Essays in Public Finance and State and Local Taxation

by

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ABSTRACT

This dissertation is in the field of public finance and taxation, with a specialization in state and local taxation in the United States. In the first chapter, it is sought to understand how business taxation at the state level affects the rate of entry and exits of businesses—or business dynamism. In the second and third chapters, The topic is approached from a different angle, and the following question is asked "how do economic shocks affect local taxation?" with a specific focus on property taxes. In the second chapter, jointly with Chiara Ferrero, it is analyzed at how the Great Recession and the precipitous decline in home prices across the country affected local property tax bases—or the assessed value of property—and local property tax rates. In the third chapter, it is analyzed how a different type of shock, robotization, and more generally structural shocks may impact local public finance, not only on the revenue side but also in terms of expenditures and public goods provision.

Business dynamism has been linked to innovation and employment creation, yet there is little empirical research on the relationship between business taxation and business operations' births and deaths. My contribution with this work would be to fill that gap and provide empirical evidence regarding the role of state taxation on establishments' entry and exit. Several identification strategies were exploited to answer that question. The paper starts with an event study and a distributed lag model to provide graphical evidence on large tax changes. In the main estimation strategy, the impact of states corporate taxation was identified using a difference-in-difference model. A negative effect of the state corporate tax on the entry of establishments and firms was documented: an increase in the top state corporate tax rate of one percentage point leads to a decline in the entry rate of about -1.5% to -3.5%. The effect on exits is positive but smaller (0.5%–1.5%) and usually not statistically significant.

Given the potential risk for endogeneity—tax changes may be correlated with unobservable local shocks, or policymakers may implement tax reforms correlated with local economic conditions—a border discontinuity identification strategy was used as well, where counties in a state experiencing a tax change were compared to counties across the state

border. Identifying the presence of spillovers is critical with that identification strategy but important overall from an empirical estimation and policy perspective as well. It was evaluated whether there were significant spillovers across state borders at the county and census tract level, no evidence was found that they were significant or that they drive the main findings. However, it was found that spillovers can be large in areas in close proximity to the border—within three to five miles. The findings are robust to changes in other state level policies, sample restrictions, and different identification strategies.

The second chapter, which is a joint work with Chiara Ferrero, begins with an ambitious data collection on historical local property tax revenues, where values and tax rates in the entire United States are assessed. Data were collected for 44 states, with some starting in 1990 until 2018—all but two states were fully covered between 2002 and 2015. This novel data set was leveraged to study the effect of falling home prices associated with the Great Recession on local property tax revenues. Accordingly, the mechanical channel through which home values affected assessed values and the policy channel through which policymakers responded to changes in the tax base were teased out.

It was found that the resilience of property tax revenues could be attributed to two main factors: a small correlation between home price changes and assessed values after 2007 as well as large increases in property tax rates in areas facing a negative shock in their tax base. Contrary to the mainstream perception, it was found that the recession had a small but negative and lasting impact on the tax base. Negative shocks were offset by as much as 80%–85% in the long run, implying that a 10% decrease in the tax base led to only a 1.5% decline in property tax revenues. Additionally, a large variation in responses was documented, and the role of property tax rate and levy limits during and post-recession was analyzed. It was perceived that rate limits seem to reduce the ability of policymakers to offset negative shocks in the tax base and lead to a bigger decline in revenues. While most jurisdictions seek to smooth out both positive and negative shocks, it was found that this is especially true in areas facing levy limits, consistent with the theory that policymakers want to avoid large downfalls.

In the last chapter, the role of a different shock is investigated, namely exposure to robotization, as well as its impact on local revenues and public goods provision. It is shown that exposure to robots leads to a decline in total revenues, driven by a large fall in tax revenues, specifically property taxes. Spending was found to be similarly affected, with expenditures on transport, capital outlays, and insurance and trust being primarily hit. The role of local autonomy, as defined by areas with functional home rule, as well as

the role of property tax limits were investigated. It was found that the decline in taxes was less pronounced in areas with higher autonomy and more pronounced in areas with strict property tax limits. Using a dataset on local property tax rates, it is shown that robotization leads to an increase in the average rate, driven largely by high autonomy areas. It is shown that these results are consistent with a model of optimal local policy, which depends on transfers and local income. Further, the importance of accounting for policy changes when investigating outcomes that are highly policy-dependent with shift-share instruments is highlighted.

CHAPTER I

In or Out? The Impact of State Business Taxation on Business Dynamism

Abstract

Business dynamism has been linked to innovation and employment creation, yet there is little empirical research on the relationship between business taxation and business operations births and deaths. Using several identification strategies that consider the potential endogeneity between tax changes and local economic conditions, a negative effect of the state corporate tax on the entry of establishments and firms is documented: an increase in the top state corporate tax rate of one percentage point leads to a decline in the entry rate of about -1.5% to -3.5%. The effect on exits is positive but smaller (0.5%–1.5%) and usually not statistically significant. Further, the presence of spillovers across state borders at the county and census tract level was evaluated, and no evidence was found that they were significant or drove the main findings. However, it was found that spillovers can be large in areas in close proximity to the border—within three to five miles. These findings are robust to changes in other state level policies, sample restrictions, and different identification strategies.

JEL Codes: H25, H32, H71, R38
Keywords: Business Taxation, Business Dynamism, State Taxation

1.1 Introduction

The secular decline in business dynamism and entrepreneurship since the 1980s in the United States has been well documented and has brought the issue of business creation and destruction back into the spotlight. Since Schumpeter's seminal work, business dynamism and "creative destruction" have been seen as essential elements of innovation and creation of growth-spurring goods and services. Despite large firms being innovators and representing a large share of patents, the notion remains that major changes in technology and consumption are brought by small, young, and job-creating firms, and it is empirically supported as well.[1] In this paper, the impact of business taxation at the state level on establishments and firms' entry and exit is studied. The number of empirical and structural studies using variation in state tax systems is growing; however, little is known regarding the impact of state taxes on business dynamism. Shedding light on this relationship is important to paint a clearer picture of the role of taxation an policy. Two years after the introduction of the Tax Cuts and Jobs Act (TCJA), the effect of corporate taxation on economic activity, employment, and growth remains a fundamental question. A usual argument used in policy circles in favor of lower taxation is that higher taxes limit entrepreneurship and risk-taking and hence threatens some fundamental and necessary characteristics that foster growth. This study provides some empirical results adding to the understanding of state tax policy in particular and corporate taxation in general.

The large variation in state tax systems, both across space and time, provides a unique setting to identify the impact of tax reforms. Evidence suggests that state corporate taxes have a negative effect on employment and income (Ljungqvist and Smolyansky (2018)) as well as the number of establishments owned by multi-state firms (Giroud and Rauh (2019)). A related question emerges: where are jobs gained and lost? Whether state tax changes affect businesses' entry and exit will guide the understanding of this question. The theoretical predictions on how corporate taxation affects firm creation, employment, and investment are clear. However, the endogeneity of tax systems and tax reforms and the difficulty in finding a setting with clear identification for empirical analysis has led to mixed results and debates. In this paper, several identification strategies were used to evaluate the question at hand. An event study analysis of large tax reforms was conducted first, and a difference-in-difference strategy exploiting the variation within states over time was implemented. Results from a border discontinuity design are presented as well, where

[1]E.g. Haltiwanger, Jarmin and Miranda (2013) showed that one of the major determinants of job creation is firm age.

identification comes from comparing outcomes in“treated” border counties experiencing a tax change and using adjacent counties across the state border as controls. This designs alleviates the threat of tax reforms being correlated with unobservable shocks. It was consistently found that corporate tax hikes reduce the entry rate of establishments, where a one percentage point increase in the corporate tax rate leads to a decline in entry of about -1.5% to -3.5% depending on the specification. The estimates from the border discontinuity design were found to be on the higher end of the spectrum in magnitude, indicating that tax hikes may be more likely to be implemented in times of rising entry and vice versa for tax cuts. Some weaker evidence was found that tax hikes lead to a small rise in exits, with a short-lived effect, which is consistent with theoretical predictions. Tax cuts were found to have a smaller and typically significant effect, leading to a small increase in entries and decrease in exits. However, evidence suggests that tax cuts may be more likely endogenous as well.

An important underlying question, which was amplified in the border discontinuity analysis, is the extent to which firm migration drives the outcome as opposed to actual births and deaths. Specifically, we may be concerned with the presence of spillovers when comparing counties across borders, which would lead to a different interpretation of the estimated effects. Although firm migration is clearly not limited to border areas, without establishment level data tracking individual units over time, such movement cannot be detected easily. In this paper, state borders were focused on to shed some additional light on spillovers and validate the understanding of tax changes in border areas. The decision to shift a firm’s location across areas is the first type of spillovers—the direct effects of a tax change on a firm’s optimal decision. However, there can also be indirect spillovers. An example of this would be lower economic activity from a tax hike impacting adjacent areas negatively as well. When testing for spillovers, it was attempted to tease apart these two effects and shed some light on both direct and indirect effects. Some results highlighting that a hike in the personal tax rate also leads to a decline in firm entry are presented, which is somewhat not too surprising as a large number of companies are not incorporated and face the personal income tax.

This paper contributes to the literature in different ways. First, new evidence is provided on the effect of state corporate taxation on business dynamism, specifically on establishments and firms’ entry and exit, exploiting several identification strategies to allow for causal interpretation. It is shown that the findings are robust to sample restrictions and various specifications as well. Second, light is shed on whether tax reforms have spillovers across state borders. In addition to performing a county level analysis, finer grain data was exploited at the census tract level. An analysis was performed evaluating the impact of a tax change on firms' entry and exit as a function of the distance to the border. This would capture localized effects that are too small to be precisely estimated in the aggregate analysis.

It is worth mentioning that the bulk of the analysis focuses on establishments' birth and death rates rather than firms. First, the goal was to evaluate how business taxation affects business activity, and it is believed that the number of business operations is the relevant metric as such. Second, the growth of existing firms, by opening and closing plants, is critical for employment, investment, and research and development. Finally, a majority of firms are single-establishment firms.[2] However, we also estimated how business taxes affect single-establishment firms, as it is important to understand the role of taxes on new businesses beyond overall economic activity.

Extensive and rich literature exists on business location decision and on the role that state and local taxes play since the pioneering work by Bartik (1985) and Carlton (1983). In recent years, there has been renewed interest in the literature on the effect of state taxes in the United States. The literature has typically taken two main approaches in exploiting the large variation in state level taxes both over time and across jurisdictions. Fajgelbaum et al. (2019) used a structural approach to look at the effect of state corporate tax cuts on firm location decisions and its welfare consequences for firm owners, workers, and landowners. The second strand uses reduced form estimations using a range of methods to overcome the endogeneity of tax systems and economic outcomes. Ljungqvist and Smolyansky (2018) evaluated the effect of corporate tax cuts and hikes on employment and income between 1970 and 2010 using a border discontinuity methodology. They found that a one percentage point increase in the corporate income tax rate led to a decline of roughly 0.24% in employment and 0.36% in income. These results held for tax increases, but the evidence was weaker on the effect of tax cuts, a result consistent with the current paper's analysis.[3] Also using a border county approach, Curtis and Decker (2018) focused on employment in young (0–1 year old) firms between 2000 and 2014. They found a large and negative effect of the corporate tax rate, with a decrease in employment of roughly 4% following a 1 p.p. increase, but small and statistically insignificant effects of the top marginal personal income tax and sales tax.

[2]In 2000, there were 6261576 firms and 7070048 establishments. In 2017, there were 6747135 firms and 7860671 establishments.

[3]They found that while tax cuts had little effect on either employment or income over, they mattered when implemented during a recession, where a one percentage point increase led to an increase of 0.64% in employment.

Giroud and Rauh (2019) used multi-state firms and found that changes in the corporate tax rate was associated with both extensive (establishment) and intensive (employment) margins of adjustment.[4] By using large individual firm data, they were able to control for endogenous selection of firms and control for time invariant characteristics. They found the number of establishments to decrease by about 0.52% when states increased the corporate tax rate for C-corporations and a smaller (0.4%) but significant effect of the state personal income tax on pass-through firms. Finally, regarding dynamism specifically, Kneller and McGowan (2012) looked at the effect of taxation on firm entry and exit rates in OECD countries between 1998 and 2005 using a difference-in-difference approach. They found results similar to that of the current paper: corporate income taxation has a negative effect on entry but no consistent effect on exit. Djankov et al. (2010) found in a 2004 cross-sectional analysis that corporate tax rates were negatively correlated with investment and entrepreneurial activity, while Da Rin, Di Giacomo and Sembenelli (2011) found that lower corporate tax rates lowered firm entry.

In the next section, the conceptual framework is presented, a simple model of general equilibrium with taxation and firm entry and exit is introduced, and how businesses are taxed at the state level as well as the data used in the analysis are discussed. The third section presents the different identification strategies implemented and discusses the main results. Section 4 shows some robustness checks and a discussion of the results. The last section presents the conclusion.

1.2 Conceptual Framework, Background and Data

In this section, the theoretical underpinnings between taxation and business dynamism are discussed. The decision to enter or exit a market for a firm is a dynamic one and will inherently depend on the decisions of other firms, as they compete for customers and resources. A simple dynamic general equilibrium model of firms' entry and exit is presented first to better understand the mechanism through which taxes affect firms' decisions. As discussed earlier, however, taxes will also affect the location decision of a firm, conditional on entering. Similarly, changes in taxation may push firms to reallocate to a different location. Beyond the model which focuses on dynamism, and does not include migration of firms, it is discussed how state taxes may affect location decisions and how it would impact theoretical predictions on dynamism.

[4] They found that roughly half of the results were driven by reallocation, while the other half constituted net creation (destruction) of jobs and establishments.

1.2.1 Dynamic General Equilibrium Model

The model is based on Sedlacek and Sterk (2019), who evaluated the effect of the TCJA on businesses, which itself is based on Hopenhayn (1992) and Hopenhayn and Rogerson (1993). The average state corporate tax was included, and the model was re-calibrated to look at the effect of a small change in corporate taxation on firm entry and exit. The key feature of the model is that it allows for endogenous firm entry and exit, allowing for the comparison of equlibria with different tax rates and how firm entry and exit rates are affected.

Here, the key aspects of the model as well as qualitative and quantitative predictions on firm entry and exit are discussed. The appendix section provides more detailed information on the construction of the model and the calibration exercise. Firms are heterogeneous in their productivity, and the market is perfectly competitive. Firms produce a homogeneous good using capital, labor and technology. At the beginning of each period, firms decide whether to continue operating or exit the market and discover their current productivity z. They choose labor l and capital k to maximize after-tax profit. Firms pay a capital income tax τ on profits. Firms also face a cost of capital adjustment specified as $\phi(k, k_{-1})$; capital depreciates at rate δ, and labor can be adjusted without any costs.[5]. Entry in the market is free; however, firms must pay an entry cost of c_e. Entrants know their lagged productivity z_{-1} and decide whether to enter or not based on their expected value function, behaving as incumbents.

The profit of continuing firms is $\pi = y - wn - i - c_f - \phi(k, k_{-1})$. If a firm exits, they sell their remaining capital and make a profit of $\pi = (1-\delta)k_{-1} - \phi(0, k_{-1})$. Firms can deduct labor costs as well as fixed costs of production and adjustment costs. Capital investment can be expensed gradually according to the rate of depreciation. The tax bill is then $T_c = \tau(\pi_c + i - \delta k)$ for continuing firms and $T_x = \tau(\pi_x + i) = -\tau\phi(0, k_{-1})$ for exiting firms. Importantly, it is assumed that firms can carry back their operating loss when they exit, hence making the tax bill negative for exiting firms.[6]

The value function of an existing firm is given by the following equation:

$$V(z_{-1}, k_{-1}) = \max \left\{ \underbrace{\mathbb{E}\{\max_{k,l} \pi_c - T_c + \frac{1}{1+r} V(z,k)\}}_{\text{Continuation value}}, \underbrace{\pi_x - T_x}_{\text{Exit value}} \right\}$$

[5]It is assumed that economic depreciation equals depreciation allowed for tax purposes

[6]Firms could carry back losses up two years until 2017 federally. Several states allow carry backs between two and three years (e.g. California, Idaho, Missouri, Oklahoma, Mississippi, Georgia, West Virginia, Virginia, Delaware and Maryland had a two-year carry back provision, while Montana, Wyoming, Utah, South Dakota and New York had a three-year provision in 2017.) In the simulation, the effect of tax reform on entry and exit without carry back rules is looked at as well.

There is a productivity cutoff z^*_{-1} at which the firm is indifferent between continuing and exiting. The cutoff increases in input prices (namely the wage rate) and production costs as they lower the present value of the firm and drive out lower productivity firms. It is assumed that there is a positive mass of entrants in equilibrium, which implies that the cost of entry is equal the the expected value of entrants, $c_e = \mathbb{E}[V_e(z_{-1})]$. The value for new firms also declines in the wage rate and production cost c_f.

Qualitative predictions

What happens when there is a reduction in the corporate income tax rate? We can first separate direct effects of tax rates which affect the present value of future profits and the indirect effects—the wage adjustment to changes in labor demand, which also affect optimal firm decisions. While the model does not consider transitions, the short-run effects on exit are potentially best captured by the partial equilibrium direct effects, while the short-run effects on entrants can be derived based on the entry condition as they behave like incumbents upon deciding to enter.

The direct effects—holding wages constant—comes from a change in the present value for incumbents. Following a decrease in the corporate income tax rate, the continuation value increases, implying fewer exits. The free entry condition implies that the number of entrants is constant in partial equilibrium; but as the number of firms increases, the entry rate declines. Looking at the entry condition, the continuation value increases, implying that there will be an increase in firm births.

The indirect effect comes from the wage adjustment. In addition to the rise in entry and the decrease in exits, existing firms increase their labor demand. This puts upward pressure on wages. As the wage rate increases, the continuation value of firms decreases, leading to an increase in the exit rate and a decrease in the firm size. The number of entrants initially increases but declines as the wage rate rises. In the equilibrium, there is an increase in the number of firms as well as the entry rate.

Note that from the optimal capital condition, it can also be shown that the optimal firm size will be smaller, allowing the number of firms to grow faster than the size of the economy. Because the expensing rate $\lambda < 1$ is below one, an increase in taxes leads to a higher marginal product of capital. Assuming capital and labor are complements, the optimal labor force per firm will be smaller as well.[7,8] We can see that the marginal product of capital increases with the tax rate, implying lower capital. It follows that the optimal labor choice will be lower as well, assuming labor-capital complementarity.

So far it has been assumed that exiting firms are able to carry back the cost of selling their remaining capital on previous tax liabilities. However, many states do not have carryback options, and it is limited in others. Additionally, carryback is usually only allowed for the previous two to three years. Firms that exit may be more likely to have little or no profits before exiting, making carryback less valuable. The current model was evaluated assuming that the tax bill for the exiting firm is zero. The results are qualitatively similar; however, the effects of a tax change on exit and entry rates are qualitatively lower, as it reduces the expected value of continuing firms and new entrants.

Quantitative predictions

The quantitative long-run analysis of corporate tax reforms is taken up here, and Sedlacek and Sterk (2019) is followed in their original setup.[9] The production function is $y = z(k^{\alpha} l^{1-\alpha})^{\theta}$, with the share of capital income $\alpha = 0.35$, and the span of control $\theta = 0.9$.[10,11] The model was calibrated with a starting tax rate of 41.6%, which is equivalent to the sum of the statutory federal tax rate of 35% between 1993 and 2017 and the average state corporate income tax between 1997 and 2017 (6.6%).

We can now evaluate the effect of tax reforms on firm entry and exit, total number of firms, and firm size. Figure A.4 in the appendix displays the general equilibrium effects of a change in the corporate income tax rate, with and without carryback. It is seen that a decline of around two percentage points (from 41.66 to 39.66) leads to an entry rate

[7]This can be perceived by deriving the optimal capital condition for a firm at time t, which is given by $\left(\frac{\partial f(k,n,z)}{\partial k}\right)(1-\tau) + \frac{i-\delta}{1+r} = 1 - \lambda\tau + \sum_{s=0}^{T} \frac{\partial \phi(k_t+s, k_{t+s-1})}{\partial k}(1-\tau)$, where the marginal benefit of an additional unit of capital is on the left-hand side and the marginal cost on the right-hand side. λ represents the present value of tax deduction from capital depreciation,and $\sum_{s=0}^{T} \frac{\partial \phi(k_t+s, k_{t+s-1})}{\partial k}(1-\tau)$ represents the present value of capital adjustment costs.

[8]$\lambda = \delta \sum_{s=0}^{T}(1-\delta)^s + (1-\delta)^{T-1}$. Remember that the present value of selling capital in the final period is equal to the investment which is $(1-\delta)k_{-1}$.

[9]A fixed operational cost c_f was included following a logistic distribution with mean μ_f and standard deviation σ_f. This implies that all firms have a positive probability of continuing, regardless of their productivity draw.

[10]These values are standard in the macroeconomics literature, and the span of control is in the range documented by Basu and Fernald (1997)

[11]The capital depreciation rate was set to $\delta = 0.08$. Productivity follows a log normal distribution $\log z = \mu_z + \rho_z \log z_{-1} + \epsilon$, with $\epsilon \sim N(0, \sigma_z^2)$. The remaining parameters (mean of TFP shocks - μ, dispersion of TFP shocks - , auto correlation of TFP shocks - ρ_z, mean of cost shocks - μ_f, and the adjustment costs parameters ζ_0 and ζ_1) were set such that the model matches specific statistics from the data. Note that the disutility of labor v was set so that the wage rate is normalized to one, and the entry cost c_e was set to normalize the mass of new firms to one.

roughly 10% higher in the equilibrium. The effect on the exit rate is similar. The average size of new firms declines by around 5%, and there is an increase of about 10%–15% in the total number of firms. These results should be interpreted carefully, as there are several factors that could lead to lower magnitudes. First, it was assumed that firms pay the statutory tax rate; however, the effective tax rate is typically much lower, and a lower statutory tax rate may not affect all businesses alike. Second, this is a closed economy setting with perfect competition. In an open economy with market concentration, the existing firms may exploit tax cuts to invest and grow, limiting the potential of new entrants; firm migration and spillovers across regions may also affect the distribution of entry and exit following tax reforms. Finally, this is a long-run equilibrium that assumes flexible wages and inelastic labor supply. If the change in wages is slow, transition paths may be long before reaching the new equilibrium. The following table summarizes the predictions of the model on entry, exit, and the total number of firms.

Predictions - 1 p.p. tax cut	Short-run	Long-run	LR effect
Birth rate	$\uparrow$	$\uparrow$	$\tilde{4} - 5\%$
Death rate	$\downarrow$	$\uparrow$	$\tilde{4} - 5\%$

Table 1.1: Summary of model predictions

1.2.2 Firm location decisions

While the general equilibrium model provides useful predictions and intuition on the role of taxes on business dynamism, it has some drawbacks. First, it is a closed economy model and does not capture the role of taxes on the firms' location decision. Second, it does not make a distinction between establishments and firms. It is important to address both these issues.

How would the inclusion of location decision for new firms and entrepreneurs affect the estimates? Assuming firm owners choose location i that maximizes profit π_i, they would choose the location with the lowest tax burden—or the highest present value of income—all else equal. For exposition, assume there are two states: A and B. Following a tax cut in state A, there will be more potential owners at the margin who will start a business in state A relative to state B. Similarly, firms at the margin of moving from state A to state B will be less likely to switch locations. Arguably, the cost of choosing a different location will be higher for existing businesses compared to potential ones, such that the effect on firm births should be of higher magnitude. In essence, the short-run effects are similar to the closed economy model. As the magnitudes in the short run increase, we may see faster long-run adjustment allowing for location decision compared to the closed economy model.

The second caveat in the model is the lack of distinction between establishments and firms. However, large firms operating in several states will also be sensitive to state tax rates when expanding their establishments. As noted by Devereux and Griffith (1998, 2003), the extensive margin of adjustment for existing firms depends on the average costs of production in the new location. As such, the top marginal statutory rate is typically closest to the average tax rate and the relevant parameter. Giroud and Rauh (2019) found statistically significant elasticities in the extensive margin of adjustment using states' top corporate marginal income tax rates. The data tracks establishments rather than firms, which implies that the estimates will capture effects on new operations and the external margin of adjustment of large firms. It is important for the interpretation of the coefficient regarding whether we can distinguish the two. While the elasticity of establishments with respect to the tax rate carries important implications in terms of employment and investment and is an important parameter, innovation and the idea of dynamism is a firm-level concept. This is discussed further in the data and estimation section, and the results on firms and establishments are presented separately.

1.2.3 Connecting theory and empirical estimations

According to the model's predictions, following a tax cut, a short-run increase in firm births and decrease in firms death should be observed, while the long run effect will be positive for both. The speed of adjustment cannot be predicted, which will depend on several local characteristics such as the rigidity in the labor market, the speed at which factor prices adjust (e.g., only labor was considered in the model, which can be extended to capture other factors such as land), the mobility of existing, and potential firms. This carries important implications: we may be able to capture the effect of tax changes on births more precisely as they face similar qualitative predictions in the short and long run, while the effect on deaths should be harder to identify, especially depending on the speed of adjustment.[12]

Another important missing piece from the theoretical framework is the legal form of organization (LFO) that firms choose. In the model, it was assume that the legal form of organization is exogenous and given for any firm. In reality, firms have different forms of

[12]Fuest, Peichl and Siegloch (2018*a*) looked at the impact of changes in local business taxation on wages in Germany. They found that wages respond quickly after the change up to roughly 3–4 years after the tax change takes place. Results in the United States on adjustment in employment and income were found to occur quickly, within one or two years following the tax change (Ljungqvist and Smolyansky (2018), Giroud and Rauh (2019), Curtis and Decker (2018)

organization and face different business income taxes. Firms electing to be C-corporations will be subject to the federal and state corporate income tax. Pass-through firms (e.g. partnerships, LLC, or S-corporations) face the personal income tax on most of their income. However, the taxation of such firms is less straightforward. First, owners are taxed, which implies that if an LLC is located in Illinois and owned by Michigan residents, the firm will not pay income tax in Illinois, and the owners will face the Michigan personal income tax on their earnings from the company. However, some states require owners to have a residence in the state where the establishment is located for it to be taxed as pass-through. Otherwise, even legal pass-through firms may be treated as C-corporations.[13] In some states, owners can also elect for the firm to be at the entity level (rather than as a pass-through firm). The rules on the taxation of pass-through businesses vary by states and across time, and determining the tax rate faced by such entities can be difficult.

In the 1970s and 1980s, C-corporations generated a vast majority of income and employment, and represented a majority of firms (excluding sole-proprietorship). Following the Tax Reform Act of 1986, the number and importance of pass-through firms increased steadily. In 2010, they represented a majority of businesses and a sizeable fraction of income and employment (around 40%). However, corporations remain a sizeable portion of businesses as well as new establishments and firms. In 2010, the average number of establishments listed as C-corps in each state was between 20% and 45%. Under these assumptions, the direct effect of a change in the corporate tax rate will be lower as it will only impact corporations. However, the indirect effects can also affect pass-through firms. Additionally, an increase in the corporate income tax could lower the rate of exit and entry of corporations, leading to a rise in the entry of pass-through firms in the equilibrium. However, the short-run implications are less clear. Pass-through firms selling intermediary goods to corporations may also experience a rise in exit and a decrease in entry as the size of their market decreases. As the empirical section evaluates an average effect of tax reforms in the short and medium run, it is important to keep in mind that tax changes may have different implications in long-run equilibrium.[14]

[13]E.g., Georgia requires all owners to be in the state or for them to file a consent form that the income generated by the firm located in Georgia will be taxed in the state.

[14]Suárez Serrato and Zidar (2018) used an effective tax rate based on the relative number of establishments that are single-state C-corporations, multi-state C-corporations, and pass-through entities. However, such a methodology would not readily apply in this context. First, publicly available data on LFO by state and counties only starts in 2010, and the current study's data starts in 1978. Second, the number of firms by LFO is likely endogenous to the tax system itself.

1.2.4 Data and descriptive statistics

A. Business taxation at the state level.

The data on the top corporate income tax and the top marginal income tax at the state level between 1978 and 2017 were used. The data were obtained from a variety of sources. First, the University of Michigan Tax database was used to get data on sales and corporate income tax between 1978 and 2002. After 2002, data from the Tax Policy Center and code corporate tax rate and brackets were used. In the main analysis, the top marginal income tax was focused on. Some states have a flat income tax, and while some states have progressive corporate income taxes, the top marginal rate usually has a pretty low threshold. The data on the top marginal personal income tax rate obtained from NBER Taxsim were employed here. Taxsim uses the effective marginal tax rate faced by household after deductions and which as such can be different than the official top marginal tax rate. To ensure accuracy, the data on the top marginal income tax rate in each state between 1978 and 2017 were obtained from the Tax Policy Center and the Tax Foundation as well.

There is a large variation in corporate and personal income tax rates in the United States. Several states impose no corporate tax rates on income (Texas, Washington, Nevada, Wyoming, South Dakota), while others have top marginal tax rates around 10% (New York, Minnesota, Iowa).[15] Other states such as Washington and Michigan had gross receipts tax until 2012. Similarly, several states have no personal income taxes, while the top marginal tax rate is around 11% in California.[16]

There has also been substantial variation in tax reforms. Figure A.3 shows corporate and personal income tax changes by state and year between 1978 and 2017. Table 1.3 shows the average magnitude of corporate and personal tax changes. The average is roughly similar, around 0.9 percentage point. Corporate tax hikes are larger, 1.3 p.p. on average, compared to 0.67 p.p. for cuts. There were 84 hikes and 136 cuts throughout the 40 years observed in our analysis. Changes in the personal income tax were found to be more frequent and equal, with the 178 increases and 199 decreases hovering around 0.9 p.p. on average.

In most specifications, state-level tax incentives in the form of financial assistance for

[15] While Texas does not have a corporate income tax, it has a franchise tax, which in 2019 was 0.575% on 10 million or less in annual revenue. In 2020, there were 20 states with a franchise tax, although the rate is small in a majority of states with some exceptions such as Texas and Delaware.

[16] Figure A.3 in the appendix shows the average tax rates and total change over the sample period, 1978–2017.

industry or general tax incentives were included, which were obtained from Giroud and Rauh (2019). In some specifications, it was controlled for other state-level tax policies, such as the sales tax rate, apportionment factors for multi-state firms, R&D and investment tax credits, and whether states have carry-back provisions.[17,18] Tax credits, provisions, and apportionment and throwback rules were obtained from Serrato and Zidar (2016) until 2014 and from the Commerce Clearing House's State Tax Handbooks for the following years. The sales tax data between 1978 and 2002 were obtained from the University of Michigan tax database and from Tax Foundation after 2002.

B. Establishment data and business dynamics

Two sources of business dynamics data were used in the analysis. The first main source data comes from the Business Dynamics Statistics (BDS), a data set provided by the Census Bureau based on administrative data. It provides county-level statistics on the number of establishment entries and exits, total firms and firm deaths, the number of establishment expansions, and contractions between 1978 and 2018.[19] The data was computed from micro-data collected for the County Business Pattern (CBP) and the Business Register. Previous versions of the BDS were based on the CBP only, which looks at the number of establishment, payroll, and employment on the week of March 12 each year. With the redesign of the program, this version of the data covers changes in business dynamism taking place in a calendar year. It is worth mentioning that the aggregate data does not distinguish between a new establishment and an establishment that migrated from another location. Entries are sometimes referred to as birth/death throughout the paper, by which it means birth/death at the county level.

Table 1.2 displays summary statistics at the county level for all counties as well as border and interior counties. Given the importance of spillovers, specifically in the border discontinuity analysis, it is important to compare border and interior counties. The last column of the table computes the differences in means between interior counties and border counties as well as a t-test for whether they are statistically significant. It can be seen that the entry and exit rates of establishments are slightly lower in border areas as well as the per capita births and deaths of establishments As it was controlled for local fixed

[17]States apportion the corporate tax liability based on a weighted formula of sales, payroll, and property in each state. Because states have different ways to assess tax liability and different apportionment formula, it is possible for firms to have some non taxed income. Some states (currently 25) have implemented a throwback rule, which states that non-taxed income can be attributed to the state where the sale originates.

[18]Some years were missing in the data on tax credits and incentives. When this occurred, the last year available was used.

[19]https://www.census.gov/data/datasets/time-series/econ/bds/bds-datasets.html

effects, it was important that border and interior counties did not have differential trends over time. T-tests were performed to see whether the changes in birth and death rates were statistically different. While the hypothesis that the levels are equal could be rejected, the one that changes ($\log \Delta Entryrate$ and $\log \Delta Exitrate$) are equal could not be rejected. This assures us that differential trends in border counties did not bias the results.

The second source of data comes from Infogroup USA for 1997–2017, which consists of the near universe of establishments in the United States. Infogroup compiled a list of US businesses using a variety of sources, including the Yellow and White Page directories, public records on business registrations, utility connects and disconnects, etc.[20]. The information includes the business name, address, geocoded location, number of employees, and industry codes. When a new business is identified with a utility connect, they are then confirmed via telephone calls within 2–3 months. This process is important because it insures us that most businesses will appear on the data set shortly after its creation.

Each business is attributed a identification number, allowing us to map the number of entries and follow businesses over time. However, it was found that 5%–10% of establishments have a different identification number over time, the majority of it being attributed to a change of address. By matching over names and addresses, these firms were recoded as existing firms. The data on longitude and latitude were used to find the census tract in which each establishment was located as well as the distance of the establishment from the border.[21] Firm entry was characterized as any firm that is observed in year t but not $t-1$. Firm exit in period $t-1$ was characterized as a firm that was last seen in period $t-1$. For each year, the number of firms, firm births and firm deaths, as well as employment in new firms at the county and at the census tract level were aggregated.[22]

Table A.1 in the appendix displays similar statistics for census tracts. All the data comes from Infogroup. It was observed that the entry and exit rate is higher at the census tract level, which is not surprising as it is possible that some firms changing location within the same county but to a new tract would be counted as an entry and exit, while they would not show in the county level data.

The second panel displays statistics by distance to the border. It is seen that the entry and exit rate is slightly higher closer to the border but not the total number of firms

[20]More information on the data is available in the appendix

[21]Specific and detailed explanations of the cleaning and geocoding is provided in the appendix.

[22]Given the process of identifying new firms, I am fairly confident most firms born during a year will be captured in the data (the exceptions might be firms that start near the end of the year). However, identifying firm exits is more difficult. A firm that goes out of business may still have an address, phone number, and utility connection for a while after exiting. As such, it is likely that I underestimated the true number of exits or that firms were classified as exits with a lag.

and employment in new firms. That may reflect higher business dynamism in areas near borders.

C. Other policies and controls

Some additional data were used as controls from various sources. Accordingly, data on local population from the Census were employed. The state minimum wage as well as unemployment compensation rules were obtained from the US Department of Labor. Unemployment compensation is based on the maximum base allowed multiplied by the top tax rate of replacement.[23] The data on Medicaid expansion were obtained from the Kaufmann foundation.[24] The data on per capita property taxes were obtained from the Census of Governments. Because it is only available every five year with years ending in ’2 and ’7, the data between 1982 and 2017 were obtained, and linear extrapolations were carried out for the remaining years. The data from the Census on shares of population by age and race were employed at the county level, and data on total population were employed at the census tract level. A linear extrapolation was done between 1980, 1990, 2000, 2010, and until 2017.[25] Data were also obtained from NHGIS, which is based on the Census and the American Community Survey on the share of population with a college degree at the county level and demographic shares at the county and census tract level. The data on which counties border state lines were obtained from Holmes et al. (1998), and data on the distance between counties’ centroids and census tracts were obtained from the NBER County and Census Tract Distance Database.

1.3 Empirical Strategy and Main Results

State tax rates are not randomly assigned, neither are state tax reforms. The first source of endogeneity comes from unobservable local characteristics correlated with both the tax rate and local economies. Here, I mean unobservable characteristics which are relatively constant in the short and medium run. This could include geography, access to infrastructure, and local networks of firms. For example, states such as California or New York have higher than average corporate and personal income tax as well as high business and economic growth. A positive relationship between the tax rate and the number of

[23] This data is available from the “Significant Provisions of State UI Laws” at https://oui.doleta.gov/unemploy/statelaws.asp

[24] https://www.kff.org/medicaid/issue-brief/status-of-state-medicaid-expansion-decisions-interactive-map/

[25] For years 1979 and 1978, the extrapolation was carried out backwards using the average yearly change between 1980 and 1990.

new firms would capture unobservable characteristics of the local economy, and it can be posited that most businesses start in California in spite of the high taxation, rather than because of it.[26]

The second source of endogeneity, related to the first one, is reverse causality stemming from dynamic selection by policymakers. That is, if changes in tax rates are systematically correlated with local economic conditions and unobserved local shocks—including firms' location decisions and the number of new firms—the coefficient will be biased. The sign of the bias depends on the reaction of policymakers. If states increase taxes when the economy grows and decrease taxes when faced with negative shocks, there will be a positive bias on the birth rate coefficient. While it may seem more likely for the federal government to do so, states face significant budget constraints, and we could expect states facing declining revenues following an economic crisis to increase taxes. The endogeneity of tax responses to local economic shocks is an empirical question. A related concern is the contemporaneous changes of several policies that potentially affect business dynamics.[27]

Finally, we may worry about potential confounders being correlated with both changes in taxation and with business dynamics. For example, exogenous tax changes in states that have different secular trends in establishment entry and exit rates will lead to biased estimates. Different identification strategies were implemented to deal with these specific issues. Throughout this study, the outcomes of interest are the log entry and exit rate of establishments at the county level. The rate was chosen not only to take into account the size of local economies but also present some results using total establishment entry and exits per capita. The main explanatory variable is the corporate tax rate, which implies that a semi-elasticity is estimated. Typically, point estimates can be interpreted as the *percent change* in the rate of establishment entry/exit following a *1 percentage point change* in the business tax rate. When results on tax hikes and cuts are presented separately, the magnitude of tax changes is used.

1.3.1 Main analysis

A. Event-study analysis

[26]The sign of the bias is unclear and depends on the correlation between tax systems and unobservable local factors. If places deemed as more desirable by firms also have higher tax burdens, such as California, the bias will be positive.

[27]Romer and Romer (2010) used textual analysis to categorize tax changes into 1. endogenous changes—stemming from economic shocks—and 2. exogenous changes—stemming from stemming from overall tax reforms and political changes. The accuracy of this methodology still needs to be tested empirically in different contexts. Giroud and Rauh (2019) used the textual method in their analysis and found highly similar effects when controlling for other characteristics. Their data set has been used here as well, which is described in the main findings.

The analysis begins by presenting some graphical evidence in the form of an event study. The following model was evaluated:

$$\log y_i t = \sum_{j=-3}^{4} \beta_j D_{i,t}^j + \Gamma X_{i,t} + \lambda_i + \mu_t + \varepsilon_{i,t} \tag{1.1}$$

where $D_{i,t}^j$ is a dummy variable that takes the value of 1 when a specific change occurs at time t, which in this case is an increase or decrease in the corporate tax rate. Following Fuest, Peichl and Siegloch (2018*b*) and Simon (2016), this specification was estimated for tax hikes and tax cuts as well as large increases and decreases. Large increases and decreases are specified as the 75th percentile for hikes and cuts respectively. In the current sample this comes to increases equal to or larger than 1.5 p.p. and tax decreases equal to or larger than 1 p.p. in magnitude. Given the large number of changes in the sample, the analysis was restricted to areas only experiencing one large tax change in the estimation window. To choose the estimation window, it was required to balance the need for a large enough window to observe how quickly tax changes impact entry and exit, potentially restricting/biasing our estimates.[28] A window with three leads and four lags were chosen, and observations where there was more than one large tax change in the estimation window were removed—effectively, any tax change for which another tax change of at least 1 p.p. occurred in a four-year lead window was removed. The focus was laid on large changes since they were most likely to bias estimates for another large change happening shortly after. The same procedure was followed with all tax changes, removing all observations for which a tax changes happened in the lead window.[29]

This model provides some insight on potential trends or confounding factors that would impact the analysis. The presence of pre-trends or correlation prior to a tax change would indicate some potential endogeneity and threaten the interpretation of the results. Borusyak and Jaravel (2021) showed that fixed effects in event studies can fail to detect endogeneity in pre-trends and proposed that researchers use random effects instead. This finding was implemented in the current analysis and estimate equation (1.1) with random effects. Additionally, year fixed effects as well as demographic and policy control variables were included as well.[30] Additionally, dummy variables were included for Ohio, Michigan,

[28] Additionally, having sufficient lags is important to observe whether changes are temporary or not.

[29] For example, Pennsylvania experienced a 3.75 p.p. tax hike in 1991, a 0.26p.p. tax cut in 1994, and a 2p.p. tax cut in 1995. Only the 1991 tax hike was retained for the analysis. Further, the model was estimated without removing any tax changes and removing only observations with a large tax change in the lead window. The results for the full sample are available in the appendix.

[30] Policy controls at the state level include the personal and sales tax rate, the minimum wage, unemployment insurance compensation, and tax incentive and financial assistance. At the county level, the fraction of local revenues coming from local taxation as well as the log property tax share per capita were included.

and Texas in years following a their tax reform, as well as a dummy interacted with the tax rate for states which collect a gross receipt tax (Ohio before the tax reform, Texas, and Washington). Standard errors were denoted by $\varepsilon_{i,t}$ and clustered at the state level to consider the correlation from units experiencing the same treatment at the state level.

B. Analytical framework

In the event study analysis, identification was achieved from within counties experiencing corporate tax reform over time. In the main specification, the same strategy was followed using a first-difference estimation around the tax change. Essentially, the following model was estimated:

$$\Delta \log y_{i,t} = \beta \Delta \tau_s^c + \Gamma \Delta X_{i,t} + \psi_d + \mu_t + \varepsilon_{i,t} \tag{1.2}$$

where $\Delta \log y_{i,t}$ is the yearly first difference outcome of interest—either the establishment entry or exit rate—$\Delta \tau_s^c$ is the change in the state corporate income tax, μ_t are period fixed effects that capture national changes in dynamism, and $\Delta \Gamma X_{i,t}$ includes state- and county-level policy and demographic controls. Additionally, ψ_d was included, which refers to census division fixed effects that capture more localized trends in business dynamism.[31] Unless otherwise specified, the same controls as stated were used for the event study framework. Standard errors $\varepsilon_{i,t}$ were also clustered at the state level.

This estimation method was chosen for several reasons. First, it allows flexible specifications such as region- and state-specific time trends as well as testing for asymmetric tax changes. Second, the number of tax changes happening in each unit varies wildly. Some states may only modify the tax rate once or twice, while others experience a lot more. In addition, other state-level policies potentially affecting dynamism may change during the same period. The flexibility of this specification also allows us to conduct heterogeneous sample analysis by removing certain observations.[32,33]

Demographic variables include the log population, the share of population between 20 and 59, the share of white and Black residents, the share of people with college education, and the share of people living in urban areas.

[31] There are nine census divisions: New England, Mid-Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, and Pacific. Some results are shown without division trends as well as using state trends.

[32] E.g. New York implemented 10 tax cuts and one hike between 1987 and 2017. Additionally, since the standard errors were expected to be serially correlated, a fixed effects model would not be more efficient. Some results are presented using a fixed effects model in the robustness check section and the appendix.

[33] A recent and rising literature has shown potential identification problems related to models with two-way fixed effects as well as identifying assumptions in DiD models with heterogeneous and staggered treatment effects. This has been touched on in the robustness check and discussion section of the paper.

As this identification strategy is akin to a difference-in-difference strategy with multiple treatments (the corporate tax change), the estimation window needs to be specified. To correctly identify the effect of a tax change, only one treatment was allowed for each estimation window. This implies that observations where more than one corporate tax change happened within the estimation period had to be removed. A three-year estimation window starting two years before the tax change was chosen. Additionally, results extending or shortening the estimation window are presented to confirm that the results are not sensitive to the window choice.

C. Distributed lag model

The fundamental assumption to identify estimates using a difference-in-difference strategy is the lack of pre-trends or parallel trends assumption between treated and control units. Essentially, this implies that the treatment should not be correlated with the outcome prior to the change. A distributed lag specification was estimated to test this assumption as well as to further investigate dynamic effects, such as delayed responses and reversal effects:

$$\Delta \log y_{i,t} = \sum_{k=-3}^{4} \beta_k \Delta \tau^c_{s,t} + \Gamma \Delta X_{i,t} + \psi_d + \mu_t + \Delta \varepsilon_{i,t} \tag{1.3}$$

where β_k captures the effect of a tax change happening at time t on the outcome before and after its implementation. The included controls are the same as described in the difference-in-difference framework. Similar to the event study, the observations for which a tax change happened in the lead window were removed.

