-\tau_c^b)}{(\varepsilon^{PD}+1)\sigma^F} - \ln\bar{\pi} + \left(-(\epsilon^{PD}+1) + (\frac{1}{\sigma^F})\right)\bar{B}_c - \frac{\ln\tilde{\mu}_{ic}}{(\varepsilon^{PD}+1)\sigma^F} + z_c\right) \end{bmatrix}$$
$$= \begin{bmatrix} -1 & \frac{1}{\sigma^W} & -\frac{\alpha}{\sigma^W} \\ -1 & -1 & 1+\eta_c \\ -1 & \varepsilon^{LD} & 0 \end{bmatrix} \times \begin{bmatrix} \ln N_c \\ \ln w_c \\ \ln r_c \end{bmatrix}$$

The expressions for log population, wages, and rents can be derived using Cramer's rule yielding the following local corporate tax elasticities:

$$\frac{\partial \ln N}{\partial \ln(1-\tau^c)} = \varepsilon^{LS}\frac{\frac{-f_c^C}{(\varepsilon^{PD}+1)\sigma^F}}{\varepsilon^{LS}-\varepsilon^{LD}}$$
$$\frac{\partial \ln w_c}{\partial \ln(1-\tau^c)} = \frac{-\frac{f_c^C}{(\varepsilon^{PD}+1)\sigma^F}}{\left(\frac{1+\eta_c-\alpha}{\sigma^W(1+\eta_c)+\alpha}\right)-\varepsilon^{LD}}$$
$$\frac{\partial \ln r_c}{\partial \ln(1-\tau^c)} = \left(\frac{1+\varepsilon^{LS}}{1+\eta_c}\right)\frac{\frac{-f_c^C}{(\varepsilon^{PD}+1)\sigma^F}}{\varepsilon^{LS}-\varepsilon^{LD}}$$
$$\frac{\partial \ln w_c}{\partial \ln(1-\tau^c)} - \alpha\frac{\partial \ln r_c}{\partial \ln(1-\tau^c)} = \sigma^W\varepsilon^{LS}\frac{\frac{-f_c^C}{(\varepsilon^{PD}+1)\sigma^F}}{\varepsilon^{LS}-\varepsilon^{LD}}$$

where $\left(\frac{1+\eta-\alpha}{\sigma^W(1+\eta)+\alpha}\right) \equiv \varepsilon^{LS}$ is the effective labor supply elasticity.

[97] Note that $\bar{\pi}$ is a actually a C-corporation and non C-Corporation share weighted average of profits in all other cities. In addition, note that $\kappa_2 \equiv \ln\kappa_0\frac{\ln\kappa}{(\varepsilon^{PD}+1)\sigma^F}$.

B.4.1 Equilibrium and Incidence Expressions

$$\Delta \ln w_{c,t} = \phi_t^2 + (\dot{w})\,\Delta \ln(1-\tau_{c,t}^b) + \frac{\lambda\left(-(\varepsilon^{PD}+1)+\frac{1}{\sigma^F}\right)}{\varepsilon^{LS}-\varepsilon^{LD}} Bartik_{c,t} + u_{c,t}^2 \tag{35}$$

$$\Delta \ln N_{c,t} = \phi_t^1 + \left(\dot{w}\varepsilon^{LS}\right)\Delta \ln(1-\tau_{c,t}^b) + \varepsilon^{LS}\frac{\lambda\left(-(\varepsilon^{PD}+1)+\frac{1}{\sigma^F}\right)}{\varepsilon^{LS}-\varepsilon^{LD}} Bartik_{c,t} + u_{c,t}^1 \tag{36}$$

$$\Delta \ln r_{c,t} = \phi_t^3 + \left(\frac{1+\varepsilon^{LS}}{1+\eta_c}\dot{w}\right)\Delta \ln(1-\tau_{c,t}^b) + \left(\frac{1+\varepsilon^{LS}}{1+\eta_c}\right)\frac{\lambda\left(-(\varepsilon^{PD}+1)+\frac{1}{\sigma^F}\right)}{\varepsilon^{LS}-\varepsilon^{LD}} Bartik_{c,t} + u_{c,t}^3 \tag{37}$$

$$\begin{aligned}\Delta \ln E_{c,t} = {} & \phi_t^4 + \left(\frac{1}{-\sigma^F(\varepsilon^{PD}+1)} - \frac{\gamma}{\sigma^F}\dot{w}\right)\Delta \ln(1-\tau_{c,t}^b) \\ & + \left(\frac{\lambda}{\sigma^F} - \frac{\gamma}{\sigma^F}\frac{\lambda\left(-(\varepsilon^{PD}+1)+\frac{1}{\sigma^F}\right)}{\varepsilon^{LS}-\varepsilon^{LD}}\right) Bartik_{c,t} + u_{c,t}^4 \end{aligned}\tag{38}$$

C Incidence and Efficiency of Corporate Taxes

C.1 Global Welfare

The welfare effects derived in section 5.2 would provide sufficient information for a state politician who is interested in maximizing local welfare. Nonetheless, maximizing local objectives can affect the welfare of agents in other locations. We now characterize the effects on both local "domestic" agents and "foreign" agents using the framework in Kline (2010) and Kline and Moretti (2013) by allowing wages and rental costs in other locations to be affected by tax changes in any given state. We extend their framework to incorporate firm owners and define aggregate social welfare $\mathcal{W}$ as the sum of the expected welfare of workers, firm owners, and land owners.[98]

$$\mathcal{W} = \mathcal{V}^W + \mathcal{V}^F + \sum_c \mathcal{V}_c^L. \tag{39}$$

The effect of a corporate tax cut in location c on aggregate worker welfare is now:

$$\frac{d\mathcal{V}^W}{d\ln(1-\tau_c^c)} = \underbrace{N_c(\dot{w}_c - \alpha\dot{r}_c)}_{\text{Domestic Workers}} + \sum_{c'\neq c}\underbrace{N_{c'}(\dot{w}_{c'} - \alpha\dot{r}_{c'})}_{\text{Foreign Workers}}.$$

Similar to the logic of Moretti (2010), who analyzes the effects of a labor demand shock in the two city case, a corporate tax cut not only benefits local workers by increasing wages, but it

[98] For simplicity, we assume that there is a continuum of workers, establishments, and landowners of measure one. We use a utilitarian social welfare function that adds up log consumption terms, but one could easily incorporate more general social welfare weights as in Saez and Stantcheva (2013).

also helps foreign workers via housing cost relief. These gains, however, can be offset to the extent that domestic workers have to pay higher rents and foreign workers earn lower wages.