D. Border discontinuity framework

One of the endogeneity threats discussed is the presence of correlations between unobserved time-varying shocks and tax changes. To circumvent this issue, a number of papers have used a border discontinuity design (Holmes et al. (1998), Dube, Lester and Reich (2010), Dube, Lester and Reich (2016), Ljungqvist and Smolyansky (2018), Curtis and Decker (2018)). Under the assumption that counties in close proximity experience similar shocks, one can compare jurisdictions across the border, using counties in a state without a tax change as controls for the ”treated” units experiencing a corporate tax hike or cut. A second advantage is that economic conditions in specific border counties may be more likely to be orthogonal to state-level policy making. In this context, identification comes from differences across treated and control border counties. The following model was estimated:

$$\Delta \log y_{i,t} = \beta \Delta \tau_s^c + \Delta \Gamma X_{i,t} + \psi_d + \gamma_{gt} + \varepsilon_{i,t} \tag{1.4}$$

where γ_{gt} is group-by-year fixed effects, absorbed yearly within pair shocks. A group is defined as a county experiencing a tax change and all its bordering counties. Because counties typically share a border with more than one other county, control units can appear more than once. Treated units, however, only appear once. The estimation began with the sample and treatment window as in the baseline estimation strategy, and bordering controls' counties were added to the sample. Any pairs where the control units experienced a tax change in the three years prior to the treated areas were removed. [34] Standard errors should also be treated differently. First, as noted by Dube, Lester and Reich (2010), we should assume serial correlation at the county level in outcomes over time. Second, the treatment is perfectly correlated for counties in the same state. In the main analysis, standard errors were clustered at the state level. In this framework, certain counties can be present in more than one pair, which signifies correlation between pairs. The residuals will not be orthogonal for counties in the same state or for pairs sharing the same border. To deal with this issue, two-way clustering was used at the state and the border segment level.[35]

The main advantage of this identification strategy is the ability to control for area-specific shocks that may bias the estimates. The drawback is that border counties may be more likely to be subject to spillover effects, which would bias the coefficients. Moreover, state borders may not be representative of a state's economy and may react differently to tax cuts or hikes. While the estimates would still be unbiased, as we seek to know more about the overall effect of business taxation, the external validity of the findings would be compromised.[36] The results are presented in the next section.

[34]The requirement that control units are untreated beyond the estimation window was extended to be conservative. Further, an approach was attempted with extending the window to two and four years before the change. Shrinking the window to two years produced coefficients of similar magnitude—about 10–20 percent smaller with similar precision. Extending the window to four years produced almost identical coefficients with slightly higher standard errors but still statistically significant at the 5% threshold.

[35]Cameron, Gelbach and Miller (2011) derived this approach showing that a large enough number of clusters (40) leads to reliable inference. In all specifications, the stata command *regfdhe* that allows us to use two-way clustering was used. In addition, this command takes into account singleton groups, which may bias standard errors.

[36]Counties in New York and New Jersey across the Hudson River likely face similar economic shocks while other counties do not. Counties in the West are typically quite large and cover large portion of the state.

1.3.2 Main Results

A. Event Study

Figure 1.3 plots coefficients obtained from the event study estimation. Starting with the establishment entry rate as the outcome (in the top panel), it is noticed that large hikes have a large negative effect, occurring mostly in the two year following the tax change. The overall impact stays constant and statistically significant until some reversal occurs four years after the change. The effects of all hikes are much smaller, although they follow a somewhat similar pattern. In the lead window, we cannot observe clear pre-trends, and estimates for both large and all hikes are close to zero.

Turning to the impact of tax cuts, the establishment entry rate was found to increase by about 2.5% the following year and was statistically significant two years after the tax change, after which there was a reversal effect. No effect of tax cuts were found at the time of the change, but a small rise in entry was observed two years after, likely driven by large cuts. Unlike large cuts, there was no reversal using the sample for all cuts, and the entry rate stayed about 2% larger four years after the change. The pre-trends look flat for large cuts, but the small cuts sample potentially shows some upward trend throughout the analysis period.

Panel (b) of the figures plots the exit rates. Large hikes do not seem to impact exit rates until two to three years after, when we see a large jump, equivalent to a 3%–4% increase, followed by a reversal. This is potentially consistent with establishments changing location rather than exiting the market. While a tax hike may discourage the entry of new business operations right away, firms wishing to move to a location with lower taxes would need time to adjust. Exit rates slowly were found to increase in the first two years following a tax hike using the full sample—although none of the estimates are statistically significant—after which the pattern is comparable to large increases. No significant pre-trends were detected, although the large and all sample changes were found to move in opposing directions. Large tax cuts were found to have a negative impact on exit rates the year following the change, but an immediate reversal occurred. On the other hand, the exit rate was found to steadily decline until three years after the change before reversing and was statistically significant in periods two and three. Pre-trends were quite flat, although we may again worry about a negative trend looking at the tax cuts sample.

Taking stock of the graphical evidence, it is seen that tax hikes have a large and immediate negative impact on establishments' entry rates, while the effect on cuts is smaller and more delayed. The evidence of the impact of cuts and hikes on exit rates is more mixed, with a large but delayed response following a large hike. Both entry and exit show signs of reversal three to four years following the change, but overall, the impact is more consistent, and the reversal effect is smaller for establishment entry.

B. Main findings

Figures 1.5 and 1.6 plots the coefficients obtained from the distributed lag model. The impact of a tax change on the establishment entry rate is immediate and large (around 2% for a 1 p.p. change in tax). It then slowly declines until three years after the tax change and experiences a reversal, similar to the observation made with the event study. Pre-trends appear flat as well, validating the identifying assumption for the main estimation strategy. The impact on exit rate is more mixed, with an initial small negative effect following a tax change—a finding opposite to theoretical implications—followed by an increase and subsequent small decreases. The reversal and small decreases are consistent with the theory and the strong impact on entry—fewer firms in previous periods imply fewer exits. However, the presence of a negative relationship, in addition to the contemporaneous negative effect prior to the change, is concerning, even if not statistically significant. When evaluating the tax cuts and hikes separately, it was seen that the tax hikes drive the findings on the entry rate. An increase in entry following a tax cut was observed as well; however, a small decrease prior to the tax change may indicate that some cuts are more likely to be endogenous. It was also found that tax hikes were associated with higher exit the two years following the change. However, there was a small potential trend prior to the change here as well. Finally, the impact of tax cuts on exits was found to be highly volatile, and statistically significant pre-trends were detected, which constitute another potential sign of endogeneity.

Overall, these results indicate that the identifying assumption is more likely to be violated for tax cuts, especially when the outcome of interest are firm exits.

Table 1.4 presents the results for the main findings. A tax change of one percentage point in magnitude is associated with a decline in the establishment entry rate of about -1.4%. The effect is driven by tax hikes, with a precisely estimated coefficient of -1.71, while the coefficient associated with a tax cut is 0.8. As discussed earlier, personal tax rate may be important given the number of unincorporated firms, and column (7) shows a small and imprecisely estimated effect of -0.43 associated with a 1 p.p. increase in the tax rate.

However, this average hides a strong negative impact of tax hikes, with a coefficient of about -1.48. A personal tax cut is associated with a non statistically significant decrease in firm entry, likely stemming from endogenous tax cuts.

Turning to exit rates, a positive but small and imprecisely estimated effect was found. A 1 p.p. increase in the corporate tax rate is associated with a rise of 0.7% in the exit rate. Corporate tax hikes and cuts display an asymmetric effect of about 0.7. Similar results were detected looking at the personal tax rate, with a 1 p.p tax increase associated with a rise of 1% in the exit rate.[37] The results were found to be consistent with or without using division fixed effects, removing state policy controls, or dropping Ohio, Michigan and Texas.[38]

It is worth discussing the role of pass-through entities and how they may change the interpretation of the results. First, if pass-through firms are not affected through indirect effects, then the estimated coefficients represent a lower bound of the true impact of a tax change on the establishment entry rate of C-corporations. If an increase in the corporate tax rate leads to a change in the entry rate of the non-corporate sector, then the true effect on corporations will depend on whether there are more or less pass-through entities following the tax change. Given the rise such businesses, it is possible that contemporaneous tax changes would have a smaller effect on entry and exit. One potential explanation on why stronger and more precise coefficients are estimated for tax hikes is that a large number of hikes took place before 1993, a time when C-corporations represented a larger share of businesses.

Table 1.5 estimates the first column of table 2 using different estimation windows. The results are consistent with shrinking the window (column 1) or extending it (columns 2-4). Consistent results were found with all windows. In columns (6) to (10), observations were dropped where a corporate tax change occurred at the same time as 1) a personal tax change of at least 0.1 p.p., 2) changes in state level tax incentives, and 3) changes in the RD or investment tax credit. The qualitative impact of a corporate tax hike on entry is similar, but with higher magnitudes, ranging from -1.8 to -3, while the evidence on tax cuts remains mixed, with a positive but small and typically not statistically significant effect. The results were found to be consistent for exits, with most coefficients indicating a small and positive increase in exit rates following a tax tax change, with the exception of

[37] While both personal and corporate tax changes were included in estimations using policy controls, only the relevant coefficient based on the estimation window of either two years prior to a corporate or personal tax change has been reported.

[38] Note that the signficantly large tax changes associated with these three states were dummied out as described earlier. On the other hand, the smaller tax changes were included.

columns (7) and (8), a large and significant increase was found for tax hikes of about 3. It was also seen that a tax cut is associated with more exits, a potential indication of the endogeneity of tax cuts with establishment exits.

States use an array of tax policies to incentive businesses to locate and invest. In addition, some states allow firms to carry back losses on previous tax payments. Multi-state firms are taxed at the state level according to a formula which includes where sales, property, and payroll are located. In table 1.6, the interaction between these tax variables and changes in the tax rate are analyzed. A tax change in states without carry-back provision has a comparable but slightly smaller effect in magnitude on entry (-0.91) and a stronger and significant effect on exit (1.6) with strong but not significant interactions (-1.6 and -2.6), respectively. The sales apportionment factor had little effect on entry rate but a strong interaction with exit rates. Note that the smallest fraction apportioned to sales is 33.3% and the largest 100%, which implies that the effect of on exit is more positive with a smaller weight put on sales. This is consistent with the theory: multi-state firms would pay the same amount of taxes regardless of where they are producing if taxation is based on where sales are located only.

A significantly strong interaction was found between the effect of a tax change on entry and both the size of R&D and investment tax credit, which range from 0% to 20% and 0% to 15% in our sample period respectively. The average R&D tax credit is 2.6%, and the average investment credit is 1.3%. A larger tax credit overall lowers the impact of a tax change on entry rates. Mixed evidence was found regarding the exit rate as the outcome variable, where an R&D tax credit increased the impact of a tax change, while investment tax credit reduced it; however, none of the estimated coefficients were statistically significant.

C. Endogenous tax changes?

To identify which tax changes are endogenous to local economic conditions, Romer and Romer (2010) implemented a narrative analysis, classifying cuts and hikes as either endogenous or exogenous based on the reasoning behind the change as explained by journalists and policymakers. Endogenous tax reforms occur when a government offsets a change in spending or offsets a factor related to output, while changes are classified as exogenous when policymakers deal with an inherited budget deficit or achieve a long-run goal. In table 1.7, the effect associated with exogenous versus endogenous cuts and hikes on the entry and exit rate is shown. It is worth mentioning that the changes classified by Romer and Romer (2010) are typically larger in magnitude. In the current sample, 58 changes are exogenous and 12 endogenous.

In column (1), a strong negative response of a tax change was found on entry for both types. The impact of a 1 p.p. exogenous increase was a lower entry rate by about 3.4% The coefficient associated with exogenous changes was large and quite implausible (-8). Notably, a strong and positive impact was found associated with exogenous tax changes on establishments exits, where a 1 p.p. hike was associated with a 2% increase in the exit rate. Endogenous changes had an opposite negative but not statistically significant effect.

In columns (3) and (4), the 12 endogenous tax changes were removed from the sample, and the findings are identical to the baseline estimates. Finally, in columns (5)-(8), the interaction between local political variables was analyzed, namely whether a state's governor is Democratic or Republican. The effects were found to be consistent on the entry rate. However, it was found that tax changes had a strong and statistically significant effect in states with a Republican governor, while the interaction term—although not significant—essentially implied no impact on exit rates in Democratically led states.

In conclusion, large and exogenously defined tax changes were found to be associated with a large negative effect on entry and a large positive effect on exit. This suggests that tax reforms endogenous to local economic conditions are likely to bias the estimated impact on exit rates negatively, while the impact of tax hikes on entry is typically more robust and consistently negative and significant.

D. Border discontinuity

The border discontinuity analysis is discussed now, which was designed to deal with the bias arising from unobserved local shocks correlated with tax reforms. The top panel in table 1.8 looks at the entry rate as the outcome variable. A large and statistically negative effect ($\beta = -3.8$) was found, which confirmed our main findings. While the coefficient was found to be 2—3 times as large as our main estimates, it cannot be reject that they are similar. Controlling for group-by-year fixed effects yielded more negative estimates, although column (4) shows a relatively similar coefficient when only including year fixed effects—an indication that the border sample used in the analysis may result in larger estimated coefficients. Weighting the sample by population yielded an estimated impact similar to our baseline findings (-1.2).

In column (5), counties with center points further apart than 50 miles (roughly the 90th percentile of distance between counties centroids) were removed, which yielded comparable outcomes.

The coefficients associated with a tax hike on exit rate were found to be similar to our baseline findings as well, with the exception of column (5), where removing far away counties yielded a larger and somewhat statistically significant coefficient ($\beta = 1.47$)). Overall, with this identification strategy, it was confirmed that tax hikes have a large and negative effect on firm entry and a small and harder-to-detect impact on exit.

1.3.3 The role of spillovers

This section evaluates the presence of spillovers. Assessing spillovers is critical for the validity of the border discontinuity design. However, it is also important for the main estimation strategy as a number of states have a majority or a sizeable portion of their economic activity at or near border areas. Assessing spillover effects is also valuable for policymakers to have a more complete understanding of the impact of business taxes on firms.

How could spillovers bias the coefficients? The answer depends on the type of spillover taking place. This is illustrated in figure A.5 in the appendix, which shows how entry is affected following a tax cut in state A in the presence of either negative or positive spillovers. By negative spillovers, I refer to firm shifting but also to general locational effects near borders. Under the assumption that it is less costly for a prospective firm to choose different locations as opposed to existing firms to exit and relocate, a stronger response would be found in entry compared to exit. More generally, if areas across borders share the same labor and consumer market, there may be overall aggregate effects higher near the border in the state experiencing a tax change. Overall, we may be worried about spillover effects across the border biasing the estimates. As the first half of the figure shows, there is a negative bias coming both from higher activity in the state experiencing the tax cut, and lower activity in the bordering state. On the other hand, there may be positive spillovers. Ljungqvist and Smolyansky (2018) found that corporate tax increases lower income. If households and businesses affected by the tax change spend and invest less on both sides of the border (or spend more following a tax cut), then there will be a positive bias in the coefficient.

A. Spillover across border counties

To identify the presence of spillovers, first, the outcomes in border counties were compared with non-border counties in the same state. The following equation was estimated:

$$\Delta \log y_{i,t} - \Delta \log \overline{y}_{int,t} = \beta \Delta \tau_s^c + \Gamma(\Delta X_{i,t} - \Delta \bar{X}_{int,t}) + \Phi \Delta P_{s,t} + \psi_d + \mu_t + \varepsilon_{i,t} \qquad (1.5)$$

where $\Delta \log \overline{y}_{int,t}$ represents the average outcome of interest in interior counties. The estimation began by focusing on counties one degree removed from the border, that is, interior counties adjacent to border counties. The dependent variable is then the difference between a border county and the average outcome of its adjacent interior counties. If counties are small, spillovers could affect a state's neighboring counties beyond the border. In a second estimation, the outcome of border counties was compared to the average of all interior counties in the state. The same way was adopted for county-level controls. Further, state-level policies were included in some estimations in case they affected border counties differently than interior counties.[39]

As an indirect test for spillovers, the effect of a change in tax policy in a specific state, $\Delta\tau_s^c$, on border versus non-border areas was analyzed. This involved asking the following question: Are different exit and entry rates seen between borders and non-border areas in e.g. Michigan, when Michigan changes its tax rate? As a direct test, the effect of a change in a neighboring state $\Delta\tau_{s_b}^c$ was considered. This involved asking whether different exit and entry rates are seen between borders and non border areas in e.g. Michigan, when Ohio changes its tax rate. Under the assumption that border and adjacent interior counties face similar shocks, the indirect test was more likely to detect negative spillovers, i.e., shifting of firms. The direct test, however, would capture both negative spillovers and positive ones, i.e. consumption spillovers.

Note that with this strategy, group-by-year fixed effects were not included. By taking the differences in outcomes between counties, the average impact of common time-varying shocks was controlled for.[40] Similar to our previous estimations, units where another corporate tax change occurred two years prior to the current hike or cut were removed. For the indirect estimation, an estimation window based on the tax change happening in the bordering county was used instead. Additionally, all observations where a state changed its corporate tax in the two years prior to the bordering state were removed.

County spillover analysis: findings

Results from equation (1.5) are presented in table 1.9. Starting with the indirect test, little evidence of spillovers was found for either hikes or cuts when comparing border counties and adjacent interior counties. Comparing border counties to all interior counties,

[39]E.g., counties could respond differently depending on the type of industry mix, the share of corporations, etc.

[40]When comparing border counties to interior counties one degree removed, an estimation strategy similar to the border discontinuity design could be followed, grouping counties within the same state instead. The results from this methodology are similar to taking the average outcome of one degree removed interior counties.

some evidence was found that that tax cuts lead to an entry rate larger in border areas. However, this result goes away weighting the sample, an indication that spillovers may take place in a few treated areas with less population.

The indirect test also found significant weak evidence of spillover for entry. A tax hike in a bordering state appeared to lead to more entry in border areas compared to all interior areas as well as to adjacent interior areas, although the estimated coefficients were not statistically significant. Tax cuts were also found to be associated with more activity, but they were also rather imprecisely estimated and more likely subject to endogeneity concerns.

Regarding exits, none of the coefficients were found to be statistically significant. They are positive, which means a tax hike leads to more exits in border areas, consistent with negative spillovers. The weighted coefficient in column (8) is basically zero, consistent with spillovers happening only in certain areas, as discussed for entry. Looking at the impact of a change in a neighboring state, some evidence of positive spillovers was found, where a tax increase leads to more exits compared to interior counties. However, this finding becomes insignificant when weighting the sample.

To summarize, clear spillover effects were not detected on either entries or exits. Some very weak evidence was found that tax hikes lead to shifting spillovers for establishment entry. For exits, evidence of both negative and positive spillovers was found. These observations are not too surprising. Firms that decide to move following a tax change may need time, while economically linked areas more subject to shifting-type spillovers may also be subject to more consumption-type spillovers.

B. Census tract analysis

County-level estimations have some drawbacks. First, some counties are small, and some are large. If spillovers are concentrated in an area of the border county, they may not be detected in the analysis. To shed additional light on the role of spillovers, census tract level data were used. This allows us to look more closely at the entry and exit rate near borders. There are theoretical reasons why spillovers may be larger near borders. Assuming moving costs partially increase with distance, existing firms near borders may be more likely to move to a new state.[41] Potential entrepreneurs who may be attached to specific areas for economic or personal reasons could relocate much more easily if they live close to the border. Another way to indirectly evaluate spillovers is to look at areas near the border following the tax change.

[41] Moving costs for existing firms can include finding new customers and new workers.

The analysis began by obtaining some graphical evidence on the effect of changes in the corporate tax rate near the border by running the following estimation strategy:

$$y_{it} = \beta\tau_{s(i)t} \times f(DIST_i) + \Gamma X_{s(i)t} + \Theta X_{it} + \lambda_i + \gamma_{gt} + \varepsilon_{it} \tag{1.6}$$

where the tax rate was made to interact with the distance of tract i to the nearest border. Effectively, the estimation strategy used was similar to the main border discontinuity estimation. Census tract level demographic controls (population, share of black, white, college educated, and 20–59 year old inhabitants) were included as well as the share of property tax at the county level, and other policies were included at the state level.

Second, the baseline equation A.1 was estimated, and tracts were made to interact based on distance bins (e.g. 0–3 miles from the border). For example, the following was estimated:

$$y_{it} = \beta\tau_{s(i)t} + \gamma_1\tau_{s(i)t} \times dist \in (0,3] + \gamma_2\tau_{s(i)t} \times dist \in (3,10] + \Theta X_{it} + \lambda_i + \gamma_{gt} + \varepsilon_{it} \tag{1.7}$$

as such we can see whether the baseline coefficient β is consistent and whether there are specific spillovers close to the border. Importantly, the county group-by-year fixed effects were continued to be included under the assumption that census tracts in border counties would face similar shocks.

One potential downside of using tract level analysis is that there would be increased noise coming from businesses moving between different tracts within the same county. While most businesses that move within a metropolitan area are tracked, it is still likely that some firms will be coded as a start-up at their new location. Second, while comprehensive and consistent over time, the census tract dataset is not based on administrative data. As long as the rate of location changes within the state is not systematically correlated with changes in taxation, the coefficients could be potentially less precisely estimated and biased toward zero, as would be expect with standard measurement error.[42]

Census tract analysis: findings

Turning to graphical evidence first, it is seen in figure 1.8 based on equation 1.6 that the effect of a change in the top corporate tax rate has a more negative effect close to

[42]An example would be as follows: if California increases its corporate income tax rate, businesses in Los Angeles county are more likely to move to another tract within the same county. Theoretically, this could be true if the changes in state-level taxation affects tracts within the same county differently, through changes in real estate prices or local competition. I am not aware of any theoretical or empirical work predicting such heterogeneous changes; as such, it is reasonable to assume no systematic correlation exists between state-level taxation and within county migration.

the border. However, the polynomial fit gets very close to the average effect around 4–5 miles away from the border. A stronger effect was not seen near the border for exits. In the bottom half of the figure, the sample was restricted to counties that are not in border-dominated states (defined as states having at least 50% of its population in border counties). The effects were found to be highly similar on entry, but at this point a negative but small effect was observed on exit, which was higher near the border. Overall, the results are not statistically significant, and standard errors are large, especially for the exit rate.

Turning to the estimation of model 1.6,the results are shown in table 1.10. Columns (1–5) look at differential effects of the corporate tax rate by binned distance to the border. It can be seen that the baseline effect in column (1) is very similar to the county-level result, although a bit lower and less precisely estimated. A change in the corporate tax rate was found to have an almost twice as large effect on entry in tracts within 1.5 miles of the border ($\beta_{0-1.5} = -2.19$ vs. $\beta = -1.5$). The results are very similar with other binned distances (columns 2–4). Overall, the main impacts are typically close to the baseline results but also imprecisely estimated. The coefficient on exit rate was found to be positive but small ($\beta = 0.46$) and comparable to the county level results. Overall, the estimated exits are slightly higher near the border ($\beta_{0-1.5} = 0.67$) and also about twice as large as the baseline.

Both entry and exit results indicate the presence of negative spillovers in the state experiencing the tax change. However, given the high concentration in areas close to the border, and county level results, I am fairly confident the main results are unlikely to be highly biased and driven by spillovers.[43]

1.4 Robustness Checks and Discussion

A. Firms or establishments

An important question that remains is regarding what type of establishments drive the current findings. Is it establishments belonging to large multi-state firms, or larger single-state firms, or to single-establishment operations? In table 1.11, some evidence on the impact of tax changes on single-establishment firms and establishments belonging to large firms is presented.

In column (1) and (2), both corporate and personal tax hikes have strong negative

[43] It is also worth pointing out that the exercise presented here at the census tract level looks at differential effects by distance to the border experiencing the tax change, which is also an indirect test for spillovers, under the assumption that different effects near the border are driven by spillovers.

impacts on the entry rate of firms. Note that this is not necessarily the creation of a firm, and this coefficient could still capture the migration of existing firms. This indicates that although many businesses are not incorporated, the corporate tax rate still has a strong effect on firm entry. A large number of tax hikes took place in the 1980s, a time when a majority of businesses were C-corporations. A 1 p.p. corporate tax hike is associated with a decline in firms birth rates by 2.5%, while a 1 p.p. increase in the personal tax rate yields a birth rate lower by 3.3%.

Turning to entry and exits of establishments which belong to firms with more than one plant, it was found that the impact of a tax hike was smaller, about -1.1, which is similar to the baseline estimates, but was somewhat imprecisely estimated. Personal tax changes were found to have very little impact on the entry of these establishments, which is consistent with the fact that larger firms are more likely to be incorporated.

Turning to firms deaths, little evidence was found that tax changes had an impact. Tax cuts are associated with fewer firm deaths; however, we should be cautious about this finding, given the larger probability that tax cuts were found to be endogenous from our previous discussions. To answer the question asked at the beginning of this section, it is clear that our findings are not driven by large firms closing and opening operations and also affect single-establishment and small firms.

B. Weighted results

One may wonder about the relative weight of some counties in the estimation. In the baseline estimation strategy, each county represents one potential treated or control unit, regardless of the size of the county. Yet some counties are much more populated than others. A second issue is that some states have more counties than others. This can be seen largely as random and rooted in the county's history. However, the implications is that tax changes in states with few counties will have fewer treated units for identification than changes in a state with a large number of counties. To see whether it has an influence on the results, the baseline estimation strategy weighting each county was estimated by the inverse probability of each state being chosen (border counties/border counties in state s).

In table A.2 in the appendix, results from our baseline estimation strategy are presented, using both population and relative county numbers' weighting methods. The outcomes for border and interior counties are shown as well. The main takeaway of our analysis is unchanged, with similar coefficients associated with both tax hikes and cuts on entry rate.

With exit rates as the outcome variable, weighting by population doubles the coefficient to about 1.3, which is also statistically significant. This seems to be driven by interior counties, which shows a strong and significant rise on exit rates following a tax hike. Table A.3 in the appendix also presents weighted results for the interaction with state specific tax policies. The negative impact of tax changes on entry was found to be consistent across estimations, a statistically significant increase on exits was found as well.

C. Fixed Effects Model

Finally, the results from a fixed effects model are presented in table A.4 in the appendix. Essentially, this is identical to 1.2 before taking the first difference.[44] Both the full samples and an estimation including cross county pairs' fixed effects were included. The negative relationship between the corporate tax was found to be negative and between -.9 and -1.4, while the border pair fixed effects model yielded larger and more precisely estimated coefficients, between -2 and -3.5. No clear impact was found on exit, which is also consistent with our previous findings, especially to the extent that the fixed effect methodology is more likely to capture the reversal documented for exits.

D. Discussion

How do the estimates compare to other results in the literature? Kneller and McGowan (2012) used variation in firm taxation among OECD countries and found a negative effect of the corporate tax rate on entry and no effect on exit. Djankov et al. (2010) found that a 10 p.p. decrease in the corporate tax rate led to a 1.4 p.p. higher entry rate. Da Rin, Di Giacomo and Sembenelli (2011) found a non-linear and varying effect roughly ranging from 0.8 to 3.5 p.p. for a 10 p.p. lower corporate rate. A semi-elasticity of about -1.5 to -2 that is document with an entry rate of about 10 percent implies that a 1 p.p. decline in the corporate rate leads to a lower entry rate of about 0.15 to 0.2 p.p., which is comparable to the findings described above.

It is valuable to put the results in context with findings on the effects of state corporate taxation on employment, income, and establishments in the United States. Ljungqvist and Smolyansky (2018) found an elasticity for income and employment with respect to the net of tax rate of about 0.3 and 0.5, while Curtis and Decker (2018) found that an increase in the corporate tax rate of one percentage point led to a decrease in employment in young (0–1 year old) firms between 3% and 5%. Their results highlighted the potentially high sensitivity of new firms to changes in business taxation, which is confirmed in this paper.

[44]We estimate $y_{it} = \beta\tau_{s(i)t} + \Gamma X_{st} + \Theta X_{it} + \lambda_i + \kappa_t + \varepsilon_{it}$, where y is the log entry or exit rate, λ_i

Giroud and Rauh (2019) found that corporations have short-run corporate tax elasticities around -0.5. Note that their results were regarding the net effect on establishments. Given the coefficients on entry and exit rates, the implied net effects would be a corporate tax semi elasticity between -1.5 and -4. We cannot readily compare the results, however, as the data used include small and single-establishment firms as well. In addition, all establishments were focused on in this paper, not just corporations, which in essence combines the direct effects on C-corporations and the indirect general equilibrium effect on pass-through firms. Serrato and Zidar (2016) found a long-run business taxation elasticity for establishments around 4. However, their results focused on long-run effects and used an effective tax rate based on the corporate and the personal income tax rate.

It is worth mentioning that there is a rising literature on the use of difference-in-difference methods with panel fixed effects, specifically with two-way fixed effects (e.g. de Chaisemartin and D'Haultfoeuille (2020), Imai and Kim (2019)). One concern pointed out by these authors is that heterogeneous treatments with two-way fixed effects may erroneously give negative weights to some observations and lead to a wrong estimated coefficient. The estimator proposed by de Chaisemartin and D'Haultfoeuille (2020) on the baseline estimation strategy (1.2) was used. A similarly negative coefficient ($\beta = -1.62$) was found, although with much larger standard errors.[45]

1.5 Conclusion

In this paper, the role of state-level business taxation on establishments and firms' entry and exit rates was evaluated. Accordingly, a strong and significant effect of tax hikes on entry was documented. Following the tax increase, there is an immediate decline which is mostly stabilized afterward. Overall, tax hikes were found to lead to an entry rate which was lower by about 1.5% to 3.5%. It was found that exits increased following a tax hike as well, although the effect is smaller and shorter lived. Graphical evidence points to a faster and stronger reversal, consistent with the theory that the decline in entry and general equilibrium effects following a hike will eventually lower the exit rate. Tax cuts were found to have qualitatively similar impacts, with a higher entry rate and lower exit rate following the change. However, the estimated coefficients were not statistically significant, and pre-trends point to a higher threat of endogeneity for cuts, specifically with exits. Using a subset of tax changes classified as exogenous or endogenous, consistent and strong impacts on entry and exit for exogenous tax changes were found. The results are

[45] Stata command *did_multiplegt* with same covariates was used on all counties based on equation 1.2.

comparable looking at establishments versus firms only, indicating that the findings are not only driven by large corporations and affect small firms as well.

To answer the specific question what the impact of the state corporate tax is on business dynamism, the main findings suggest that a hike in the tax rate leads to a decrease in dynamism and economic activity, driven by decrease in the entry rate. The impact of corporate tax cuts is less clear, with some evidence found that they may lead to higher economic activity and dynamism. It is also important to keep in mind that these findings are based on a short-run analysis, and long-run predictions on dynamism, especially for exits, would be different. Medium- and long-run identification on the effect of tax changes remains challenging and a great territory for future research.

Using census tracts and a border distance analysis, it was shown that there are potentially large spillovers across state borders. A 1 p.p. increase in the corporate tax rate leads to an additional 0.5% to 1% decline in firm entry near borders and a small (0.3%) but positive effect on exits. However, the effects are highly concentrated, roughly between three and five miles. The aggregate analysis at the county level failed to detect big or precise spillovers, although some evidence of allocation/shifting types of spillovers was found on establishment entry and both shifting and indirect spillover with exits.

I view my contribution to the understanding of the relationship between state business taxation and firm entry and exit in the United States as a first stab. The slow and steady shift from corporations to pass-trough entities that started after the 1986 federal tax reform may have different implications for future tax changes. New research could shed more light on this issue by exploiting more precise data on firms' legal form of organization. Migration may play an important role as well, and the ability to track small and growing firms over time would be substantial. Beyond entry and exit, to what extent do state taxes influence growth, investment, and job creation are critical questions. These and many more questions would benefit tremendously from quality fine-grain establishment- and firm-level data.

1.6 Tables

Table 1.2: Summary Statistics - *County level data*

	All counties		Border counties		Non-border counties		Diff means
	Mean	S.d	Mean	S.d	Mean	S.d	(t-test)
Firm dynamics							
Entry rate	11.11	3.85	10.96	3.73	11.19	3.92	-0.18^c
Estab. entry/cap	0.23	0.11	0.22	0.11	0.23	0.11	-0.015^c
100×Δ Log entry rate	-1.83	28.13	-1.79	28.03	-1.85	28.20	0.37
Exit rate	9.68	2.96	9.65	2.91	9.70	3.00	-0.011^c
Estab. exit/cap	0.20	0.09	0.20	0.09	0.20	0.09	0.015
100×Δ Log exit rate	-1.07	29.20	-1.04	29.17	-1.08	29.22	0.37
Total establishments	1,901	6,408	1,913	5,744	1,894	6,778	91
Demographic shares							
Share white	84.24	18.38	85.25	17.62	83.63	18.80	
Share black	8.83	14.47	8.50	14.52	9.03	14.44	
Share age 20-59	51.02	4.27	50.91	4.09	51.09	4.37	
Share college	10.98	6.56	10.95	6.52	11.00	6.59	
Share urban	39.30	32.40	38.59	32.38	39.72	32.40	
Population (1000s)	87.6	286.4	88.9	252.8	86.9	304.9	
Other controls							
Property tax share	79.50	40.64	79.63	44.34	79.43	38.22	
Sales tax rate	4.75	1.49.					
Minimum wage	5.07	1.68					
Observations	129,519		48,503		81,016		
Counties	3,131		1,183		1,948		

These summary statistics are calculated over the period 1978-2017. I drop counties for which some data is missing for all years. Data on firm dynamics come from the Business Dynamics Statistics (BDS). The share of white, black and 20-59 y.o. in the population comes from the Census Bureau. The share with a college degree and in urban area comes from NHGIS. Other controls come from the Department of labor (UI replacement rate, minimum wage), the Census of Governments (property tax share) and the sales tax rate comes from various sources - see text and appendix for more detail. Per capita data is calculated as per 1000 inhabitants. The last column shows the difference in means between non-border and border counties and the superscript shows whether a t-test can reject the null hypothesis that the mean is the same for border and non-border counties.

Table 1.3: State corporate and personal income tax changes 1978-2017

	Mean	Standard Deviation	Count
Δ_c Corporate tax rate (magnitude)	0.92	1.09	220
$\Delta_c > 0$	1.31	1.45	84
$\Delta_c < 0$	-0.67	0.70	136
Δ Personal tax rate (magnitude)	0.89	1.08	377
$\Delta_p > 0$	0.90	0.81	178
$\Delta_p < 0$	-0.87	1.28	199

The top panel of this table displays the average, standard deviation, and total number of corporate tax change, as well as separately for hikes and cuts. The bottom panel shows the same information for changes in the personal income tax rate. Changes cover years 1978 to 2017. See text for data sources.

Table 1.4: County level panel regression - baseline

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ΔLog *Entry rate*					Log *Entry*	ΔLog *Entry rate*	
Δ Corp. tax rate	-1.39^c	-1.33^c	-1.38^c	-1.52^c				
	(0.46)	(0.48)	(0.50)	(0.49)				
Magnitude τ_c hike					-1.71^b	-1.72^b		
					(0.73)	(0.73)		
Magnitude τ_c cut					0.79	0.03		
					(0.74)	(0.44)		
Δ Pers. tax rate							-0.43	
							(0.39)	
Magnitude τ_p hike								-1.48^c
								(0.39)
Magnitude τ_p cut								-1.08
								(0.75)
Demographic controls	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Division FE	✓		✓	✓	✓	✓	✓	✓
Drop OH MI TX			✓					
State policy controls	✓	✓	✓		✓	✓	✓	✓
Adjusted R^2	0.07	0.07	0.06	0.07	0.07	0.06	0.04	0.04
Observations	20,860	20,860	16,978	20,928	20,860	23,739	19,751	19,751

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

Continued on next page

Table 1.4 – *Continued from previous page*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ΔLog *Exit rate*					Log *Exit*	ΔLog *Exit rate*	
Δ Corp. tax rate	0.70	0.66	0.38	0.66				
	(0.45)	(0.62)	(0.64)	(0.62)				
Magnitude τ_c hike					0.66	1.06		
					(1.07)	(1.03)		
Magnitude τ_c cut					-0.69	-0.74		
					(0.88)	(0.95)		
Δ Pers. tax rate							0.66	
							(0.45)	
Magnitude τ_p hike								1.00
								(0.61)
Magnitude τ_p cut								-0.22
								(0.83)
Demographic controls	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Division FE	✓		✓	✓	✓	✓	✓	✓
Drop OH MI TX			✓					
State policy controls	✓	✓	✓		✓	✓	✓	✓
Adjusted R^2	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07
Observations	20,854	20,854	16,977	20,854	20,854	20,800	19,717	19,717

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table features outcomes from model 1.2. The top panel shows coefficients with log establishment entry rate (or log establishment entry per capita in column 6) as the outcome variable, and the bottom panel log exit rate. The estimation window consists in the year of the change and two years prior. Only observations with a single tax change for the corporate income tax rate in columns 1-6 are kept, while only a single personal tax change for columns 7-8 are kept. Demographic controls include demographic shares, share of property taxes at the county level and population. State policy controls include the corporate, personal and sales tax rate, the minimum wage, and unemployment compensation. It also includes tax incentives and financial assistance to industries at the state level. Because they experienced major tax reforms, I drop Ohio, Michigan and Texas in some estimations.

Table 1.5: Main results - contemporaneous tax changes and estimation window

Outcome:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ΔLog ***Entry rate***	Estimation window around tax change				No contemporaneous change w/					
	$[-1;0]$	$[-3;0]$	$[-2;1]$	$[-3;1]$	Pers. tax		Tax incent.		RD & Inv. tax credit	
Δ Corp. tax	-1.11^b	-1.28^b	-1.49^c	-1.36^b	-2.42^c		-2.22^c		-1.39^c	
	(0.47)	(0.57)	(0.49)	(0.61)	(0.81)		(0.46)		(0.44)	
Magnitude tax hike						-2.80^b		-3.02^c		-1.78^b
						(1.29)		(0.98)		(0.71)
Magnitude tax cut						1.81^a		1.10^a		0.64
						(1.05)		(0.56)		(0.73)
County controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
State policy controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year & Division FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Adjusted R^2	0.08	0.07	0.08	0.09	0.07	0.07	0.07	0.07	0.07	0.07
Observations	14,154	25,165	18,646	21,391	18,768	18,768	19,897	19,897	20,592	20,592

State clustered standard errors in parentheses

^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

Continued on next page

Table 1.5 – *Continued from previous page*

Outcome:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Δ**Log *Exit rate***	Estimation window around tax change				No contemporaneous change w/					
	$[-1;0]$	$[-3;0]$	$[-2;1]$	$[-3;1]$	Pers. tax		Tax incent.		RD & Inv. tax credit	
Δ Corp. tax	0.50	0.30	0.86	0.40	-0.68		1.67^{c}		0.68	
	(0.57)	(0.64)	(0.62)	(0.60)	(1.00)		(0.53)		(0.64)	
Magnitude tax hike						-0.79		3.15^{c}		0.75
						(1.54)		(0.80)		(1.04)
Magnitude tax cut						0.52		0.41		-0.56
						(1.09)		(0.93)		(0.98)
County controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
State policy controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year & Division FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Adjusted R^2	0.09	0.07	0.08	0.08	0.08	0.08	0.07	0.07	0.08	0.08
Observations	14,152	25,140	18,644	21,397	18,762	18,762	19,891	19,891	20,587	20,587

State clustered standard errors in parentheses

^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table features outcomes from model 1.2 using different estimation windows in columns 1-4, to insure that results are not driven by the choice of window. The first column only includes one lead year prior to a tax change, the second column includes three lead years, and the third and fourth column add a lag year. Note that the tax sample identifying the coefficient may be different as we only allow one change to tax place within an estimation window. Columns 6-10 removes tax changes that occur simultaneously with a personal tax change greater than .05p.p., state level tax incentives, or a change in either the R&D or investment tax credit.

Table 1.6: Main results - other tax policies

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Interaction with	State has carryback		Sales apport. factor		State RD Tax Credit		State Inv. Tax Credit	
	Entry rate	*Exit rate*	*Entry rate*	*Exit rate*	*Entry rate*	*Exit rate*	*Entry rate*	*Exit rate*
Δ Corp. tax	-0.91	1.66^b	-1.70^a	-1.29	-2.38^c	0.52	-1.94^c	1.20
	(0.63)	(0.64)	(0.91)	(2.89)	(0.61)	(1.02)	(0.46)	(0.81)
$\Delta\tau^c \times (Carryback = 1)$	-1.62	-2.64						
	(1.58)	(2.12)						
$\Delta\tau^c \times (100 - \alpha_{sales})$			0.00	0.04				
			(0.02)	(0.05)				
$\Delta\tau^c \times RD\ Tax\ Credit$					2.43^c	0.86		
					(0.87)	(1.41)		
$\Delta\tau^c \times Inv.\ Tax\ Credit$							2.16^a	-1.29
							(1.10)	(1.36)
County controls	✓	✓	✓	✓	✓	✓	✓	✓
State policy controls	✓	✓	✓	✓	✓	✓	✓	✓
Year & Division FE	✓	✓	✓	✓	✓	✓	✓	✓
Adjusted R^2	0.07	0.08	0.06	0.07	0.07	0.08	0.07	0.08
Observations	20,860	20,388	20,728	20,721	20,390	20,388	20,390	20,388

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table features outcomes from model 1.2 looking at the interaction between a change in the corporate tax rate and features of corporate taxation. The first two columns look at whether the impact is different in states with at least a two year carryback allowance. The third and fourth column interact the tax change with 100 minus the percentage of income apportioned based on where the sales of the firm is located. We would expect the effect of a tax change to be smaller in magnitude the larger a state apportions based on sales, since a smaller fraction of income will be taxed in that state, assuming a sizeable fraction of sales happen in other states. The last four column interact a change in the tax rate with the R&D and Investment tax credit. Important tax credit may reduce the impact of a tax change, as firms effectively pay lower effective tax rates when benefiting from the credit.

Table 1.7: Narrative analysis and political factors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Entry rate	*Exit rate*	*Entry rate*	*Exit rate*	*Entry rate*		*Exit rate*	
Exogenous $\Delta\tau^c$	-3.41^c	1.96^c						
	(1.07)	(0.64)						
Endogenous $\Delta\tau^c$	-8.40^c	-1.72						
	(2.65)	(1.47)						
Magnitude tax hike			-1.58^b	0.41				
			(0.77)	(1.17)				
Magnitude tax cut			0.65	-0.74				
			(0.63)	(0.86)				
Δ Corp. tax					-1.56^b	-1.27^c	1.35^b	1.39^c
					(0.66)	(0.46)	(0.64)	(0.39)
$\Delta\tau^c\times$ Dem governor					0.53	0.10	-2.10	-1.53
					(0.90)	(0.96)	(1.72)	(1.16)
County controls	✓	✓	✓	✓	✓	✓	✓	✓
State policy controls	✓	✓	✓	✓	✓	✓	✓	✓
Year & Division FE	✓	✓	✓	✓	✓	✓	✓	✓
No "endog. changes"			✓	✓				
Pop. Weighted						✓		✓
Adjusted R^2	0.14	0.22	0.06	0.07	0.07	0.18	0.08	0.24
Observations	1,614	1,611	20,477	20,471	20,844	20,844	20,838	20,838

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table features outcomes from model 1.2 using the sample of exogenous and endogenous tax changes as specified by Romer and Romer (2010). The third and fourth column remove the endogenous tax changes from the sample of identifying tax rates used in the main estimation. Columns 5-8 presents the result from the interaction of the tax change with whether a governor is Democratic or not. The few time periods in states with a politically independent governors are dropped from the estimation.