The effect of a cut in corporate taxes on aggregate firm owner welfare can be written as:

$$\frac{d\mathcal{V}^F}{d\ln(1-\tau_c^c)} = E_c\dot{\pi}_c + \sum_{c'\neq c} E_{c'}\gamma(\varepsilon^{PD}+1)\frac{dw_{c'}^c}{d\ln(1-\tau_c^c)} \tag{40}$$

where E_c is the share of establishments in location c, $\dot{\pi}_c$ is the percentage change in after-tax profits in location c, γ is the output elasticity of labor, and ε^{PD} is the product demand elasticity. As in Bradford (1978), factor price changes affect all firm owners foreign and domestic. In particular, owners of domestic firms benefit from the mechanical decrease in tax liabilities and capital costs, but have to pay higher wages. Owners of foreign firms do not get the mechanical or capital cost changes, but they do gain from lower wage costs since fewer establishments bid up wages in their local labor markets.

Finally, landowner welfare changes by $\frac{\dot{N}_c+\dot{w}_c}{1+\eta_c}$ in each location. The aggregate of these effects may be positive or negative depending on the net flows of workers and establishments. Empirically estimating global incidence is beyond the scope of this paper (see Fajgelbaum et al. (2014) for such an analysis), yet these calculations illustrate the effects of spatial equilibrium forces on aggregate welfare when policies are set by maximizing local objectives.

C.2 Efficiency

The previous section detailed the effects of corporate tax changes on the welfare of workers, firm owners, and landlords. In this section, we turn to efficiency considerations by analyzing how state corporate taxes affect a social planner's problem.[99] The social planner maximizes global welfare $\mathcal{W} = \mathcal{V}^W + \mathcal{V}^F + \mathcal{V}^L$ over $\{\tau_c^c\}$ subject to a revenue requirement. The lagrangian takes the following form:

$$\mathcal{L} = \mathcal{W} - \lambda\left(\underbrace{\tau_c^c E_c\bar{\pi}_c^p + \sum_{c'\neq c}\tau_{c'}^c E_{c'}\bar{\pi}_{c'}^p}_{\text{Tax Revenue}} - \text{RR}\right) \tag{41}$$

where $\bar{\pi}_c^p$ is the average pretax profit of establishments in location c and RR is the government's revenue requirement.[100]

[99] This accounting has abstracted away from welfare benefits of government spending which could improve amenities or local productivity. See Suárez Serrato and Wingender (2011) for an analysis of the welfare effects of government spending changes.

[100] We evaluate these costs starting from point of symmetric statutory rates of zero in all locations for simplicity. In general, the initial distribution of tax rates impacts conclusions. For instance, suppose all states except CA had

A consistent message from the previous section is that the effect of a corporate tax change on $\mathcal{W}$ does not depend on behavioral responses. However, behavioral responses have important budgetary consequences that reveal the economic distortions of corporate taxes.[101] There are two key effects of establishment behavior on the government's budget. The first effect is due to marginal establishments that changed locations as in Busso et al. (2013). These establishments are roughly as profitable as they would have been in their original location without the tax cut yet tax revenues from these firms decrease. Since the tax revenue required to pay for these cuts depends on how many establishments move, establishment mobility has direct implications for efficiency costs. It follows from Equation 12 that establishment mobility is decreasing in the dispersion of productivity σ^F. As a result, greater productivity dispersion lowers efficiency costs. Intuitively, if establishments are inframarginal due to location specific productivity advantages, small changes in taxes will not induce establishments to move and will not require excessive payments to new establishments. Measuring this effects empirically requires estimates of the parameters of model.

The second effect on the budget is due to spatial distortions created by local corporate tax changes. Lower taxes induce some establishments to leave the locations where they would be most productive. As a consequence, scale of production, business revenues, tax collections, and aggregate welfare decline. In addition, greater dispersion in (non-sales apportioned) state corporate rates exacerbate these effects. Measuring these effect is more complicated as it requires measures of changes in profitability due to establishment relocation and is an important topic for future research.[102]

Although characterizing global efficiency is beyond the scope of this project, in Section 7.2 we characterize the impacts of behavioral responses on local budgets from the perspective of state politicians. Additionally, we derive states' revenue-maximizing tax rates and relate them to the efficiency costs of state corporate taxes.

a 5% rate. If CA has a 6% rate, cutting corporate taxes there by one percent would not only increase production but also reduce distortions. However, if CA started at 4% and lowered rates to 3%, then production would increase but the cut would also exacerbate distortions since some establishments that would more productive elsewhere would move to CA.

[101]See Hendren (2013) for a discussion of the generality of this calculation.

[102]In Cullen et al. (2014) we explore how establishment relocation affects productivity as measured by patent activity and in Fajgelbaum et al. (2014) we quantify aggregate misallocation in productivity due to corporate state taxes.

D Revenue-Maximizing Corporate Tax Rate

In the next two sections, we briefly derive the revenue-maximizing corporate tax rate under two scenarios about the underlying policy-maker's objective. First, we consider the case when the the policy-maker's objective is to maximize corporate tax revenue while ignoring other tax collections. The second case assumes the policy-maker's objective is to maximize all forms of tax revenue. We show that, while the revenue-maximizing tax rate is inversely related to firm mobility, firm mobility on its own does not justify a low maximal tax rate. This conclusion, however, is weakened when the policy-maker's objective considers the effects of corporate tax changes on other revenue sources.

D.1 Maximal Tax Rate with No Other State Taxes

Local (corporate) tax revenue is given by

$$TaxRev_c = E_c \bar{\pi}_c \frac{\tau_c^c}{1-\tau_c^c}$$

Taking logs and differentiating with respect to $\ln(1-\tau_c^c)$ we have

$$\frac{d \ln TaxRev_c}{d \ln(1-\tau_c^c)} = \frac{d \ln E_c}{d \ln(1-\tau_c^c)} + \dot{\bar{\pi}}_c - 1 - \frac{1-\tau_c^c}{\tau_c^c}$$

Setting the expression above equal to zero and rearranging we have:

$$\tau_c^* = \frac{1}{\dot{\bar{\pi}}_c + \dot{E}_c}.$$

D.1.1 Maximal Tax Rate with Other State Taxes

Consider now the maximum tax rate for corporate income when the state also collects personal income.[103] Local tax revenue is given by

$$TotalTaxRev_c = E_c \bar{\pi}_c \frac{\tau_c^c}{1-\tau_c^c} + N_c w_c \tau_c^i$$

Following a derivation similar to that in the previous section we find a revenue-maximizing tax rate given by:

$$\tau_c^{**} = \frac{1}{\dot{\bar{\pi}}_c + \dot{E}_c + (\text{revshare}_c^{\text{pers}}/\text{revshare}_c^{C})(\dot{w}_c + \dot{N}_c)},$$

where $\text{revshare}_c^{\text{pers}}/\text{revshare}_c^{C}$ is the relative share of personal tax revenues and corporate tax revenues.

[103] In this derivation we lump sales revenue and personal income tax revenue together. We also ignore the effects of corporate taxes on property tax revenue since states do not collect property taxes. However, there are interesting fiscal externalities on localities that do collect property taxes.

D.1.2 Calculating the Tax Elasticity of Establishment Location for States

This section describes the calculation of the elasticity of establishment location with respect to **state** corporate tax rates and explores two forms of heterogeneity that may affect this elasticity: size of location (in terms of market share of establishments) and the effects of apportionment across locations in a given state.

State Tax Revenue

In the simple case without apportionment effects, state corporate tax revenue is given by

$$TaxRev_s = E_s \bar{\pi}_s \frac{\tau_s^c}{1-\tau_s^c}$$

where E_s is the share of national establishments in state s and $\frac{\bar{\pi}_s}{1-\tau_s^c}$ is average pre-tax profits. Taking logs and differentiating with respect to $\ln(1-\tau_s^c)$ we have

$$\frac{d\ln TaxRev_s}{d\ln(1-\tau_s^c)} = \frac{d\ln E_s}{d\ln(1-\tau_s^c)} + \tilde{\pi}_s - 1 - \frac{1-\tau_s^c}{\tau_s^c}$$

To derive the key component of the expression above – the state level location elasticity $\frac{d\ln E_s}{d\ln(1-\tau_s^c)}$ – first consider the elasticity with respect to changes at the local conspuma level.

Local Elasticity

Let $t_{c'}$ be effective corporate rate paid in location c' . Suppose that a policy can be enacted that changes only $t_{c'}$ but not other corporate tax rates in the same state. From standard logit formulae (see Train (2009), Chapter 3.6), the elasticity of establishment location for a given location c is given by:

$$\frac{d\log E_c}{d\log(1-t_{c'})} = \begin{cases} \frac{1}{-\sigma^F(\varepsilon^{PD}+1)}(1-E_c) & \text{if } c'=c \\ -\frac{1}{-\sigma^F(\varepsilon^{PD}+1)}E_c & \text{otherwise.} \end{cases}$$

As we show below, this is not the same exercise as changing the state corporate tax rate. The reason is that the change in the state rate affects the rates of every location within a state and is thus described by a simultaneous change in every state rather than just a change in c'. The correct calculation needs to account for both within states changes in establishment location as well as across state changes in establishment location that occur from this joint change.

We now derive the elasticity at the state level under two different cases.

No Apportionment Taxation

Let τ_S^c be the state corporate tax rate in state S and assume that $t_c = \tau_S^c$ for every c in S. The experiment of changing τ_S^c corresponds to simultaneously changing the rate in every conspuma c in state S. The elasticity of the state tax on establishment location for a given location c is then given by:

$$\begin{aligned}\frac{d\log E_c}{d\log(1-t_S^{Corp})} &= \sum_{c'\in S}\frac{d\log E_c}{d\log(1-t_{c'})}\frac{d\log(1-t_{c'})}{d\log(1-\tau_s^c)}\\ &= \frac{1}{-\sigma^F(\varepsilon^{PD}+1)}\left(1-\sum_{c'\in S}E_c'\right),\end{aligned}$$

where we use the assumption that $\frac{d\log(1-t_{c'})}{d\log(1-\tau_s^c)} = 1$. Letting $E_S \equiv \sum\limits_{c'\in S} E_{c'}$ describe the share of establishments in the state, we find that this elasticity is smaller that the own-tax elasticity in a given location by the fraction:

$$\frac{1-E_S}{1-E_c} < 1.$$

This result shows that as taxes are simultaneously reduced in several places, fewer establishments will move into a given location with a tax cut. From this result we can log-linearize to arrive at the elasticity at the state level, which is given by:

$$\begin{aligned}\frac{d\log E_S}{d\log(1-\tau_s^c)} &= \sum_{c\in S}\left(\frac{E_c}{E_S}\right)\frac{d\log E_c}{d\log(1-\tau_s^c)}\\ &= \frac{1}{-\sigma^F(\varepsilon^{PD}+1)}\left(1-E_S\right).\end{aligned} \tag{42}$$

Apportionment Taxation

The result in Equation 42 holds when $\frac{d\log(1-t_c)}{d\log(1-\tau_s^c)} = 1$. However, due to different rules across states and different activity weights across locations in a given state this derivative is not generally equal to one. Following the same logic as above, it can be shown that:

$$\frac{d\log E_S}{d\log(1-\tau_s^c)} = \frac{1}{-\sigma^F(\varepsilon^{PD}+1)}\left(1-E_S\right)\left(\sum_{c\in S}\left(\frac{E_c}{E_S}\right)\frac{d\log(1-t_c)}{d\log(1-\tau_s^c)}\right),$$

where the last term measures the size-weighted average effect of a change in the state corporate rate on the effective rate paid by firms in a given state.

This formula accounts for differences across states that are due to size of the state as well as to the formulae used to determine state taxes and the distribution of economic activity within each state. Note that

$$\frac{d\log(1-t_c)}{d\log(1-\tau_s^c)} = \frac{(1-\tau_s^c)}{(1-t_c)} \times \left[(\theta_s^x a_s^x + \theta_s^w a_s^w + \theta_s^\rho a_c^\rho) + \tau_s^c \left(\theta_s^w \frac{\partial a_s^w}{\partial t_s^{Corp}} + \theta_s^\rho \frac{\partial a_s^\rho}{\partial t_s^{Corp}} \right) \right], \tag{43}$$

where θ_S^j is the apportionment weight on factor j and a_s^j is the activity weight is for factor j and where $j = x, w, \rho$ correspond to sales, payroll, and property, respectively.