Table 1.8: Border discontinuity analysis

	(1)	(2)	(3)	(4)	(5)	(6)
	ΔLog *Entry rate*					
Magnitude tax hike	-3.79[b]	-3.92[b]	-3.26[b]	-3.42[c]	-3.76[a]	-1.21[a]
	(1.62)	(1.59)	(1.58)	(1.07)	(1.91)	(0.71)
Magnitude tax cut	-0.40	0.12	0.46	1.00	-0.99	-0.35
	(1.34)	(1.60)	(1.52)	(1.08)	(1.86)	(1.00)
Demographic county controls	✓	✓	✓	✓	✓	✓
Group×Year FE	✓	✓	✓		✓	✓
State policy controls	✓	✓		✓	✓	✓
Division trend	✓			✓	✓	✓
No far counties (center$>50m$)					✓	
Pop. Weighted						✓
Adjusted R^2	0.39	0.39	0.38	0.09	0.41	0.52
Observations	4,380	4,380	4,414	2,997	3,489	4,380

	(1)	(2)	(3)	(4)	(5)	(6)
	ΔLog *Exit rate*					
Magnitude tax hike	0.64	0.82	0.32	0.31	1.47[a]	0.38
	(1.22)	(0.86)	(1.42)	(1.37)	(0.75)	(1.67)
Magnitude tax cut	0.53	2.17[a]	1.38	1.31	0.38	0.45
	(3.27)	(1.13)	(3.36)	(2.93)	(1.95)	(3.34)
Demographic county controls	✓	✓	✓	✓	✓	✓
Group×Year FE	✓	✓	✓		✓	✓
State policy controls	✓	✓		✓	✓	✓
Division trend	✓			✓	✓	✓
No far counties (center$>50m$)					✓	
Pop. Weighted						✓
Adjusted R^2	0.42	0.59	0.42	0.09	0.11	0.43
Observations	4,368	4,368	4,368	2,967	2,990	3,478

State and border clustered standard errors in parentheses
[a] $p < 0.10$, [b] $p < 0.05$, [c] $p < 0.01$

This table features outcomes from the border discontinuity model 1.4. The main difference is the inclusion of adjacent counties across the state border acting as control variables. Groups are defined as the treated county and all adjacent border counties. Some border counties may appear twice or more as control units if they border more than one county. In column 5, we remove county pairs that are more than 50 miles apart based on the centroid of both counties respectively. Population weighs use the national share of a county's population. We remove control counties where a tax change occurred in the three years prior to the change in the treated unit. Standard errors are clustered at the state and border segment (state A and state B form a segment e.g.), to take into consideration serial correlation along these two dimensions.

Table 1.9: Spillovers: county level analysis

Δ**Log Dif *Entry rate***	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Comparison group	Interior adjacent counties						All interior counties			
Magnitude tax hike	0.69	0.08	-1.00				-1.18	-0.75		
	(0.90)	(1.08)	(1.21)				(1.38)	(0.84)		
Magnitude tax cut	0.43	1.94	-0.30				3.25^b	-0.35		
	(1.47)	(1.70)	(1.87)				(1.36)	(1.20)		
Direct test										
Magnitude state border tax hike				0.09	0.24	1.49			0.69	0.85^a
				(1.14)	(1.10)	(0.99)			(0.75)	(0.43)
Magnitude state border tax cut				1.55	2.28	0.30			1.52	0.80
				(1.82)	(1.91)	(1.16)			(1.57)	(0.87)
County controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
State level policies		✓	✓		✓	✓	✓	✓	✓	✓
Pop. weighted			✓			✓		✓		✓
Adjusted R^2	0.02	0.03	0.05	0.02	0.03	0.05	0.02	0.07	0.02	0.06
Observations	4,748	4,748	4,748	4,015	4,015	4,015	7,048	7,048	5,904	5,904

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

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Table 1.9 – *Continued from previous page*

Δ**Log Dif*Exit rate***	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Comparison group	Interior adjacent counties						All interior counties			
Magnitude tax hike	0.07	0.45	1.15				1.17	-0.21		
	(1.04)	(1.07)	(0.99)				(1.21)	(0.74)		
Magnitude tax cut	1.55	0.61	1.31				1.21	1.64		
	(2.60)	(2.59)	(1.87)				(1.88)	(1.98)		
Direct test										
Magnitude state border tax hike				1.42[a]	1.27	0.32			0.69	0.66
				(0.83)	(0.93)	(0.98)			(0.75)	(0.57)
Magnitude state border tax cut				1.41	1.70	-0.49			1.52	0.16
				(1.31)	(1.26)	(1.24)			(1.57)	(0.82)
County controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
State level policies		✓	✓		✓	✓	✓	✓	✓	✓
Pop. weighted			✓			✓		✓		✓
Adjusted R^2	0.01	0.02	0.04	0.02	0.03	0.06	0.02	0.08	0.02	0.07
Observations	4,749	4,749	4,749	4,083	4,083	4,083	7,049	7,049	5,904	5,889

State clustered standard errors in parentheses

^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table features outcomes from the border spillover model 1.5. The outcome variable is the difference between a county's entry or exit rate, and either the average entry/exit rate of all adjacent interior counties, or all interior counties in a state. The indirect tests compares border counties with some interior counties when a tax change happens in the same state. The direct test compares the same outcome when a tax occurs in a bordering state. A positive/negative coefficient associated with the entry or exit rate for a tax hike implies that there is more/less entry in border counties compared to interior counties. The standard errors are also two way clustered when looking at the impact of a tax change in a bordering state.

Table 1.10: Spillovers: census tract analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Log *Entry rate*					Log *Exit rate*			Log *Churn*
Corp. rate	-1.61	-1.50	-1.49	-1.30	0.46	0.37	0.37	0.40	-0.67
	(1.17)	(1.16)	(1.16)	(1.12)	(0.69)	(0.69)	(0.70)	(0.69)	(0.68)
$\tau_c \times [0, 1.5)$		-0.69^c				0.30^b			
		(0.20)				(0.14)			
$\tau_c \times [1.5, 5)$		-0.36^a				0.22^b			
		(0.18)				(0.11)			
$\tau_c \times [5, 10)$		-0.18				0.19^b			
		(0.14)				(0.08)			
$\tau_c \times [0, 3)$			-0.62^c				0.27^b		-0.03
			(0.14)				(0.13)		(0.14)
$\tau_c \times [3, 10)$			-0.19				0.20^b		0.08
			(0.15)				(0.08)		(0.12)
$\tau_c \times [0, 5)$				-0.44^c				0.16	
				(0.14)				(0.14)	
$\tau_c \times [5, 15)$				-0.21^a				0.08	
				(0.12)				(0.12)	
Pers rate.	0.30	0.31	0.31	0.23	-0.09	-0.10	-0.10	-0.10	0.59
	(0.94)	(0.94)	(0.94)	(0.89)	(0.90)	(0.90)	(0.89)	(0.90)	(0.37)
County FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Group-year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Demographic controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
State policies	✓	✓	✓	✓	✓	✓	✓	✓	✓
Adjusted R^2	0.47	0.47	0.47	0.48	0.69	0.69	0.69	0.69	0.65
Tract$\times$ year obs.	892,353	892,353	892,353	892,353	813,520	813,520	813,520	813,520	813,520

Two way state and border segment clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table evaluates whether census tracts near borders react differently when a state changes its corporate tax rate. The estimation is based on model 1.6, where I interact census tracts in bins by distance to the border. All estimations include census tract level demographic controls, county level share of property tax rate, distance to the border, county fixed effects, county pair by year fixed effects, and state level policy controls. Standard errors are two-way clustered at the state and border segment level. Churn rate is defined as the addition of establishment exits and entries.

Table 1.11: Firms or establishments?

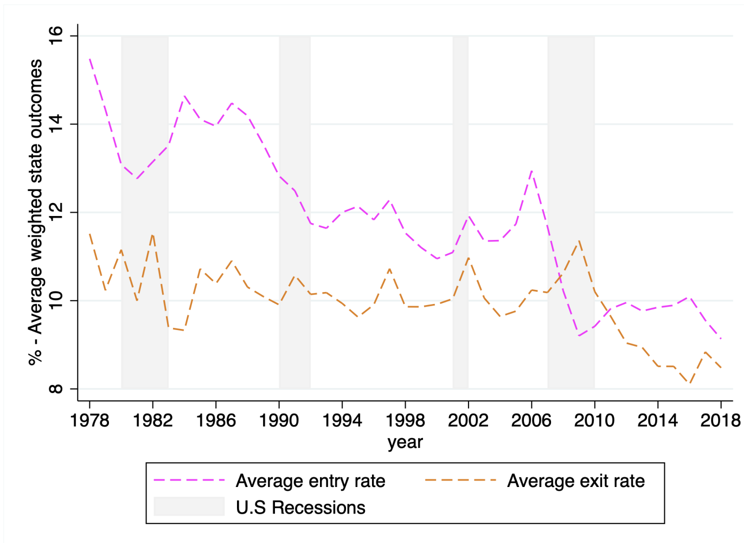
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Δ firm birth rate		Δ estab only entry rate		Δ firm death rate		Δ estab only exit rate	
Magnitude τ_c hike	-2.55^b		-1.12		0.29		-0.78	
	(1.21)		(0.91)		(1.07)		(0.90)	
Magnitude τ_c cut	-0.18		0.21		-2.04^c		0.62	
	(1.84)		(1.51)		(0.61)		(1.25)	
Magnitude τ_p hike		-3.30^c		0.06		0.59		1.75
		(0.96)		(0.79)		(0.56)		(1.15)
Magnitude τ_p cut		-1.39		-0.19		-1.16		0.27
		(1.57)		(1.22)		(1.04)		(1.49)
Year & Division FE	✓	✓	✓	✓	✓	✓	✓	✓
Demographic controls	✓	✓	✓	✓	✓	✓	✓	✓
State policies	✓	✓	✓	✓	✓	✓	✓	✓
Adjusted R^2	0.05	0.04	0.06	0.08	0.08	0.08	0.04	0.04
Observations	33,546	18,042	33,324	17,933	33,995	18,300	33,017	18,827

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table features outcomes from the main model comparing the impact of tax changes on firm only birth and death rates, and on establishments only (i.e. not single establishment firms). All specifications otherwise are similar to table 1.4.

1.7 Figures

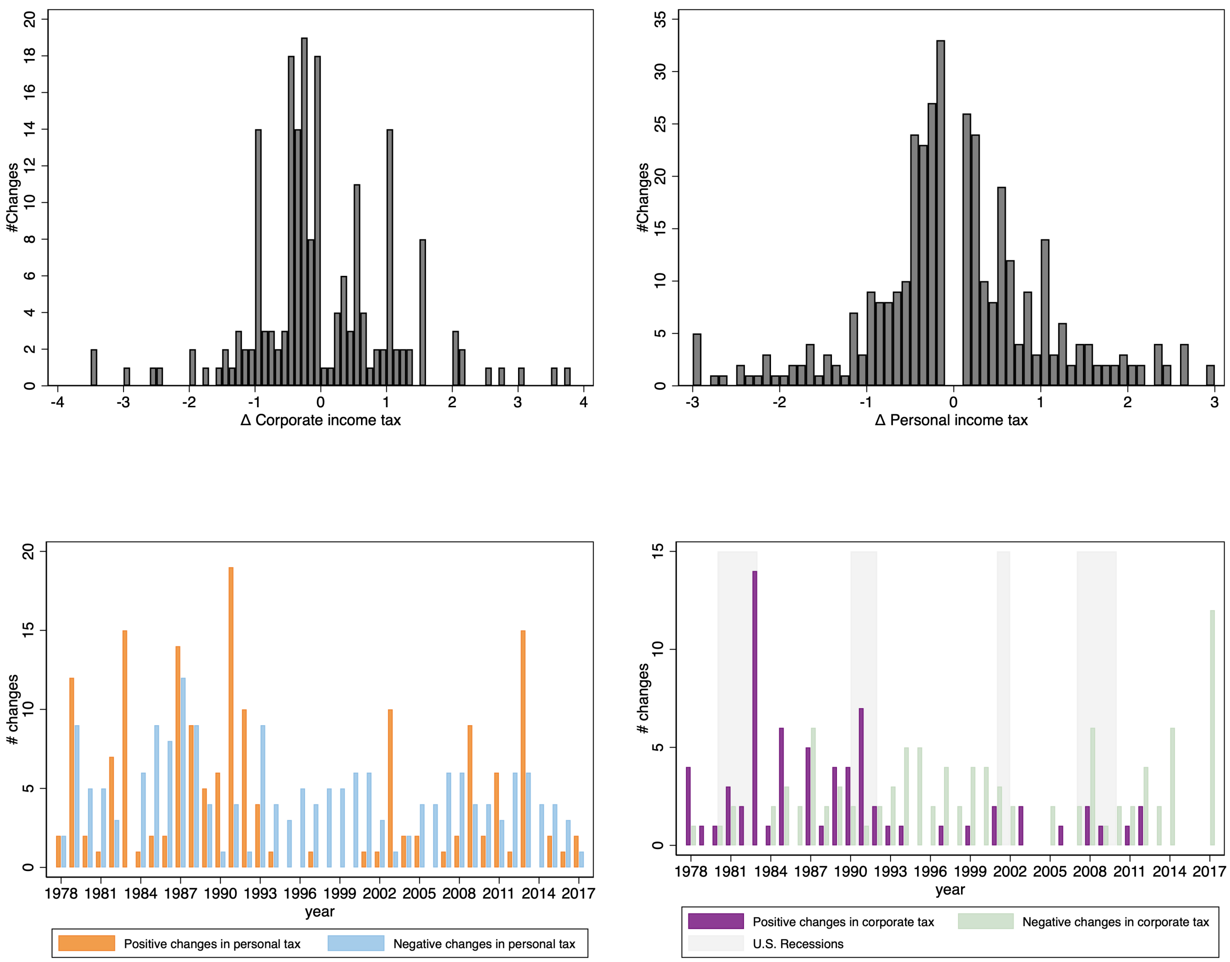
Figure 1.1: Trends in business dynamism and state taxation



State population weighted average entry and exit rate of establishments

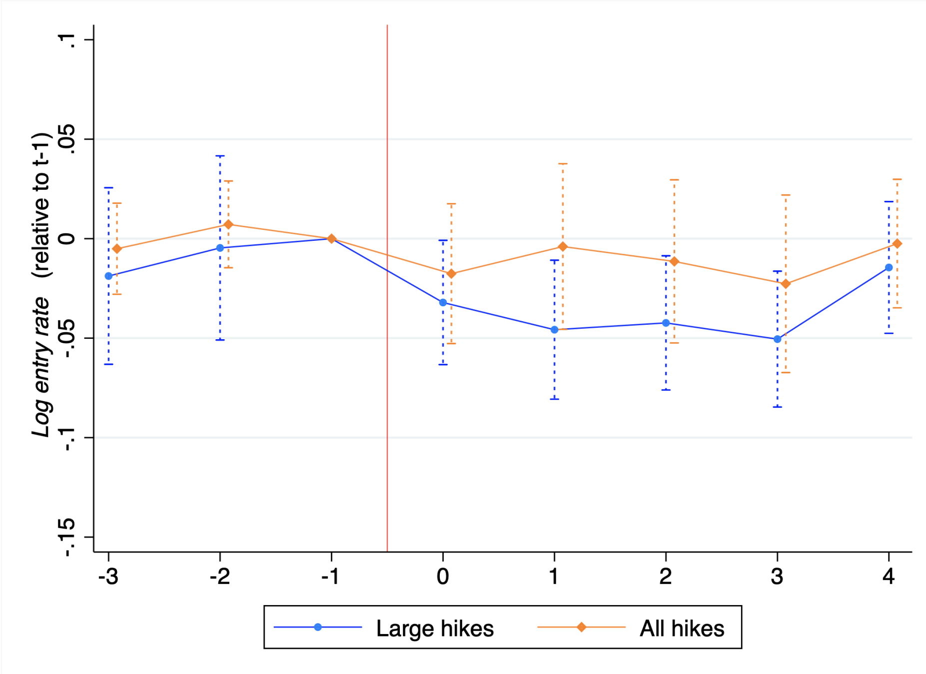
The top panel depicts the average entry and exit rate from state level data between 1978 and 2017, weighted by the average state population in that time period. The grey regions depicts year in which the U.S economy was in a recession. The bottom panel depicts the median, 25th, and 75th percentile in state corporate income tax rates.

Figure 1.2: Changes in state taxes: 1978-2017



The first two figures show the distribution of corporate and personal income tax changes between 1978 and 2017. Personal income tax changes smaller than .05 percentage points are excluded. The second figure shows the number of positive and negative changes by year. Ohio, Michigan, and Texas are excluded panels. See text and appendix for additional information on state taxation.

Figure 1.3: Event study analysis - establishments entry rate



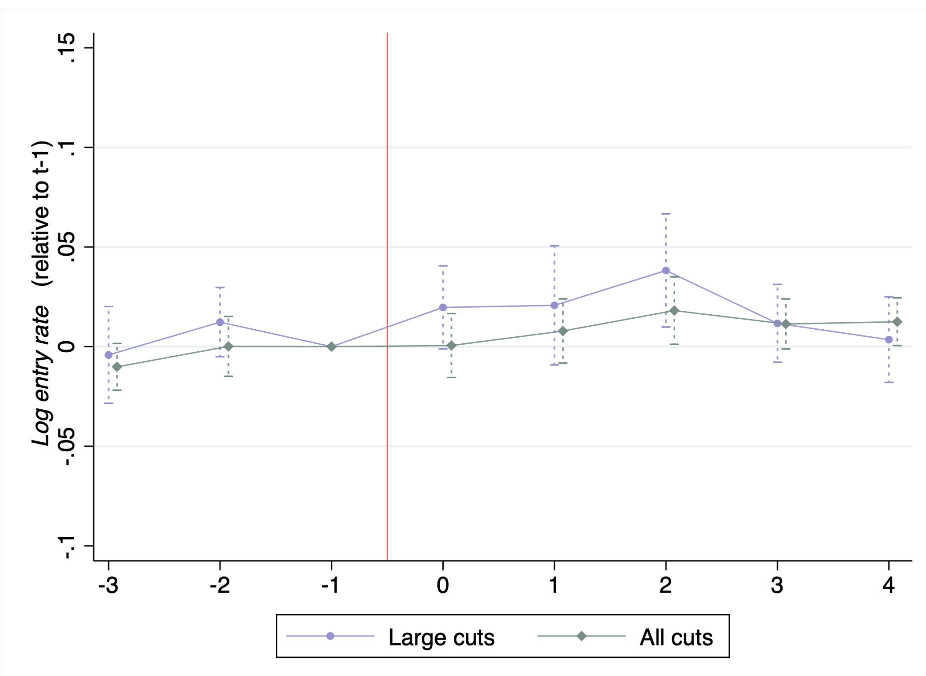
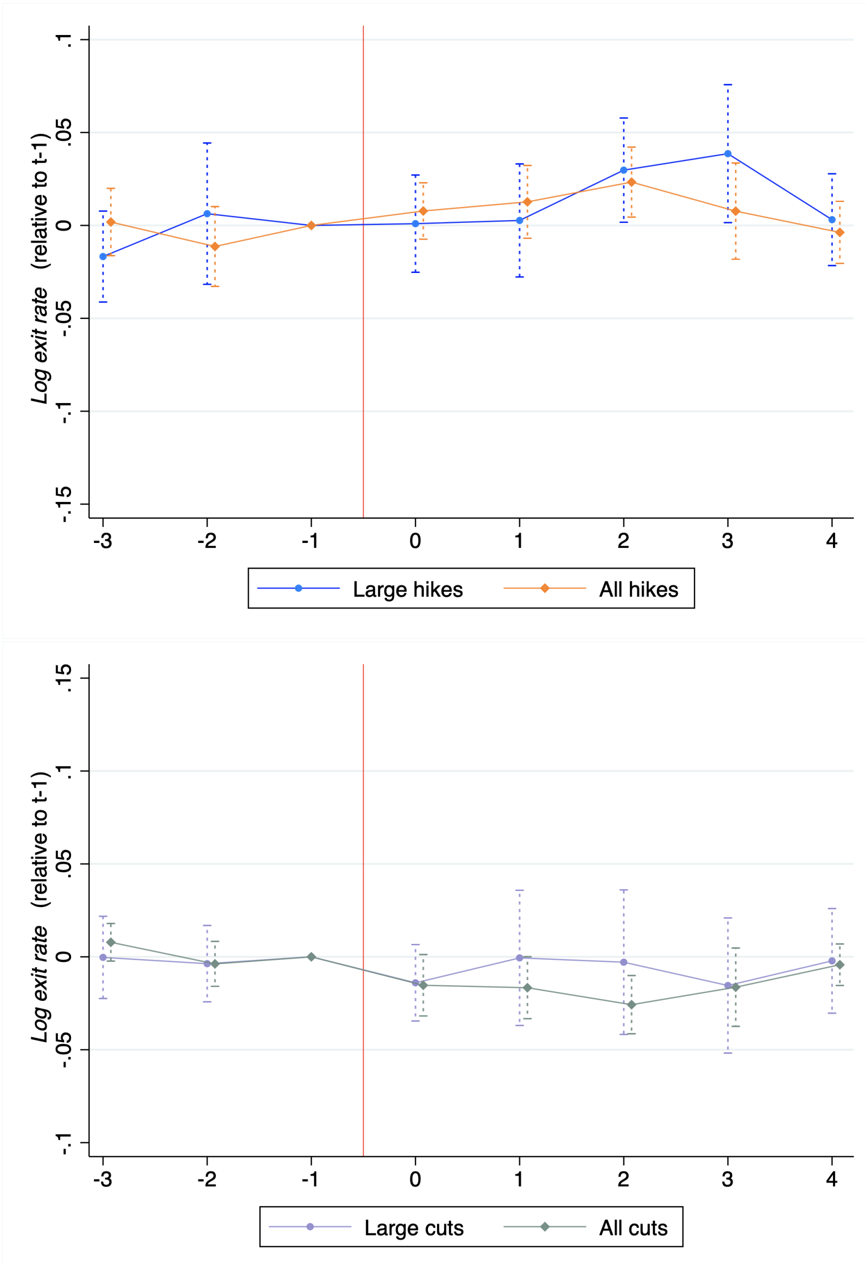
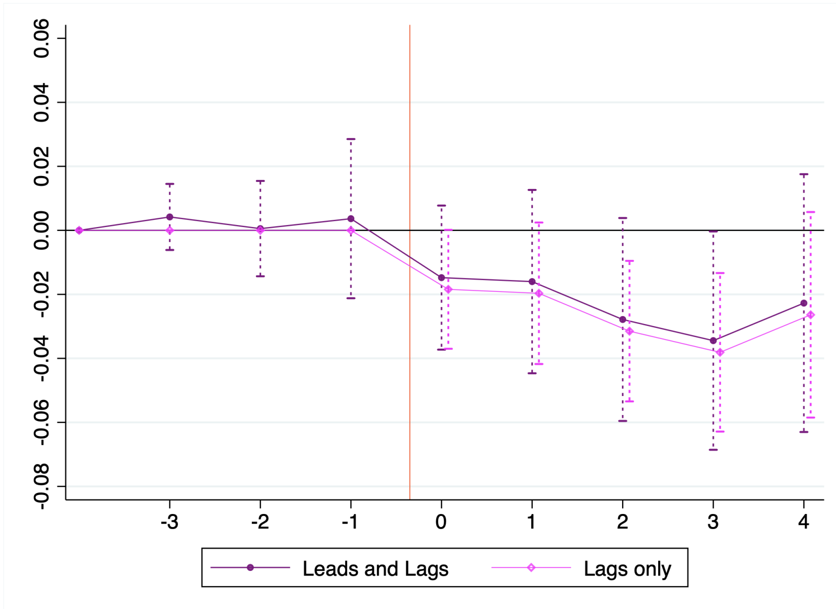


Figure 1.4: Event study analysis - establishments exit rate

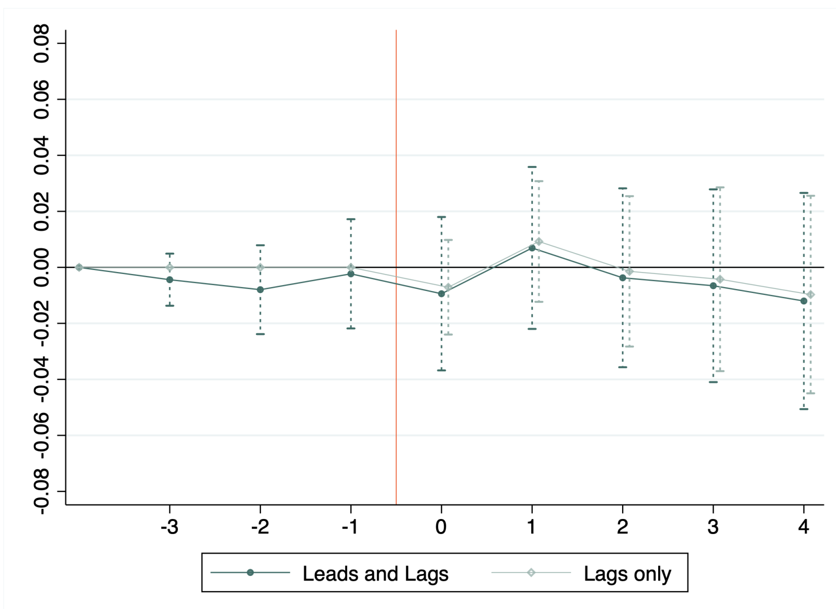


This figure plots the coefficients from the event study described in the estimation strategy section. Large changes are the 75th percentile of hikes and cuts respectively. We restrict the large hike/cuts sample to large changes for which no other large change occurred in the lead window. For the all hikes/cuts sample, we similarly restrict the sample for which another change occurs in the three years prior to the change. W remove Michigan, Ohio and Texas tax changes. We include county and year fixed effects. We include the same controls as in the main estimation strategy: county demographic shares, population local property tax share and amount per capita, state policies (personal, sales tax rates, minimum wage, tax incentives and financial assistance programs, unemployment insurance compensation.)

Figure 1.5: Dynamic effect of corporate tax change on establishment entry and exit rate



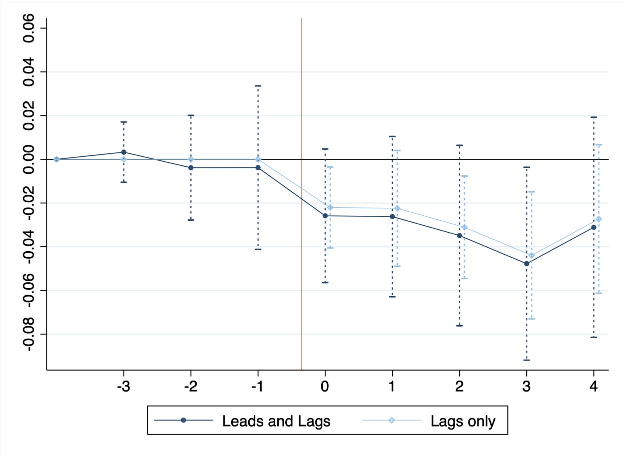
Effect of a tax change on log establishment **entry** rate



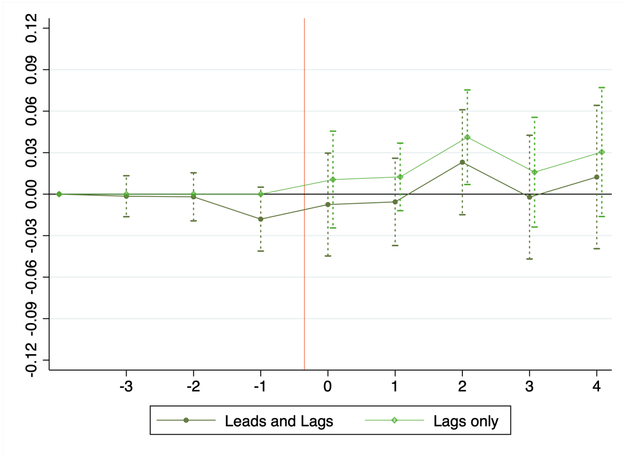
Effect of a tax change on log establishment **exit** rate

These figures plot the linear combination of the coefficients estimated from the distributed lag model from the dynamic analysis section, as well as the 95% confidence intervals. We plot both the linear combination of both leads and lags, as well as the linear combination of lags only. Only looking at lags is akin to an impact response function starting from the tax change. We restrict the sample to tax changes for which no other large change occurs in the lead window. We include the same controls as in the main estimation strategy: changes in county demographic shares, population local property tax share and amount per capita, state policies (personal, sales tax rates, minimum wage, tax incentives and financial assistance programs, unemployment insurance compensation.) We also include a year fixed effect, and a census division fixed effect which captures yearly shocks and regional trends in dynamism.

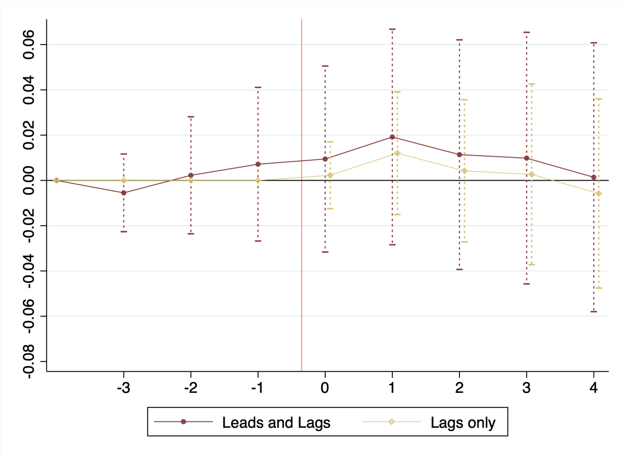
Figure 1.6: Dynamic effect of tax hikes/cuts on establishment entry and exit rate



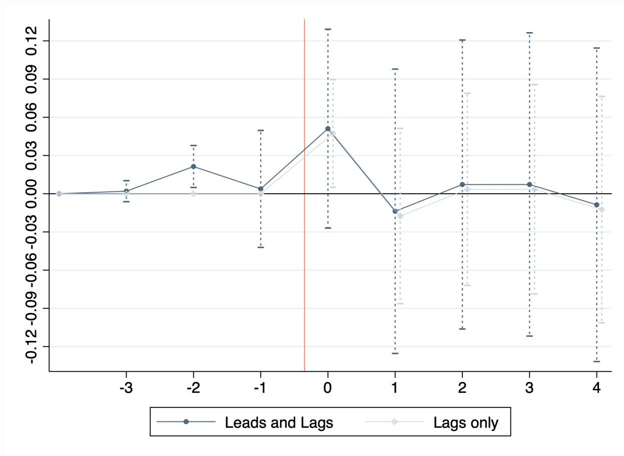
Tax hike on entry rate



Tax cut on entry rate



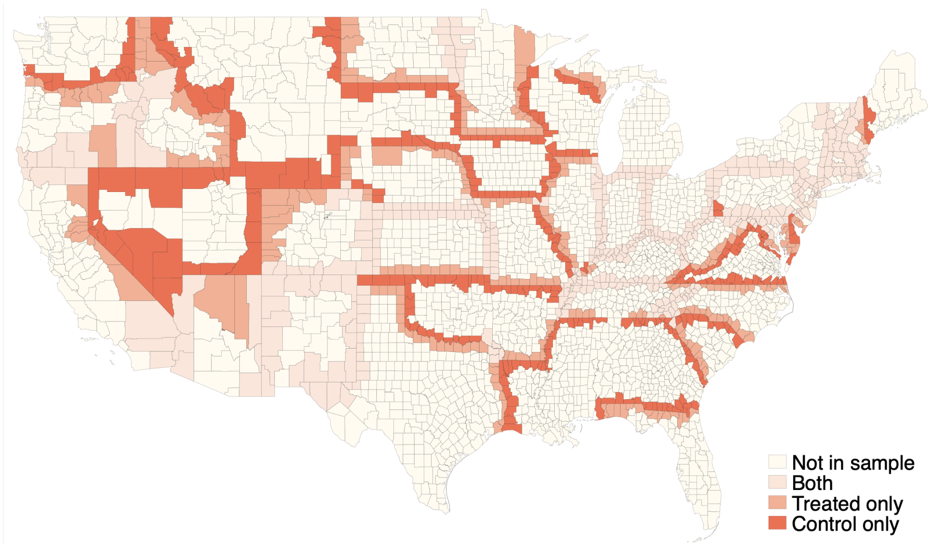
Tax hike on exit rate



Tax cut on exit rate

In this figure, we focus on tax cuts and hikes separately. See previous figure for details.

Figure 1.7: Treated and control border counties

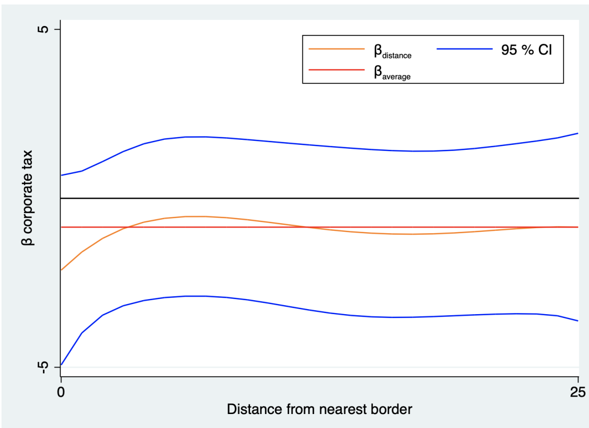


This graph depicts which controls are part of the border discontinuity design model, as well as which is either treated, control, or both - for different tax changes and estimation windows. We remove counties with lake borders, as well as treated counties where the control county experienced a tax change during the same period or during the three years prior. We also keep treated counties which experience a unique tax change in our estimation window of two years before hte tax change

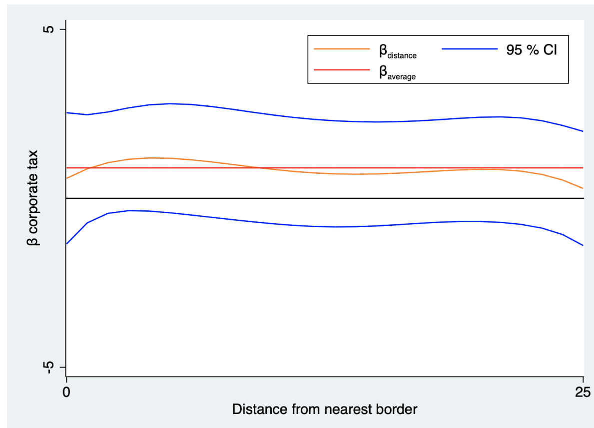
Figure 1.8: Effect of corporate tax based on border distance

Polynomial (n=4) interaction - 25 miles from border

Entry rate

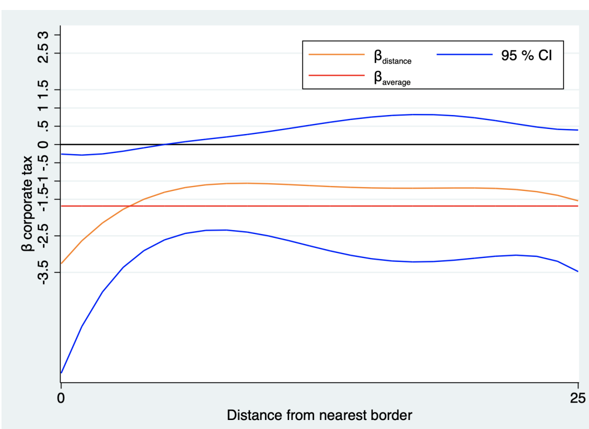


Exit rate

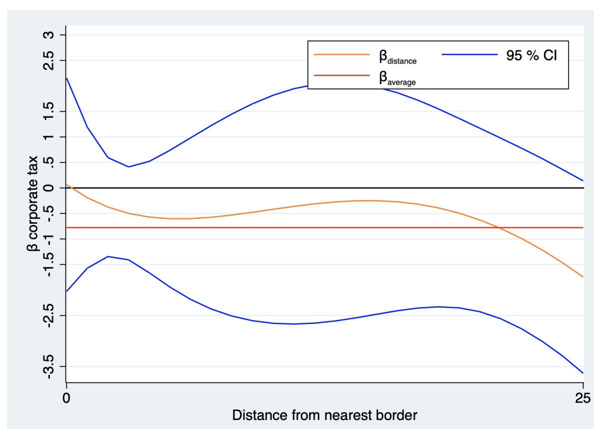


Without border dominated states

Entry rate



Exit rate



These graphs are based on equation 1.6, focusing on tracts within 25 miles from the border. the red line depicts the baseline effect without any distance interaction, while the orange line computes the effect by distance from the border by adding the coefficients on the distance interacted with the tax rate polynomial. Blue lines represent the 95% confidence interval. The bottom panel is the same estimation, but focuses on state that are not border dominated.

CHAPTER II

What Happened to Property Taxes after the Great Recession?

From a work with Chiara Ferrero

Abstract

Newly collected data on property tax rates, assessment values, and property tax levies were used to study the effect of falling home prices associated with the Great Recession on local property tax revenues. The mechanical channel through which home values affected assessed values as well as the policy channel through which policymakers responded to changes in the tax base were teased out. It was found that the resilience of property tax revenues can be attributed to two main factors: a small correlation between home price changes and assessed values after 2007 and large increases in property tax rates in areas facing a negative shock in their tax base. Contrary to the mainstream perception, it was found that the recession had a small but negative and lasting impact on the tax base. Negative shocks were offset by as much as 80%–85% in the long run, implying that a 10% decrease in the tax base led to only a 1.5% decline in property tax revenues. A large variation in responses are documented, and the role of property tax rate and levy limits during and post-recession are analyzed. Rate limits seem to reduce the ability of policymakers to offset negative shocks in the tax base and lead to a bigger decline in revenues. Jurisdictions with a levy limit are much more likely to smooth out negative and positive shocks.

JEL Codes: H12, H20, H71, R31, R51
Keywords: State and Local Taxation, Property Taxes, Great Recession, Property Tax Limits

2.1 Introduction

Property taxes are one of the main sources of financing for local governments, which rely on tax revenues and state transfers to provide services such as education and fire protection. In 2012, property taxes constituted about 1% of state revenues, 27% of county revenues, and 20% of municipalities' revenues. There is also a lot of variance in the reliance on property taxes. Property tax collections make up about 31% of all state and local tax revenues in New Hampshire and only about 7% in Alabama. They are usually administered locally, with rules varying widely across the nation. This is perhaps one of the reasons why there is still little evidence of how property rates and revenues changed after the Great Recession. As the crisis unfolded and home values dropped precipitously, many feared disastrous consequences for local budgets. However, while the consensus is that the shock caused by the Great Recession had a negative impact on the finances of local and state governments, the most dire predictions were mostly avoided. It is true that on average property taxes did not fall as much as expected during and after the crisis, yet this story potentially hides important heterogeneity across jurisdictions and locations.

In this paper, a novel dataset that allows us to shed more light on the effects of the Great Recession on assessed values—the property tax base—and tax collections is exploited, and a deeper understanding of the underlying mechanisms is provided. Data on property tax rates, assessment values and levies for local governments in 44 states between 2000 and 2018 were collected, which is in our knowledge the most extensive collection of this kind so far. The time period covered by our data moreover allowed us to study the effects of the recession on property tax policy in the short and medium run. The data was leveraged to disentangle the mechanical and policy effects behind aggregate changes in property tax revenues. The mechanical effect refers to the change in the tax base following a decline in property values. The policy effect refers to the change in the tax rate by policymakers to potentially offset changes in the base. The property tax levy is generally obtained by multiplying the net assessed value of a property with the applicable tax rate (often described as millage, or mill rate). The net assessed value of property depends on the underlying property value and on the assessment ratio and deductions that apply. Therefore, a change in property values changes the levy mechanically through a change in the assessed value. As most local governments face balanced budget requirements, a decline in the tax base implies either an increase in the tax rate applied—which is referred to as offsetting—or cuts in spending.

An important feature of local property taxation in the United States is the array of rules and limitations that restrain local policymakers. The limits are widespread and have been adopted in some form by the large majority of states. They are usually applied to rates, assessed values, or levies and may differ substantially in how binding they are. Property tax limitations are seen as a way to constrain policy makers and increase their accountability. Limits have always garnered attention from economists and policymakers, who seek to understand the extent to which they are binding and how much they distort local decisions. In this study, additionally data were collected on different types of property tax limits, and light is shed on their role and impact on observed tax rates and levies after the recession. In particular, the focus is placed on whether the presence of limits hinders the ability of jurisdictions to recover from the shock.

In a preview of the findings, it is shown that changes in home values had a lagged effect on assessed values. The lagged effect is likely due to several factors, such as for example the length of the reappraisal cycles. On average, a 1% increase/decrease in home prices was associated with a 0.2–0.5% increase/decrease in assessed values. This relationship became weaker after the Great Recession, due to the slowness of adjustment in the tax base and the volatility of home prices. A first-difference model was used to study the policy channel by looking at the impact of changes in the tax base on the mill rate. It was found that on average, positive and negative changes in the tax base were offset by an opposite change in the mill rate: a 10% increase in the tax base was associated with a 5.6% decrease in the mill rate. Evidence was found that the amount of offsetting depends on the intensity of the shock, with negative shocks resulting in higher offsetting. Additionally, while small negative shocks are offset almost fully, small positive increases in the tax base are typically not offset by policymakers. This is consistent with policymakers taking advantage of small expansions in the tax base to increase tax revenue.

Turning to the role of limits, it was found that localities with rate limits are able to offset changes in the tax base less and are on average less likely to recover to pre-crisis levels of per capita property tax revenues. These findings hold in the short and medium run, although the limits seem to be most binding when looking at yearly changes. The role of levy limits was studied as well and it was found that, in presence of levy limits, localities' property tax revenues change less in response to a change in the tax base, which holds true for both for negative and positive changes. Overall, it is shown that policymakers seek to smooth shocks and avoid abrupt increases or declines in revenues.

The decrease in property values in the Great Recession had a small but lasting effect on the property tax base and property tax revenues. Although many localities were able to maintain relatively stable tax bases and revenues, about a quarter of localities had not recovered to 2007 levels of levy per capita in 2015. It was found that declines in the tax base after 2007 were offset by changes in the tax rates by 80–85% on average in the medium run: a 10% decrease in property values between 2007 and 2015 was associated with a 1.5% decrease in property tax revenues.

The current paper contributes to the broad literature on property tax. In particular, new light is shed on the relationship between property prices and the tax base and new evidence is provided on the reaction of local policymakers during and after the Great Recession. Additionally, we add to the literature on the role of property tax limits and their impact on tax rates and revenues. While the literature on property tax is broadly well developed, still little is known on how local governments responded to the Great Recession. An important reason is the lack of aggregate data on all three fundamental aspects of property tax systems: the tax base, the tax rates, and revenues. We believe this data collection is a significant contribution as well and can help us deepen our understanding of local property tax systems overall.

Several studies have sought to shed light on the relationship between home prices and local tax revenues. Doerner and Ihlanfeldt (2011) found an asymmetric effect, where a rise in home prices led to higher revenues but a decline in market values had little effect on tax collections. Lutz (2008) and Lutz, Molloy and Shan (2011) provided evidence on how assessed values responded to changes in property values and how tax revenues responded to changes in house prices. Lutz (2008) found that there was a lag between changes in property values and changes in assessed values and that the long run elasticity of tax levies and market value of properties was about 0.4. Lutz, Molloy and Shan (2011) also found a small elasticity of property tax revenue with a house price index. They argued that the lag between market and assessed values and millage offset can explain this result. Alm, Buschman and Sjoquist (2011) instead analyzed the impact of declining property values on local government revenues and found that, notwithstanding large variation across localities, overall, local governments had responded differently to the Great Recession than state governments to avoid pitfalls in revenue. Using school districts in Georgia, they showed that policymakers offset declining home values by increasing the millage rate.

Other studies have focused specifically on the role of policy makers' reactions to the Great Recession. The National League of Cities conducted multiples surveys after the Great Recession to gather more evidence on how local policy makers react to negative revenue shocks[1]. The first course of action was drawing reserves, followed by cuts in non-essential expenditures, and increases in fees and other utilities. Notably, millage rate offset was rarely used in the survey's responses. An older study by Wolman (1983) argued that the optimal response depended on the timing and view of policy by citizens. As in the survey, reserves are drawn first, but then higher taxes are preferred, while cuts in non-essential expenditures take third place.[2]

Skidmore and Scorsone (2011) focused on Michigan and studied how localities changed expenditures due to fiscal stress, not focusing instead on other mechanisms such as changes in tax rates. They found that localities experiencing fiscal stress between 2005 and 2009 were more likely to cut non-essential expenditures. Dye and Reschovsky (2008) instead analyzed changes in state aid and whether local governments responded by raising tax rates, finding that school districts increased tax rates by $0.23 for a dollar decrease in state aid on average. In the current paper, focus is placed on the extent to which policy makers change mill rates in response to a change in tax base, and it was possible to study this in the short and medium term in the majority of states.

The study closest to the current one is by Cromwell and Ihlanfeldt (2015), who focused on Florida and looked at millage rate and expenditure adjustments following lower transfers and a decline in property tax base during the crisis. They found that local policymakers both cut expenditures and offset the decline in the tax base by raising millage rates and that the response varied in part due to the monopoly power of local governments or the degree of competition with other neighboring localities. In this paper, it is studied how assessed values, levies, and mill rates change in response to a change in property values, and the role of limits is highlighted.

Property tax limits and their effectiveness have been extensively studied. Examples of efforts to categorize and study property tax limitations include Paquin (2015), Mullins (1995), Sapotichne et al. (2015), and Maher and Deller (2013). Amongst others, Dye and McGuire (1997) and Preston and Ichniowski (1991) studied the effectiveness of property tax limitations. At the state level, Poterba (1994*b*) evaluated the role of tax and expenditure limitations and fiscal institutions. He found that states with higher restraint were typically correlated with faster fiscal adjustment using data from the late 1980s. He also demonstrated the importance of political factors: states with full party control have a

[1] See for example Hoene and Pagano (2010)

[2] While surprising, the structure of local taxes may explain this results these seemingly opposite results. In many jurisdictions the tax rate reflects changes in local expenditures and is not a policy choice per se. The mechanical effect on rates will be to offset cuts in other revenues, although many policymakers may not interpret it that way.

slower adjustment, and spending cuts and tax increases are smaller during gubernatorial election years. The current paper exploits data gathered from Paquin (2015) and Lincoln Institute and of Public Policy (2021*b*) to evaluate how the presence of rate limits and levy limits, in particular at the jurisdiction level, has impacted the change in property tax revenues after the Great Recession. Increasing attention is being devoted in the literature to the effect that tax limitations have on the erosion of the tax base overall and on the distortionary effects that limits and rules related to reappraisal may produce. Berry (2021) and Avenancio-León and Howard (2019) are two examples of recent research focusing on assessment and reappraisal values and shedding light on limitations of the methods used in assessment. More work is needed to fully appreciate the role that limits and assessment rules have on property tax collection. This paper contributes in particular to the role of limits in a time of property values and tax base decrease.

Note that throughout the paper, the term of tax levy is commonly used when referring to the amount of revenue generated, as it is common terminology in property taxation. Moreover, assessed value is sometimes referred to as NAV, or net assessed value. The word net implies that NAV captures the actual tax base after taking into account exemptions and reductions in assessment.[3] The rest of the paper is structured as follows: section 2 provides more details on property tax systems in the United States and describes the data collection process as well as other data used in the analysis. Section 3 details the mechanism behind the relationship between home values and local tax revenues and provides theoretical predictions. In section 4, the methodology and empirical findings are presented, and section 6 concludes the paper.

2.2 Property taxes and data

Property taxes are critical for local revenues and a major source of funding for not only services such as schools but also fire or police departments. All states rely on property taxes to some extent, and while they may be levied by all levels of jurisdictions in some states, they are most commonly used as a tool by municipalities and school districts. Counties often impose a property tax as well, however with the exception of some states where most of the levy occurs at the county level and is then redistributed to lower jurisdictions counties' collections are typically small. State governments may also levy a state-level

[3] In some states, it was not possible to distinguish between both. For the majority of tax collected, the assessed values clearly described as the net taxable amount were collected, or when gross and net values were available, net amounts were used in the analysis.

property tax (e.g. Georgia); however, they often largely rely on other sources of income such as sales taxes and income taxes.[4]

The tax base for the property tax is broadly determined by the value of taxable property in a state. The largest share of taxable property is residential real estate, however, different classes of properties may be taxed, including for example commercial and agricultural property. The importance of commercial property taxes as a fraction of local revenue varies considerably. Colorado is notable as its laws require that a certain percentage of ad valorem taxes come from commercial property, which leads to a large discrepancy between the taxation of residential and commercial property. Some states impose different tax rates on property types, while others have a uniform rate. When collecting data, some states only report the total assessed value of taxable property at the jurisdiction level, while others report it by categories. Throughout the analysis, when assessed value is referred to, real estate value is typically implied, which combines commercial and residential properties. This excludes public utilities, agricultural land, or the value of natural resources in certain areas. Although a residential property index was used, it is reasonable to expect residential and commercial values to be correlated over time.

States in general use market value to assess the taxable value of property but may differ in the fraction of market value they tax or in the exemptions available. Typical exemptions include primary residences, or homestead, buildings of historical values, business incentives, or special treatment of older property owners. While market and assessed values are strongly correlated, there are several factors that can weaken that correlation. First, several states implement limits on how much the assessed value of a property can change on a yearly basis.[5] Second, some properties may not be reappraised every year, and there is typically a lag between actual change in market value and appraisal. Appraisal is done by individuals, and the methods vary across time and jurisdictions. Most states implement ways to limit the variability of taxes paid across areas and use equalization methods to optimize horizontal equity for homeowners.[6] Third, and related to the specification

[4]Another fundamental source of revenue for both state and local jurisdictions is transfers. When revenue is discussed, own source of revenue is typically implied; however, transfers are important for policymakers and will affect their decisions about spending and taxation.

[5]The most well-known example of this is Prop 13 in California which limits the yearly change in assessed value for residential property of 2% a year and allows full reappraisals to happen only when the property is sold. This leads to a large discrepancy between assessed and market values in areas with large increases in housing values over time. Additionally, the maximum tax levy on a property cannot exceed 1% of its real market value.

[6]In this context, horizontal equity implies that for a given tax rate and market value, taxes paid will be the same regardless of location. In other words, the same relationship exists between market and assessed

of our estimation strategy, if residential and commercial values are not highly correlated, the coefficient associated with the home price index will be biased downward because of measurement error. In areas where commercial property makes up a sizeable portion of the tax base, the estimated correlation was expected to be a lower bound of the true relationship. These issues are discussed in more detail in the mechanism section of the paper.

Once the taxable value of property is determined, the actual tax collected depends on the rate imposed. The property tax works differently than other main taxes, such as the sales or income tax, as in combination with the tax base, the tax rate is the main feature chosen by state policymakers when implementing tax reform. In the example of the sales tax, typically few changes in the tax base happen over time. On the other hand, the property tax rate is typically never chosen directly and depends on the amount of revenue needed in a jurisdiction and the tax base—in this case the value of assessed property. For example, in New York, school boards and municipal policymakers decide a budget in May, and using the value of assessed property in March that year, they set the tax rate equal to the total levy needed divided by the net taxable value of property. This mechanism is what stands behind the view of property tax as a "residual" tax or a tax that is determined once all other variables in the budget are set.

The tax rate for property taxes is often referred to as the mill rate, because it is usually expressed as the amount of dollars paid per $1000 worth of assessed property. Multiplying the mill by 10 effectively gives the amount of taxes to be paid as a percentage of assessed value. Depending on the state, different taxing jurisdictions may impose different mill rates, so that the overall property tax paid by a homeowner will depend on the combined rate of all the applicable jurisdictions. Local politicians can also face significant restrictions in managing property tax revenues. The majority of states impose some rate limits, levy limits, assessment limits, or a combination of the three which may require that changes go through a vote and need to be approved by residents of the jurisdiction. This is discussed in more detail later.

The next section describes the data collection process for property tax revenues, mill rates, assessment values, and property tax limits.

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value on all jurisdictions of the state.

2.2.1 Local property tax data

Data were collected on local property tax rates, assessment, and levy in 45 states in the United States between 1990 and 2018.[7] The mill rate for only a handful of states was obtained (Idaho, Indiana, Maryland, North Carolina, Pennsylvania, Rhode Island, West Virginia). Further, the data on tax revenues in Kentucky were not found either. All remaining states have data for at least two of the three variables mentioned.[8] To our knowledge, there is no current database that aggregates local property tax data. The Census of Government collects data on spending and revenue from all levels of government every five years as well as yearly for states, and large counties and municipalities. However, it does not contain information on tax rates and assessment values.

The current data were gathered from three main sources: state annual reports, state tax administration—through their website or direct contact—and the Lincoln Institute of Land Policy. The Lincoln Institute of Land Policy collects data on the features of local tax systems and raw property tax rate data from states[9]. The data obtained from the three sources above were transcribed and restructured to have consistent series over time for each state and across areas.

This paper focuses on total net taxable assessed values, property tax levies, and mill rates by county. Table 2.1 lists the data available for all states as well as the years covered. The majority of states reports aggregate data at the county level. However, states may vary with some reporting data at the taxing jurisdiction level (e.g. school district, municipality, etc.). In those cases, the available data were aggregated at the county level. The column "Aggregated" denotes states for which the mill rate was calculated based on the average of mill rates from all taxing jurisdictions at the county level. This method can lead to slightly skewed averages in either directions depending on whether smaller jurisdictions have a lower or higher tax rates.

Additionally, states may differ in how information on property tax is delivered. In some cases, only the the tax base (assessed values) and total levy are provided, while in others more details on the source of levy by jurisdiction, the type of property assessed and taxed (e.g. residential or commercial property), or the use of the levy are available. More detailed information on the data cleaning and gathering process and state-specific details on sources and available information and variables are provided in the appendix.

[7]No data was available for the state of Alaska, Hawaii, Oklahoma, South Carolina, South Dakota, and Washington D.C.

[8]We typically have full panels between the start and end date of data available at a state, with the exception of three states (NH, ID, KY) which have some missing years.

[9]Lincoln Institute and of Public Policy (2021*a*), Lincoln Institute and of Public Policy (2021*b*)

Note that in the paper, tax levies, tax revenues, or tax collections are interchangeably referred to. It is important to note that the data collected in this paper were on taxes levied. In other words, it is based on the local government's budget and represents what the constituents owe. This is not the same as tax collections if there is some level of tax delinquency. Unfortunately, data on both the taxes levied and the taxes actually collected is not always available for every state, and thus, the current results should be interpreted only regarding taxes levied. There is a potential concern as to whether the taxes collected deviate substantially from the taxes levied and how this might potentially affect our results. One factor that might ease this concern is that local governments often set property tax levies in a residual manner, meaning that the mill rates are chosen so that the resulting levy covers the portion of the budget that is not funded after other sources of revenue are taken into account. Thus, one might think that local governments would not set levies that are considerably different from the amount of taxes they are able to collect. Anecdotal evidence suggests delinquency rates are overall small and below 1% or between 1% and 3% in most states.[10]

2.2.2 Property Tax Limitations

Property tax limitations have been adopted by all states with the exception of Hawaii, New Hampshire, Tennessee[11], and Vermont. Limits are usually applied to increases in assessed values, levies, or rates with the aim to regulate property tax revenue. Tax rate limits may be applied at the jurisdiction level, or there could also be an overall limit on the tax rate that any property owner pays on their property. Similarly, levy limits may be formulated as a limit on the growth rate of the aggregate levy at the jurisdiction level or as a limit on the growth rate of individual property owners' tax obligations. Limitations regarding assessments tend to put constraints on how fast assessments can rise. This is helpful in avoiding increases in tax burden which are not determined by policy but instead by a rise in market values.

The formulation of limits varies widely across states and even jurisdictions and can include a possibility for local governments to override the limit with a pre-determined majority vote. In other cases, limits are determined through formulas and depend on other quantities such as inflation.

The share of states with some limits has not changed significantly in the last few years,

[10]See https://www.corelogic.com/intelligence/buy-stories/property-tax-delinquency-varies-across-states

[11]Tennessee has a truth in taxation requirement

as fewer new limits have been established. Data gathered by Paquin (2015) revealed that 74% of states have some limits on rates, 34% of states have some limits on assessments, and 72% of states have some limits on levies. Only 14% have a combination of some rate, assessment and levy limits. The presence of limits by itself is not indicative of how binding they might be: as rules vary widely state by state, some limits may be substantially stricter than others. Table B.2 in the appendix shows which states have some type of assessment, rate, and levy limits in year 2007, specifying whether rate limits and levy limits apply to the property or the jurisdiction aggregated amount. Additionally, the appendix contains additional information on the data on property tax limitations used.

While property tax limits are often popular with taxpayers, as they are seen as a way to gain more control over unexpected or unwarranted increases in property taxes, an increasing amount of attention has been devoted in the literature to the effects that limits have on horizontal equity in property taxation (especially regarding assessment limits and reappraisal rules) and on resilience of local finances to economic shocks. Including data on the presence of limits allows us to broaden our question to include the role of limits as well. In this paper, the data by Paquin (2015) and Lincoln Institute and of Public Policy (2021*b*) were used as well as direct research state by state to find which states have limits and classify them. In the mechanism section, it is described in more details how limits may affect policymakers' decisions when facing different types of shocks.

2.2.3 Other data

Two measures were collected for local property values. The first home price index is issued by the Federal Housing Finance Agency (FHFA). The FHFA index is computed using sales prices and appraisal values for mortgages bought or guaranteed by Fannie Mae and Freddie Mac. Small counties with few transactions were found to be typically missing from the data. The number of counties covered was 1435 in 1990 and 2412 after 2000. The sample is consistent throughout our estimation period (2000–2016). A second housing price measures comes from Zillow.[12] Zillow separates its price index into three categories: low-tier, mid-tier, and high-tier. Mid-tier represents the typical home value in the 35th to 65th percentile range. Zillow data covers fewer counties than the FHFA index, so it was not our primary choice; however, it was leveraged to validate some results from the FHFA

[12]Data from the FHFA can be found at https://www.fhfa.gov/DataTools/Downloads/Pages/House-Price-Index.aspx. Data from Zillow Research can be found at https://www.zillow.com/research/data/

index.[13].

The main data source on state and local revenues and expenditures in the United States is the Census of Governments.[14] This data were used to compute the share that several sources of revenues represent at the county level, as localities may differ on how much they rely on revenue sources such as property taxes, other taxes, or intergovernmental transfers from states and the federal government. The Census of Governments data only covers all jurisdictions every five years, in years ending with '02 or '07. The Annual Survey of State and Local Government Finances covers all years but limits the sample to state-level finances and large cities and counties.

Demographic data at the county level (total population and share of the population by race and age groups) comes from the Census and is based on revised intercensal estimates. Data from NHGIS were used as well[15], which is based on the Census and the American Community Survey on the share of population with a college degree and the share of urban residents at the county level. Data on unemployment rate used as a control in some estimations comes from the Bureau of Labor Statistics. [16] All price-related variables (including the home price index) were adjusted for inflation in 2010 dollars using the GDP deflator provided by the Federal Reserve Bank of St.Louis.

2.2.4 Summary statistics

Figure 1 plots the log HPI, NAV, millage, and tax levy between 2002 and 2015. The top panel includes all information available for all four variables, while the bottom panel removes counties for which the home price index is missing. Note that all values are adjusted for inflation (except for the mill rate, which is not a price variable), and levy and assessed values are calculated per capita. Behind the aggregate change in home values and property tax features displayed in figure 2.1 lies a lot of variation. Table 2.2 displays summary statistics for the four variables mentioned. The first panel computes statistics based on yearly variation between 2000 and 2016, 2000 and 2007, and 2008 and 2015. The bottom panel displays summary statistics for three periods with three-, five-, and eight-year

[13]Top-tier ZHVI is the typical value for homes within the 65th to 95th percentile range for a given region, and bottom-tier ZHVI indicates the typical value for homes that fall within the 5th to 35th percentile range. All data were seasonally adjusted.

[14]Census of government data:https://www.census.gov/programs-surveys/cog.html

[15]National Historical Geographic Information System

[16]Census population data:https://www.census.gov/data/tables/time-series/demo/popest/2010s-counties-detail.html. NHGIS data:https://www.nhgis.org/user-resources/datasets-overview Unemployment rate: https://www.bls.gov/lau/

differences: the immediate aftermath the recession (2007–2010), the difference between the highest and lowest average home price index in our period (2007–2012), and the difference before the recession and after recovery (2015)[17].
Over our entire time period, the average yearly change was found to be 0.5% for home prices, 1.6% for assessed values, 2.3% for tax levy, and about 0.9% for the mil rate. However, these results are the outcome of averaging between drastically different pre- and post- recession periods. Additionally, the percentiles and standard deviation show significant variation across counties. HPI, NAV, and property tax revenues increased in similar proportion between 2002 and 2007, indicating that there was not a lot of millage offsetting on average and that policymakers used the rise in home values to raise taxes. In post-recession periods, however, a different story emerges. Between 2008 and 2015, it is seen that home prices experienced on average a 1.8% decrease but assessed values instead increased by around 0.8%, and revenues by about 1.9%, while the mill rate was on average 1.2% higher. The yearly patterns post 2007 are consistent with the longer time differences in terms of signs but of larger magnitude. While assessed values went down in some areas (as we can observe from the 25th percentile), the tax base remained stable on average, while property taxes increased despite the fall in home values. This can be attributed to the rise in property tax rates.

For all time periods, a large variation can be observed in the distribution of changes in the variable of interests. This is also highlighted in figure 2 which plots the yearly average and median change as well as the inter-quartile range, in boxes, and 1.5 times the 25th and 75th percentile with whiskers. Substantial variation can be observed across units. Figure 3 plots the trends in states with and without rate limits and levy limits. The trends for HPI and assessed value per capita are comparable across the four panels. In absence of rate limits, the mill rate was found to decrease on average before 2010 and started inverting the trend only after 2010, whereas in presence of rate limits, the mill rate was found to start increasing sooner. Different patterns can also be seen between areas with and without levy limits. In particular, localities with levy limits are characterized by larger increases in the mill rate, whereas localities without levy limits seem to offset less with mill rates. Surprisingly, the levy appeared to also start increasing after 2011 in localities with levy limits, whereas in localities without levy limits, it decreased between 2011 and 2013.

These results highlight the variation over time and across localities on the effect that

[17] 2015 was chosen rather than 2016 or 2017 as a handful of states have missing data after 2015.

changing home prices have on tax revenues. The following section focuses on the mechanisms behind this relationship.

2.3 Mechanism

Let us start by defining the total revenue as $R = Transfers + Property\ Taxes + NonProperty\ Taxes$ ($R = R_g + R_p + R_{np}$), where $R_p = A \times \tau_m = T$, the assessed value times the mill rate. The change in revenue can then be decomposed as follows. $\Delta R_p = \Delta A \times \tau_m + A \times \Delta\tau_m$. The first item is the mechanical effect of a change in the tax base, and the second item is the policy effect from a change in the tax rate based on the current tax base.[18] For exposition, it is assumed that transfers and other taxes are not directly impacted by home values.[19]

Given that local policymakers typically choose a budget which then determines the property tax liability, and by extension the tax rate, the change in the mill rate based on policymakers' choice of levy can be determined as follows:

$$\Delta\tau_{m,t} = \Delta B_t - \frac{1}{A_t}\Big\{\Delta A_t \times \tau_{m,t-1} + \Delta R_{np,t} + \Delta R_{g,t}\Big\}$$

where ΔB is the chosen change in a local government's budget. Overall. the degree of millage offset will depend on the change in assessed values, the amount of revenues from other sources, and the chosen budget, which together determine the levy required.

To understand why the decline in home values had little impact in the aggregate but large variation across areas, the role of the Great Recession on 1) the tax base and 2) local tax policy must be analyzed first. The first mechanism is the relationship between the housing market and the taxable value of real estate—the property tax base. Home values are typically assessed by county officials based on the estimated market value by the assessor and the assessment ratio, which multiplied by the market value determines

[18] Note that here for simplification it is assumed that the assessed values are not a variable impacted by policy choices. However, the assessed values may be affected by policy. A prime example is the large number of states with limits on assessment growth—either on individual properties or on the aggregate value of property in the state. Local governments also affect the taxable value of property by allowing exemptions or reductions for specific goods. Homestead residences typically are granted exemptions and reduction on their assessed value. Local incentives that reduce tax liability for businesses are also quite common.

[19] There is an extensive literature on the relationship between home values and consumption, which finds that higher housing wealth leads to higher consumption. Home prices may also affect the consumption of goods associated with home purchases and construction, affecting sales tax and fee collections.

the assessed value, effectively the property tax base:[20]

$$Levy = Assessment\ ratio \times Market\ Value \times MillRate \div 1000$$

While we expect assessed values and housing markets to be correlated, there might be significant differences between the two for several reasons.

First, there is a natural lag as property tax levies are typically based on the previous year's assessed values. For example, in Minnesota, the assessed values were determined by January 1, 2020, tax levy is chosen by the legislature in the summer, and taxes would be payable by January 2021. Our dataset determines the year of the tax base when it is used to determine levy, which is 2020 in this example. However, the tax base reflects values from 2019, creating this short lag.

Second, property is typically not appraised every year. Several states have re-appraisal schedules every two to three years, creating a lag between changes in market values and assessed values. In jurisdictions with infrequent reappraisal, temporary changes in value may not be reflected in assessment at all. An extreme example of this is Delaware, where the most recent assessment of the three counties was in 1983. Although county assessors have guidelines on how to estimate the market value of property, they ultimately have some discretion in determining the taxable value. This can create disparities across and within jurisdictions as well as across time. Recent research has highlighted how the relative tax burden can vary substantially based on the value of the home (Berry (2021)) or the demographic characteristics of a neighborhood (Avenancio-León and Howard (2019)). These are important findings that highlight how property appraisal and its relationship with market value is murky and varies widely. Additionally, it is common to reassess homes when they are bought and sold. As the number of homes sold in the years following the Great Recession dropped, it is likely that the share of property reassessed dropped as well.[21]

Third, many states have assessment limits, which restrict the maximum amount by which the assessed value of a house can increase year to year. In areas with rapidly rising real estate prices, these limits can create substantial wedge between the taxable value and the market value of property.[22] The extent to which assessment limits are binding and

[20]As previously discussed, numerous states and localities have exemptions and deductions which lower the taxable value of specific properties. Nonetheless, the final taxable value would be the estimated market value times the assessment ratio, minus applicable exemptions. While the exemptions can and are revised by state and local officials, they are typically specified amounts and thus do not depend on the value of a home. E.g., in Michigan the base exemption was $40,475 in 2020, and that figure is revised every three years.

[21]The number of homes sold went from seven millions in 2005 to just above four millions in 2008 and five millions in 2013 (See https://www.statista.com/statistics/226144/us-existing-home-sales/).

[22]E.g., this is the case in Florida where assessed values are required to not exceed market values. As an

their effects on property tax collections are fascinating questions, which is left for future research. [23]

Finally, the measure of local values will be measured with error. The relative taxation of homes along the value distribution is not captured by a single index. The presence of non residential property in the tax base, mainly commercial property, will also lead to measurement error if their change in value is not highly correlated, which may also be more likely in the short run.

The second mechanism behind the relation between property values and tax revenues is what determines the millage rate—the tax rate applied to taxable assessed values to determine the property tax levy. For other sources of government revenues such as sales or income taxes, the exact tax base is unknown when policymakers determine the tax rate. The property tax base on the other hand is known in advance of the fiscal year. Hence the mechanism through which the millage rate is set is different from the one through which other tax rates are set. Usually, local governments decide on a budget and then estimate the property tax levy to be the total amount of spending minus expected other revenues. This mechanism coined the "residual view," whereby policymakers decide on a budget, and the mill rate offsets changes in the tax base accordingly. Assuming no changes in spending and other revenue sources, a rise in assessed values should be accompanied by a similar decline in the mill rate. Critiques of this view offer an alternative hypothesis called "fiscal illusion." They posit that a rise in the tax base can be followed by a rise in tax levy, as policymakers exploit the salience of the tax rate, and "hide" increases in levy behind partial offsets in the mill rate, which nonetheless declines. An alternative view is that changes in the tax base and home values can also imply a shift in preferences for public goods provision and taxation, explaining the partial offsetting. In this paper, the focus is on disentangling the effect of the tax base and policy changes and abstract from changes in preferences. The estimation strategy uses first-differences, essentially removing constant local regulations, characteristic,s and preferences. The extent to which the Great Recession changed preferences toward local taxation is another important and fascinating

example, take a house that was bought for $100,000 in 2000 and assessed at $50,000. The assessed value should be the minimum between the estimated market value times assessment ratio (e.g. here 0.5) and the maximum amount allowed to increase given the limits. In 2007, that house was worth $200,000, but was assessed at $75,000 because of assessment limits. If the value of the house goes down to $150,000, the assessed value will remain the same. If the value goes below $150,000, then the assessed value will go down. In either case, the correlation between assessed value and home market value is either zero or much lower than in periods when the housing market was going up.

[23] Assessment limits were not included in our analysis as the focus here is on the Great Recession and the role of the real estate crash. Theoretically, assessment limits were not expected to be binding in areas experiencing declines in property values.

question for future research.

2.3.1 Limits and local policy-making

As discussed earlier, in addition to assessment limits, the other two common and primary types of limits are levy and rate limits. Policymakers may offset declines in assessed values to manage or avoid a decline in tax revenue. In that situation, rate limits are most likely to be binding. Rate limits may have different effects in the short and medium run as well. For example, they may be more likely to be binding in the short run. Imagine a county that experiences a one-year temporary decline in assessed values. Policymakers will offset that decline by increasing the tax rate as much as the limit allows. If assessed values go back up in the following years, they will be able to recover the previous loss in revenues by keeping the mill rate the same or not lowering it as much as another county which did not experience a previous decline in revenues. Essentially, in this scenario, the limit creates short-run variation in tax revenue but is not binding in the medium run. On the other hand, a persistent decline in the tax base may imply that the rate limit is forcing lower tax revenues permanently. After the Great Recession, home prices bottomed out in 2012 and assessed values shortly after. This scenario is more likely to make rate limits binding on a yearly basis as well as in the short and medium run.

The role of levy limits was analyzed as well, which may have had an impact on recovery post Great Recession for two main reasons. First, areas experiencing small declines in property values or even increases may want to increase revenues coming from property taxes, especially if they face declines from other sources, such as local sales taxes or intergovernmental transfers. Second, jurisdictions with stringent levy limits facing negative shocks in their tax base may be reluctant to reduce levy, as it may be more difficult for them to "catch up." Thus, while the levy limit itself may not be binding, forward-looking policymakers may optimize their current decisions based on expectations about the future tax base and the stringency of the limits.

2.4 Empirical Analysis

This section presents evidence on the relationship between the home price index and assessed values as well as on the effect of a change in the tax base on local property tax revenues and tax rates. The role of levy and rate limits in the aftermath of the Great Recession and the extent to which they bound and affected recovery was investigated.[24]

[24]In our yearly analysis, the yearly changes in the tax base, tax collection, or tax base where the amount was more than doubled or was reduced by more than half (i.e. a change higher than 100% or smaller than

2.4.1 Housing market and assessed values - the role of the tax base

The first step in the analysis involved evaluating the effect of home prices on the tax base, i.e., total county assessed value per capita. Given the large heterogeneity in assessment rules and methods both across and within states, the model was evaluated in first differences. Essentially, the variation in home prices over time in a county between 2000 and 2016 was exploited:

$$\Delta \log NAV_t = \beta \Delta \log HPI_t + \varepsilon_t \tag{2.1}$$

where NAV is the net assessed value per capita, and HPI is the county level home price index. Both variables were adjusted for inflation.[25] Cluster standard errors were used at the county level to take into account serial correlation over time. As discussed and observed in figure 2.1, there can be a significant lag between assessed values and market values. To test for this, the following equation with three lag changes in the home price index was estimated:

$$\Delta \log NAV = \beta_0 \Delta \log HPI_t + \beta_1 \Delta \log HPI_{t-1} + \beta_2 \Delta \log HPI_{t-2} + \beta_3 \Delta \log HPI_{t-3} + \varepsilon_t$$

Column 3 in table 2.3 shows that, on average, a 1% increase in home prices is associated with an increase of 0.3% in the property tax base the same year. However, we know that assessed values typically lag home values, depending on the assessment rules across counties.[26] Adding three lagged values confirmed that lagged changes have stronger predictive power. The coefficient with the contemporaneous change was unsurprisingly at that point only 0.1 and likely the result of inter-temporal correlation in property changes. All lags were found to have significant coefficients and larger estimates ($\beta_{lag1} = 0.21, \beta_{lag2} = 0.18, \beta_{lag3} = 0.13$). Column (5) replicates the analysis but weighing results by population. The overall outcomes are very similar, indicating that in the aggregate, population is not associated with large differences in the relationship between home values and the tax base. Although not likely, changes in demographic and economic characteristics could be associated with changes in assessment rules. Column (6) includes controls variables, and the coefficients are virtually similar. Column (6) also restricts the sample to counties observed

-50%) were removed. In the long-difference analysis, the highest 1% change in magnitude of the same three variables was removed. The main reason behind this decision is the potential for mistakes in the raw data. Additionally, translating some PDFs and scanned documents occasionally resulted in small discrepancies as well. Not removing outliers resulted in almost identical results, with slightly lower estimates due to measurement error and slightly higher standard errors. However, the qualitative findings and statistical significance remained..

[25]The GDP deflator provided by the Federal Reserve Bank of St. Louis was used to adjust all price related variables, effectively levy, assessed values, and the home price index.

[26]In the first two columns, the model was estimated in levels, with and without county fixed effects.

every year between 2000 and 2016 and yields similar results as well. Column (7) uses a different measure for home values: the price of a median home value sold in a county. The coefficients are about 10%–20% smaller, but again the qualitative results are comparable.

Columns (8) and (9) split the sample before and after 2008. The relationship between changes in home values and the tax base is much weaker in the second period: the coefficients on log hpi are between 50 and 60% smaller after the Great Recession, indicating that the tax base was less likely to be affected by changes in home prices after recession.

Long differences and asymmetric responses

To focus on the effect post-2007, the models were estimated using three-, five- and eight-year differences.[27] This allowed us to estimate whether the relationship between the tax base and property values was different for positive changes and negative changes in home values. Essentially, the following was estimated:

$$\Delta_{3y} \log NAV_t = \beta_1 \Delta_{3y} \log HPI_t \times (HPI_t > 0) + \beta_2 \Delta_{3y} \log HPI_t \times (HPI_t < 0) + \varepsilon_t$$

The first striking observation is that there is essentially no correlation between changes in home prices and changes in assessed values between 2007 and 2010, for both positive and negative changes. Note that very few observations had positive changes, and only 164 counties experienced increases, while 2,264 counties saw a decline in property values.

Looking at the 2007–2012 and 2007–2015 changes, it is noticed that the coefficients associated with both positive and negative changes in home prices strengthen and the coefficient associated with lower home values becomes statistically significant ($\beta_{07-12} = 0.18$). The weighted results are consistent, with a higher estimated relationship in magnitude between lower home values and a lower tax base. This could be an indication that the home price index is less subject to measurement error in more populated areas or that assessment rules, limits, and the frequency of appraisal is correlated with population density. However, the coefficient on log positive HPI is large and negative, implying that a rise in home prices is associated with a decline in the tax base. This is likely the result of volatility in home prices throughout this time period and the fact that recovery in values only started in 2012 in most places. With the exception of the last column of weighted results, it cannot be rejected that in the aggregate, and over the medium run, adjustment in the tax base is symmetrical for increases and declines in home values. [28]

[27] 2010 was chosen as it was the first year when the recession ended officially, 2012 as it was the year home prices bottomed out, and 2015 rather than later years for sample reasons, since the data of some states were lost after 2015.

[28] To further test for symmetrical responses, the yearly model was tested with third lagged differences—i.e.,

Taking stock of the mechanical effect

Before moving to the policy analysis, it is worth recapping what has been learned so far about the relationship between home values and assessed values. First and unsurprisingly, the home price index was found to have a precise and strong effect on the tax base, whereby a 10% change in the former led to a 3%–5% change in the latter. Second, there was a significant lag—up to several years—until changes in property values were reflected in the tax base. Third, the relationship between home prices and assessed values was found to be significantly weaker after the Great Recession. The main explanation is the combination of slow adjustment and high volatility in home prices. Fourth, symmetric effects of changes in the home price index on net assessed values were typically found.

2.4.2 Housing market and property tax revenues—the role of policy

We can now turn to the role of policy. Given a specific change in assessed values, how did the levy and tax rate change? To answer this question, the following equation was estimated:

$$\Delta \log Levy_t = \beta \Delta \log NAV_t + \varepsilon_t \tag{2.2}$$

where $\Delta \log Levy_t$ is the difference in log property tax revenue per capita adjusted for inflation. The upper panel of table 2.5 shows results for this regression. The first column coefficient implies that a 1% increase in the tax base leads to a 0.5% increase in tax revenue. Asymmetric responses were tested for in column (2): a positive shock was found to yield a stronger effect compared to a negative shock ($\beta_{\Delta>0} = 0.56$ and $\beta_{\Delta<0} = -0.4$). It is possible that areas relying on different sources of income experience different trends in their adjustment to the tax base. In addition, changes in population and income may change preferences toward local taxation.[29] In column (3), the change in demographic characteristics, change in income per capita and unemployment rate as well as the fraction of local income coming from property taxes, other own revenues, and transfers are included. The qualitative results are similar, but the response to a positive shock is smaller, and the response to a negative shock is larger in magnitude. While this could indicate changes in preferences, it is also possible that controls are correlated with local home prices and, by extension, the tax base. In that case, such controls would be characterized

by regressing $\Delta \log NAV$ on $\log HPI_t - \log HPI_{t-3}$. The results are shown in table B.4 in the appendix and confirm that symmetrical adjustment of assessed values cannot typically be rejected to local home values.

[29] This type of sorting pioneered by Tiebout (1953) could imply that trends are accentuated over time until a local area reaches an equilibrium. If sorting is orthogonal to observable characteristics, it cannot be controlled for. However, if Tiebout sorting is uncorrelated with changes in assessed values, our coefficient will not be biased.

as “bad controls,” since their effect stems from their correlation with the underlying variation in the explanatory variable. By taking first differences, all time-consistent variations across jurisdiction were effectively controlled for. It was chosen not to include controls in following estimations, given that the likelihood of having bad controls outweighs the omitted variable bias issue in our opinion.

The weighted specification gave consistent results, with estimates being slightly lower in magnitude.[30] Estimated coefficients shown in columns (5) and (6) were found to be similarly consistent before and after 2008.[31]

We now turn to the effect of the tax base on the mill rate, which is shown in the lower panel. Unsurprisingly, estimates were found of the opposite sign and similar magnitude as the levy. Both positive and negative shocks were found to be roughly 50% offset by mileage decrease/increase. Offsetting of negative shocks was a bit smaller on average (50% for negative shocks versus 40% for positive shocks on average). In different words, this means a 1% increase in the tax base is associated with a decrease in the mill rate of about .4%, implying that 40% of the positive shock was offset. [32]

Finally, it may be of concern that assessed values are endogenous. An example would be local policymakers changing rules of assessment, such as reducing the frequency of re-appraisal and limiting downward changes in assessment of giving local assessors new instructions on how to assess homes, either formally or informally. While there is no concrete and systematic evidence that this took place, the previous model was evaluated using an instrumental variable specification, where the change in tax base (NAV) was instrumented using the change in home prices. The instrumented results are shown in column (7) of table 2.5. The estimated coefficients are largely similar, indicating that the level of endogeneity of assessed value to changes in home prices is potentially not very large or common.

Testing for non-linear effects

It is possible that policymakers react differently to small and large shocks. For example, small shocks may be adjusted using other sources of income. For small positive shocks, a

[30] E.g. a 10% decline in the tax base was associated with a 3.6% decline in revenues, compared to a 4% decline in our baseline.

[31] The smaller effect in magnitude of a negative change in NAV may be a reflection of samples and heterogeneous responses, given the small number of places experiencing a negative shock in their assessed value before 2008.

[32] As policymakers react to assessed values, it is the correct variable to use to understand policy changes. However, it can also be interesting to look at the correlation between home values and policy outcomes. The results of regression levy and mill rate on the third lagged difference in the home price index is shown—similar to table B.4.

lower degree of rate offsetting may be less salient. Large shocks may force policymakers to have referendums in states with rate limits. A quadratic polynomial version of equation 2.2 was estimated for both levy per capita and mill rate as the outcome variable of interest.[33] The predicted outcomes were then plotted based on the change in positive or negative net assessed values in figure 5. The left-hand side panels display the predicted values for the linear model, which confirm the symmetric responses with slightly more rate offsetting for negative shocks. When analyzing the polynomial model, it is seen that there is very little rate offsetting for negative shocks up to roughly a 30% decline in the tax base, after which it increases with a steeper slope. The effect of positive shocks is much closer to the linear model outcome, with the exception of small shocks, which are not offset at all.

These results overall shed light on policy responses as a function of the intensity of the shock on the tax base. Small negative shocks (less than a 5%–7% change) are offset almost fully, while small positive shocks are not offset at all. Policymakers seek to smooth tax revenues as much as possible and potentially take advantage of less salient changes.

The Great Recession and long-differences

Next we turn to the short- and medium-run analysis of how changes in the tax base affected local tax rates and levies. The same periods as in our earlier tax base analysis were used, namely 2007–2010, 2007–2012, and 2007–2015. The results are shown in table 2.6. The first observation is that the average effect of a change of 1% in the tax base is linked to a .5% change in levy. This result, however, hides important difference between areas experiencing positive and negative shocks in their tax base. While a positive shock is strongly correlated with an increase in tax levy, a negative shock has a small and imprecise effect—for the 2007–2012 difference, $\beta_{\Delta>0} = 0.71$ and $\beta_{\Delta<0} = -0.12$.

The mill rate results show that declines in the tax base were offset by a much larger magnitude: mill rates hikes were found to offset between 70% and 80% of a decline in the tax base. On the other hand, increases in the tax base were barely offset by a lower mill rate—between 25% and 30%.

2.4.3 The role of levy and rate limits after 2007

The previous results investigated how changes in assessed values related to changes in property taxes levied and in mill rates. The majority of states however impose some

[33]Effectively, the following was estimated: $\Delta \log Levy_t = \sum_{k=1}^{4} \beta_k (\Delta \log NAV_t)^k \times (\Delta \log NAV_t > 0)^k + \sum_{j=1}^{4} \beta_j (\Delta \log NAV_t)^j \times (\Delta \log NAV_t < 0) + \varepsilon_t$.

form of property tax limits, the most common being rate limits and levy limits, followed by assessment limits. Limits can be formulated in a variety of ways, but their overall aim is to prevent sudden tax increases. The role of rate and levy limits is focused on here. Assessment limits typically restrict growth in assessed values, and since the focus was placed on the period between 2007 and 2012, they are likely to be less binding. In times of steeply declining assessed values, localities would need to increase mill rates substantially to offset the change in the tax base and maintain a constant levy. Limits on tax rates are then more likely to become binding in periods of sustained assessed value decrease and to limit the capability of localities to avoid a decrease in levy. A "rate limit" dummy variable was used that takes value 1 for localities in which any type of rate limits hold, and a "levy limit" dummy variable was used that takes value 1 whenever a locality has an aggregate levy limit. More details on the limits data are available in the appendix.

The role of rate limits and levy limits during the Great Recession was investigated by estimating the following model for $\Delta \log Levy_t$ and for $\Delta \log Mill_t$:

$$\begin{aligned}\Delta \log Y_t = \beta_1 \Delta \log NAVpos_t + \beta_2 \Delta \log NAVneg_t + \gamma_1 \Delta \log NAVpos_t \times Levy\ Limit \\ + \gamma_2 \Delta \log NAVneg_t \times Levy\ Limit + \varepsilon_t\end{aligned} \tag{2.3}$$

In table 2.7, it is seen that the presence of levy limits reduces the change in levy after a positive change in assessed values, so that in jurisdictions with levy limits, a 10% increase in assessed values is associated with an increase in levy of 6.4%, lower than localities without limits, for which it is 7%. Notably, levy limits were found to reduce the change in levy also in the case of declines in assessed values. A 10% decrease is associated with a 6% lower levy in localities without levy limit and a 3.1% decrease in localities with levy limits. Even though they are not likely to be binding when the tax base is decreasing, this observation could be explained by localities with strict levy growth limits being reluctant to allow large drops in levies. The presence of growth limits would then make the "catch up" phase in tax revenues more difficult. In column 1, it is observed that in the presence of a rate limit, a negative change in assessed values is associated with a larger decrease in tax revenue. This implies that in presence of rate limits, offsetting the change in the tax base becomes more difficult, and the levy declines more as a result. In case of a positive change in assessed values instead, the rate limit does not affect the change in levy.

The bottom panel of Table 2.7 analyzes the patterns related to changes in the mill rate. The presence of rate limits decreases the extent to which localities are able to offset the impact of a change in assessed values, in particular in the case of negative shocks. If in localities without any rate limits a 10% decrease in net assessed value is on average associated with a 7.9% increase in mill rate, the presence of limits reduced this effect to 4.4% on average. The results for aggregate levy limit are consistent with the model with levy as the dependent variable: in presence of a levy limit, localities tend to offset a negative change in assessed values more. In columns 3 and 4, the weighted results show a negative and significant coefficient associated with positive shocks and levy limit interaction. This is likely driven by few localities experiencing an increase in assessed values between 2007 and 2012, which they offset by a larger decrease in mill rates.

While table 2.7 presented results for one-year differences, Table 2.8 looks at three-, five-, and eight-year changes. It was found that in the medium run, rate limits do not have significant effects on the change in levy. Levy limits, on the other hand, have a significant impact: in column 6, localities with levy limits are associated with smaller increases in levy in response to positive changes in assessed values. Coefficients on the 3 and 5 years positive changes and levy limits instead are not significant: this is not surprising, as the majority of the sample saw a decline in the tax base between 2007–2010 and 2007–2012. In all three specifications, however, the coefficient on negative changes in tax base and levy limits is statistically significant. This implies that in the presence of a levy limit, a decrease in tax base between 2007 and 2010, 2007 and 2012, and 2007 and 2015 was associated with a small increase in levy. This is consistent with the results found in the previous table, which suggested that localities with levy limits are more likely to offset changes in the tax base. This is also visible in the bottom half of the table, which shows that localities with levy limits are associated with larger offset in mill rates in response to both negative and positive changes in assessed values. The coefficients on the presence of rate limits instead are only significant for the short term and not in the medium term. This seems to indicate that rate limits are binding in the short run, on a yearly basis, but less likely so over longer periods of time. A potential explanation is the possibility of overrides, through referendums for example, or other changes in property tax collection. In addition, localities that face stringent limits in some years may "catch up" in years when the limits are not binding.

Non-linear effects: when are rate limits effective?

To shed light on the effect of rate limits on mill rates and tax levy for a given tax base shock, the four degree polynomial version of equation 2.2 was evaluated separately for counties with and without a jurisdiction rate limit. As in the previous section, the predicted values were plotted in levy and local mill rate for a given change in the tax base in figure 6.[34]

Looking at the linear predicted values first, it was observed that counties with a jurisdiction rate limit experienced similar effects, with the magnitude of the mill response being slightly larger for both positive and negative shocks in areas without limits. Turning to the polynomial plot, a different picture emerges. For negative shocks below a 40% decline in the tax base—which is effectively more than 95% of counties for our sample—places with a rate limit offset the decline in the tax base less. For larger shocks, the reverse was found to happen. This suggests that when the negative shock is large, even counties with limit are able to raise the mill rate. For example, a large number of states with rate limits allow referendums to increase the rate beyond the maximum authorized. On the other hand, the effect of a positive shock is almost identical for areas with and without limit, an expected result when limits are least likely to be binding. To read the graph more easily, the confidence intervals for the polynomial model were not plotted. It is worth noting that intervals overlap for areas with and without a limit, implying heterogeneity in how binding limits actually are. As discussed previously, the stringency and details vary widely state to state, and some limits would be expected to be virtually never binding, while others would severely restrain the ability of policymakers to adjust tax rates.

2.4.4 Taking stock

We can now take stock of our analysis on how the decline in home prices between 2007 and 2012 affected the tax base and how policymakers responded to positive and negative shocks to provide answers to some broad questions in the literature. First, upon observing a decline in property tax revenue, we can weigh in on how much of the change can be attributed to a change in the tax base and how much can be attributed to a change in policy.[35] Second, an estimate of the short- and medium-run correlation between home prices and local property tax policy ca be provided. These questions are intimately related to the previous discussion focusing on the policy response to a change in the tax base. Here, one step is taken backward, and the findings are used to shed light on the mechanism between home prices and the outcomes of interest.

Looking at table 2.9, the first observation is that outcomes are very similar both shortly after the great recession (2007–2010) and in the medium run (2007–2015). In a nutshell,

[34]This exercise was also carried out with all rate limits. The results are qualitatively and quantitatively similar and available upon request.