E Empirical Appendix

E.1 Single-Equation Estimates of Labor Supply, Housing Supply, and Establishment Location

In this appendix we present a complementary approach to our main estimation methodology by estimating the labor supply, housing supply, and establishment location equations separately. By isolating each equation, we clarify the potential estimation pitfalls, we show the sources of variation that we use to overcome these pitfalls, and we explore how the structural estimates relate to economic features in our model. By contrast, in our main strategy we estimate a simultaneous equation model that incorporates all of the spatial equilibrium forces of our model. This approach uses classical minimum distance methods to match the reduced-form effects of business tax changes on equilibrium outcomes with the prediction from our model. This strategy improves the precision of our estimates and allows for inference on the incidence to workers, landowners, and firm owners.

E.1.1 Labor Supply

Equation 6 relates changes in labor supply $\Delta \ln N_{c,t}$ to changes in wages $\Delta \ln w_{c,t}$, rental costs $\Delta \ln r_{c,t}$, and amenities $\Delta \bar{A}_{c,t}$ in location c and year t:

$$\Delta \ln N_{c,t} = \frac{\Delta \ln w_{c,t} - \alpha \Delta \ln r_{c,t}}{\sigma^W} + \frac{\Delta \bar{A}_{c,t}}{\sigma^W}. \tag{44}$$

where σ^W is the dispersion of idiosyncratic worker location preferences. We define log real wage changes, $\Delta \ln \text{Real Wage}_{c,t} \equiv \Delta \ln w_{c,t} - \alpha \Delta \ln r_{c,t}$, where we calibrate $\alpha = 0.3$ using data form the Consumer Expenditure Survey. In order to implement this equation, consider estimating the following empirical analogue:

$$\Delta \ln N_{c,t} = \beta^{LS} \Delta \ln \text{Real Wage}_{c,t} + \mathbf{D}'_{s,t} \mathbf{\Psi}_{s,t}^{LS} + \nu_{c,t}^{LS} \tag{45}$$

where the changes are decadal changes in year $t \in 1990, 2000, 2010$ are relative to year $t-10$, β^{LS} is total effect of real wage changes, and $\mathbf{D}_{s,t} = \begin{bmatrix} \mathrm{I}(t=1990) & \ldots & \mathrm{I}(t=2010) & \mathrm{I}(Midwest1990)_{s,t} \end{bmatrix}'$ is a vector with year dummies as well as state dummies for states in the industrial midwest in the 1980s, and $\nu_{c,t}^{LS}$ is the error term. From Equation 44, it follows that the error term will be composed partly of aggregate amenity shocks to a given area. Since changes in real wages and changes in amenities are likely negatively correlated, an OLS estimate of β^{LS} will be biased downwards. Intuitively, rightward shifts in supply due to amenity improvements result in apparently flatter local labor supply curves. Since σ^W is related to the inverse of β^{LS}, attenuation in β^{LS} results in overestimates of σ^W. In order to deal with this endogeneity concern, we instrument for real wage changes using the Bartik instrument for local labor demand as well as changes in taxes $\Delta \ln(1-\tau_{c,t}^c)$. The exclusion restriction is that workers only value changes in labor demand and corporate taxes only through their effects on the real wage.[104]

Table A1 provides estimates for the preference dispersion parameter σ^W using both OLS and IV approaches. In both cases, we estimate $\hat{\sigma}^W$ as a non-linear function of the estimated $\hat{\beta}^{LS}$ using the delta method. Comparing Columns (1) and (2), we find that OLS indeed overestimates the parameter σ^W relative to the IV estimate. Our IV estimate yields a point estimate of $\hat{\sigma}^W = 0.72$ that is significantly different than zero at the 1% level with a standard error of 0.28. Figure A2 depicts the relationship of these estimates to worker mobility. Figure A2 plots the mean log change in population for several bins of log change in real wages as well as the fitted values of a first stage regression of changes in log real wages on the Bartik shock and the tax shock. The fitted lines plot the associated estimates from OLS and IV regressions and show that the IV estimates imply that workers are indeed three times more mobile than the OLS estimates would imply. The IV estimate implies that a \$1 increase in the real wages leads to an increase in population of 1.64. In Section 6.1 we discuss how this estimate relates to others in the literature.

E.1.2 Housing Market

Equation 7 from our model provides the following estimable equation for housing costs:

$$\Delta \ln r_{c,t} = \beta^{HM}(\Delta \ln N_{c,t} + \Delta \ln w_{c,t}) + \mathbf{D}'_{s,t}\boldsymbol{\Psi}_{s,t}^{HM} + \nu_{c,t}^{HM} \tag{46}$$

where the changes are decadal changes in year $t \in 1990, 2000, 2010$ relative to year $t-10$, $\mathbf{D}_{s,t}$ is a vector with year dummies as well as state dummies for states in the industrial midwest in the

[104] In order to ensure that this is the case, we control for changes in state personal income taxes that might drive both the location of establishments and workers.

1980s, and $\nu_{c,t}^{HM}$ is the error term. The structural model implies that $\beta^{HM} = \frac{1}{1+\eta}$, the average elasticity of housing supply.

As discussed in the previous section, the error term in this equation is partly composed of productivity shocks to the housing sector. To the extent that these shocks are positively correlated with changes in population, we would expect that OLS estimates of the coefficient β^{HM} might be biased. We avoid this potential issue by estimating this equation via IV, where we instrument for changes in population and wages using corporate tax changes and Bartik productivity shocks. As before, we report estimates of the parameter η from a delta method calculation.

Table A1 provides estimates for η. Column (3) provides the OLS estimate and Column (4) provides the IV estimate, which gives a similar, though slightly smaller estimate of the elasticity of housing supply of $0.834 (SE = 0.432)$. The parameter implies that a 1% increase in population or wages would raise rental costs by $0.55\% (SE = 0.12)$, which is a statistically significant effect at the 99% level. While not perfectly comparable to previous estimates, this estimate is within the range of parameters from previous studies including those in Notowidigdo (2013) and Suárez Serrato and Wingender (2011).[105]

E.1.3 Establishment Location and Labor Demand

Log differencing Equation 12 we obtain the following equation:

$$\Delta \ln E_{c,t} = \underbrace{\left(\frac{\mu - 1}{\sigma^F} - \frac{\gamma}{\sigma^F}\dot{w}\right)}_{\beta^{ES}} \Delta \ln(1 - \tau_{c,t}^b) + \mathbf{D}'_{s,t}\mathbf{\Psi}_{s,t}^{ES} + \nu_{c,t}^{ES}.$$

To observe the interpretation of the coefficient β^{ES} as a combination of direct and indirect effects, consider first estimating the following alternative equation for establishment share growth:

$$\Delta \ln E_{c,t} = \beta^{ES} \Delta \ln(1 - \tau_{c,t}^b) + \beta_2^{ES} \Delta \ln w_{c,t} + \mathbf{D}'_{s,t}\mathbf{\Psi}_{s,t}^{ES} + \nu_{c,t}^{ES}. \tag{47}$$

If both changes in wages and changes in taxes are exogenous, Equation 47 shows that β^{ES} would be related to $\frac{1}{-(\varepsilon^{PD}+1)\sigma^F}$ and that a coefficient on wages β_2^{ES} would be related to $-\left(\frac{\gamma}{\sigma^F}\right)$.

[105] Our housing supply elasticity parameter and corresponding estimates are not directly comparable due to our model's assumption of Cobb Douglas housing demand rather than the assumption that each household inelastically demands one unit of housing. This feature makes rent a function of both wages and population rather than just population and slightly alters the functional form. We adopt the Cobb-Douglas assumption to allow households to adjust to shocks over the long run, but this feature is not an essential part of our model or results. In an earlier version of the paper, we used inelastic demand and found similar results to those reported here.

The key issue in estimating this equation is that the structural error term, i.e. the change in common productivity $\Delta\bar{B}_{c,t}$, is likely positively correlated with wages. This omitted variable would likely bias an OLS estimation and produce estimates of the output elasticity of labor γ that are negative, contrary to any plausible economic model. Indeed, Column (5) of Table A1 presents the implied estimates from such a regression. As predicted, this estimation yields a non-sensical, negative estimate of the output elasticity of labor $\hat{\gamma}$, which would imply an up-ward sloping labor demand curve.

In order to deal with this endogeneity problem we exclude the endogenous regressor $\Delta \ln w_{c,t}$ (i.e., we impose the constraint that $\beta_2^{ES} = 0$). This exclusion, however, changes the interpretation of the parameter β^{ES}. This estimate corresponds to the reduced form effects of a business tax cut on establishment growth as reported in Table 4, Column 4. The estimation of the parameter σ^F from this equation is presented in Section 6.3.1.

E.2 An Instrumental Variable Approach Based on Albouy (2009)

In this appendix we present an alternative identification strategy for the parameters of the firm location equation based on an insight of Albouy (2009). Albouy (2009) first pointed out that identical workers in higher-cost locations have a higher tax burden since the federal income tax system does not account for costs of living.[106] We use this insight to argue that a federal personal income tax cut will make higher-cost locations relatively more attractive. Thus, we use the heterogeneous effects of national personal income tax changes across locations with different housing market characteristics to isolate variation in local wages that is driven by a relative labor supply shock and that is plausibly exogenous from productivity shocks. This logic implies that the interaction of federal changes in tax rates with local cost of living indexes is a valid relative supply shock of population across areas that can be used to trace the labor demand curve.

Consider estimating the following equation for establishment share growth:

$$\Delta \ln E_{c,t} = \beta_1^{\text{Albouy}} \Delta(1-\tau_{c,t}^b) + \beta_2^{\text{Albouy}} \Delta \ln w_{c,t} + \mathbf{D}'_{s,t}\mathbf{\Psi}_{s,t}^{\text{Albouy}} + \nu_{c,t}^{\text{Albouy}} \tag{48}$$

where ϕ_t^{Albouy} is a fixed effect, $\tau_{c,t}^b$ are corporate share weighted average of business taxes. Our strategy to recover the parameters β_2^{Albouy} is to instrument for changes in wages with the interaction of mechanical federal personal income tax changes $\Delta \ln(1-t_t^i)$ from Zidar (2013) with lagged

[106]Indeed, Albouy (2009) shows that identical workers in above-average-cost locations pay 27% tax premiums resulting in an unequal geographic burden of federal taxation.

housing values and rental costs with lagged log rental costs from the prior decade $\ln r_{c,t-10}$. We use lagged rents from the prior decade since current rent levels are likely related to changes in productivity. Using this instrumental variable along with our measure of corporate tax changes, we can recover both γ and σ^F as functions of β_1^{Albouy} and β_2^{Albouy} and an assumed value of ε^{PD}. Table A2 presents the estimates of β_1^{Albouy} and β_2^{Albouy} as well as the implied values of γ and σ^F when we calibrate $\varepsilon^{PD} = -2.5$ for a variety of specifications. Column (1) estimates the equation via OLS and finds a negative value of γ implying an upward-sloping labor demand curve. Column (2) further controls for productivity shocks including the Bartik employment shock and a related shift-share shock on establishment-level productivity that we construct using data from RefUSA. Including these shocks helps the instrument isolate variation in wages that is not related to productivity shocks. However, the latter productivity shock is only available for the last 10 year period of our data. Columns (3) and (4) present estimates of Equation 48 using the Albouy instrument based on lagged rental costs and lagged housing values, respectively, as an instrument. While the instruments are not overly strong, as measured by the F-stat from the first stage, they provide estimates of γ that are positive and include plausible values such as 0.15 or 0.25 in their 95%-confidence intervals. Nonetheless, these estimates are not very precise. Finally, column (5) calibrates $\gamma = 0.15$, our preferred value, and estimates the respective σ^F, which is smaller than the OLS version but still slightly larger than the estimates from Section 6.

Table A1: Estimates of Structural Parameters

	(1)	(2)	(3)	(4)	(5)	(6)
	Worker Location		Housing Supply		Firm Location	
	OLS	IV	OLS	IV	OLS	CMD
Idiosyncratic Location	2.312***	0.717***				
Preference Dispersion σ^W	(0.767)	(0.277)				
Elasticity of Housing			0.963***	0.834*		
Supply η			(0.208)	(0.432)		
Idiosyncratic Location					0.331*	0.097*
Productivity Dispersion σ^F					(0.174)	(0.058)
Output Elasticity					-0.316	
of Labor γ					(0.225)	
N	1470	1470	1470	1470	1470	1470
Instrument		Bartik & Tax		Bartik & Tax		
First Stage F-stat		46.718		15.32		
Calibrated Parameters:						
ε^{PD}					-2.5	-2.5
γ						0.15
σ^W						0.7
η						1.75