[35]Where the change attributed to the tax base can be larger than 1% and the change in policy negative, effectively offsetting the negative shock.

the change in home prices had very little explanatory power on revenue per capita, with an effect close to zero ($\beta_{07-15} = -0.05$ with $s.d. = 0.10$). This result is mostly driven by negative shocks (which make up a vast majority of counties for all time periods). The few areas with positive changes in home values actually increased their revenues per capita substantially, whereby a 1% increase in the home price index was associated with an increase in levy of 1.6%. That result should however be understood with a grain of salt, as it is driven by a small number of counties. Very few places experienced positive changes in property values, and these increases were small. Perhaps jurisdictions with more stable home prices shifted to higher reliance on property taxes, especially if they faced declining revenues from other sources. These are important questions for future research.

Turning to the results on mill rate at the bottom of table 2.9, we see that negative shocks were offset by an increase in the mill rate: a 10% decline in the home price index led to a 1.2% increase between 2007 and 2010 and a 3% increase between 2007 and 2015. These numbers highlight the importance of having data on assessed values. One could wrongly conclude that policymakers only partially offset decline in home values. However, table 2.4 highlights that between 2007 and 2015 the correlation between home prices and the tax base was only 0.2 on average. This implies that the mill rate response to the change in the home price index fully offsets the decline in the tax base and more, which explains why levies have not decreased.

2.4.5 The road to recovery

Figure 7 plots the share of counties with values of HPI, NAV, levy, and mill rate higher than in 2007. It can be observed that while the property values remained lower than 2007 through 2016 for the large majority of localities, assessed values remained at 2007 values or higher in about 50% of localities. The majority of localities were able to retain levels of levy per capita to the 2007 level or higher; however, a fraction (around 30%) of localities had not recovered the same level of levy per capita in 2016. When looking at the unweighted plots in figure 8, one can notice that in localities with rate limits in the medium run, the mill rate was at the 2007 level in a lower share of localities; similarly, the levy 2007 level was recovered in a lower share of localities. Figure 9 instead analyzes the share of counties with higher outcomes compared to 2007 by levy limit sub-sample. Overall, in both weighted and unweighted plots, a lower share of counties without levy limits seemed to recover 2007-level levy than counties with levy limits. While the trajectory regarding mill rate levels is similar, this may hide heterogeneity in how much localities increase the mill rate, as the plot in figure 9 only takes into consideration whether the rate is at the level of 2007 or higher. In Table 2.7 though, it was found that localities with levy limits tend to offset changes in NAV more than localities with no levy limits. Thus, the levy limits results in figure 9 could be driven by the inframarginal effect of some localities with levy limits increasing mill rates more than localities without levy limits.

A probit model was also evaluated to study how the presence of rate limits may affect the ability of localities to recover the level of levy per capita they had in 2007 before the Great Recession. [36] The margins were plotted from the unweighted regressions in Figure 10, and it was found in Panel a that the presence of a mill rate does not have a statistically significant impact on the probability that the rate in t is greater than the 2007 rate. In Panel b, the average effect of a mill rate limit on the probability that a locality recovers the level of levy per capita available in 2007 was plotted. It was found that the effect was negative and significant for some years, with the probability that the levy per capita was recovered lower by between 14 and 19 percentage points between 2012 and 2016 for localities with rate limits. Finally, the marginal effect of changes in net assessed values on the probability that levy recovers to the 2007 levels was plotted in Panel c, and the marginal effect of changes in property values on the probability that assessed values recover the 2007 levels was plotted in Panel d.[37]. In Panel c, a one percentage point increase in NAV per capita between 2008 and 2007 increases the probability that levy per capita is higher in 2008 than in 2007 by almost three percentage points. The effect of an increase in NAV on the recovery of levy was found to remain positive and significant through 2016, albeit with a lower margin coefficient of around 0.01. In Panel d, the effect of a one percentage point increase in HPI between 2008 and 2007 on the probability that the per capita net assessed value in 2008 was higher than in 2007 is not statistically significant and close to zero. The margin coefficient was found to steadily increase between 2008 and 2011 and hovers around 0.01. Thus, for years between 2011 and 2016, a one percentage point increase in HPI is associated with a one percentage point increase in the probability that the net assessed values per capita recovered or surpassed the 2007 levels.

[36]Specifically, the following estimations were run for $t \in [2008 - 2015]$:

$$\mathbb{1}(Mill\ Rate_t > Mill\ Rate_{2007}) = \beta_1 \Delta_{t-2007} \log NAV\ per\ capita + \beta_2 Rate\ Limit + \varepsilon_t$$
$$\mathbb{1}(Levy\ per\ capita_t > Levy\ per\ capita_{2007}) = \beta_1 \Delta_{t-2007} \log NAV\ per\ capita + \beta_2 Rate\ Limit + \varepsilon_t$$
$$\mathbb{1}(Levy\ per\ capita_t > Levy\ per\ capita_{2007}) = \beta_1 \Delta_{t-2007} \log NAV\ per\ capita + \varepsilon_t$$
$$\mathbb{1}(NAV\ per\ capita_t > NAV\ per\ capita_{2007}) = \beta_1 \Delta_{t-2007} \log HPI + \varepsilon_t$$

[37]Results for Panels c and d refer to percentage point changes in NAV and HPI

2.5 Conclusion

This paper sought to shed some light on what happened to property taxes during and after the Great Recession. As home prices plummeted throughout the United States, many economists and policymakers wondered how that would impact property taxes, one of the largest sources of local revenues. Some worried that fiscal crisis would be commonplace in many areas of the country. Undoubtedly, several state and local governments faced hardships in the years following the recession, yet the most dire predictions did not materialize. Leveraging a newly collected dataset on local assessed values, property tax levies, and local tax rates between 2000 and 2016, some new answers were provided in this paper.

First, local assessed values, i.e. the tax base, was on average not affected until a few years after the initial decline in home prices. Even by 2015, a 10% decline in average home values from 2007 led to a decline in assessed values of only about 2%. One possible explanation is the difference between when values are determined for the tax base, the time they are levied and collected, as well as infrequent reassessments. Future research could shed light on other factors, such as the role of jurisdiction specific assessment rules, the role of county assessors, changes in assessment rules before and after the crisis, as well as the effect of assessment limits. Identifying what features of local property tax systems yield more or less stable assessed values would be of importance for tax policy understanding.

Second, it was shown that policymakers react strongly to changes in assessed values. Both increases and decreases in the tax base are offset by adjusting the millage rate. It was found that yearly changes in the tax rate are about symmetrical—i.e., the policy response to positive and negative shocks is similar and indicates that policymakers seek to avoid abrupt changes in local property tax revenues. However, the length and severity of the decline in property values between 2007 and 2012 implied that shortly after the recession, and up to 2015, the compounded millage offset for negative shocks was large. Between 2007 and 2015, a 10% decline in the tax base led to an increase in the mill rate of 8%, an almost complete offsetting, which contrasts with positive changes. Over the same time period, a 10% rise in the tax base led to a decline in the rate of about 3% and an increase in revenues of 7%. Again, this suggests that policymakers seek to avoid decline in tax revenues across many years but take advantage of increases in the medium run. Comparing weighted and unweighted results, qualitatively similar responses were found, but of slightly different magnitudes. While our estimates were typically estimated with high precision, this also suggests that local responses to shocks are quite heterogeneous. More research is needed to understand what drives different policy responses, such as the role of local property tax features, reliance on local taxes, or local preferences.

Third, and regarding the last point, one of the most (in)famous features of local property tax systems was analyzed: levy and rate limits. Rate limits may restrain policymakers in their ability to offset declines in the tax base, while levy limits may create incentives to avoid temporary declines in tax revenues, as limits on levies' growth would make it more difficult to make up for current losses in future periods or forbid the use of property revenues to compensate for changes in other sources of income.

It was found that areas with property tax rate limits offset yearly shocks in their tax base less, which implies a larger decline in revenue. While still having a reducing millage offsetting effect, rate limits seem to be less important in the short run. This is consistent with some areas being restrained some years, while in years where the limit is not binding, policymakers are able to "catch up.". Levy limits were found to reduce the rise in tax levy in years where the tax base increases, consistent with theoretical predictions. Levy limits also reduce the effect of negative shocks on tax revenues and are associated with higher offsetting. A potential explanation is that policymakers seek to smooth out negative shocks and avoid larger declines, which are likely to stick longer. Overall, it was shown that tax limits are associated with considerably different responses to shocks in that tax base, and we believe more research is warranted to hone down on the exact mechanism through which they work.

To summarize, the current research exploited newly collected data on assessed values and millage rates to disentangle the role of policy and the effect of the tax base when evaluating how property values affect property tax revenues. It was shown that policymakers respond to both positive and negative shocks. The combination of a stable tax base and increases in tax rates explains why property tax collections remained stable after the Great Recession. Rate limits seem to restrain millage increases following negative shocks. Both the tax base, policy responses, and the effect of limits were found display a lot of variation across jurisdictions. A lot of interesting questions remain, such as how the shock affected reliance on and local preferences toward property taxes, how shocks in other local sources of revenues shaped policy, or which specific features of tax limits were most binding post 2008.

2.6 Tables

Table 2.1: Data collected: summary

	Mill rate	Assessed values	Tax levy	Years available	Aggregated
Alabama	✓	✓	✓	2000-2017	Both
Alaska		No data			
Arizona	✓	✓	✓	1999-2017	
Arkansas	✓	✓	✓	2005-2018	Both
California	✓	✓	✓	1998-2016	
Colorado	✓	✓	✓	2001-2018	
Connecticut	✓	✓	✓	1991-2017	✓
Delaware	✓	✓	✓	1996-2015	✓
Florida	✓	✓	✓	1999-2019	Both
Georgia	✓	✓	✓	1994-2019	
Hawaii		No data			
Idaho	✓			2001-2017	
Illinois	✓	✓	✓	1990-2018	
Indiana	✓			1998-2016	✓
Iowa	✓	✓	✓	1999-2016	Both
Kansas	✓	✓	✓	1987-2018	
Kentucky	✓	✓		1999-2018	✓
Louisiana	✓	✓	✓	2002-2017	
Maine	✓	✓	✓	2001-2016	
Maryland	✓			2002-2016	✓
Massachusetts	✓	✓	✓	1981-2017	
Michigan	✓	✓	✓	2004-2016	
Minnesota	✓	✓	✓	2000-2017	
Mississippi	✓	✓	✓**	1995-2019	
Missouri	✓	✓	✓	2000-2019	Both
Montana	✓	✓	✓	1998-2015	
Nebraska	✓	✓	✓	1997-2020	
Nevada	✓	✓	✓	2000-2017	
New Hampshire	✓	✓	✓	2001-2017	Both
New Jersey	✓	✓	✓	1997-2017	✓
New Mexico	✓	✓	✓	2003-2020	
New York	✓	✓	✓	2002-2018	Both
North Carolina	✓			1991-2017	✓
North Dakota	✓	✓	✓	1997-2017	
Ohio	✓	✓	✓	1990-2019	
Oklahoma		No data			
Oregon	✓	✓	✓	2001-2016	
Pennsylvania	✓			1988-2018	✓
Rhode Island	✓			2000-2017	✓
South Carolina		No data			
South Dakota		No data			
Tennessee	✓	✓	✓	2000-2017	
Texas	✓	✓	✓	1999-2017	
Utah	✓	✓	✓	2000-2019	
Vermont	✓	✓	✓	2004-2016*	Both
Virginia	✓	✓	✓	1991-2017	✓
Washington	✓	✓	✓	2001-2019	
West Virginia	✓			2003-2017	✓
Wisconsin	✓	✓	✓	1989-2018	
Wyoming	✓	✓	✓	1998-2016	✓

Our baseline mill rate is computed as the total tax levy divided by the taxable assessed value $\times$ 1000. The column Aggregated indicates whether the data was collected at the county level or for at the taxing district level, and then aggregated for all counties.

Table 2.2: Summary Statistics: %Δ by periods: HPI, tax levy, assessed values, mill rate

Yearly statistics						
Δ Yearly - 2000-2016	Mean	Median	p25	p75	sd	count
%Δ HPI	0.47	0.39	-2.43	3.13	5.45	29,247
%Δ NAV per capita	1.60	0.33	-1.98	3.74	7.83	38,385
%Δ Property tax levy per capita	2.28	1.50	-1.08	4.80	8.20	38,385
%Δ Mill rate	0.92	0.22	-1.45	3.04	8.22	38,385
Δ Yearly - 2000-2007	Mean	p50	p25	p75	sd	count
%Δ HPI	2.77	1.88	-0.02	4.58	4.86	12,414
%Δ NAV per capita	2.73	1.27	-1.47	5.08	7.97	16,405
%Δ Property tax levy per capita	3.08	2.45	-0.37	5.65	7.45	16,405
%Δ Mill rate	0.75	0.24	-1.82	3.30	7.73	16,405
Δ Yearly - 2008-2015	Mean	p50	p25	p75	sd	count
%Δ HPI	-1.99	-1.89	-4.59	0.73	5.11	13,927
%Δ NAV per capita	0.81	-0.28	-2.43	2.83	8.02	18,137
%Δ Property tax levy per capita	1.91	0.94	-1.50	4.24	8.85	18,137
%Δ Mill rate	1.21	0.28	-1.12	3.05	8.78	18,137

Long differences						
$\Delta 2007-2010$	Mean	p50	p25	p75	sd	count
%Δ HPI	-11.74	-9.49	-16.60	-4.59	10.72	1,776
%Δ NAV per capita	3.98	1.64	-5.09	10.67	16.85	2,230
%Δ Property tax levy per capita	6.47	5.68	-0.53	12.37	13.22	2,230
%Δ Mill rate	3.19	1.60	-2.35	8.49	11.91	2,230
$\Delta 2007-2012$	Mean	p50	p25	p75	sd	count
%Δ HPI	-17.95	-16.29	-25.78	-8.97	13.41	1,768
%Δ NAV per capita	3.53	0.35	-9.53	12.59	21.86	2,243
%Δ Property tax levy per capita	8.81	6.99	-1.47	16.89	18.14	2,243
%Δ Mill rate	6.60	3.43	-2.25	13.76	16.39	2,243
$\Delta 2007-2015$	Mean	p50	p25	p75	sd	count
%Δ HPI	-14.89	-15.93	-23.84	-7.36	13.46	1,767
%Δ NAV per capita	8.95	1.44	-12.26	17.35	36.83	2,182
%Δ Property tax levy per capita	14.45	10.33	-1.40	24.84	26.22	2,182
%Δ Mill rate	8.26	4.96	-2.05	17.95	22.38	2,182

HPI denotes the home price index and is provided by the Federal Housing Finance Agency. NAV refers to Net Assessed Value and represents the tax base on which is levied ad valorem property taxes. Lvy per capita is the total ad valorem property tax revenue from all jurisdictions at the county level. Mill rate is the millage rate, defined as the tax levy divided by the tax base.

Table 2.3: The tax base: Home price index and assessed values 2000-2016

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dep. variable	***Log NAV***$_t$		Δ ***Log NAV***$_t$						
	All years		All years					$y < 2008$	≥ 2008
$\log HPI_t$	0.10^c	0.17^c							
	(0.00)	(0.00)							
$\Delta \log HPI_t$			0.28^c	0.10^c	0.02	0.10^c		0.11^c	0.06^c
			(0.01)	(0.01)	(0.02)	(0.01)		(0.02)	(0.01)
$\Delta \log HPI_{t-1}$				0.21^c	0.24^c	0.21^c		0.30^c	0.13^c
				(0.01)	(0.03)	(0.01)		(0.02)	(0.01)
$\Delta \log HPI_{t-2}$				0.18^c	0.21^c	0.18^c		0.27^c	0.16^c
				(0.01)	(0.04)	(0.01)		(0.02)	(0.02)
$\Delta \log HPI_{t-3}$				0.13^c	0.13^c	0.11^c		0.22^c	0.09^c
				(0.01)	(0.02)	(0.01)		(0.02)	(0.01)
$\Delta \log Zillow_t$							0.08^c		
							(0.01)		
$\Delta \log Zillow_{t-1}$							0.19^c		
							(0.02)		
$\Delta \log Zillow_{t-2}$							0.12^c		
							(0.02)		
$\Delta \log Zillow_{t-3}$							0.14^c		
							(0.02)		
County FE		✓							
Pop. Weighted					✓				
Controls						✓			
Sample	All	All	All	All	All	Balanced	All	All	All
R^2	0.05	0.08	0.05	0.14	0.34	0.18	0.15	0.23	0.08
Observations	29,735	29,735	29,730	29,352	29,352	27,641	21,611	12,584	16,768

Standard errors are clustered at the county level to take into account county level policy and serial correlation. All variables are adjusted for inflation using the GDP deflator and using 2000 as the reference year. HPI denotes the home price index and is provided by the Federal Housing Finance Agency. NAV refers to Net Assessed Value and represents the tax base on which is levied ad valorem property taxes. Zillow referes to the median typical home sold. Weights are based on the average national share in the county population between 2000 and 2010. Demographic controls include the share of white, black, college-educated, and urban residents, as well as the share of 20-29, 30-39, 40-49, and 50-59 years old in a county. Income controls include the county log personal income per capita, log employment, log wage income, and unemployment rate. Fraction includes the share of county revenues from own source, from property taxes, from other taxes, and from transfers. The balanced sample refers to counties which are observed every single year between 2000 and 2016.

Table 2.4: The tax base: long differences

Unweighted results

Dep. var: Δ ***Log NAV***$_t$	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta \log HPI$	0.03		0.18^b		0.22^b	
	(0.10)		(0.07)		(0.09)	
$\Delta \log HPI > 0$		0.02		0.16		0.42
		(0.42)		(0.21)		(0.58)
$\lvert\Delta \log HPI < 0\rvert$		-0.03		-0.18^b		-0.21^b
		(0.11)		(0.07)		(0.09)
R^2	0.00	0.00	0.07	0.07	0.04	0.05
Observations	1,839	1,839	1,825	1,825	1,826	1,826

Weighted results

Dep. var: Δ ***Log NAV***$_t$	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta \log HPI$	0.17		0.36^c		0.44^c	
	(0.14)		(0.12)		(0.15)	
$\Delta \log HPI > 0$		-0.07		-0.11		-1.47^b
		(0.58)		(0.31)		(0.59)
$\lvert\Delta \log HPI < 0\rvert$		-0.17		-0.36^c		-0.48^c
		(0.14)		(0.12)		(0.15)
R^2	0.13	0.13	0.41	0.41	0.27	0.36
Observations	1,839	1,839	1,825	1,825	1,826	1,826

Standard errors are clustered at the county level to take into account county level policy and serial correlation. All variables are adjusted for inflation using the GDP deflator and using 2000 as the reference year. Assessed values are computed per capita. HPI denotes the home price index and is provided by the Federal Housing Finance Agency. NAV refers to Net Assessed Value and represents the tax base on which is levied ad valorem property taxes. Weights are based on the average national share in the county population between 2000 and 2010.

Table 2.5: The policy effect: the tax base and property tax revenues

Dep. var: Δ ***Log levy per cap***	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Years	2000-2016				$y < 2008$	≥ 2008	All - IV
$\Delta \log NAV_t$	0.52^c						0.56^c
	(0.01)						(0.03)
Δ log $NAV_t > 0$		0.56^c	0.43^c	0.56^c	0.53^c	0.59^c	
		(0.01)	(0.01)	(0.03)	(0.02)	(0.02)	
$\lvert\Delta$ log $NAV_t < 0\rvert$		-0.40^c	-0.56^c	-0.36^c	-0.20^c	-0.47^c	
		(0.02)	(0.02)	(0.06)	(0.04)	(0.02)	
Dem controls			✓	✓			
Income controls			✓	✓			
Local finance controls			✓	✓			
Pop. Weighted				✓			
R^2	0.25	0.25	0.29	0.34	0.26	0.26	
Observations	36,598	36,598	36,583	36,583	16,395	20,203	27,920

Dep. var: Δ ***Log mill rate***	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Years	2000-2016				$y < 2008$	≥ 2008	All - IV
$\Delta \log NAV_t$	-0.43^c						-0.44^c
	(0.01)						(0.03)
$\Delta \log NAV_t > 0$		-0.40^c	-0.53^c	-0.42^c	-0.44^c	-0.37^c	
		(0.01)	(0.01)	(0.03)	(0.01)	(0.02)	
$\lvert\Delta \log NAV_t < 0\rvert$		0.51^c	0.35^c	0.62^c	0.78^c	0.41^c	
		(0.02)	(0.02)	(0.06)	(0.04)	(0.02)	
Dem controls			✓	✓			
Income controls			✓	✓			
Local finance controls			✓	✓			
Pop. Weighted				✓			
R^2	0.18	0.18	0.22	0.34	0.25	0.14	
Observations	36,598	36,598	36,583	36,583	16,395	20,203	27,920

Standard errors are clustered at the county level to take into account county level policy and serial correlation. All variables except for the mill rate are adjusted for inflation using the GDP deflator and using 2000 as the reference year. HPI denotes the home price index and is provided by the Federal Housing Finance Agency. NAV refers to Net Assessed Value and represents the tax base on which is levied ad valorem property taxes. Log levy per capita ita is the total ad valorem property tax revenue from all jurisdictions at the county level. Log mill rate is the log of the millage rate, defined as the tax levy divided by the tax base. Weights are based on the average national share in the county population between 2000 and 2010. Demographic controls include the share of white, black, college-educated, and urban residents, as well as the share of 20-29, 30-39, 40-49, and 50-59 years old in a county. Income controls include the county log personal income per capita, log employment, log wage income, and unemployment rate. Fraction includes the share of county revenues from own source, from property taxes, from other taxes, and from transfers.

Table 2.6: The Great Recession: disentangling the tax base and policy effect

Dep. var: Δ ***Log levy per capita***	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta \log NAV$	0.47^c		0.47^c		0.52^c	
	(0.08)		(0.10)		(0.10)	
$\Delta \log NAV > 0$		0.60^c		0.71^c		0.68^c
		(0.08)		(0.09)		(0.09)
$\lvert\Delta \log NAV < 0\rvert$		-0.14		-0.12		-0.11
		(0.20)		(0.17)		(0.24)
R^2	0.28	0.34	0.27	0.37	0.31	0.39
Observations	2,176	2,176	2,205	2,205	2,161	2,161

Dep. var: Δ ***Log mill rate***	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta \log NAV$	-0.43^c		-0.47^c		-0.44^c	
	(0.08)		(0.09)		(0.09)	
$\Delta \log NAV > 0$		-0.32^c		-0.24^c		-0.29^c
		(0.06)		(0.05)		(0.07)
$\lvert\Delta \log NAV < 0\rvert$		0.68^c		0.82^c		0.82^c
		(0.23)		(0.18)		(0.25)
R^2	0.22	0.25	0.27	0.37	0.26	0.34
Observations	2,175	2,175	2,204	2,204	2,160	2,160

Standard errors are clustered at the county level to take into account county level policy and serial correlation. All variables except for the mill rate are adjusted for inflation using the GDP deflator and using 2000 as the reference year. HPI denotes the home price index and is provided by the Federal Housing Finance Agency. NAV refers to Net Assessed Value and represents the tax base on which is levied ad valorem property taxes. Log levy per capita ita is the total ad valorem property tax revenue from all jurisdictions at the county level. Log mill rate is the log of the millage rate, defined as the tax levy divided by the tax base. Weights are based on the average national share in the county population between 2000 and 2010.

Table 2.7: The Great Recession: The role of rate and levy limits 2007-2012 (any rate limit - aggregate levy limit)

Dep. var: Δ ***Log levy per capita***	(1)	(2)	(3)	(4)
Years	Yearly Δ for years 2007-2012			
$\Delta \log NAV_t > 0$	0.65^c	0.70^c	0.50^c	0.80^c
	(0.02)	(0.02)	(0.05)	(0.07)
$\lvert\Delta \log NAV_t < 0\rvert$	-0.20^c	-0.60^c	-0.16^c	-0.72^c
	(0.03)	(0.02)	(0.04)	(0.03)
$\Delta \log NAV_t > 0 \times rate\ limit$	0.00		0.10	
	(0.03)		(0.07)	
$\lvert\Delta \log NAV_t < 0\rvert \times rate\ limit$	-0.31^c		-0.33^c	
	(0.03)		(0.06)	
$\Delta \log NAV_t > 0 \times agg.\ levy\ limit$		-0.06^b		-0.36^c
		(0.03)		(0.07)
$\lvert\Delta \log NAV_t < 0\rvert \times agg.\ levy\ limit$		0.29^c		0.48^c
		(0.03)		(0.05)
Pop. Weighted			✓	✓
R^2	0.38	0.38	0.40	0.46
Observations	12,877	12,877	12,877	12,877

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Table 2.7 – *Continued from previous page*

Dep. var: Δ ***Log mill rate***	(1)	(2)	(3)	(4)
Years	Yearly Δ for years 2007-2012			
$\Delta \log NAV_t > 0$	-0.33^c	-0.30^c	-0.49^c	-0.20^c
	(0.02)	(0.02)	(0.05)	(0.07)
$\|\Delta \log NAV_t < 0\|$	0.79^c	0.37^c	0.83^c	0.24^c
	(0.03)	(0.02)	(0.04)	(0.03)
$\Delta \log NAV_t > 0 \times rate\ limit$	0.06^b		0.14^b	
	(0.03)		(0.07)	
$\|\Delta \log NAV_t < 0\| \times rate\ limit$	-0.35^c		-0.35^c	
	(0.03)		(0.07)	
$\Delta \log NAV_t > 0 \times agg.\ levy\ limit$		0.02		-0.29^c
		(0.02)		(0.07)
$\|\Delta \log NAV_t < 0\| \times agg.\ levy\ limit$		0.27^c		0.53^c
		(0.03)		(0.05)
Pop. Weighted			✓	✓
R^2	0.20	0.20	0.34	0.41
Observations	12,877	12,877	12,877	12,877

Standard errors are clustered at the county level to take into account county level policy and serial correlation. All variables except for the mill rate are adjusted for inflation using the GDP deflator and using 2000 as the reference year. HPI denotes the home price index and is provided by the Federal Housing Finance Agency. NAV refers to Net Assessed Value and represents the tax base on which is levied ad valorem property taxes. Log levy per capita ita is the total ad valorem property tax revenue from all jurisdictions at the county level. Log mill rate is the log of the millage rate, defined as the tax levy divided by the tax base. Weights are based on the average national share in the county population between 2000 and 2010. Rate limit equals 1 when a state has some type of rate limit as defined in the text and table B.2 in the appendix. Aggregate levy limit equals 1 when a state has a levy limit on the change in total revenues for counties, cities and other jurisdictions such as school districts.

Table 2.8: The Great Recession: the role of limits - long differences

Dep. var: Δ ***Log levy per capita***	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta \log NAV > 0$	0.55[c]	0.61[c]	0.72[c]	0.71[c]	0.72[c]	0.94[c]
	(0.07)	(0.10)	(0.10)	(0.11)	(0.18)	(0.05)
$\lvert\Delta \log NAV < 0\rvert$	-0.16[a]	-0.57[c]	0.01	-0.51[c]	0.23[c]	-0.63[c]
	(0.09)	(0.06)	(0.07)	(0.14)	(0.07)	(0.08)
$\Delta \log NAV > 0 \times rate\ lim$	0.09		-0.02		-0.06	
	(0.13)		(0.16)		(0.21)	
$\lvert\Delta \log NAV < 0\rvert \times rate\ lim$	0.03		-0.16		-0.39	
	(0.27)		(0.24)		(0.28)	
$\Delta \log NAV > 0 \times agg\ levy\ lim$		-0.01		-0.01		-0.28[c]
		(0.14)		(0.15)		(0.10)
$\lvert\Delta \log NAV < 0\rvert \times agg\ levy\ lim$		0.81[c]		0.67[c]		0.89[c]
		(0.22)		(0.23)		(0.22)
r2	0.34	0.40	0.37	0.42	0.40	0.46
N	2,176	2,176	2,205	2,205	2,161	2,161

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Table 2.8 – *Continued from previous page*

Dep. var: Δ ***Log mill rate***	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta \log NAV > 0$	-0.47^c	-0.40^c	-0.28^b	-0.28^b	-0.27	-0.06
	(0.07)	(0.10)	(0.10)	(0.11)	(0.19)	(0.05)
$\|\Delta \log NAV < 0\|$	0.79^c	0.35^c	0.99^c	0.46^c	1.16^c	0.32^c
	(0.06)	(0.10)	(0.07)	(0.16)	(0.08)	(0.10)
$\Delta \log NAV > 0 \times rate\ lim$	0.23^b		0.06		-0.02	
	(0.10)		(0.12)		(0.20)	
$\|\Delta \log NAV < 0\| \times rate\ lim$	-0.13		-0.21		-0.39	
	(0.30)		(0.25)		(0.30)	
$\Delta \log NAV > 0 \times agg\ levy\ lim$		0.11		0.06		-0.24^b
		(0.12)		(0.12)		(0.09)
$\|\Delta \log NAV < 0\| \times agg\ levy\ lim$		0.62^a		0.64^b		0.85^c
		(0.35)		(0.25)		(0.26)
r2	0.26	0.29	0.38	0.42	0.34	0.41
N	2,175	2,175	2,204	2,204	2,160	2,160

Standard errors are clustered at the county level to take into account county level policy and serial correlation. All variables except for the mill rate are adjusted for inflation using the GDP deflator and using 2000 as the reference year. HPI denotes the home price index and is provided by the Federal Housing Finance Agency. NAV refers to Net Assessed Value and represents the tax base on which is levied ad valorem property taxes. Log levy per capita ita is the total ad valorem property tax revenue from all jurisdictions at the county level. Log mill rate is the log of the millage rate, defined as the tax levy divided by the tax base. Weights are based on the average national share in the county population between 2000 and 2010. Rate limit equals 1 when a state has some type of rate limit as defined in the text and table B.2 in the appendix. Aggregate levy limit equals 1 when a state has a levy limit on the change in total revenues for counties, cities and other jurisdictions such as school districts.

Table 2.9: Tax base versus policy effect: taking stock

Dep. var: Δ ***Log levy per capita***	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta \log HPI$	-0.12		-0.05		-0.05	
	(0.07)		(0.06)		(0.10)	
$\Delta \log\ HPI > 0$		1.25^c		1.24^c		1.59^c
		(0.28)		(0.43)		(0.22)
$\lvert\Delta \log\ HPI < 0\rvert$		0.12		0.06		0.10
		(0.07)		(0.06)		(0.11)
R^2	0.04	0.07	0.01	0.04	0.00	0.12
Observations	1,686	1,686	1,713	1,713	1,686	1,686

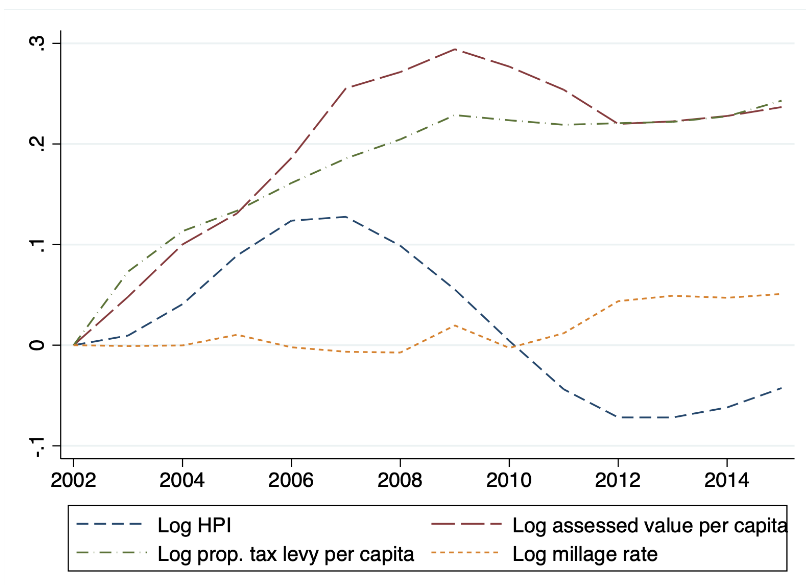
Dep. var: Δ ***Log mill rate***	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta\ \log\ HPI$	-0.11^b		-0.21^c		-0.29^c	
	(0.04)		(0.05)		(0.06)	
$\Delta \log HPI > 0$		0.13		0.00		0.11
		(0.97)		(0.76)		(1.05)
$\lvert\Delta \log HPI < 0\rvert$		0.12^b		0.22^c		0.31^c
		(0.05)		(0.05)		(0.06)
R^2	0.03	0.04	0.14	0.14	0.12	0.12
Observations	1,685	1,685	1,712	1,712	1,685	1,685

Standard errors are clustered at the county level to take into account county level policy and serial correlation. All variables except for the mill rate are adjusted for inflation using the GDP deflator and using 2000 as the reference year. HPI denotes the home price index and is provided by the Federal Housing Finance Agency. NAV refers to Net Assessed Value and represents the tax base on which is levied ad valorem property taxes. Log levy per capita ita is the total ad valorem property tax revenue from all jurisdictions at the county level. Log mill rate is the log of the millage rate, defined as the tax levy divided by the tax base. Weights are based on the average national share in the county population between 2000 and 2010.

2.7 Figures

Figure 2.1: Changes in HPI, Assessed values, property tax levy and mill rate

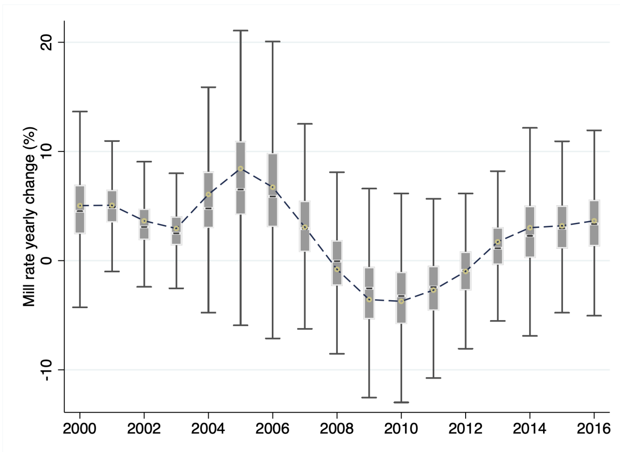
(a) U.S. average change 2000-2015 - full sample



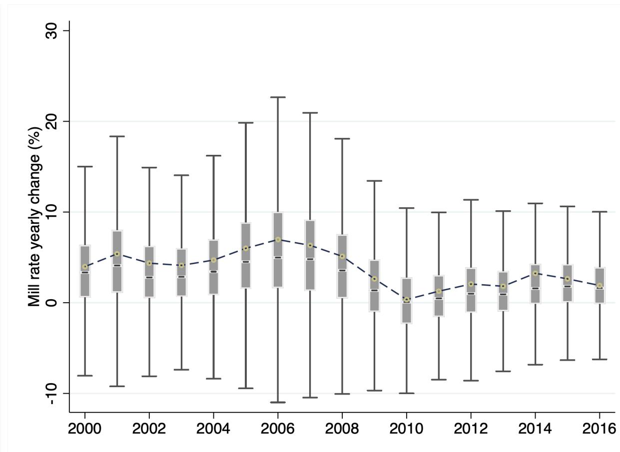
(b) U.S. average change 2000-2015 - areas with HPI available

Top figure plots the county unweighted US average change in the four denominated variables starting in year 2002. The bottom figures plots the unweighted US average change of the four denominated variables only using counties for which the home price index is available.

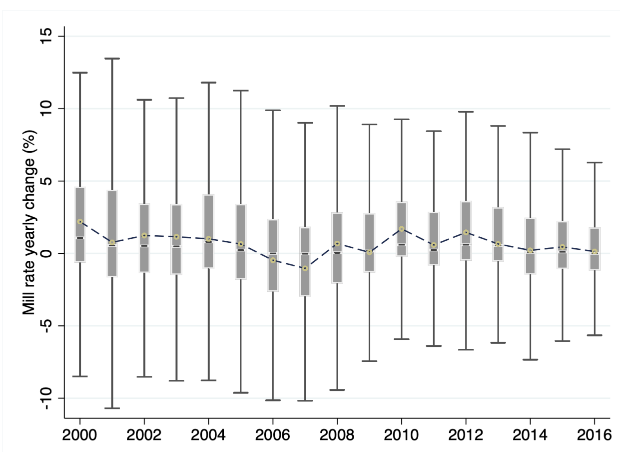
Figure 2.2: Median and inter-quartile range of yearly changes 2000-2016



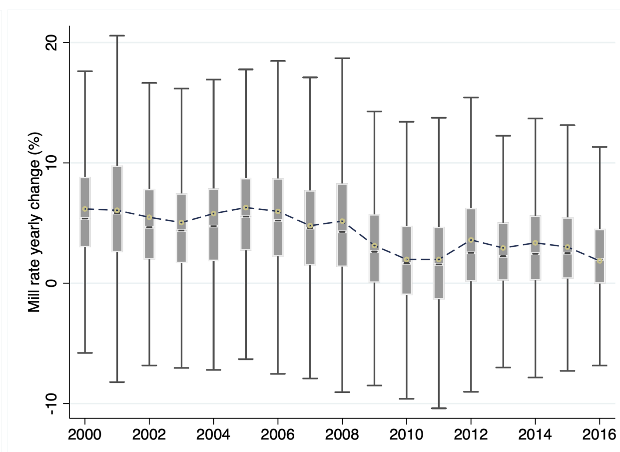
(a) % Change in housing prices



(b) % Change in assessed value



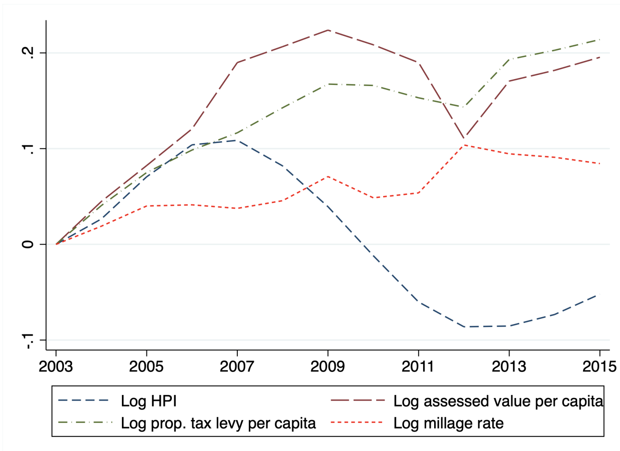
(c) % Change in mill rate



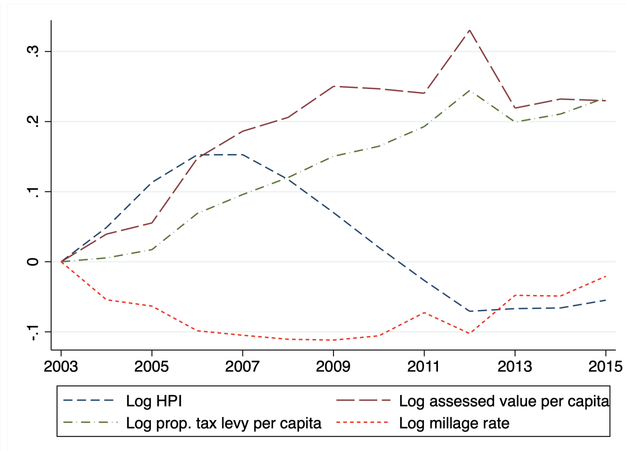
(d) % Change in property tax levy

Our baseline mill rate is computed as the total tax levy divided by the taxable assessed value $\times$ 1000. The column ”Mill avg.” indicates whether the mill rate was computed by finding an average of the mill rate for multiple jurisdictions in the county. When both are available, we use the baseline mill rate. The column Aggregated indicates whether the data was collected at the county level or for at the taxing district level, and then aggregated for all counties.

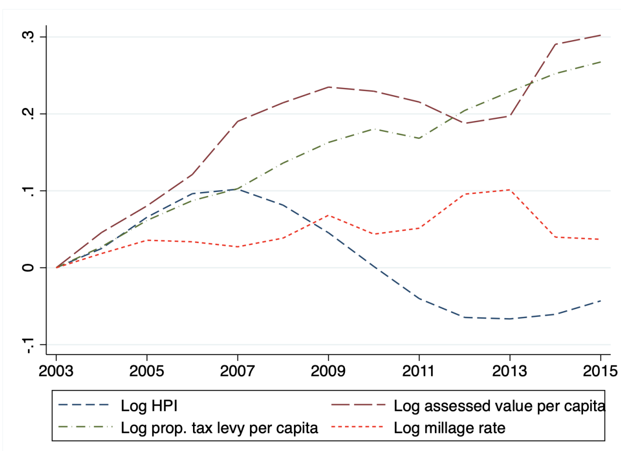
Figure 2.3: Changes in HPI, Assessed values, property tax levy and mill rate - subsamples



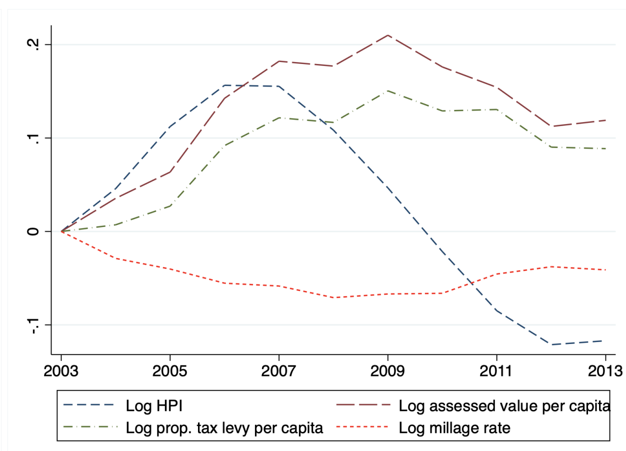
(a) Counties with some rate limits



(b) Counties without some rate limits



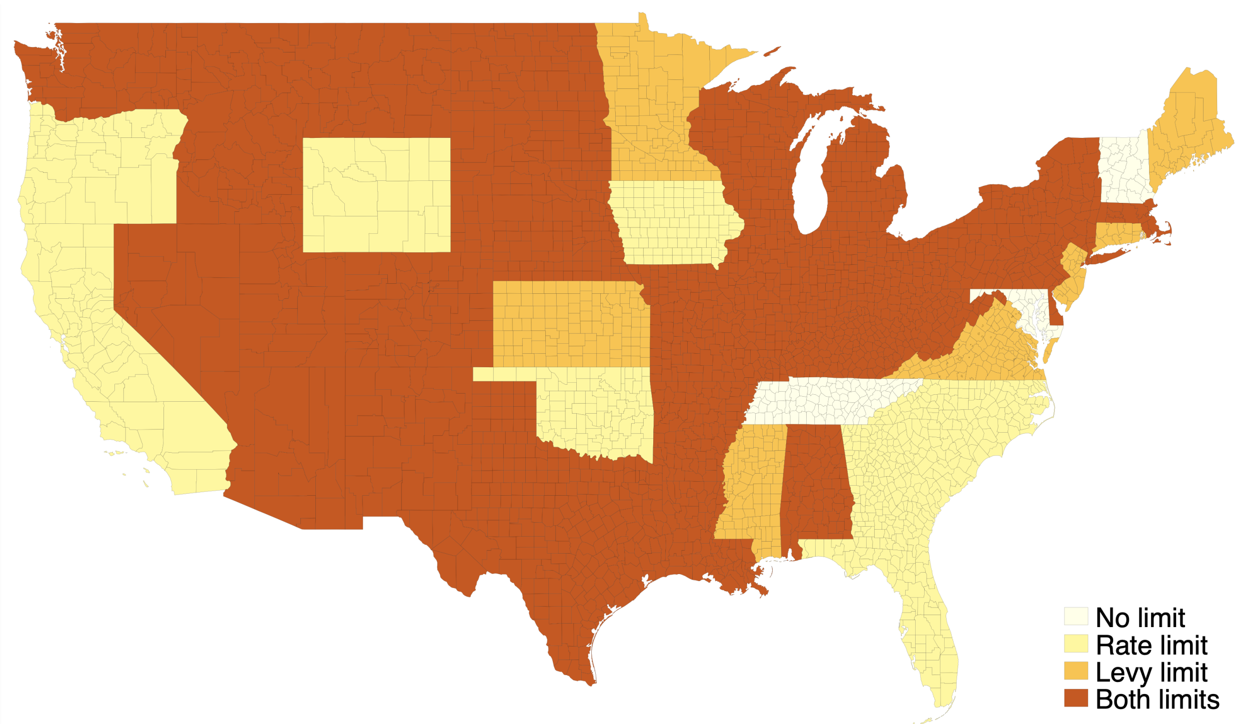
(c) Counties with some levy limits



(d) Counties without some levy limits

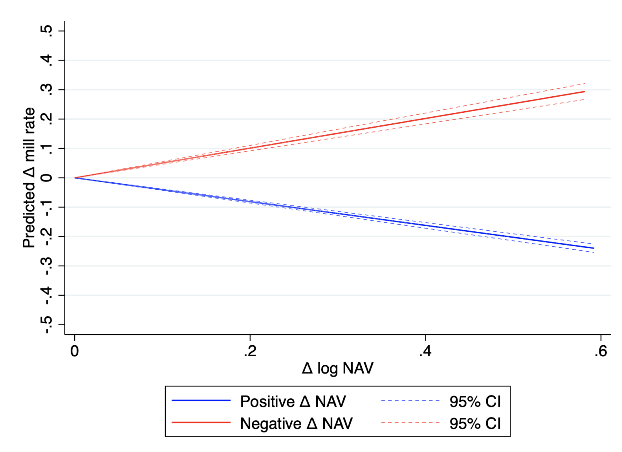
This top figure plots the county unweighted US average change in the four denominated variables starting in year 2003, by whether counties are in a state with or without any rate limit, or with/without any aggregate levy limit. Refer to tables and text for exact definition of rate and aggregate levy limits.