NOTES: This table shows the estimated coefficients of the parameters in our structural model. The data are decade changes from 1980-1990, 1990-2000, and 2000-2010 for 490 county-groups. See Section 2 for data sources. Col (1)-(2) estimate the parameter of worker preference dispersion σ^W, Col (3)-(4) the parameter of the housing supply equation η, and Col (5)-(6) the parameters of the firm location equation γ and σ^F. Col (1)-(5) are estimated via OLS or IV as noted and the parameters are recovered via delta-method calculations. Col (6) is recovered using a classical minimum distance approach. See Section 6 for more details on the specific equations and calibration choices. ε^{PD} denotes the elasticity of product demand. Regressions use initial population as weights and include year fixed effects and dummies for states in the industrial midwest in the 1980s. Standard errors clustered by state are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

Table A2: Estimates of Firm Location Parameters based on Albouy IV

	(1) OLS	(2) OLS	(3) IV	(4) IV	(5) IV
Change in Adj. Wages	0.517***	0.268	-0.798	-0.787	
	(0.156)	(0.177)	(1.243)	(1.333)	
Change in Firm Tax keep share	1.574	1.741	2.618*	2.620*	
	(1.374)	(1.244)	(1.457)	(1.460)	
$-\gamma * d\text{Wages} - \frac{d(1-t)}{\epsilon+1}$					4.082**
					(1.981)
Output Elasticity γ	-0.219	-0.103	0.203	0.200	
	(0.186)	(0.100)	(0.353)	(0.376)	
Inverse Elasticity of Firm Mobility σ^F	0.424	0.383	0.255	0.254*	0.245**
	(0.370)	(0.273)	(0.142)	(0.142)	(0.119)
N	490	490	490	490	490
Productivity Controls	N	Y	Y	Y	Y
Instrument: Fed Tax X			Lag Rent	Lag H Value	Lag Rent & Tax
First Stage F-stat			9.976	8.737	48.251
Calibrated Parameters:					
ε^{PD}	-2.5	-2.5	-2.5	-2.5	-2.5
γ					0.15

Notes: This table shows the estimated coefficients of the firm location equation. The data are decade changes from 2000-2010 for 490 county-groups. Specifications (2)-(5) control for productivity shocks at the county-group level including the employment Bartik shock as well as a shift-share shock of plant-level productivity. The instruments used are the interactions of national changes in federal income tax rates with county-group values of the lagged log rental rate and housing value from the ACS. See Section 2 for data sources. The first three columns show the coefficients of OLS and IV regressions while the fourth and fifth columns show the associated structural parameters recovered using a delta-method calculation. Col (5) calibrates the parameters γ and ε^{PD} prior to estimation. Section 6 for more details on the specific equation. Regressions use initial population as weights and include year fixed effects and dummies for states in the industrial midwest in the 1980s. Standard errors clustered by state are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

Table A3: Revenue-Maximizing Corporate Tax Rates By State

State	Establishment Share E_s	Revenue Ratio $\text{rev}_s^{\text{pers}}/\text{rev}_s^C$	Sales Apport. Weight θ_s^x	Corporate Tax Rate τ_s	Revenue Max. Corp. Rate τ_s^*	τ_s^{**}	$\tau_s^{**}/(1-\theta_s^x)$
Alabama	1.4	16	33	6.5	36.9	2.3	3.4
Alaska	0.3	0	33	9.4	39.4	28.1	42.1
Arizona	1.8	22	80	7.0	36.0	1.7	8.6
Arkansas	0.9	15	50	6.5	37.1	2.5	4.9
California	11.7	9	50	8.8	39.0	3.9	7.8
Colorado	2.1	21	100	4.6	37.4	1.8	
Connecticut	1.2	22	50	7.5	37.5	1.7	3.5
Delaware	0.3	9	33	8.7	35.4	3.8	5.8
Florida	6.7	15	50	5.5	37.8	2.5	5.1
Georgia	3.0	20	100	6.0	35.3	1.9	
Hawaii	0.4	57	33	6.4	33.8	0.7	1.0
Idaho	0.6	26	50	7.6	41.8	1.5	2.9
Illinois	4.3	9	100	7.3	38.3	4.0	
Indiana	2.0	21	90	8.5	40.3	1.8	18.4
Iowa	1.1	30	100	12.0	39.0	1.3	
Kansas	1.0	16	33	7.1	36.9	2.3	3.5
Kentucky	1.2	20	50	6.0	37.9	1.9	3.7
Louisiana	1.4	18	100	8.0	39.3	2.1	
Maine	0.6	17	100	8.9	42.1	2.2	
Maryland	1.8	14	50	8.3	38.4	2.7	5.3
Massachusetts	2.3	9	50	8.8	38.9	3.9	7.8
Michigan	3.0	26	100	4.9	38.3	1.5	
Minnesota	2.0	20	87	9.8	40.9	1.9	14.7
Mississippi	0.8	17	33	5.0	36.7	2.2	3.3
Missouri	2.1	43	33	6.3	37.8	0.9	1.4
Montana	0.5	13	33	6.8	46.6	2.8	4.2
Nebraska	0.7	22	100	7.8	38.4	1.7	
Nevada	0.8		100	0.0	34.8		
New Hampshire	0.5	2	50	8.5	37.7	13.2	26.4
New Jersey	3.1	11	50	9.0	37.4	3.4	6.9
New Mexico	0.6	26	33	7.6	39.1	1.5	2.2
New York	7.1	14	100	7.1	43.0	2.6	
North Carolina	3.0	14	50	6.9	37.8	2.6	5.2
North Dakota	0.3	14	33	6.4	44.2	2.6	4.0
Ohio	3.5	141	60	8.5	38.0	0.3	0.7
Oklahoma	1.2	24	33	6.0	38.5	1.6	2.4
Oregon	1.5	17	100	7.9	40.2	2.2	
Pennsylvania	4.1	15	90	10.0	40.9	2.5	24.9
Rhode Island	0.4	19	33	9.0	42.8	2.0	3.0
South Carolina	1.4	45	100	5.0	36.9	0.9	
South Dakota	0.4	35	100	0.0	46.1	1.1	
Tennessee	1.8	9	50	6.5	35.0	3.9	7.8
Texas	7.2		100	0.0	36.4		
Utah	0.9	18	50	5.0	38.0	2.1	4.1
Vermont	0.3	16	50	8.5	43.3	2.4	4.8
Virginia	1.5	18	50	6.0	36.0	2.0	4.1
Washington	2.4		100	0.0	38.9		
West Virginia	0.5	16	50	8.5	37.1	2.3	4.6
Wisconsin	1.9	15	100	7.9	40.2	2.5	
Wyoming	0.3		100	0.0	40.5		

NOTES: This table shows the corporate tax revenue-maximizing corporate tax rate τ_s^* and the total tax revenue-maximizing corporate tax rate τ_s^{**}, which accounts for some fiscal externalities. These calculations are based on 2010 data and **average national parameter estimates** and do not incorporate heterogeneous housing markets. See Section 7 and Section D in the appendix for details. Sources: U.S. Census ASG and those in Section 2.

Figure A1: Time Series of State Corporate Tax Rates by State

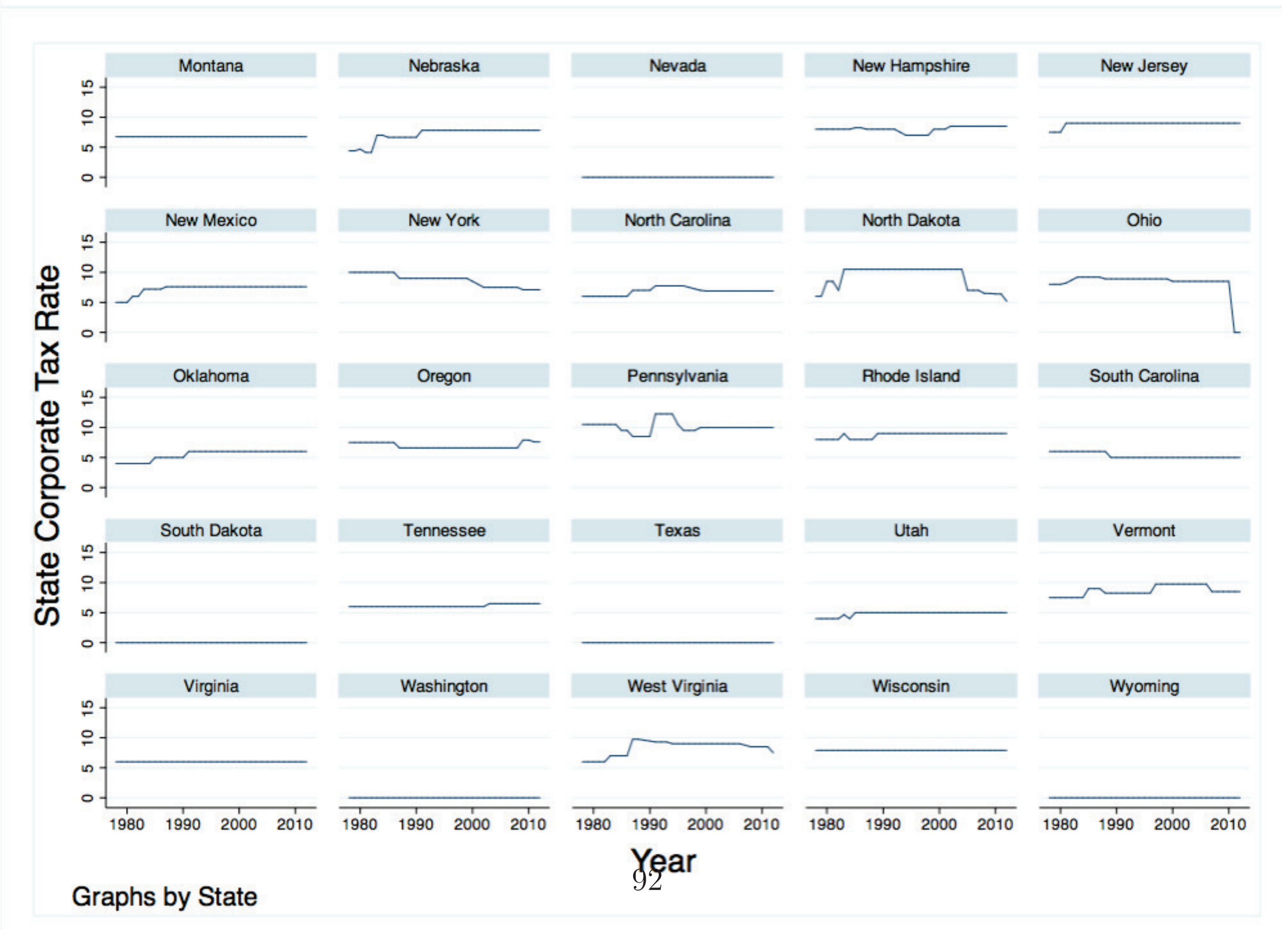
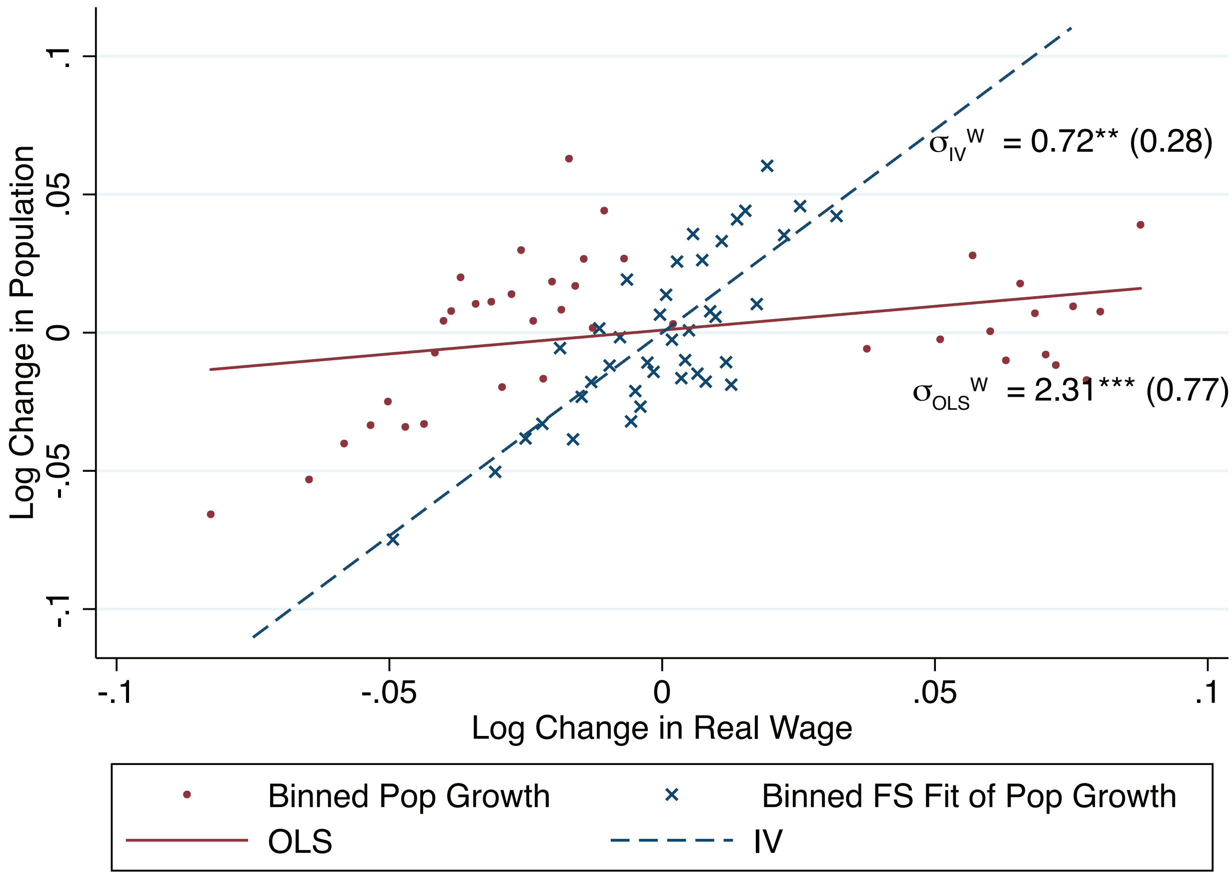