Figure 2.4: States with aggregate levy limit, and jurisdiction rate limit

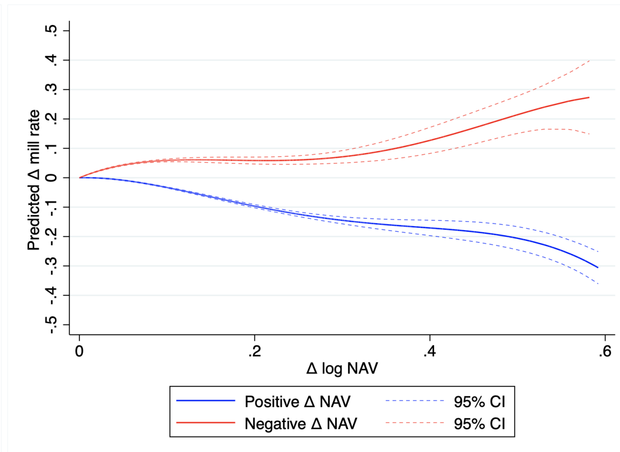


The map depicts which states have some rate limit, some levy limit or both. A rate limit here is defined as either limitation on the maximum rate applied to specific property as a percentage of market or assessed value, or limits on the mill rate chosen by local jurisdictions.

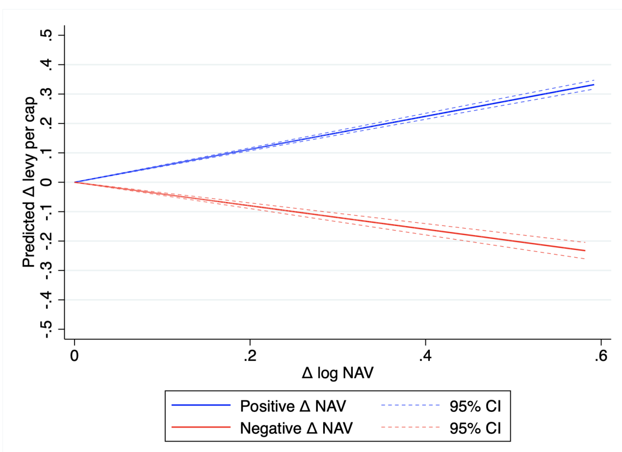
Figure 2.5: Testing for non linear effects - Full sample



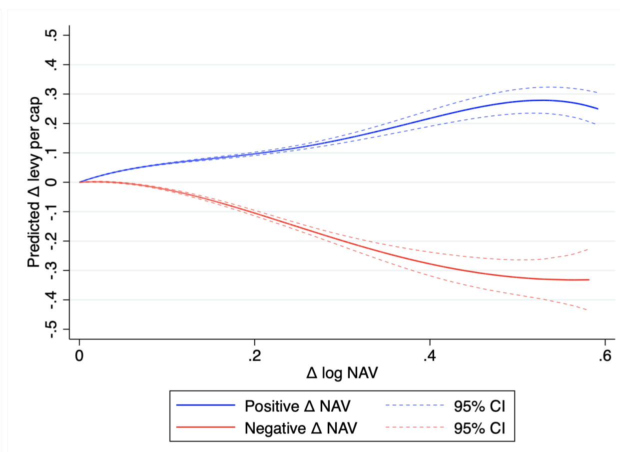
(a) Log mill rate - Linear model



(b) Log mill rate - Polynomial 4 model



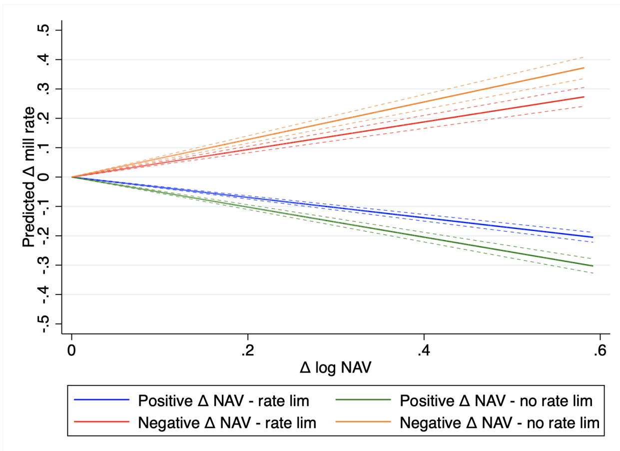
(c) Log levy per capita ita - Linear model



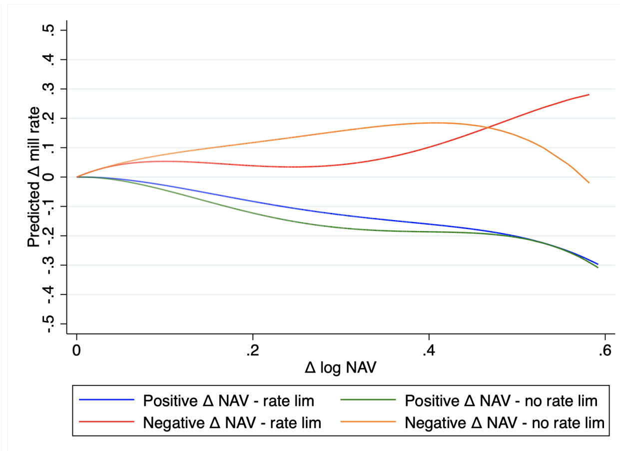
(d) Log levy per capita ita - Polynomial 4 model

These figures plot the predicted value from the linear and four polynomial regression of the change in levy on assessed value: $\Delta \log Levy_t = \sum_{k=1}^{4} \beta_k (\Delta \log NAV_t)^k \times (\Delta \log NAV_t > 0)^k + \sum_{j=1}^{4} \beta_j (\Delta \log NAV_t)^j \times (\Delta \log NAV_t < 0) + \varepsilon_t$. The top figures look at change in mill rate as the outcome, while the bottom figures look at the change in levy per capital.

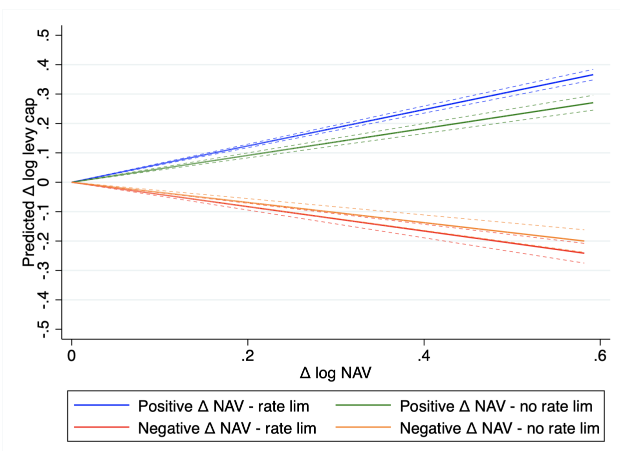
Figure 2.6: Testing for non linear effects - By rate limit



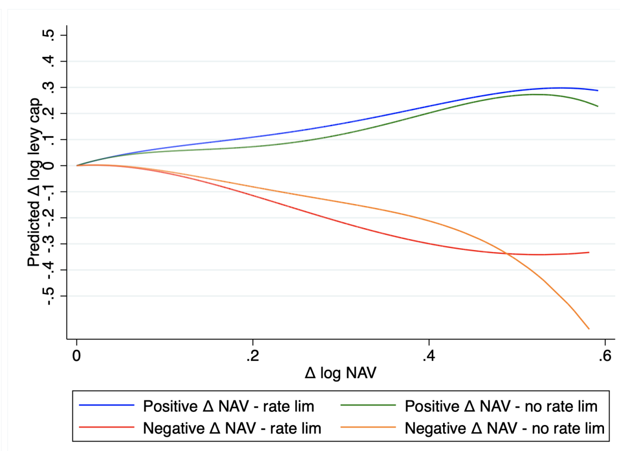
(a) Log mill - Lin. model by rate limit



(b) Log mill - Poly 4 model by rate limit



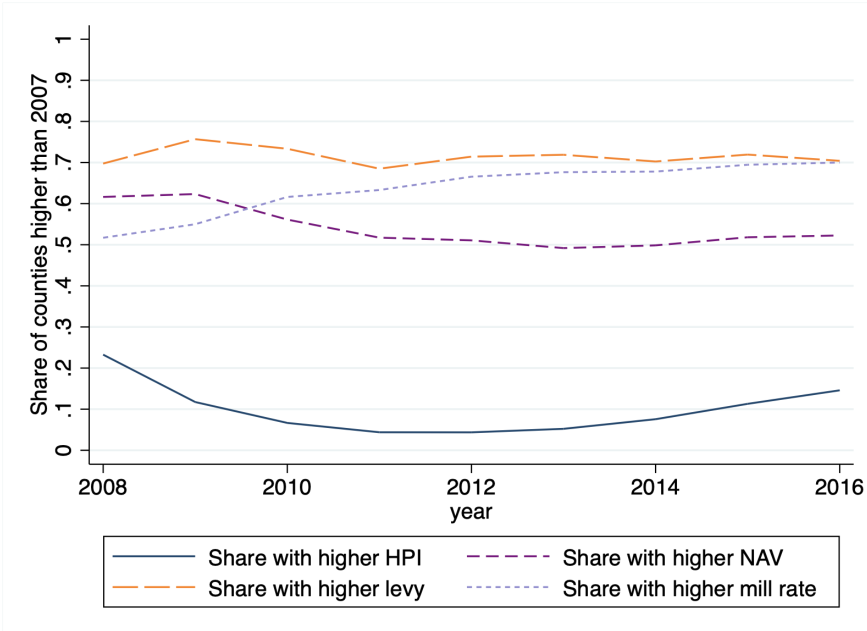
(c) Log levy per capita - Lin. model by rate limit



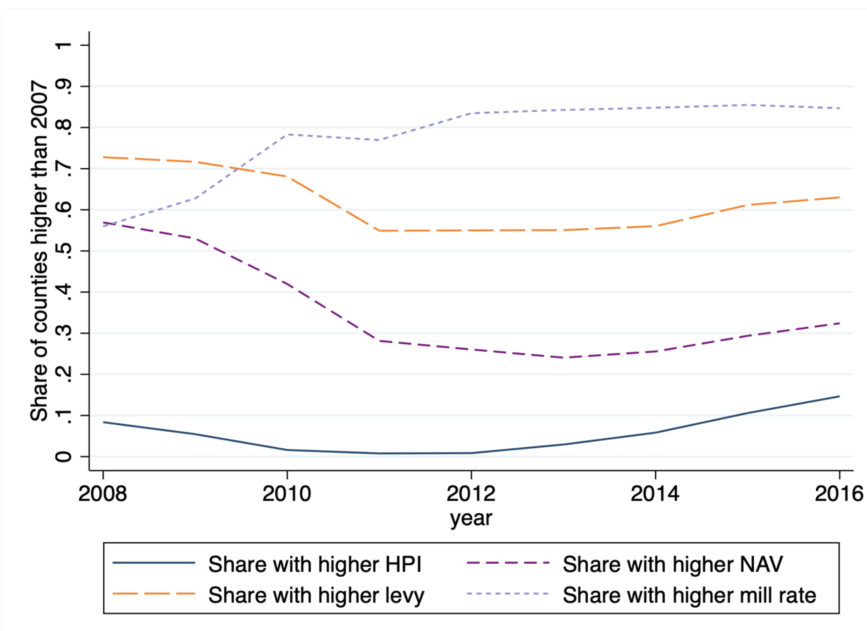
(d) Log levy per capita - Poly 4 model by rate limit

These figures plot the predicted value from the linear and four polynomial regression of the change in levy on assessed value: $\Delta \log Levy_t = \sum_{k=1}^{4} \beta_k (\Delta \log NAV_t)^k \times (\Delta \log NAV_t > 0)^k + \sum_{j=1}^{4} \beta_j (\Delta \log NAV_t)^j \times (\Delta \log NAV_t < 0) + \varepsilon_t$. The top figures look at change in mill rate as the outcome, while the bottom figures look at the change in levy per capital.

Figure 2.7: Recovery: share of counties with higher values compared to 2007



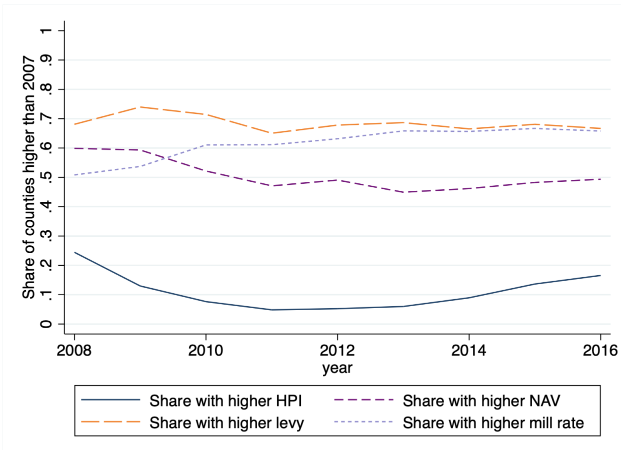
(a) U.S. unweighted average change



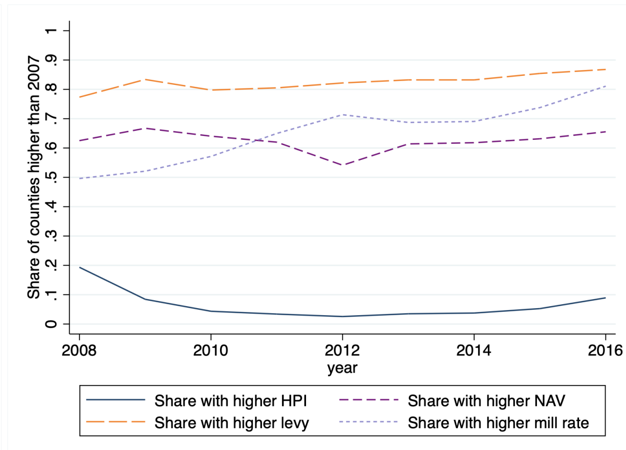
(b) U.S. population unweighted average change

These figures plot fraction of counties with higher HPI, NAV, levy, and mill rate, compared to 2007. The bottom panel weighs results by average county population in our sample period. All values are calculated per capita and adjusted for inflation.

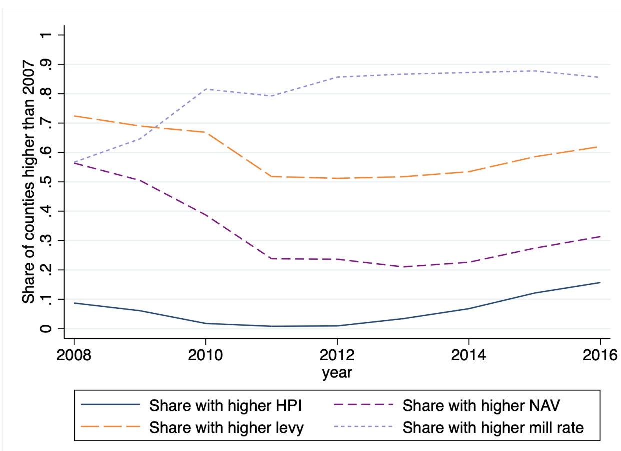
Figure 2.8: Share of counties with higher outcomes compared to 2007 - by jurisdiction rate limit



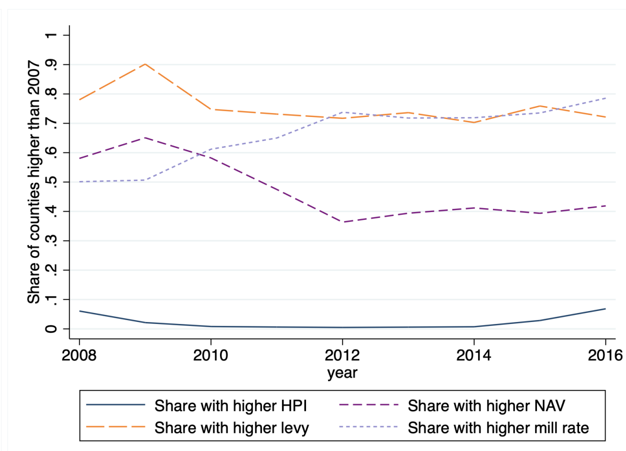
(a) Counties w/ some rate limit - Unweighted



(b) Counties w/o some rate limit - Unweighted



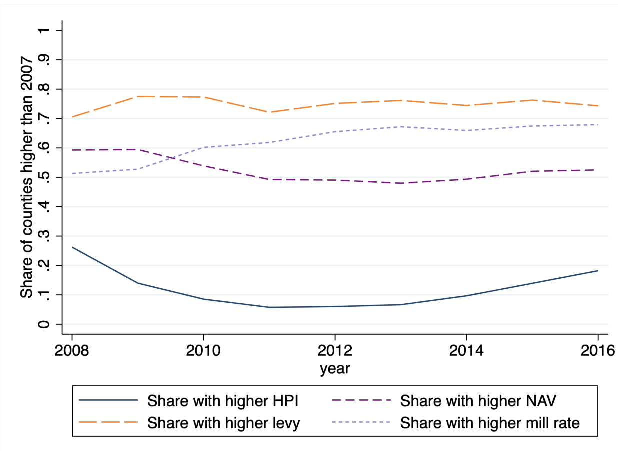
(c) Counties w/ some rate limit - Pop Weighted



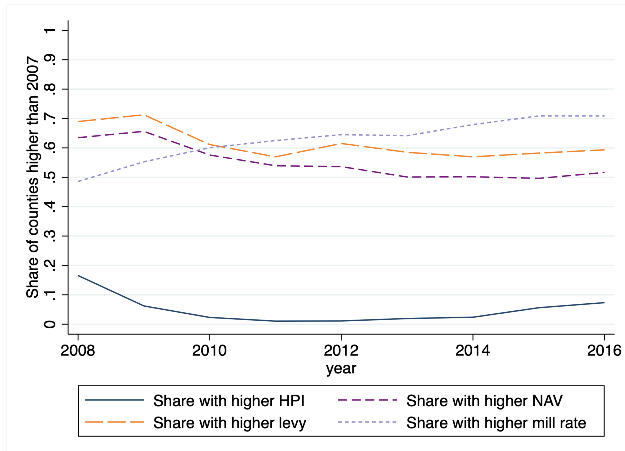
(d) Counties w/o some rate limit - Pop Weighted

These figures plot fraction of counties with higher HPI, NAV, levy, and mill rate, compared to 2007 in states with and without some rate limit in the top panel. The bottom panel weighs results by average county population in our sample period. All values are calculated per capita and adjusted for inflation.

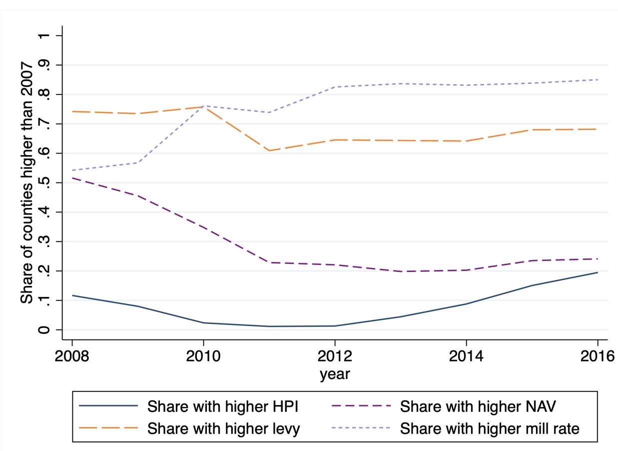
Figure 2.9: Share of counties with higher outcomes compared to 2007 - by levy limit



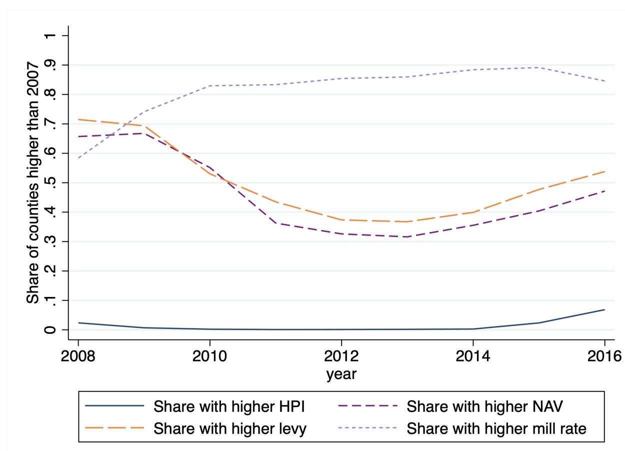
(a) Counties w/ some levy limit - Unweighted



(b) Counties w/o some levy limit - Unweighted



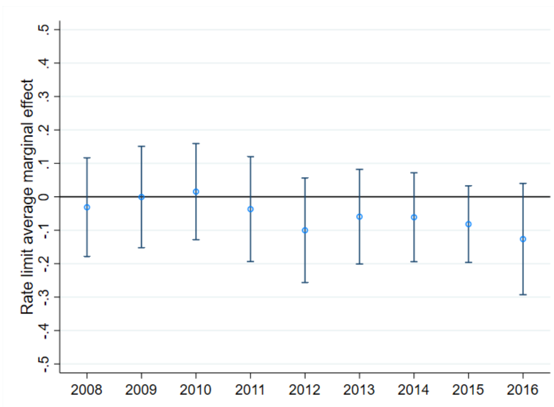
(c) Counties w/ some levy limit - Pop Weighted



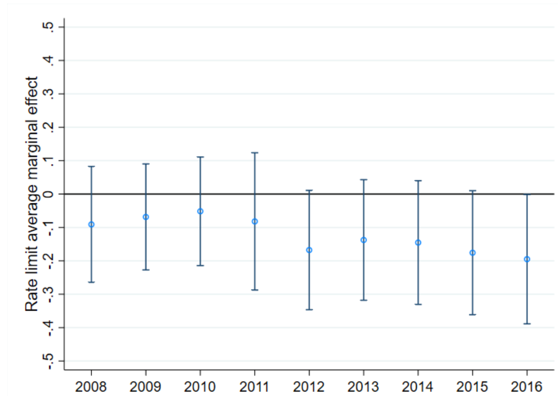
(d) Counties w/o some levy limit - Pop Weighted

These figures plot fraction of counties with higher HPI, NAV, levy, and mill rate, compared to 2007 in states with and without some levy limit in the top panel. The bottom panel weighs results by average county population in our sample period. All values are calculated per capita and adjusted for inflation.

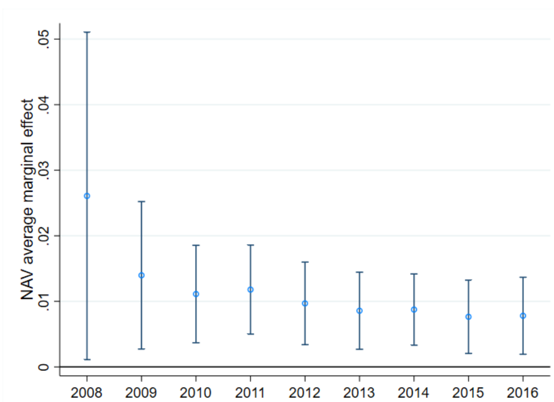
Figure 2.10: Likelihood of recovery - 2007-2016



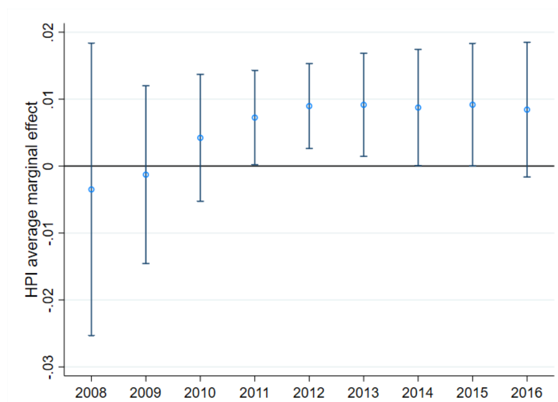
(a) Probit - $mill\ rate_t > mill\ rate_{2007}$



(b) Probit - $levy\ per\ capita_t > levy\ per\ capita_{t2007}$



(c) Probit - $levy\ per\ capita_t > levy\ per\ capita_{t2007}$



(d) Probit - $nav\ per\ capita_t > nav\ per\ capita_{t2007}$

The tables plot the average marginal effects from yearly probit regressions. In Panels a and b we control for the log change in net assessed values between t and 2007. Standard errors are clustered at the state level. Results for panels c and d refer to percentage point changes in NAV and HPI.

CHAPTER III

Robotization, Structural Shocks, and Local Public Finance

Abstract

How did exposure to robotization impact local revenues and public goods provision? In this paper, it is shown that exposure to robots leads to a decline in total revenues, driven by a large fall in tax revenues, specifically property taxes. Spending was found to be similarly affected, with expenditures on transport, capital outlays, and insurance and trust being primarily hit. The role of local autonomy, as defined by areas with functional home rule, as well as the role of property tax limits were investigated. It was found that the decline in taxes was less pronounced in areas with higher autonomy and more pronounced in areas with strict property tax limits. Using a dataset on local property tax rates, it is shown that robotization leads to an increase in the average rate, driven largely by high autonomy areas. It is shown that these results are consistent with a model of optimal local policy, which depends on transfers and local income. Further, the importance of accounting for policy changes when investigating outcomes that are highly policy dependent with shift-share instruments is highlighted.

JEL Codes: JEL Codes: H41, H71, H72, H77, R51

Keywords: Structural Shocks, Robotization, Local Public Goods, Local Taxation

3.1 Introduction and motivation

Increased globalization and rapid technological changes have had a profound influence in reshaping local labor markets in the past 30 years. In this paper, the effect of exposure to robotization is analyzed, and its impact on local governments, specifically on revenues, as well as expenditures and public goods provision is evaluated.[1] Additionally, new data on local property tax policy were used to ascertain whether exposure to robotization led to changes in property tax rates.

While there is growing evidence on the impact of structural shocks on local labor market outcomes, little is known on how they affect the provision of local public goods as well as the structure of local revenues. One could typically associate robotization with growth, technological development, as well as wealth creation. Picture high-technology machinery, and you will likely imagine wealthy and fast-growing areas such as Silicon Valley. This would lead to expectations that robots lead to higher tax revenues. However, not everyone gains from robotization. Although there can be obvious complementarity between certain jobs and new technologies, robotization and automation have also historically been used as labor substitutes. Recent work by Acemoglu and Restrepo (2017) documents the profound impact that automation has had on local labor markets since 1990, with an additional robot leading to lower wages (0.25%–0.5%) and lower employment to population ratio (0.18–0.34 percentage points). These effects are qualitatively comparable to another major recent structural shock, namely the import competition from China.[2]

The decline in wages and overall employment may have had important consequences for local revenues and expenditures. The most important sources of revenues for local governments besides transfers is property taxes, while sales taxes can be large in certain areas. A lower demand for housing, resulting in lower relative property values, and reduced consumption implies potentially large downfalls in revenues. Ultimately, the null hypothesis of the effect of robotization on local public finance need not necessarily be zero and could be positive or negative. The net effect on public finance will depend on how many areas and workers benefit from robots as well as where the gains and the losses are located.

Local policymakers were expected to respond as well, which could exacerbate or lessen the impact of a shock. For example, they could decide to shift the burden of tax from

[1] Given the importance of Chinese import competition as a structural shock on labor markets, this shock is discussed as well.

[2] The seminal work by Autor, Dorn and Hanson (2013*a*) provides the theoretical and empirical foundations on the effect of Chinese import penetration on wages and employment.

workers hit by shocks to those who were not or those who even benefited from it. Second, changes in the provision of public goods such as education or public safety may have long-lasting and important effects on human capital development and well-being in regions most affected by the shock. Adding another layer of complexity, the ability to choose the level of taxation and spending locally varies greatly. As such, the focus was placed on the role of local constraints and autonomy. The role of local government's autonomy, especially their dynamic effects, is of growing importance, and it was aimed to shed some light on important mechanisms affecting local public finance.

As most state and local governments face weak to extremely strict balanced budget constraints, as well as tax and expenditure limits, policymakers must be expected to respond to shocks on local labor markets to the extent revenues and/or expenditures are affected. However, it is also unclear what the optimal response is. Local preferences toward public goods provision and taxation will dictate the optimal local response in terms of revenue and spending adjustments. The local policy response function is unlikely to be linear and will depend on several factors. For example, optimal local taxation and spending is highly influenced by the amount of transfers received by localities. The level of local tax competition may also influence the optimal response. Structural shocks could potentially increase the degree of local tax competition. Theoretically, a shock on local income will also affect the relative marginal benefit of providing public goods. In this paper, a simple model of two-layered government was derived to predict the local response and test these predictions.

Robotization and automation are likely to keep increasing and can have a potentially important impact in the future on labor market and local public finance. The results of this paper would also guide our understanding of the future penetration of machines and increased use of industrial robots. Beyond the effect of robotization on local public finance, this work could also help shed additional light on structural shocks more generally and their effect on local public goods provision and taxation.

Turning to the empirical side, structural shocks are typically computed as shift-share instruments. Since Bartik (1991), shift-share instruments have been used in a wide variety of contexts, from immigration to international trade. The wide applicability from the design of the instrument and its intuitive concept has gained traction among economists. The main idea behind shift-share instruments relies on computing local shares of industry and interacting them with the "shock," a national or global change in a variable of interest (e.g., the change in imports from China in an industry, or the change in immigrants). Conceptually, the local shock captures the exposure of the locality to global trends. To alleviate concerns about the shares capturing anticipation effects to the shocks, researchers typically use historical data. Incidentally, the national shock may be endogenous to local changes. A recent work, however, points out that the shares themselves should be seen as the instrument. Goldsmith-Pinkham, Sorkin and Swift (2018) showed that the IV coefficient capturing the average treatment effect of the shock can be thought of as a weighted average, where the weights are represented by the shares and capture the relative exposure of an area. They argued that researchers should think of the exclusion restriction with respect to the shares themselves, not only with respect to the shock. They proposed several tests that researchers can use to determine whether the outcome variable of interest may be endogenous with respect to the shares.

In this paper, some of the methods discussed in the recent literature were used to alleviate the concerns about the shares' endogeneity. Additionally, it is shown that when the outcome is affected by policy choices, the coefficient of interest captures both the direct "mechanical" effects of the shocks as well the "indirect" policy effects. The intuition is similar to an omitted variable bias although to the extent that the policy responses are caused by the shock; the coefficient can still be interpreted as causal. However, a potential bias exists when dealing with multi-period estimations. Intuitively, since shocks are correlated over time by design, and assuming policymakers react to contemporaneous shocks, the policy effect at time t will be correlated with the shocks in all previous periods leading to a bias.

The paper most closely related to the current work is by Feler and Senses (2017), who evaluated the effect of exposure to Chinese import competition on local business activity, local revenues and spending, and other local outcomes such as crime or pupil per teacher. They found a strong and negative impact of increased import competition and identified lower property values, which led to lower revenues and expenditures, as the main factor. More generally, the current work is viewed as part of the literature that evaluates local governments' response to economic shocks. Cromwell and Ihlanfeldt (2015) evaluated how cities and counties in Florida react to lower intergovernmental transfers as well as lower property tax revenues. They found that local governments increase mileage rates and cut capital spending and expenditures, especially on nonessential services. Shoag, Tuttle and Veuger (2019) used national bankruptcies of big-box retail chains to study abrupt exogenous declines in local sales tax revenues. Their results indicated lower spending on safety and administrative services. In addition, they found that the decline was more pronounced in areas with low fiscal autonomy.

Local governments' response also varies according to the degree of local autonomy.

Cities in home rule states raise taxes or issue bonds and have a swifter reaction. Using death penalty trials as exogenous shocks on a county's budget, Baicker (2004) showed that these costs are financed by increases in local taxes as well as decreases in police and capital spending. She also found significant inter-jurisdictional spillovers. At the state level, the seminal work by Poterba (1994*a*) evaluated the importance of fiscal institutions as well as tax and expenditure limitations. He found that for states, higher restraint rules were correlated with faster fiscal adjustment in the late 1980s and that political factors play an important role as well: full party control leads to a slower adjustment, while spending cuts and tax hikes are much smaller during gubernatorial election years.

To summarize, the current paper's contribution is the following. First, we believe we are the first to document the effect of increased exposure to robotization on local public finance outcomes. It is shown that robots had a negative impact on revenues and spending.[3] Second, the importance of local fiscal autonomy, as well as property tax limits, for local policymakers to adjust following structural shocks is demonstrated. Finally, it is shown that shift-share instruments will lead to a bias in multi-period estimations when the outcome variable of interest is highly policy dependent. The potential size of the bias is explored in different circumstances, and certain evidence is presented in the current context.

In the next section, information is provided on both shocks and our data, and the estimation strategy is derived. Section 3 discusses the channels of transmission for the shocks, presents the baseline results for the entire sample and by level of local fiscal autonomy. The role of local policy is discussed more specifically in section 4. A simple model is presented to predict how local governments set optimal local taxes to predict their potential reaction to the shocks and show estimates on the effect of the shocks on local tax policy. Then, it is shown how shift-share instruments are potentially biased. In section 5, some robustness checks are conducted, and the results are discussed. The last section concludes the paper.

3.2 Estimation strategy

First, the structural shocks used in the estimation strategy is described. The rest of this section describes how the shocks were computed. Then a description of the data is presented.

[3] It is shown that the impact of robots on local revenues and expenditures is distinct and larger than the exposure to Chinese imports.

3.2.1 Exposure to robotization

Exposure to rising import competition is a local industry-weighted sum of exposure to national changes in imports. The current measure of exposure to robotization follows the recent work by Acemoglu and Restrepo (2017). Robots are capital equipment that do not require human operation and are designed to perform manual tasks and automate production.[4] It is similar to the "China shock" in spirit but also includes an adjustment for industries' growth rates. One concern is that robot-heavy industries may also be growing at higher rates compared to other industries. The shock aimed to capture the increase use of robots within industries, rather than the rise in robotization originating from the growth in the industry itself. The shock was computed as follows:

$$\Delta \text{Exposure Robots}_{ct} = \sum_j \frac{L_{jct-1}}{L_{jt-1}} \Delta APR_{jt} \tag{3.1}$$

where APR represents the adjusted penetration of robots in industry $j - \frac{\Delta R_{jt}}{L^i_{jt-1}} - g_{jt}\frac{R_{jt}}{L_{jt-1}}$. As pointed out by Acemoglu and Restrepo (2017), one may worry about shocks in local labor demand driving the adoption of robots. Second, the adoption of robots by firms in one area may affect the decision by other firms in the same area to invest in robotization. Robotization in five European countries was used to instrument for the national change in robots.

$$\Delta \widehat{APR}_{jt} = \frac{1}{5} \sum_{i \in EURO5} \left[\frac{\Delta R^i_{jt}}{L^i_{jt-1}} - g^i_{jt} \frac{R_{jt}}{L^i_{jt-1}} \right] \tag{3.2}$$

where $\widehat{APR}_{jt}$ is the average change in robot exposure in five European countries. Because industry-level data on the use of robots is only available in the United States starting from 2004, only the reduced-form estimation could be used when performing the multi-period analysis. To circumvent this issue, a "long" form model between 1993 and 2007 was estimated using the use of robotization in the United States and robot penetration in Europe as an instrument. A map of relative exposure by commuting zone is shown in figure 3.1.

[4]From Acemoglu and Restrepo (2017): "The International Federation of Robotics—IFR for short—defines an industrial robot as 'an automatically controlled, reprogrammable, and multipurpose machine' (IFR, 2014). That is, industrial robots are fully autonomous machines that do not need a human operator and that can be programmed to perform several manual tasks such as welding, painting, assembling, handling materials, or packaging. Textile looms, elevators, cranes, transportation bands or coffee makers are not industrial robots as they have a unique purpose, cannot be reprogrammed to perform other tasks, and/or require a human operator."

3.2.2 Empirical Design

In the baseline framework to evaluate how structural shocks affect local governmental outcomes, constant observable local characteristics that may be correlated with both the outcome of interest and with the instrument were taken into account. The following first-difference model was estimated:

$$\Delta Y_{ct} = \alpha_t + \beta_1 \Delta \widehat{Shock}_{ct} + X_{it}'\Gamma + \theta_t + \lambda_s + \epsilon_{ct} \tag{3.3}$$

where $X_{it}'\Gamma$ includes baseline differences between commuting zones at the beginning of the period.[5] Additionally, because local demographic characteristics may be correlated with the amount and type of revenues, and local public good provision, the demographic share of different age and race groups was included.[6] As discussed earlier, the basic framework is a two-period stacked first difference model. Given that the "robots" shock could only be computed after 2004 in the United States, only the reduced form estimation was performed with the stacked model. A time fixed effect that captures differential trends at the national level between the two periods was included, and to follow ADH, the baseline regression was estimated using divisions fixed effects that capture differential trends at the division level.[7] 10-year equivalent changes were used, such that the shocks' data matched the other data we had[8] In some of our specifications, two-digit industry-level shares were also included in the base period. Controlling for trends in large industry groups may be important if we believe that there is variation among large industry group over time, which are potentially correlated with the outcome variable of interest. Similarly, most of our specifications included the fraction of different sources of revenues in the base period. The share was included in own revenue, taxes, and property taxes. This controls for the fact that the initial revenue mix may also affect the change in different types of revenues. For example, it could be imagined that areas that rely heavily on property taxes may want to

[5]The design followed Autor, Dorn and Hanson and included the start-of-period share of employment in manufacturing, the population share with a college education, the population share that is foreign born, the share of employment in routine occupations, and the average offshorability index of occupations in the commuting zone.

[6]For example, Alesina, Baqir and Easterly (1999) showed that the provision of local public goods in the United States was inversely proportional to ethnic fragmentation. Population age might also affect the type and level of local spending, as older individuals may have different preferences for public goods (e.g., Jäger and Schmidt (2016)). The data from the county-level intercensal population data were used, and the shares of the population aged 15–34,35–54, 55 and over, the share of black residents, and Hispanic residents, and the share of men were included.

[7]Some results without fixed effects capturing trends are presented in the appendix.

[8]Exposure to robotization shocks were calculated between 1993 and 2000 and 2000 and 2007. Both were rescaled by 10/7. Import shocks were calculated between 1990 and 2000 and 2000 and 2007, and the second one was rescaled by 10/7. While the primary shock of interest was exposure to robotization, rescaling both shocks also allowed us to compare them.

diversify their revenue mix over time or on the contrary increase their reliance on property taxes over time.

When looking at the role of local autonomy and property tax limits, the following model was evaluated:

$$\Delta Y_{ct} = \alpha_t + \beta_1 \Delta \widehat{Shock}_{ct} + \beta_2 \Delta \widehat{Shock}_{ct} \times HR + X'_{it}\Gamma + \theta_t + \lambda_s + \epsilon_{ct} \tag{3.4}$$

where HR is a binary indicator equal to 1 when a commuting zone is in a state with functional home rule. Essentially, the same model as in equation 1 was estimated, making the shock interact with the binary indicator. Since the model is in first difference, HR was not included as a variable, as it would capture trends in areas with functional home rule and could mistakenly absorb variation attributed to the shocks.

Our results were clustered at the state level, defining the cluster in each commuting zone as the state with the largest population share in multi-state commuting zones. The state was chosen as a clustering unit because given the structure of local taxation, it was believed that relevant clusters signify all jurisdictions facing similar rules and fiscal autonomy. Observations within the same state should then be highly correlated across each other and over time.

3.2.3 Data

The shocks data from Acemoglu and Restrepo (2017) were used for the exposure to robotization.[9] Log average wage from ADH as well as commuting zone level control variables were used[10]. The commuting zone employment to population ratio was obtained from Acemoglu and Restrepo (2017).

The data on local public finance from the Census of State and Local Governments (CSLG) were used. The CSLG is carried out every year for states and large counties and municipalities and gathers information on revenues and expenditures. For smaller jurisdictions, the Census Bureau collects data every five years, with years ending in '2 and'7. Our shocks cover the time period from 1990 to 2007. A linear extrapolation of the 1997 and 2002 Census for 2000 was used, and the Census of 1992 was employed for 1990 data. Because the Chinese imports and robotization were still in an infancy period in the early

[9] Shocks from Autor, Dorn and Hanson (2013*a*) were used for exposure to import competition from China. It was possible to replicate their shocks as well as derive shocks at the state and county level following the same methodology. Due to a lack of access to the robots' data by industry, Acemoglu and Restrepo (2017) was used for all robotization shocks.

[10] List all controls from ADH such as the share of workers in manufacturing, the share of workers with a bachelor

1990s, we believe it is unlikely that 1992 was affected by the shocks in any significant manner.[11] Both changes were extrapolated to get 10-year differences as well.

In the present analysis, the state of Michigan was excluded for three important reasons. First, Michigan passed Proposal A to reduce the reliance of school funding on property taxes. The sweeping reform led to a drop in property taxes of nearly 30% in 1994 and introduced new limits on the growth rate of property tax levy and home assessment.[12] Second, Michigan was one of the states most impacted by robotization: the average for our measure of robot penetration is twice the national average, and the three commuting zones with the highest robotization impact are in Michigan. Finally, the structure of local taxation in Michigan differs from most other states, where the state levies a State Education Tax, which is then transferred back to municipalities. As such, lower local taxes collected would likely impact transfers more than local taxes. While another handful of states passed new legislation on local taxation during the present study's analysis period, none were of the scope of Michigan and in states highly impacted by robotization.[13]

The current data on the local housing market comes from two different sources. First, data on median home value were used as well as the share of homes in different value ranges from USA counties, which uses data from the US Decennial Census for 1990 and 2000 and the American Community Survey for 2006–2008. Data for 2007 are the average value for all years between 2006 and 2008. Second, a measure of local housing prices was used from Zillow which computes a local price index measuring the change in a typical home.[14]. Because data is not available for most areas before the mid 1990s, data between 1995 and 2007 were used, which covers 2022 counties and 616 commuting zones.

The demographic data at the county level from the Census Bureau of Economic Analysis (BEA) as well. These include the share of population by gender, age, and race/ethnicity.

3.2.3.1 Local policy data

Property tax rates and assessment ratio

In a related project with Chiara Ferrero, a historical collection of local property tax rates, assessment information and levy was collected by hand and compiled. Archived mill tax rate and assessment information from state level data, such as annual tax reports, were used. The data ranged from 1980–2018, and mill rate data for 44 states and assessment

[11]An extrapolation of 1987 and 1992 was used for 1990 as a robustness check, and the results were significantly similar and consistent.

[12]Source: The Michigan Property Tax Real and Personal, Michigan Department of Treasury, Office of Revenue and Tax Analysis,May 2002

[13]Results including Michigan are presented in the appendix as well.

[14]More information is available at https://www.zillow.com/research/data/

data for 39 states were obtained. When the state provided a county average directly, that information was used. Some states have data averaged at the county level, while others have data at the municipality and school district level. The total valuation was aggregated at the county level. With the local tax rate, the average tax rate for each layer of government for all jurisdictions in the same county was used, and the tax rates were added up to find the county level average.[15] In this project, the unit of observation is the commuting zone, which combines several counties. The total assessed value of property per capita for was aggregated at the commuting zone level for each county. For the mill rate, the aggregate assessed values and levy at the commuting zone were used, and the effective mill rate was defined as the ratio of levy over assessed value.