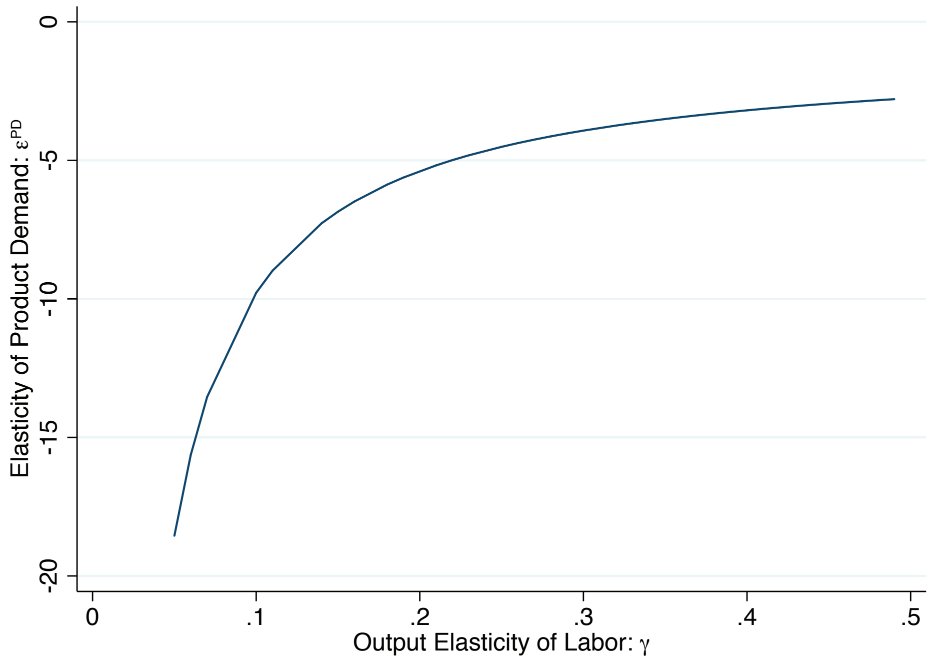
Figure A2: Estimates of Worker Location Equation



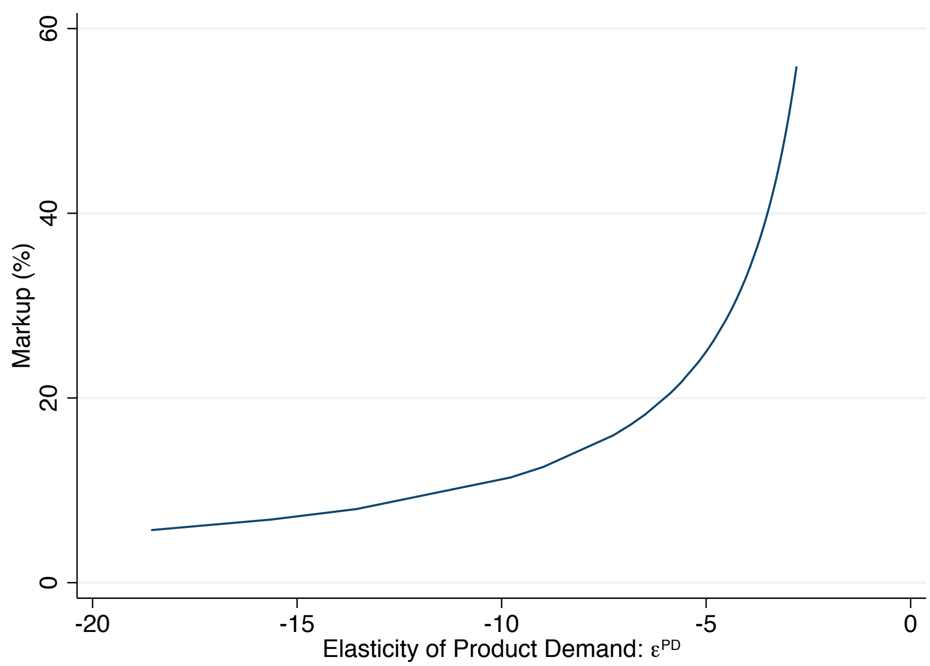
Notes: This figure illustrates the importance of accounting for regional amenities when estimating the parameters that govern worker mobility. Ignoring amenity changes attenuates the effects of wage changes on population changes. In particular, the figure shows the mean log change in population by bin of log change in real wage as well as the fitted values of a first stage regression of real wage on the Bartik shock and the tax shock. Using these fitted values illustrates how real wage changes (that are orthogonal to amenity changes) relate to population changes. The fitted lines in the figure plot the associated estimates via OLS and IV from Table A1. Standard errors clustered by state are in parentheses and *** p<0.01, ** p<0.05, * p<0.1.

Figure A3: Estimates of ε^{PD} and Associated Markups for Values of γ

Panel (a) Estimates of ε^{PD}



Panel (b) Estimates of Product Markups



Notes: These figures show the estimated value of ε^{PD} for different values of γ in Panel (a). These estimates correspond to different version of the CMD model with two shocks as in Panel (b) of Table 5. Panel (b) plots the associated markup for a given value of ε^{PD}.