Local fiscal autonomy and local tax limits

Defining and measuring the level of local autonomy can be a complicated task, both because the definition itself of local autonomy varies across situations and because of the large variation in state laws and degrees of freedom accorded to local governments. While extensive literature has been produced in public policy documenting differences in structures of government across states, a lot remains to be done to understand how autonomy interacts with revenue shocks. In the current context, the interest lies not only in the ability of local government to adapt to structural shocks in terms of expenditures and public goods provision but also regarding whether the sources of revenues are impacted differently across states granting different levels of autonomy.

The first measure of local autonomy follows Shoag, Tuttle and Veuger (2019) and comes from the 1993 report from the Advisory Commission on Intergovernmental Relations (ACIR). States are classified by whether cities or counties operate under the structural or functional home rule. Structural home rule is defined as the ability of local policymakers to choose their own form of government (e.g., size of city councils), while those with functional home rule have greater autonomy over specific local government function such as taxation. In 1993, there were 40 states with cities operating under structural home rule and 28 allowed city governments functional home rule while 21 states had functional rule for county-level government. 31 states had either county or city level functional home rule while 18 allowed both. In the main specification, functional home rule is defined as that of states which allow it for either cities, as cities and school districts typically have a much larger role in levying revenues than county-level governments, and robustness checks analysis were carried out defining structural home rule states as either for cities

[15] For example, the simple average for all school districts in the same county was found, and the same was done for all municipalities.

only or for either cities or counties.

Local property tax limits

A large fraction of local revenues comes from property taxes, and as such property tax limits may affect the ability of local governments to either increase property taxes to make up for declining revenues from transfers or other local taxes. Property tax limits typically fall into three categories: tax rate limits, assessment limits, and/or overall revenue limits. Property tax rates limits usually specify a maximum statutory rate, while assessment limits are typically defined as maximum percentage-wise increase in the assessed value of a home year-to-year.[16] Levy limits usually put a cap on year-to-year growth rate in property tax collections.[17] In 2017, 46 states had some form of property tax limitations. Our two primary sources are from Winters (2008) and Augustine (2009) who list overall or specific property rate limits, assessment limits, and overall and real estate revenues and expenditure limits for each state. The current analysis covers years 1992–2007, during which a few states passed new legislation on local tax limits. However, for the vast majority of states, these limits were in place before 1990, and given that the exposure to robotization and import competition increased rapidly in the late 1990s and early 2000, it is unlikely that structural shocks led to policy changes before the mid 1990s. There, local property tax limits in place in 1995 are defined.[18]

When faced with structural shocks affecting all sources of revenues, including property tax collections, we want to measure the ability of local governments to shift their reliance on property taxes. As such, an assessment limit would not block governments to increase the tax rate and vice versa. More importantly, if local governments receive less in transfers or collect less from other sources, the critical binding factor will be overall levy limits. Additionally, if structural shocks have a negative effect on home prices, the assessment limit is unlikely to be binding. Areas that want to increase the tax rate to make up for a relative decline in the tax base or shift to property taxes would be likely to raise rates and/or overall amount of property taxes collected. As such, in the current analysis, the focus was placed on states which have a combination of levy and rate limit. The exact

[16]Perhaps the most notorious example of this is Proposition 13 in California which sets the maximum real estate tax rate at 1% and the maximum assessment value increase to 2%, unless ownership of the property changes.

[17]Proposition 2 1/2 in Massachusetts, for example, limits the growth rate of property taxes collected from existing homes to 2.5% annually.

[18]It might still be a concern that changes occurring during the current time period of study affected local tax revenues, however, only a handful of states passed new laws between 1995 and 2005. Pennsylvania and Rhode Island for example passed new property tax revenue limits in 2006, but it is unlikely to have had an effect on data prior to 2007.

classification for each state based on functional home rule and tax limits is depicted in figure 3.2.

3.3 Reduced form results

In this section, the results of the reduced form analysis are analyzed. First, channels of transmission from structural shocks to local revenues and expenditures are discussed.

3.3.1 Channels

State governments in the United States rely primarily on sales taxes, intergovernmental transfers, income taxes, and charges and fees. Local governments rely heavily on intergovernmental transfers and charges and fees as well; however, but tax revenues come mainly from property taxes. While some cities and counties in the United States have the ability to set additional sales taxes and income taxes, it is limited to a few states.[19] A direct effect of lower wages and employment induced by rising robotization and import competition would be a decline in the income tax base as well as a decline in consumption. At the local level, an indirect effect of declining wages and employment opportunities would be a decline in demand for housing, or even an increase supply of housing, either due to migration to a different area, or due to workers affected by the shocks not being able to pay for their mortgages. The home prices and assessment values used to determine the property tax are not perfectly correlated, hence the relatively lower fluctuation in property tax revenues compared to income and sales tax revenues. However, while local governments may not immediately adjust assessment values following a decline—or slower rise—in home prices, one could expect medium- and long-run adjustment to take place, such that declining home prices would be eventually followed by a decline in property tax bases.

Incidentally, one may suspect that state and local governments would respond to the shock. The vast majority of state governments are subject to balanced budget requirements, of which the stringency and level of enforcement varies across states. Localities are typically also subject to tight budget rules, such that they are forced to balance budgets in relatively short time frames—typically a fiscal year, although this can be a slightly longer time frame depending on the state. Responses might then be expected both in terms of tax policy and in terms of expenditures. Some state legislatures face additional complications and limits on the ability to implement tax changes. It is also worth mentioning that

[19] Table 3.2 shows the amount per capita (in 2000 USD) for major revenues and spending categories in all sub state local governments. Intergovernmental transfers made up about 37% of revenue in 1997, taxes about 30%, and the rest was comprised of charges, fees, and other miscellaneous revenue.

robotization may create high paying jobs, capital gain, and overall growth which may have a positive impact on revenues. However, it is unclear whether the gains associated with robots happen in the same areas where machines are implemented.

In addition to varying degrees of autonomy and constraints, depending on local politicians' preferences, one might expect heterogeneous policy responses across jurisdictions. Characterizing how policy response affects our outcome of interest thus depends on several local characteristics. In the next section, a simple model that highlights how shocks may affect optimal state and local policies is introduced.

3.3.2 Results

Table 3.1 displays the mean and standard deviation for exposure to import competition from China and the instrumented variable between 1991 and 2000 and 2000 and 2007, rescaled to 10-year equivalents, as well as for the entire 1991–2007 time period. Values are in thousands of dollars of imports per worker, such that the average exposure is of an increase of $1,910 in imports per worker from China in the US between 1990 and 2007, and the instrumented variable captures an increase just slightly smaller, an increase of $1,770 in imports per worker. Adjusted penetration of robots was measured by the number of robots per thousand worker. The data by industry in the United States starting in 2004 were obtained. For the 1993–2007 period, the change in the instrumented adjusted penetration was of about 1.00 robots per worker per 10-year scaled period. The ten-year equivalent penetration of robots in the US between 2004 and 2007 was 0.7 robots per 1,000 workers.

To have a baseline on the relative effects of the shocks on local employment and income, some of the results of the effects of shocks on local labor markets were replicated first. Columns (1) and (4) in table C.1 in the appendix show the results for our baseline specification. It is seen that an increase in one robot per thousand worker leads to a 10-year adjusted decline of roughly 2.3% in weekly wages. The effect on employment is also significant, with an additional robot per thousand worker leading to a lower employment to population ratio by 0.6 percentage point. [20]

Turning to how robotization affected housing markets, it is seen that increased exposure had a significant and negative impact on the median home price as well as on the local price index. An additional robot was associated with a decline of 9.2% in the value

[20] The current results are similar to Acemoglu and Restrepo (2017), although slightly smaller in magnitude, as a different set of controls was used in this paper.

of a median house and 6.5% for the home price index. [21]
The effect of the shock on local public finance outcomes is analyzed now. Table 3.3 displays the results for the baseline specification on revenues and expenditures. Exposure to robotization leads to lower revenue, with a coefficient of roughly β=-3.95, implying a roughly 4% decline in total local revenues per each additional adjusted robot. Again, while this may sound large, this is the reduced form estimate. Based on 2004–2007 data, the rate of robotization per 1,000 workers was about half. A back-of-the-envelope calculation would thus estimate the effect of an additional robot in the US to lower total local revenue by about 2%. Throughout the paper, an adjusted instrumented robot is signified to when an additional robot is mentioned. This effect was found to be driven by a decline in taxes (β=-5.7), especially property taxes (β=-5.5), and to some extent transfers (β=-2), although the effect was not significant for both state and federal transfers.

The bottom panel in table 3.3 looks at expenditures. Higher robot penetration leads to a decline of 2.9% in total expenditure, 1.5% in education spending (although not statistically significant), and large declines in safety and transport (β=-2.13) and β=-5.75 respectively). A noticeable effect is also seen on capital outlays (β=-5), and insurance/non-debt related financial obligations (β=-4.75).

The interaction between local autonomy and the shocks is studied now. Because local autonomy and local restrictions are typically one-sided and restrict the growth of local governments, rather than their reduction, the results will be driven by local preferences and how local policymakers respond. For example, if following a mechanical decline in revenues, the policymakers' optimal decision would be to slash spending, and little or no difference should be seen between areas with higher or lower fiscal autonomy. On the other hand, if policymakers decide to make up for loss revenue by increasing taxes, fees, or by finding other sources of revenue, a stronger decline in taxes should be seen for places with lower autonomy. In table 3.4 the measure of local fiscal autonomy is included—whether states grant functional home rule to cities and counties—and made to interact with the shocks. Second, the results of the shock made to interact with whether a region has both levy and rate limits for property taxes are presented. Note that it was also required to ensure that the impact of robotization on the labor and housing market was not significantly different in areas with and without home rule and tax limits. Table C.1 in the appendix presents estimates from model 2. The impact was found to be highly similar

[21] Data for the home price index is only available for a subset of counties, especially in the 1990s. The data for 1994 were used, and the difference between 1994 and 2000 was scaled up to obtain a 10-year equivalent change.

overall for all outcomes, and none of the interacted coefficients were large or statistically significant.

In terms of total revenues, no differences were seen between areas with and without functional home rule. Similarly, regions with and without property tax limits were found to be affected similarly by exposure to robotization. Although aggregate revenues looked similar, important differences were seen in specific sources. Total taxes and property taxes were found to be affected less negatively in areas with home rule (β_{noHR}=-7.5 and β_{HR}=-5.2), although the interacted coefficient was not statistically significant. Places with higher autonomy saw a larger reduction in transfer for a similar shock (β_{noHR}=-0.5 and β_{HR}=-2.4). This indicates that although the impact on overall revenues is similar, areas with functional home rule experienced shocks differently with a larger decline in transfers and a smaller decline in taxes. Unsurprisingly, areas with property tax limits saw a larger decline in taxes, driven by a much larger decline in property taxes (β_{noLim}=-2.16 and β_{Lim}=-6.6). They also experienced a smaller negative effect in transfers (β_{noLim}=-4.1 and β_{Lim}=-1.2).

In terms of expenditures, again, little differences were seen between areas. None of the interacted coefficients were statistically significant, and most were small in size as well. The only major exception is a much larger decline in capital outlays in commuting zones without functional home rule (β_{noHR}=-8.9 and β_{HR}=-5.2). It can be concluded that while the presence of limits and home rule seems to affect how jurisdictions react to structural shocks in terms of revenues, there is little difference on expenditures.

3.3.3 Long-run IV results

The drawback in the stacked estimation is that we only the reduced-form effect is analyzed. While it gives some information on the sign of shocks, and whether they are statistically significant, the magnitudes can be difficult to interpret. To evaluate the actual impact of exposure to robotization, the long-form model was evaluated with an instrumental variable, looking at differences between 1993 and 2007.[22] The downside of this model is that long-run adjustment can make it more difficult to precisely identify the impact of the shocks.

Table 3.5 presents the long-run IV model with and without interaction with functional home rules. All other controls are similar to the stacked estimation. The first observation is that total revenues in the long run do not seem to be affected by robotization, with the exception of areas with functional home rule, which experience a larger decline (β_{noHR}=-0

[22]To match our data from 1990, the shock was effectively rescaled to a 17-year shock between 1990 and 2007.

and β_{HR}=-1.2). However, the shock has an impact on the source of revenue, and is associated with lower taxes and higher transfers. An additional robot per thousand workers leads to a 2.7% decline in total taxes, and a 2% increase in transfers. Interestingly, we see a significant difference in areas with home rule. Robotization leads to a smaller decline in taxes (β_{noHR}=-3 and β_{HR}=-1.5), and large differences in transfers (β_{noHR}=2.8 and β_{HR}=-0.5). In terms of expenditures, little effect was seen in the general estimation as well as in the interaction with the presence of home rule. This is consistent with our stacked results. While exposure to shocks may affect the sources of revenues, in the long run it has little impact on overall revenues or expenditures. Note that these findings are consistent with both jurisdictions adjusting to structural changes over time in terms of policy as well as natural adjustment in the labor and housing market, which makes it more difficult to identify long-run effects.

3.3.4 Sample selection and shift-share instruments

A recent and rising section of literature on shift-share instruments has shed some light on the mechanics behind them. Goldsmith-Pinkham, Sorkin and Swift (2018) argued that the exclusion restriction should be stated in terms of both shares and shocks. A shift share instrument captures a weighted average treatment effect, where the weights are the relative exposure to the shock, captured by the shares. Naturally, one may worry that shares are correlated with unobservable characteristics that affect the level of the outcome of interest. To deal with this issue, most research designs using shift-share instruments use first-difference models. However, shares may not satisfy the exclusion restrictions if they are correlated with trends in the dependent variables. Effectively, this implies that researchers should ensure that shares are uncorrelated with the *change* in the outcome of interest. Goldsmith-Pinkham, Sorkin and Swift (2018) offered ways to test for this by highlighting three main methodologies. First, researchers should check whether or not shares are correlated with outcomes other than the ones posited by the researchers. In the current context, shares should be uncorrelated with local factors which have differential trends, and have an effect on wages. Second, researchers should test for trends in the instrument when data makes it possible. Third, researchers can consider alternative estimators and run overidentification tests, which builds on the idea that shift-share instruments in fact combine several instruments in a specific manner.[23]

[23] Alternatively, Borusyak, Hull and Jaravel (2018) pointed out that running a regression on shift-share instruments is similar to running a regression on industry weighted average. This allows researchers to condition for industry-specific fixed effects that capture potential industry trends correlated with the outcome of interest.

In the current context, the primary concern is then that the shocks are correlated with trends in local public finance outcomes rather than having a causal effect. First, the effect of shocks on local labor markets could be correlated with the structure of local revenues. The baseline regression was run with the fraction of income coming from different sources in the base period as the outcome variable with no significant results being. Second, shocks may be correlated with trends in the structure of local public income. To test for this, regressions using the change in our variable of interest between 1977 and 1987 as the dependent variable were run.[24] As shown in table 3.6, there was no overall significant correlation between the exposure to robotization and total revenues, taxes, transfers, and expenditures when using no controls. When introducing division fixed effects and interaction with the presence of home rule, no large or statistically significant correlations were found either, with the exception of a small positive correlation between education spending and robotization. Finally, the same controls as in the baseline model were included, and no statistically significant effect was found, with a small and negative correlation with taxes and a small and positive correlation with transfers in areas with the functional home rule.

To summarize, these findings indicate there is no consistent and precise correlation between public finance outcomes and the shocks, overall, or in areas with or without home rule. We believe it is highly unlikely that serial correlation between local trends and our measures of shocks drove our main results. To limit the role of trends, the change in the respective variable of interest between 1977 and 1987 as a control was also included in all our specifications.

The next section looks more closely at the role of local policy, develops a simple model to derive predictions on the reaction of local governments, and shows how shift-share instruments will bias coefficients when the outcome of interest is highly policy dependent.

3.4 The role of policy

This section investigates the role of policy in response to local shocks. First, a simple two-layer model of government where local policymakers choose an optimal tax rate based on local income and on transfers received from the state is introduced. Subsequently, it is shown how local tax rates and assessment were affected by both shocks, using the data described in section 2. Second, it is shown how shift-share instruments bias outcomes

[24] Regressions using changes between 1977 and 1992 and between 1982 and 1992 were run as well. The results were very similar and are available on request.

that are highly dependent on policy. Further, some evidence is shown that the mechanical effect of shocks on local property taxes was somewhat lower in low-autonomy places and somewhat larger in high-autonomy places.

3.4.1 Model of local policymaking

A simple model with two levels of government is introduced here. The goal of the simple and stylized model is to illustrate how local taxes and public goods provision are affected by income shocks. This framework also highlights the relationship between goods provided at the state level as well as goods provided at the local level.

There are J regions in each state. There are two types of individuals: high skill (and high income) and low skill. The fraction of high-skill type in each region is denoted by α_{hj}, with $\sum_i \alpha_{ij} = 1$. It is assumed that agents derive utility from consumption of private goods and public goods $U(c_{ij}, g_j, g_s)$, where c_{ij} is the consumption of type i in region j, g_j is the amount of public goods provided at the local level, and g_s is the amount of public goods provided at the state level. For tractability, it is assumed that labor is supplied inelastically, and there is no mobility. Local governments and state governments levy a tax on income (or consumption since there is no saving), and the individual's budget constraint is $c_{ij} = y_{ij}(1 - \tau_j - \tau_s)$. State governments provide transfers to the regions, denoted by r_j. The local government's budget constraint is $\tau_j \sum_i \alpha_{ij} y_{ij} + r_j = g_j$, and the state government budget constraint is $\tau_s \sum_j \sum_i \alpha_{ij} y_{ijs} = g_s - \sum_j r_j$.

It is assumed that the following set of events happens:

1. At the beginning of the period, both governments observe the share of each types and the income level in each region.
2. State governments pick the tax rate, transfers and state-provided public goods, and the information becomes public.
3. Local governments observe the transfers they receive and the tax rate imposed at the state level. They choose their tax rate and amount of public good provision.

For now it is assumed that both local and state policymakers act as social planners and maximize social welfare functions for their constituents. The first-order condition for the local policymaker is as follows:

$$\frac{\partial}{\partial \tau_j} : \quad \sum_i \alpha_{ij} \Big(\frac{\partial u}{\partial c_{ij}} y_{ij} = \frac{\partial u}{\partial g_j} y_j \Big)$$

Because state policymakers choose their optimal tax policy anticipating the response function of the local government, $\frac{\partial \tau_s}{\partial \tau_j} = 0$. Local policymakers then choose a tax rate τ_j and an amount of public good provision that equals the weighted marginal utility of consumption (i.e., the marginal cost of public funds) for each type to the total marginal utility of increasing public good provision.

$$\sum_i \alpha_{ij}\beta_{ij}\frac{\partial u}{\partial c_{ij}} = \sum_i \alpha_{ij}\frac{\partial u}{\partial g_j}$$

where the weights on the marginal utility of private consumption is equal to the share of each type (α_{ij}) times the share of income for each type in the region - $\beta_{ij} = \frac{y_{ij}}{y_j}$.

At the state level, politicians maximize the utility of all residents, taking into account the localities' response. The first order conditions are as follows:

$$\frac{\partial}{\partial \tau_s} : \sum_j\sum_i \alpha_{ij}\frac{\partial u}{\partial c_{ij}} y_{ij}\Big[1 + \frac{\partial \tau_j^*}{\partial \tau_s}\Big] = \sum_j\sum_i \alpha_{ij}\left(\frac{\partial u}{\partial g_s}y_s + \frac{\partial u}{\partial g_j}\frac{\partial \tau_j^*}{\partial \tau_s}y_j\right)$$

$$\frac{\partial}{\partial r_j} : \sum_i \alpha_{ij}\frac{\partial u}{\partial c_{ij}} y_{ij}\frac{\partial \tau_j^*}{\partial r_j} = \sum_i \alpha_{ij}\frac{\partial u}{\partial g_j}\Big[1 + \frac{\partial \tau_j^*}{\partial r_j}y_j\Big] - \sum_j\sum_i \alpha_{ij}\frac{\partial u}{\partial g_s}$$

Assuming that the transfer rule is symmetric and $r_j = r$

$$\frac{\partial}{\partial r_j} : \sum_j\sum_i \alpha_{ij}\frac{\partial u}{\partial c_{ij}} y_{ij}\frac{\partial \tau_j^*}{\partial r_j} = \sum_j\sum_i \alpha_{ij}\frac{\partial u}{\partial g_j}\Big[1 + \frac{\partial \tau_j^*}{\partial r_j}y_j\Big] - J\sum_j\sum_i \alpha_{ij}\frac{\partial u}{\partial g_s}$$

When choosing the optimal tax rate at the state level, policymakers have to balance the amount of distortion it creates through changes in local tax rates and the increase in marginal utility through higher public good provision (assuming transfers are kept constant). Similarly, transfers increase the amount of local public good provision but distort the local tax rate.

Let us choose a specific example for the utility function and derive optimal tax rates and transfers. It is assumed that the utility function is additively separable between private consumption and public goods and that the utility function is quasi-linear - $u(c, g) = c + v(g)$. Hence, the local optimum is defined as follows: $\sum_i \alpha_{ij}\beta_{ij} = v'(g_j)$. An example would be $v(g) = log(g)$. In which case, the following is obtained

$$\tau_j = \frac{1}{y_j \sum_i \alpha_{ij}\beta_{ij}} - \frac{r_j}{y_j}$$

What happens when there is a change in income?

$$\frac{\partial \tau_j}{\partial y_j} = -\frac{1}{y_j^2} + \frac{r_j}{y_j^2} - \frac{1}{y_j}\frac{\partial r_j}{\partial y_j}$$

If transfers and the share of incomes stay constant ($\frac{\partial r_j}{\partial y_j} = 0$), there are two forces affecting optimal taxes. Lower income means that the amount of public goods provided per capita by transfer r_j increases, leading to a lower tax rate locally. On the other hand, the relative marginal benefit of providing public goods goes up, since the marginal utility of consumption is constant, which leads to a higher tax. The relative effect depends on the size of transfers r_j as well as how transfers change following a shock in income. How would a change in the share of poor versus rich individuals affect the tax rate? Assuming no changes in relative income, it follows that when there are more poor people in region j, the optimal tax rate increases since $\sum_i \alpha_{ij}\beta_{ij}$ decreases. Intuitively, the shift in the budget constraint leads to under provision of public goods—since the value of public good is independent on income—and the tax rate increases to equate the marginal cost of public fund and marginal benefit. If on the other hand there is a shift in the distribution from poor to rich, such that total income does not change, there will be no effect on the income tax. If we assume elastic labor supply and that rich individuals have higher elasticities of taxable income, an increase in share of poor individuals and a right shift in the income distribution can lead to an increase in tax rate.[25]
At the state level, the optimal condition for the tax rate becomes $\tau_s = \frac{1}{\sum_j \sum_i \alpha_{ij}\gamma_{ij}} + \frac{\sum_j r_j}{y_s}$. With this utility function, transfers are never optimal because of the positive effect on local public good provision ($1 + \frac{\partial \tau_j^*}{\partial r_j} y_j = 0$). On the other hand, the state tax rate does not distort optimal local choices. The optimal tax rate is then simply

$$\tau_s = \frac{1}{y_s \sum_j \sum_i \alpha_{ij}\gamma_{ij}} = \frac{1}{y_s}$$

where $\gamma_{ij} = \frac{y_{ij}}{y_s}$. It can be seen that a decrease in income leads to a higher tax rate.

3.4.1.1 Political incentives

To capture how political incentives may affect the optimal level of taxation and public good provision as well as the optimal response to a shock, first-order conditions were

[25] If we assume that labor is not supplied inelastically, the optimal tax rate then becomes $\frac{\partial \tau_j}{\partial y_j} = -\frac{1}{y_j^2 \sum_i \alpha_{ij}\beta_{ij}(1+\epsilon_{ij}} + \frac{r_j}{y_j^2} + \frac{\partial \tau_j}{\partial \beta_{ij}}\frac{\partial \beta_{ij}}{\partial y_j}$, where $\epsilon_{ij} = \frac{\partial y_{ij}}{\partial(1-\tau_j-\tau_s}\frac{1-\tau_j-\tau_s}{y_{ij}}$ is the elasticity of taxable income with respect to the next of (total) tax rate. Now the optimal amount of public good and tax rate considers the distortionary effect of taxes on each group. The same logic applies, but the magnitude changes, from the added distortion.

derived under the median voter theorem. Now, policymakers maximize the utility of the median voter. The first-order condition at the local level becomes the following:

$$\frac{y_{mj}}{y_j}\frac{\partial u_m}{\partial c_{im}} = \frac{\partial u_m}{\partial g_j}$$

It follows that the optimal local income tax rate with utility function $u = c + log(g)$ is

$$\tau_j = \frac{1}{y_{mj}} - \frac{r_j}{y_j}$$

Now the distribution of income and the relative income of the median voter is essential to determine the local tax. The effect of a decline in average income is unambiguous and leads to a higher tax ($\frac{\partial \tau_j}{\partial y_j} = \frac{r_j}{y_j^2}$), while a decrease in the median income leads to a lower tax. For tractability, it is assumed that state policymakers are elected statewide and thus maximize the utility of the median voter overall. The optimal state tax rate is

$$\tau_s = \frac{1}{y_{ms}} + \frac{Jr}{y_s}$$

which simplifies to $\tau_s = \frac{1}{y_s}$, given that there are no transfers with this utility function. At the state level, a decrease in the median voter income and a decrease in the average income lead to a decline in the tax rate. Importantly, if the average income goes down, but the median income is unchanged, there will be a decline in the provision of public goods. The goal of this section was to highlight that even with a very simple model, it can be shown that optimal local responses in terms of tax policy and public good provision depends not only on the local average income but also on the distribution of income as well as the share of individuals who are poor or rich. It also highlights the relationship between local and state government. Local governments take into consideration both transfers and state tax policies when choosing the optimal bundle of tax and public goods. It was also shown that political incentives, derived from a simple median voter framework, potentially leads to differential responses from the social planner. The next section describes the estimation strategy to evaluate the effect of structural shocks on tax revenues and expenditures.

3.4.2 The effect of shocks on local property tax policy

Table 3.7 presents how exposure to robotization affects local property tax policy. [26] The top panel looks at the impact on the mill rate, assessed values, and the ratio of assessed values to local home prices. It was seen that an additional instrumented robot led to an increase in the property tax rate of about 3%. This effect was almost fully driven by areas with structural home rule (β_{noHR}=0.14 and β_{HR}=3.15). The increase was also smaller in areas with tax limits (β_{noLim}=4.06 and β_{Lim}=2.5). However, none of the coefficients in the interacted models were significant, indicating a wide range of responses. Unsurprisingly, it was seen that the shocks had a negative impact on assessed values with similar effects in areas with home rule. Assessed values declined more for a given exposure to robotization in jurisdictions with property tax limits. Further, little impact was seen on the assessment ratio, indicating that the shocks did not have a major impact on assessment rules.

In the bottom panel, the baseline model restricting the sample to areas for which property tax data was obtained is estimated. The magnitudes are smaller and less precisely estimated than the results shown in tables 3.3 and 3.4. However, the qualitative impacts of the shocks are similar, indicating that our findings are not sample-specific. Overall, it can be concluded that areas with more autonomy seem to react differently by increasing the property tax rate for a given shock. Areas with rate and levy limits increase the tax rate less than areas without limits, even though they experience a decline almost twice as large on their tax base.

To summarize, it was found that areas which experience lower transfers for a given exposure to robotization are more likely to increase their tax rate, consistent with the model. This prediction also aligns with our previous findings where areas with autonomy experienced a larger decline in total transfers and a smaller decline in taxes. It was shown that the smaller decline in taxes was mostly due to an increase in the property tax rate.

3.4.2.1 Omitted variable bias

As discussed earlier, the coefficients of interest in tables 3.3 and 3.4 include both mechanical and policy effects. Policy can be seen as an omitted variable. Policy responses

[26] As discussed in the data section, the average data between 1994 and 1995, 2000 and 2001, and 2006 and 2007 were used. Using the data for 1995 rather than 1990 allowed us to use a much larger sample in the first time period. Moreover, the two-year average was used to obtain a more precise estimate. Using the data from 2000 and 2007 rather than the two-year average did not change our results. The change was rescaled to obtain a 10-year equivalent

due to the shocks are part of the overall effect of structural changes on local public finance, and hence, it is not termed as an omitted variable bias. Rather, the coefficient can be thought of as capturing both the direct and indirect effects of shocks. However, as shift-share instruments rely on the industry shares from the base period, shocks will be highly correlated over time. Intuitively, if the policy response in period 2 is correlated with the shock in period 2, it will be correlated with the shock in period 1 by construction. Simply put, assume shocks are correlated over time—$Cov(Shock_{st}, Shock_{s,t-1}) \gg 0$. Second, assume that shocks have a direct effect on outcome—$Cov(Shock_{st}, Y_{st}) \gg 0$. Finally, assume that policy response (k_{st}) is correlated with the outcome of interest (e.g. tax revenues)—$Cov[k_s, Y_{st}] \neq 0]$. Given these three assumptions, policy is correlated with all *previous shocks*— $Cov(k_{s,t}, Shock_{s,t-1}) \neq 0$.

It can be shown that the expected coefficient β_1 will be as follows (with the full derivation in the appendix):

$$E[\hat{\beta_1}] == \beta_1 + \gamma\beta_2\big(1 + E[\Delta Shock_{st}^2]^{-1} E[\Delta Shock_{st} \sum_{t=1}^{T} \alpha^t \Delta Shock_{st-j}] \tag{3.5}$$

where it is assumed that the correlation between the current shock and the first change in policy is zero ($E[\Delta Shock_{st} \alpha^T \Delta\kappa_{st-T}] = 0$ as well as the correlation between the shock and the residual in the policy function ($E[\sum_{t=0}^{T} \alpha^t \Delta e_{st-j}]$. The expected value for the coefficient is then equal to the direct effect of the shock, the indirect effect of the shock, and what we call the mechanical bias, which comes from serial correlation of the shock over estimation periods. The indirect effect of the shock is the product of the effect of the shock on policy (γ) and the effect of policy on the outcome variable (β_2). The specificity of shift-share instruments is that they are by design correlated over time, as practitioners usually keep the shares constant using the base year. Even when the shares are updated, they will be imperfectly correlated over time. Thus, the term $E[\Delta Shock_{st}^2]^{-1} E[\Delta Shock_{st} \sum_{t=1}^{T} \alpha^t \Delta Shock_{st-j}]$ creates a mechanical bias. How large it is depends on the number of periods T, on the degree of path dependence of the policy (α), and on the degree of correlation within shocks over time.

3.4.2.2 Disentangling direct effects, indirect effects, and bias

Can we put a sign and number on the indirect effect of the policy and on the bias? The answer depends on the number of policies that we expect to be correlated with the shocks as well as the relationship between the policy and the outcome variables. In the context of the structural shocks investigated in this paper, the first question we can ask is whether or not the indirect effect and bias is large when estimating the effect of the shock on local labor market outcomes. We can start with β_2, which captures the effect of the policy, e.g., a tax change on the share of employed individuals, or on wages. We can reasonably expect β_2 to be significantly small.

As an example, let us take the effect of the shock on the wage bill and how tax policy response may bias the coefficient. Chetty et al. (2011) reviewed the evidence on labor supply elasticity estimates and found ranges between around 0.2 and 0.8. Here, $\beta \approx -0.2$ was picked to be conservative, such that an increase in the tax rate of one percentage point leads to a decline in the wage bill of 0.2%. Second, let us assume that policymakers adjust the tax rate to exactly make up for half of loss revenue. This is somewhat arbitrary, but it is seen as a reasonable estimate, as we would expect a decline in expenditures and a rise in transfers to make up for some of the loss in revenue. From Acemoglu and Restrepo (2017), it is assumed that one robot per thousand workers decreases the total wage bill by about 1%. Hence the tax rate would have to increase by roughly one percentage point to make up for loss revenue, which implies $\gamma \approx 1$. This would imply that 10% of the impact of robots could come from indirect effects through the tax responses. When using a multi-period approach, the bias would be close to -0.1, assuming $\alpha = 1$ and shocks are highly correlated over time. Acemoglu and Restrepo (2017) typically found more negative responses in the "stacked," i.e., multi-period estimates, which is consistent with our theory. However, two important caveats were identified here. First, local governments rely on property taxes. A rise in property taxation could be interpreted as a rise in the cost of housing consumption and could lead to an increase in labor supply if individuals are budget constrained or have a very low elasticity of substitution between the consumption of housing and other goods. Second, evaluating the effect of other policies such as changes in welfare spending or transportation on wages and labor supply may be difficult.

Now let us consider the outcome variable being tax revenues. To find β_2, the mechanical and behavioral effect of a change in tax rate needs to be evaluated. For small changes, the envelope theorem can be applied, and focus can be placed on the mechanical effect. A one percentage point increase would then imply $beta_2 \approx 10$ or 10% increase in tax collections, assuming an average state tax rate of 10%. Coefficient γ captures the tax policy response to the shock. Again, it is assumed that the change in the tax rate compensates for the loss of revenues from the direct effect of the shock on tax revenues, which is $\Delta Y * \tau$, where ΔY is the change in the wage bill. Again using a 10% tax rate, $\gamma \approx 1 * .1 = .1$ is obtained, which implies $\beta_2\gamma = 1$. This implies a large indirect effect which unlike in our previous examples has an opposite side to the direct effect. Things are greatly simplified here, as tax policies and expenditures decisions are taken jointly and are also affected by the amount of transfers governments receive. However, we believe it is critical to keep in mind how important both the mechanical effect and the bias can be when interpreting results. There is a rising literature that evaluates the effect of the China shock on a range of outcomes such as health, crime, etc. that can be highly policy dependent.

3.4.3 Estimation with policies

While it is difficult to precisely estimate the role of the bias, one can potentially use observed changes in policy as controls to “block” the policy effects of the shock and find the mechanical effect. There are two important challenges with such a methodology. First, there may be data limitations on the type of local policies that is observed and available. Additionally, researchers need to deal with the large variety of local systems, such that local nominal tax rates may have significantly different effective tax rates across regions. Second, one would need to accurately identify the types of policies that are response to shocks (hence $\gamma > 0$) as well as have a significant impact on the outcome variable of interest ($\beta_2 > 0$). It is to the discretion of the researcher to determine which policies are relevant in the estimation strategy.

Another strategy is to evaluate β_2, γ, and α separately. The effect of the policy on the outcome variable of interest can be evaluated directly for areas that have available data, with the assumption that the sub sample of states and regions that have a comparable data on policy leads to consistent estimates. That is, it needs to be assumed that the availability of policy data is quasi-random and is uncorrelated with the shocks and the effect of the shock. Even then, one may worry about restricting the sample size, which could lead to highly imprecise estimations. Fundamentally, β_2 captures the joint effect of policy changes on the outcome variable. Let us take income tax collections as an example. If we focus on the direct effect of policies, then we can evaluate how much an income tax rate change will affect tax revenues, which will be the addition of the mechanical effect of the tax change and the behavioral response.

For the sample of state and counties for which policy data was obtained, it was investigated how including the policy change as a dependent variable affected the relevant coefficients in table 3.8. Accordingly, property tax revenues and transfers were analyzed. Property taxes constitutes the outcome variable that is directly affected by the policy, while transfers potentially affect optimal policy; it was not expected to find that the tax rate was correlated with changes in transfers, especially in the medium run. Column (1) shows the baseline result without including the change in property tax rate, and column (2) includes changes in tax policy. In the baseline sample, including the tax rate had almost no effect on the outcome, indicating that the role of policy and the bias were relatively small. Turning to areas with home rule, it was observed that the negative effect of exposure to robotization increased in areas with low local autonomy—from -7.7 to -6.6, a decline of more than 15%. The interacted coefficient in high autonomy states was found to decline from about 5.8 to 4.4. The tax rate itself was positively correlated with property tax revenues, as expected. The results are somewhat consistent with the predictions and findings on the effect of shocks on tax rates. In places with low autonomy, a decline in tax rates implies a negative bias, while in places with high autonomy, a rise (or no change) in tax rates relative to other areas leads to a positive bias. In terms of transfers, no differences were found when including the policy, which is consistent with the predictions.

However, it is worth pointing out that coefficients in the estimations including changes in tax rates should not be interpreted purely as the mechanical effect of the shocks—given the whole array of other policies that affected overall revenues and property taxes.

3.5 Discussion and robustness checks

In this section, the role of weighting is discussed, and some results with an unweighted specification are presented. This section also looks at another major structural shock, import competition from China. Finally, it mentions other ways to evaluate local autonomy.

To summarize our findings so far, it was shown that exposure to robotization leads to a decline in revenues, mostly driven by a decline in property taxes, although transfers and other sources of revenues went down as well for a given exposure. This had a negative effect on spending, with the largest categories hit negatively being transport, capital outlays, and insurance and other non-debt related financial obligations. Taxes declined less in jurisdictions with more autonomy and more in areas with strict property tax limits. It was revealed that exposure to robotization leads to an increase in the tax rate, which is driven by areas with more autonomy, which also see a decline in transfers compared to other areas.

3.5.1 Unweighted results

It is important to note that the results are weighted by local population. To the extent that we care about the overall effect on the population from lower public services or higher tax burdens, we want to weigh by local population. However, unweighted results also provide information. If local outcomes depend on policy changes, small and large jurisdictions may have considerably different reactions. A policy response function is unlikely to be linear. For example, cities may use different tools to react to a small shock or a large shock. As the outcome of interest is calculated per capita, unweighted results thus give us an average across commuting zones, which implies that laws implemented in small and large commuting zones will be on equal footing in our estimation strategy.

Table C.4 and C.6 in the appendix shows the unweighted results for the baseline estimation strategy and the interaction with local autonomy. The qualitative results are significantly similar, but the magnitudes for most coefficients are halved or more. The statistical significance of some results (transfers specifically) in high autonomy places disappears. Overall, the conclusions are not unchanged from the weighted estimations. Areas more densely populated seem to have stronger responses as demonstrated by the coefficients smaller in magnitude in the unweighted results.

Table C.8 shows the unweighted results from the long-run IV estimation, and again considerably similar outcomes were found qualitatively, with slightly smaller magnitudes.

It is also worth pointing out the outcomes when including Michigan, which are shown in table C.3 in the appendix. The impact of robotization on expenditures is very similar, with the only exception being the negative impact on safety and education being statistically significant, while non-debt related financial obligations and insurance loses its significance. However, significantly different results were observed in revenue. Total revenue was still found to decline but by lesser amounts, while no impact on taxes but a large decline in transfers, driven by state transfers, was observed. This highlights how the specificity of Michigan regarding its property tax and transfer structure can affect the result, given its status as one of the most affected states by robotization as well.

3.5.2 The role of Chinese import competition

One may still wonder whether there is potential correlation between exposure to robotization and import competition from China. Additionally, given that both shocks are structural and have been pinned as having had a major impact on local labor markets in the United States, a comparison is warranted. In table C.5, it is analyzed whether the impact of robotization is affected by adding the “China shock”. The coefficients associated with robotization are similar to our baseline estimation, about 10%–20% smaller in magnitude with similar statistical significance. Exposure to import competition from China itself was also associated with a decline in revenues and expenditures, similar to findings by Feler and Senses (2017), although with typically smaller magnitude. In table C.7, the interaction between the shock and local autonomy or strict property tax limits is analyzed. Almost no coefficient was found to be statistically significant, and no pattern was found that would highlight different impacts, unlike with robotization.

Notably, with the long-run estimation shown in table C.9, no effect of the China shock was seen on either revenues or expenditures. If anything, it had a positive impact on both. This clearly highlights how long-run adjustments can make it difficult to identify the role of structural shocks, especially in the case of policy-dependent outcomes.

A quantitative comparison between the two shocks is difficult, given the different metrics used and the lack of robotization data in the United States before 2004. Qualitatively, both shocks seem to primarily affect local revenues through a decline in property taxes, largely driven by the negative effect of the shocks on home prices. Notably, education was found to decline more than total expenditures for a given exposure to Chinese competition, while it was the opposite for robotization. Safety was found to be negatively affected by an additional robot but not by exposure to import competition. While there was some correlation between both shocks, their intensity varied across commuting zones. The different outcomes in expenditures were found to be potentially driven by differences in preferences for local public goods as well as the local structures of government. Overall, more research is required on the relationship between preferences for local public goods provision and responses to structural shocks.

3.5.3 Other measures of local autonomy

So far, local autonomy has been defined as states that allow either cities or counties to have more power in levying taxes and choosing spending. In table C.10, the results when focusing on states that allow only cities to do so are presented. Moreover, specific focus was placed on levy limits as opposed to the combination of rate and levy limits. The results are very similar to our baseline, indicating that autonomy of cities and levy limits are the driving forces behind our previous results. This is not too surprising, as the sample with a city-only autonomy is largely similar to either city or counties, with a couple of exceptions.

3.6 Conclusion

In this paper, it was shown that exposure to robotization leads to a decline in local revenues, mostly driven by overall declines in total taxes and property taxes. The effect on transfers is small and statistically not significant but negative. Local expenditures were also found to decline for each additional robot, with safety, transport, and insurance and trust spending declining the most. There was a small but imprecise decline in education spending. Areas with higher fiscal autonomy, specified as states which grant localities functional home rule, experienced a similar decline in revenue and spending. However, they faced smaller declines in taxes and larger declines in transfers. The effect on expenditures was similar in areas with high and low autonomy, with the exception of capital outlays, for which the negative effect was about half as large in high autonomy jurisdictions. States with levy and rate limits experienced a larger decline in taxes, driven by a much larger reduction in property taxes. However, they faced much smaller losses in transfers.

In the pre-trend analysis, it was shown that it is unlikely that differential trends between regions drove our results, a potential concern with shift-share instruments. Using a collected database on local property tax rates and assessment values, differential responses between areas with high and low fiscal autonomy were highlighted. Places with low autonomy showed no impact of robotization on tax rates, while property tax rates were found to increase in high-autonomy jurisdictions. It was shown that these results are consistent with a simple model of optimal local tax policy, which depends on local income and transfers. Areas that increased taxes were also found to face larger declines in transfers.

It was shown that when the outcome is policy-dependent, there is an omitted variable bias resulting from the correlation between the shocks over time and their effect on policy. In this application, the bias is unlikely to be large. When including changes in tax rates to block the property tax policy channels, similar outcomes were found, although slightly smaller in magnitude for areas with large jurisdiction, a potential sign of a small bias.

Robots and automation are not going anywhere. We believe there are important questions that would benefit from further research, which could provide more evidence on the relationship between autonomy, preferences for public good, revenue mixes, and levels of taxation. A deeper understanding of the extent to which the structure of transfers influence local response to structural shocks—in the short and long run—would be highly valuable. We also believe there is some promising research to be done on the role of local political incentives and how they affect policy changes.

3.7 Tables

Table 3.1: Shocks: summary statistics - shocks

10-year scaled Δ	1990-2000		2000-2007		Average 1990-2007	
	mean	sd	mean	sd	mean	sd
$\Delta\widehat{Robots}$ $1993-2007$	0.65	0.58	1.35	1.07	1.00	0.93
$\Delta Robots_{US}$ $2004-07$	.	.	0.70	0.84	0.70	0.84
$\Delta\widehat{IPW}$	1.01	1.07	2.52	2.57	1.77	2.11
ΔIPW_{US}	1.18	1.80	2.64	3.05	1.91	2.61
Observations	701		701		1402	

1990-2000	(1)		(2)		(3)		(4)		(5)	
	No Funct. HR		Funct. HR		Levy lim.		No levy lim.		Prop. tax samp.	
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
$\Delta\widehat{Robots}_{1993-2000}$	0.75	0.51	0.61	0.59	0.70	0.56	0.60	0.58	0.73	0.61
$\Delta\widehat{IPW}$	1.29	1.21	0.92	1.01	1.18	1.17	0.87	0.97	0.85	0.78
ΔIPW_{US}	1.39	1.89	1.12	1.77	1.26	1.40	1.12	2.08	1.17	1.79
Observations	172		529		317		384		220	

2000-2007	(1)		(2)		(3)		(4)		(5)	
	No Funct. HR		Funct. HR		Levy lim.		No levy lim.		Prop. tax samp.	
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
$\Delta\widehat{Robots}_{2000-07}$	1.62	1.07	1.26	1.05	1.41	0.94	1.29	1.16	1.45	1.04
$\Delta Robots_{US\ 2004-07}$	0.86	1.03	0.64	0.77	0.68	0.75	0.71	0.92	0.74	0.84
$\Delta\widehat{IPW}$	2.86	2.53	2.41	2.57	2.77	2.48	2.31	2.62	2.65	2.60
ΔIPW_{US}	2.97	2.42	2.53	3.22	3.18	3.25	2.19	2.81	2.78	3.19
Observations	172		529		317		384		491	

Changes are 10-year equivalent re-scaled shocks except for the 1990-2007 average, which is 17-year scaled. The second panel shows the summary statistics for states classified either as operating under the functional home rule or not (columns 1 and 2) and for states that have either a y. The third column of the second panel displays the summary statistics for the commuting zones for which we have local property tax data. For commuting zones crossing 2 states, the level of autonomy is defined by the state with the highest share of the population. The state with the highest population share changes in 3 commuting zones over time, and these have been dropped from the estimations.

Table 3.2: Shocks: summary statistics - local government revenues and expenditures

	No Functional HR		Functional HR		Prop. tax sample	
	1990	2007	1990	2007	1990	2007
	(1)	(2)	(3)	(4)	(5)	(6)
Total revenue	2,561	4,059	2,569	3,922	2,401	4,139
Own sources	1,611	2,565	1,614	2,380	1,548	2,623
Taxes	725	1,141	800	1,145	829	1,211
Property taxes	597	865	668	894	699	944
Sales and income taxes	109	259	112	233	115	249
Other taxes	19	18	20	18	15	18
Charge and misc.	600	1,011	541	861	520	986
Other revenue	287	412	273	374	199	425
Total transfers	950	1,495	955	1,542	853	1,516
Federal transfers	70	127	94	153	63	130
State transfers	819	1,269	787	1,283	739	1,276
Total expenditure	2,519	3,916	2,548	3,857	2,345	4,036
Education	1,070	1,622	1,065	1,585	1,062	1,642
Safety	180	336	171	297	172	337
Health	39	74	47	94	42	85
Transport	153	195	189	255	158	210
Housing	32	57	36	63	33	63
Parks	54	95	54	105	46	99
Welfare	39	50	98	118	50	90
Sanitation	79	135	97	159	90	151
Liquidity, insurance, trust	310	433	300	423	216	468
Interest	133	115	147	109	121	124
Capital Outlays	288	492	301	483	241	508
Observations	382	382	337	337	222	479

Figures are per capita revenue and expenditure. The first 4 columns are the non-weighted average across commuting zones for 1990 and 2000 in low autonomy and high autonomy states respectively. The All figures are in 2000 USD and have been adjusted for inflation using the Consumer Price Index.

Table 3.3: Effect of shocks on local revenues and expenditures

	Revenues		Taxes				Transfers		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total	Own	Total	Property	Other	Misc.	Total	Federal	State
$\widehat{Robots}_{\Delta 10year}$	-3.95^c	-4.35^c	-5.71^c	-5.54^b	-1.48	-3.17^b	-2.01	-3.91	-1.46
	(0.98)	(1.09)	(1.59)	(2.07)	(4.19)	(1.46)	(1.57)	(3.47)	(1.50)
Demographic & base controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.29	0.18	0.30	0.25	0.34	0.12	0.20	0.13	0.31
CZ-by-year	1,402	1,402	1,402	1,402	1,312	1,402	1,402	1,392	1,402

State clustered standard errors in parentheses

^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

Continued on next page

Table 3.3 – *Continued from previous page*

	Expenditures							Debt	
	(1) Total	(2) Educ.	(3) Safety	(4) Transport	(5) Sanitation	(6) Capital	(7) Insurance	(8) Interest	(9) Total
$\widehat{Robots}_{\Delta 10yr}$	-2.94^c	-1.45	-2.13^a	-5.75^b	-0.11	-5.04	-4.75^b	-0.26	-0.12
	(0.93)	(1.18)	(1.25)	(2.72)	(2.46)	(3.40)	(2.26)	(2.69)	(2.56)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.12	0.25	0.22	0.10	0.13	0.08	0.10	0.29	0.24
CZ-by-year	1,402	1,402	1,402	1,402	1,384	1,402	1,402	1,395	1,402

State clustered standard errors in parentheses

^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table shows result for model 3.3. The outcome variable is the log difference in local per capita spending and expenditure from the Census of Government Finance, adjusted for inflation. We use data for 1992 and 2007, as well as extrapolated data between 1997 and 2002, to get 2010 figures. All variables are rescaled to get two 10-year changes. Standard errors are clustered at the state level. We include demographic shares, as well as the share in manufacture, foreign born, college-educated, women in the labor force, share of workforce that are routine tasks or easily outsourced (following Autor, Dorn and Hanson (2013*b*)). We also include the fraction of revenue from own source, taxes, property taxes, transfers, and miscellaneous at the beginning of each period as a control. All the shares and fractions are based on the base period (1990 and 2000). We also include the difference in outcomes between 1977 and 1987, as well as division and period fixed effects to take into account trends. All regressions are weighted by the share of population in the commuting zone in 1990 unless specified otherwise.

Table 3.4: Effect of shocks on local revenues: with local autonomy measure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total revenues		Total taxes		Property taxes		Total transfers	
$\widehat{Robots}_{\Delta 10year}$	-4.08[c]	-4.25[c]	-7.53[c]	-3.75[c]	-7.47[b]	-2.16	-0.51	-4.10[b]
	(1.47)	(1.29)	(2.31)	(1.21)	(3.34)	(1.73)	(2.14)	(1.96)
$\widehat{Robots}_{\Delta 10year} \times HR$	0.15		2.28		2.44		-1.85	
	(0.98)		(1.42)		(2.27)		(1.82)	
$\widehat{Robots}_{\Delta 10year} \times Lim$		0.40		-2.66[a]		-4.60[a]		2.91[a]
		(1.13)		(1.53)		(2.42)		(1.57)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.29	0.29	0.30	0.30	0.26	0.26	0.21	0.21
CZ-by-year	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total expenditures		Education		Safety		Capital Outlays	
$\widehat{Robots}_{\Delta 10year}$	-3.33[b]	-3.44[c]	-2.36	-1.90	-0.92	-1.57	-8.97[a]	-4.67
	(1.48)	(1.17)	(1.59)	(1.51)	(1.49)	(1.36)	(5.28)	(3.45)
$\widehat{Robots}_{\Delta 10year} \times HR$	0.47		1.13		-1.48		4.81	
	(1.04)		(1.37)		(1.21)		(3.27)	
$\widehat{Robots}_{\Delta 10year} \times Lim$		0.67		0.61		-0.76		-0.51
		(1.25)		(1.40)		(1.37)		(4.07)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.12	0.12	0.25	0.25	0.22	0.22	0.08	0.08
CZ-by-year	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402

State clustered standard errors in parentheses
$^a\ p < 0.10$, $^b\ p < 0.05$, $^c\ p < 0.01$

In this table, we evaluate model 3.4, which interacts exposure to robotization with local autonomy as defined by being in a jurisdiction with functional home rule. We also interact the shock with states that have both levy and rate limits. See table 3.3 notes for controls - all estimations include the same controls. All estimations are weighted by the national population share in 1990. See text for a discussion on local autonomy and local property tax limits.

Table 3.5: Effect of shocks on local revenues: IV estimation 1993-2007

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total revenues		Total taxes		Property taxes		Total transfers	
$Robots_{\Delta 17year}$	-0.30	-0.01	-2.64^c	-2.98^c	-2.14^c	-2.22^c	1.99^c	2.75^c
	(0.47)	(0.43)	(0.49)	(0.41)	(0.75)	(0.77)	(0.75)	(0.58)
$Robots_{\Delta 17year} \times HR$		-1.19^a		1.54^b		0.42		-3.20^b
		(0.71)		(0.73)		(1.06)		(1.41)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.38	0.38	0.39	0.39	0.35	0.34	0.34	0.34
CZ-by-year	704	704	704	704	704	704	704	704

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total expenditures		Education		Safety		Capital Outlays	
$Robots_{\Delta 17year}$	-0.41	-0.20	0.61	0.51	-1.00	-0.93	-1.00	-1.60
	(0.47)	(0.45)	(0.44)	(0.41)	(0.70)	(0.74)	(1.52)	(1.39)
$Robots_{\Delta 17year} \times HR$		-0.91		0.41		-0.29		2.46
		(0.71)		(0.81)		(0.96)		(1.59)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.28	0.28	0.48	0.48	0.45	0.45	0.23	0.23
CZ-by-year	704	704	704	704	704	704	704	704

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table looks evaluates the IV model using changes between 1993 and 2007, adjusted for inflation. All varialbles are per capita. The robots shock in the United States is calculated between 2004 and 2007, and rescaled to get a 14-year change. Both the Chinese shock and the shift-share instrument are rescaled to get a 14-year difference. The specification is identical to table 3.4 and includes the same controls. The estimation is weighted by 1990 commuting zone population. There is no time trend since there is only one observed period. Standard errors are clustered at the state level. See table 3.3 and 3.4 for details on controls and definition of home rule.

Table 3.6: Exogeneity test: 1977-1987 change as outcome variable

$\Delta_{1977-1987}$ in dependent variable - no controls

	Revenues		Taxes			Transfers		Expenditures	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total	Own	Total	Prop	Salesinc.	Total	State	Total	Educ
$\widehat{Robots}_{93-07}$	-0.57	-0.02	-0.13	0.35	-0.03	1.51	0.89	-0.51	0.55
	(0.64)	(0.02)	(1.61)	(1.82)	(0.06)	(0.97)	(1.06)	(0.79)	(0.86)
R^2	0.02	0.02	0.01	0.02	0.02	0.00	0.00	0.02	0.00
CZ-by-year	701	701	701	701	701	701	701	701	701

$\Delta_{1977-1987}$ in dependent variable - division fixed effects

	Revenues		Taxes			Transfers		Expenditures	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total	Own	Total	Prop	Salesinc.	Total	State	Total	Educ
$\widehat{Robots}_{93-07}$	0.98	0.01	-0.43	-0.56	0.03	1.93	1.03	1.04	1.55^{a}
	(0.73)	(0.02)	(1.83)	(2.19)	(0.03)	(1.17)	(1.41)	(1.01)	(0.79)
$\widehat{Robots}_{93-07}$	-1.11	-0.03	-1.27	-0.84	-0.09	1.06	1.96	-1.04	-0.91
Structural HR	(0.86)	(0.02)	(2.12)	(2.51)	(0.08)	(1.53)	(1.87)	(1.11)	(0.97)
R^2	0.35	0.52	0.63	0.62	0.17	0.20	0.18	0.30	0.41
CZ-by-year	701	701	701	701	656	701	701	701	701

$\Delta_{1977-1987}$ in dependent variable - full specification

	Revenues		Taxes			Transfers		Expenditures	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total	Own	Total	Prop	Salesinc.	Total	State	Total	Educ
$\widehat{Robots}_{93-07}$	0.65	0.00	-0.16	0.08	0.01	0.99	0.61	0.49	0.77
	(0.57)	(0.01)	(1.39)	(1.58)	(0.04)	(1.04)	(1.24)	(0.89)	(0.61)
$\widehat{Robots}_{93-07}$	-0.09	-0.02	-1.61	-1.90	-0.07	1.88	2.65	-0.01	-0.20
Structural HR	(0.69)	(0.02)	(1.57)	(1.87)	(0.07)	(1.41)	(1.72)	(1.03)	(0.81)
R^2	0.48	0.63	0.71	0.74	0.21	0.35	0.32	0.40	0.53
CZ-by-year	701	701	701	701	656	701	701	701	701

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table evaluates the role of pre-trends in local public finance outcomes. The dependent variable is the change between 1977 and 1987 of the outcome of interest. The first panel has no fixed effects or controls, the second panel includes division fixed effects, while the last panel is the same full specification as tables 3.3 and 3.4.

Table 3.7: Effect of shocks on local tax rates and assessment - 1993-2007

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Log mill rate			Log assessed value			Log assess.ratio		
$\widehat{Robots}_{\Delta 10yr}$	3.11[a]	0.14	4.06	-3.74[b]	-4.56	-2.39	0.40	1.15	-0.25
	(1.55)	(3.19)	(2.50)	(1.74)	(3.75)	(3.14)	(2.03)	(3.76)	(3.01)
$\widehat{Robots}_{\Delta 10yr} \times HR$		2.99			0.83			-0.76	
		(2.42)			(3.10)			(2.90)	
$\widehat{Robots}_{\Delta 10yr} \times Lim$			-1.56			-2.22			1.07
			(2.67)			(3.83)			(3.86)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.50	0.51	0.51	0.44	0.44	0.44	0.47	0.47	0.47
CZ-by-year	656	656	656	656	656	656	594	594	594

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total revenues		Property taxes		Total transfers		Home price Index	
$\widehat{Robots}_{\Delta 10yr}$	-2.60[a]	-1.82	-5.69[c]	-1.24	2.84	-2.88	-5.84[c]	-2.14[a]
	(1.39)	(1.36)	(1.70)	(1.63)	(2.30)	(1.86)	(1.99)	(1.19)
$\widehat{Robots}_{\Delta 10yr} \times HR$	-0.06		2.46[b]		-3.87		1.68	
	(0.92)		(1.18)		(2.32)		(1.88)	
$\widehat{Robots}_{\Delta 10yr} \times Lim$		-1.37		-3.34[b]		3.05		-3.36[c]
		(1.59)		(1.50)		(2.41)		(1.15)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.45	0.45	0.63	0.63	0.39	0.39	0.81	0.82
CZ-by-year	656	656	656	656	656	656	594	594

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table looks at the effect of robotization on local property tax rates, and assessed values, and the ratio of assessed values and home prices between 1993 and 2007, with two time periods 1993-2000, and 2000-2007. Property tax rates are in mills (tax per 1,000 valuation). Assessment ratio is defined as the change in assessed property value per capita (and adjusted for inflation), while assessment ratio is the later divided by local price index at the county level. See text for more details on the source and computation of tax rates and assessed value at the commuting zone. All controls are the same as table 3.3

Table 3.8: Blocking the property tax policy channel

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Property Taxes				Transfers			
$\widehat{Robots}_{\Delta 10year}$	-3.61^b	-3.53^c	-7.72^b	-6.61^b	-0.67	-0.68	-0.21	0.07
	(1.40)	(1.29)	(3.30)	(2.94)	(1.29)	(1.30)	(1.82)	(1.77)
$\widehat{Robots}_{\Delta 10year} \times HR$			5.80	4.37			0.45	0.08
			(3.87)	(3.39)			(2.68)	(2.49)
Δ Log Mill rate		0.07^b		0.07^b		-0.01		0.02
		(0.03)		(0.03)		(0.02)		(0.03)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.58	0.59	0.52	0.53	0.28	0.28	0.20	0.21
CZ-by-year	786	786	786	786	786	786	786	786

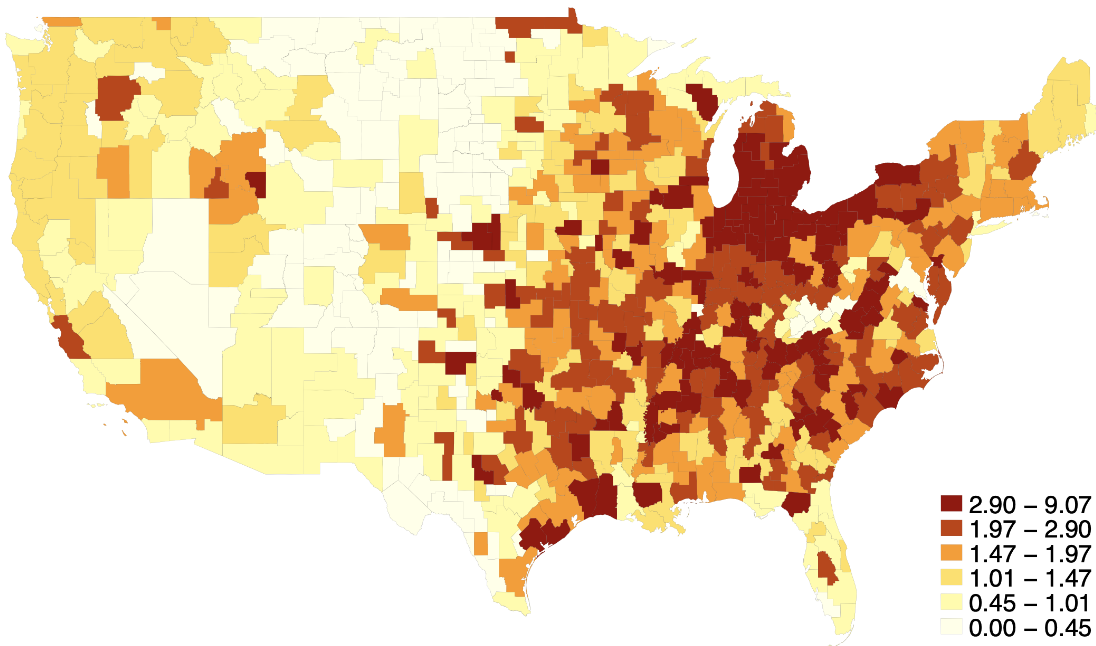
State clustered standard errors in parentheses

^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table evaluates our baseline specification from table 3.4 including property tax changes as an independent variable to absorb the indirect effect of policy on the outcome variable. Essentially it is designed to block the local property tax rate policy channel. Standard errors are clustered at the state level. See table 3.3 for a description of controls and table 3.4 for definition of home rule.

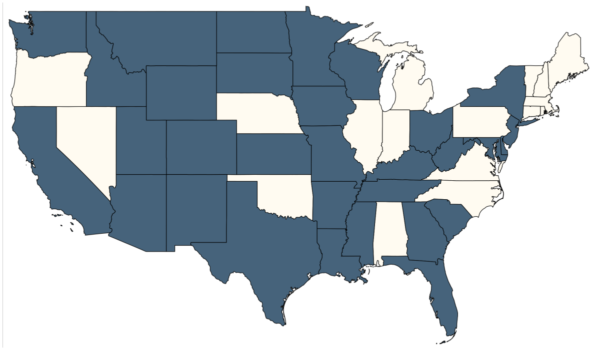
3.8 Figures

Figure 3.1: Change in exposure to robotization in robots per 1,000 worker - 1993-2007

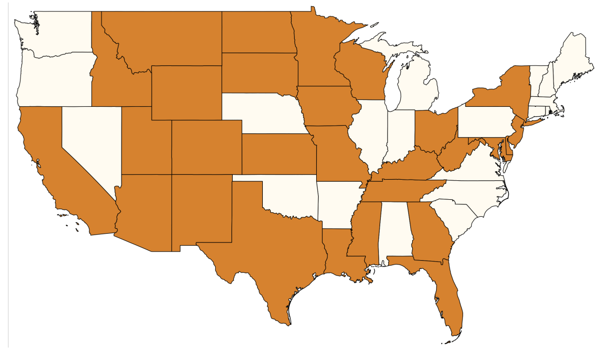


This figure shows the commuting zone exposure to our shift-share instrument for robot penetration, which is based on the use of robots in European countries between 1993 and 2007. See text for details on how the shocks are computed.

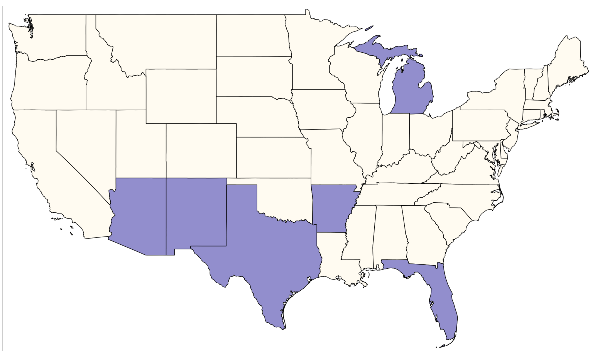
Figure 3.2: Maps of local fiscal autonomy



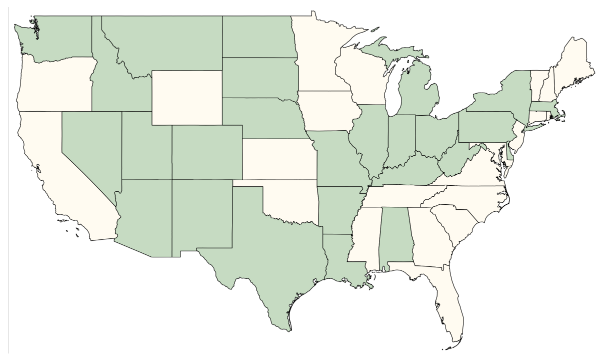
(a) Functional home rule - cities or counties



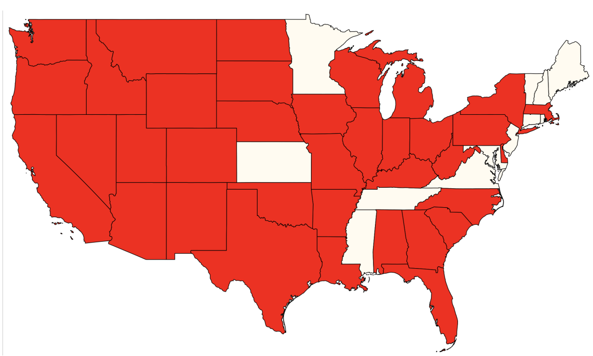
(b) Function home rule - cities only



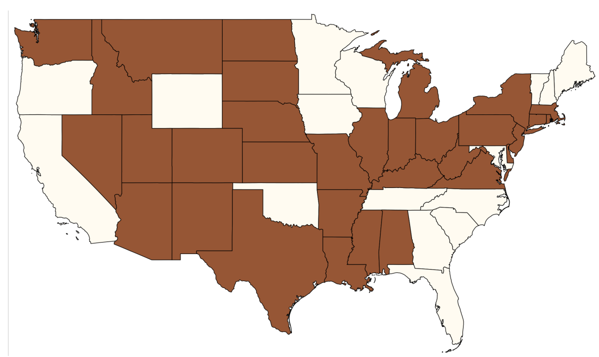
(c) Property tax levy limit, rate limit, assessment limit



(d) Levy limit and rate limit



(e) Property tax rate limit



(f) Property tax levy limit

These Chapter3/Figures depict which states are classified as having high or low levels of local autonomy either based on whether they are granted functional home rule - panels (a), (b) - or whether states have property tax limits. Panel (c) displays states with all three types of limits on local property taxation with levy, assessment, and rates. Panel (d) shows which state have overall levy limit, and a tax rate limits.Panel (e) shows which states have a rate limit, and panel (f) which state have a levy limit. See text for more information on the limits and functional home rule.

APPENDIX A

Chapter I Supporting Material

A.1 Additional Tables

Table A.1: Summary Statistics - *Census tract data*

	Mean	S.d.	Mean	S.d.	Mean	S.d.
Firm dynamics						
Entry rate	11.03	5.89	10.63	5.73	11.03	5.94
Exit rate	11.81	16.80	11.87	17.18	12.14	17.20
New firms per 100 people	0.34	1.53	0.32	1.18	0.35	1.75
Total firms per 100 people	2.84	2.11	2.83	2.07	2.88	2.15
Employment in new firms	86.33	107.29	83.29	103.59	88.78	109.06
Demographic data						
Share white	0.69	0.27	0.69	0.28	0.68	0.27
Share black	0.13	0.19	0.14	0.20	0.12	0.19
Share 20-59 years old	0.53	0.10	0.52	0.10	0.53	0.11
Share college	0.19	0.13	0.19	0.14	0.19	0.13
Population	4,382	1,830	4,343	1,764	4,434	1,893
Observations	1123602		405177		661000	

Average - by distance to the border

	(1)	(2)	(3)	(4)	(5)	(6)
Distance from border	<5 miles	5-10 m	10-20m	20-40m	40-60 m	60+ miles
Firm dynamics						
Entry rate	10.71	10.60	10.48	10.48	10.18	10.53
Exit rate	11.95	11.86	11.75	11.77	11.34	11.79
New firms per 100 people	0.33	0.32	0.32	0.33	0.31	0.32
Total firms per 100 people	2.74	2.81	2.88	2.86	2.90	2.83
Employment in new firms	78.44	81.28	87.35	84.62	83.49	83.33
Demographic data						
Share white	0.64	0.67	0.73	0.72	0.77	0.70
Share black	0.17	0.16	0.13	0.14	0.12	0.15
Share 20-59 years old	0.53	0.52	0.52	0.52	0.52	0.52
Share college	0.20	0.19	0.20	0.19	0.17	0.19
Population	4,153	4,289	4,435	4,247	4,340	4,283
Observations	112510	85713	123315	173579	31305	526422

The summary statistics are calculated with Infogroup data from 1997-2017. I discard the 1% outliers for entry and exit rate. I also discard tracts without observations for at least 16 years over the sample period. Demographic data come from the NGHIS and I use county level data when census tract data is not available.

Table A.2: County level panel regression - weighted results

	(1)	(2)	(3)	(4)	(5)	(6)
	ΔLog *Entry rate*					
Magnitude tax hike	-1.39^{c}	-1.21	-1.63	-1.04	-1.68^{b}	-1.57^{c}
	(0.44)	(0.76)	(1.13)	(0.62)	(0.74)	(0.43)
Magnitude tax cut	0.86	0.73	3.26^{b}	1.17^{a}	-0.81	0.68
	(0.67)	(0.61)	(1.27)	(0.68)	(1.11)	(0.83)
County controls	✓	✓	✓	✓	✓	✓
State policy controls	✓	✓	✓	✓	✓	✓
Year & Division FE	✓	✓	✓	✓	✓	✓
Pop Weighted	✓			✓		✓
# Counties Weighted		✓				
Border counties			✓	✓		
Adjusted R^2	0.18	0.07	0.08	0.20	0.07	0.19
Observations	20,860	20,860	8,143	8,143	12,717	12,717

	(1)	(2)	(3)	(4)	(5)	(6)
	ΔLog *Exit rate*					
Magnitude tax hike	1.28^{b}	0.14	0.68	0.67	0.51	1.69^{c}
	(0.50)	(0.78)	(1.04)	(0.50)	(1.35)	(0.57)
Magnitude tax cut	-0.48	0.77	0.53	-0.05	-1.71^{a}	-0.65
	(1.01)	(1.04)	(1.81)	(1.47)	(0.97)	(0.88)
County controls	✓	✓	✓	✓	✓	✓
State policy controls	✓	✓	✓	✓	✓	✓
Year & Division FE	✓	✓	✓	✓	✓	✓
Pop Weighted	✓			✓		✓
# Counties Weighted		✓				
Border counties			✓	✓		
Adjusted R^2	0.24	0.10	0.09	0.26	0.08	0.24
Observations	20,854	20,854	8,139	8,139	12,715	12,715

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table features population or number of counties weighted outcomes from table 1.4. Population weighs are based on the national share of a county's population. Number of counties weighs are the inverse probability of a county in a specific state being selected. This puts more weight on states with very few counties (e.g. Rhode Island), and less weighs on states that have a lot more observations due to the larger number of counties (e.g. Texas). Refer to table 1.4 for more information about the variables included in the estimation.

Table A.3: Main results - other tax policies weighted

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Interaction with	State has carryback		Sales apport. factor		State RD Tax Credit		State Inv. Tax Credit	
	Entry rate	*Exit rate*	*Entry rate*	*Exit rate*	*Entry rate*	*Exit rate*	*Entry rate*	*Exit rate*
Δ Corp. tax	-1.20[c]	1.11[b]	-1.56[a]	0.72	-1.70[c]	1.26[b]	-1.68[c]	1.27[b]
	(0.40)	(0.51)	(0.81)	(1.62)	(0.32)	(0.50)	(0.31)	(0.49)
$\Delta\tau^c \times (Carryback = 1)$	-0.59	0.09						
	(1.03)	(1.31)						
$\Delta\tau^c \times (100 - \alpha_{sales})$			0.01	0.01				
			(0.01)	(0.03)				
rdtax_corp					1.18	-0.40		
					(0.71)	(1.00)		
inv_corp							1.35	-0.52
							(0.95)	(0.82)
County controls	✓	✓	✓	✓	✓	✓	✓	✓
State policy controls	✓	✓	✓	✓	✓	✓	✓	✓
Year & Division FE	✓	✓	✓	✓	✓	✓	✓	✓
Adjusted R^2	0.18	0.24	0.17	0.24	0.18	0.24	0.18	0.24
Observations	20,390	20,388	20,728	20,721	20,390	20,388	20,390	20,388

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table features population or number of counties weighted outcomes from table 1.4. Population weighs are based on the national share of a county's population. Refer to table 1.4 for more information about the variables included in the estimation.

Table A.4: Robustness check: fixed effects model

Log *Entry rate*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Full sample fixed effect					Border pair fixed effect model			
corprate	-1.10^{b}	-1.40^{b}	-0.88^{b}	-0.67	-1.03^{a}	-3.44^{c}	-3.55^{c}	-3.24^{c}	-1.91^{a}
	(0.48)	(0.53)	(0.41)	(0.44)	(0.58)	(1.02)	(0.77)	(0.96)	(1.07)
persrate	1.01^{b}	0.38	1.03^{c}	0.78^{b}		0.36	0.34	0.26	0.68
	(0.38)	(0.41)	(0.37)	(0.37)		(0.75)	(0.38)	(0.74)	(0.69)
Demographic controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Weighted		✓					✓		
State × Recession			✓					✓	
Includes OH, MI, TX				✓					✓
State Policy controls	✓	✓	✓	✓		✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓				
Border group× yr FE						✓	✓	✓	✓
Adjusted R^2	0.45	0.49	0.45	0.44	0.44	0.81	0.93	0.81	0.80
Observations	50,432	50,432	50,432	65,726	50,432	10,808	10,808	10,808	12,210

Continued on next page

Table A.4 – *Continued from previous page*

Log *Exit rate*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Full sample county fixed effect					Border pair county fixed effects			
corprate	0.05	-0.54	-0.14	0.07	0.12	-1.98^b	-1.46	-1.05	-1.52
	(0.41)	(0.58)	(0.47)	(0.43)	(0.70)	(0.81)	(0.90)	(1.32)	(1.09)
persrate	1.51^c	0.71	1.46^c	1.20^c		0.55	-0.16	0.32	0.33
	(0.45)	(0.48)	(0.46)	(0.42)		(0.43)	(0.35)	(0.43)	(0.43)
Demographic controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Weighted		✓					✓		
State × Recession			✓					✓	
Includes OH, MI, TX				✓					✓
State Policy controls	✓	✓	✓	✓		✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓				
Border group× yr FE						✓	✓	✓	✓
Adjusted R^2	0.26	0.26	0.26	0.26	0.25	0.72	0.83	0.73	0.73
Observations	50,412	50,412	50,412	65,672	50,412	10,830	10,830	10,830	12,228

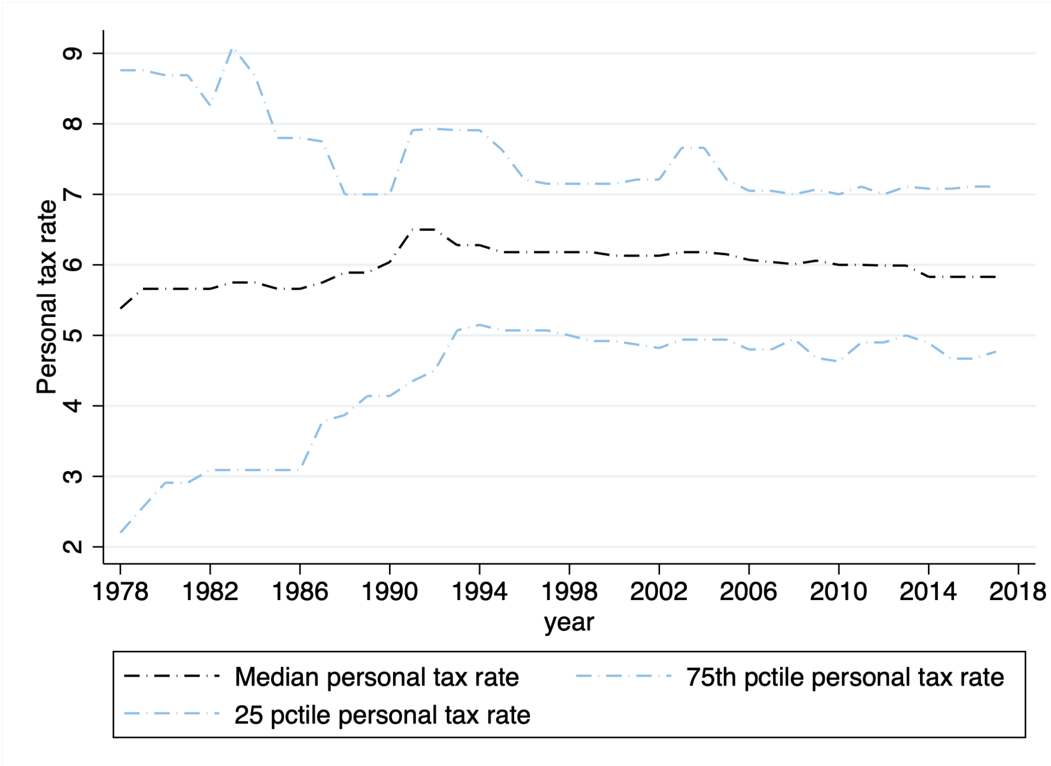
State clustered standard errors in parentheses

^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table features results from a fixed effect model. Essentially it estimates coefficients from $y_{it} = \beta\tau_{s(i)t} + \Gamma X_{st} + \Theta X_{it} + \lambda_i + \kappa_t + \varepsilon_{it}$, where y is the log entry or exit rate, λ_i are county fixed effects, while all other variables are similar from our main estimation strategy but not first differenced. In columns 6-9, we include a group-by year fixed effect, which controls for group specific shocks. See text and table 1.4 for more details on how groups are chosen. In addition, we remove Ohio, Michigan and Texas from most estimations as they experienced significant tax reforms through our sample period. When doing the border group analysis, we exclude any pair that experienced a tax change in both counties within a three year window. We also remove all states which experienced tax changes two years in a row. In some estimations, we include a state by recession fixed effects, to attenuate the impact of a tax change happening during a recession.

A.2 Additional Figures

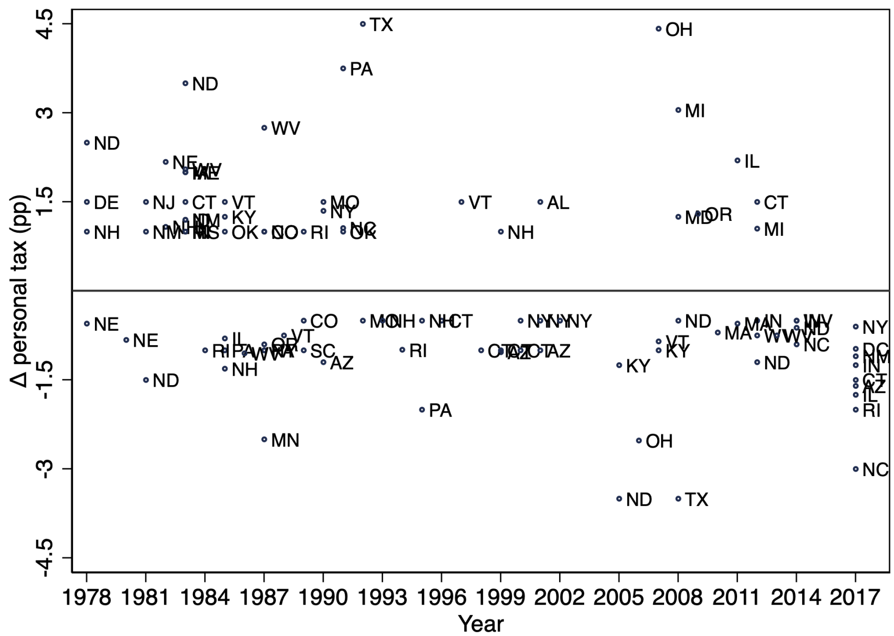
Figure A.1: Trends in State Taxation



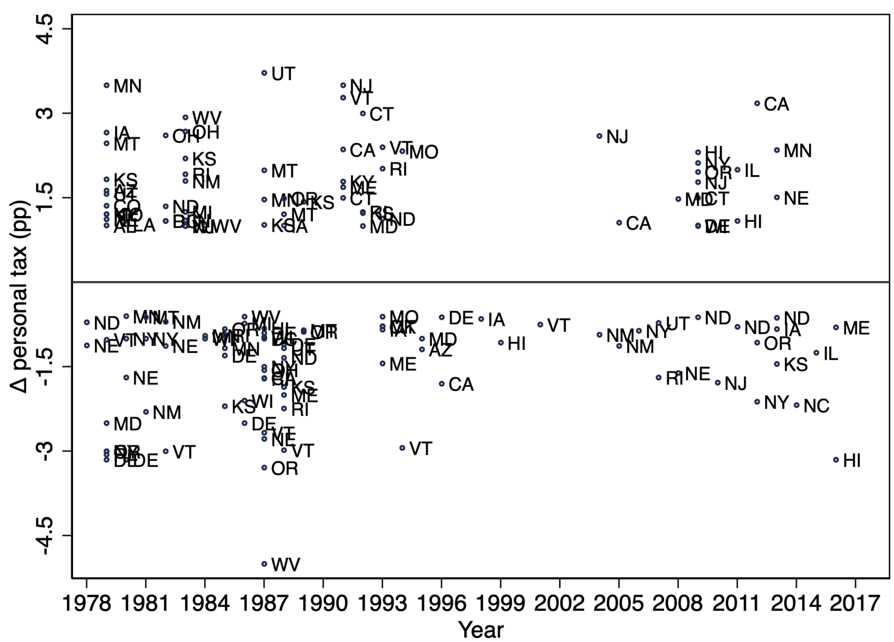
(a) Changes in corporate income tax

The figure depicts the median, 25th, and 75th percentile in state personal income tax rates.

Figure A.2: Large changes in state taxes: 1978-2016



(a) Large changes in corporate income tax

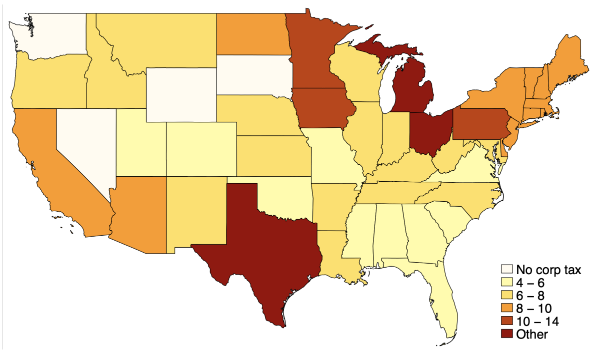


(b) Large changes in personal income tax

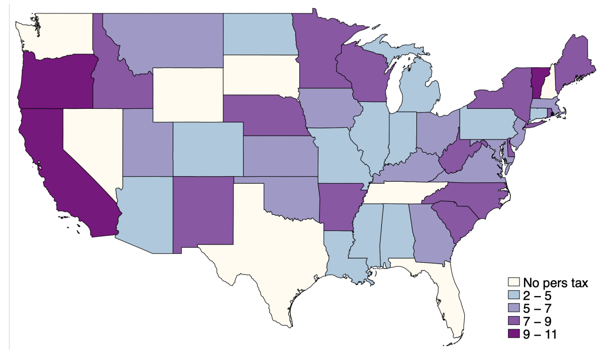
These figures depicts states experiencing large changes as defined as the 75th percentile of tax hikes and cuts respectively. The top panel shows large changes in the corporate income tax, while the bottom panel illustrates states with large changes in the personal income tax.

Figure A.3: Corporate and personal income tax average and change.

Average top marginal tax rate 1978-2017

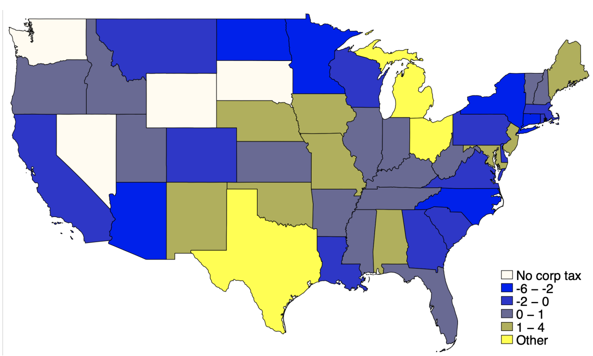


(a) Corporate income tax

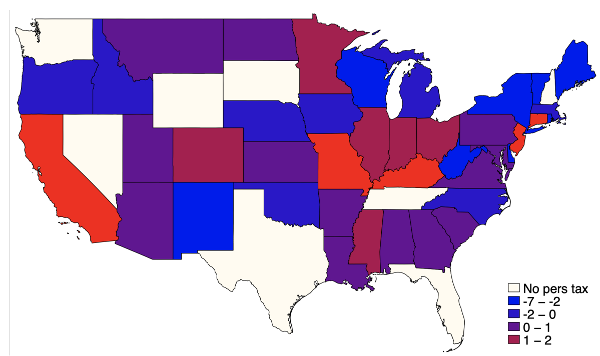


(b) Personal income tax

Change in top marginal tax rate 1978-2017



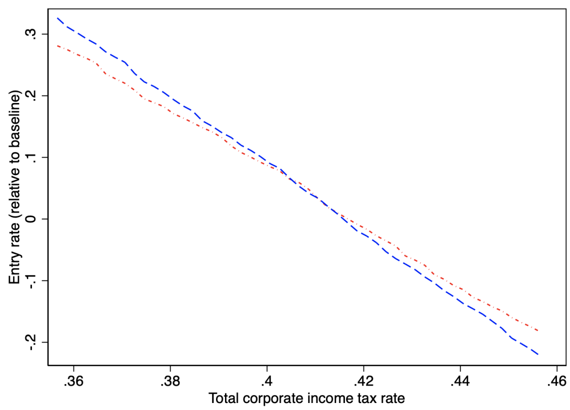
(c) Corporate income tax



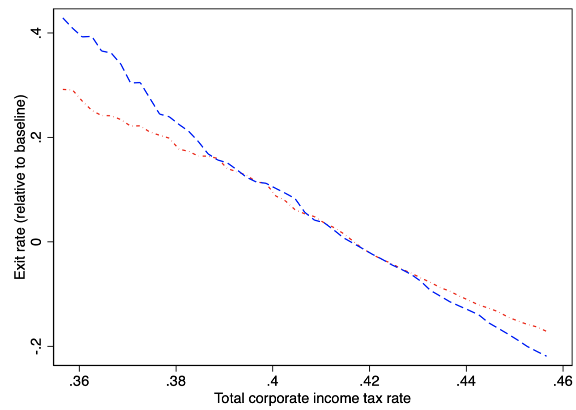
(d) Personal income tax

In this figure I show the average top marginal and personal income tax rates and the total change in top marginal tax rates between 1978 and 2017. See main text and appendix for data sources and more information on tax reforms during this time period.

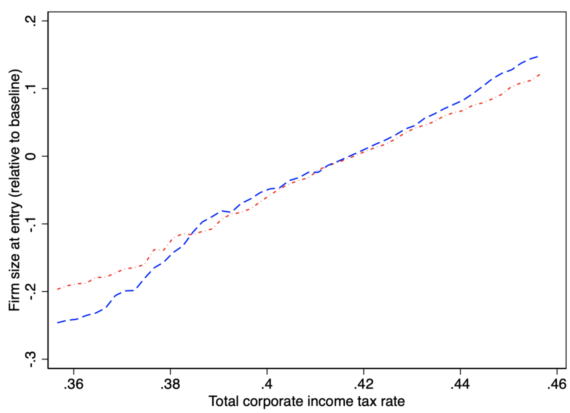
Figure A.4: Model simulation with changes in total statutory corporate tax rate



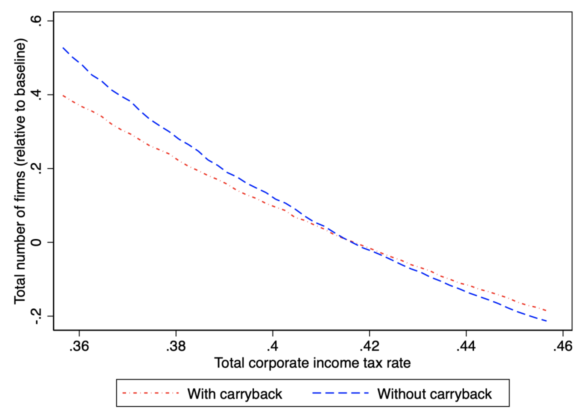
(a) Entry rate



(b) Exit rate



(c) Average size of new firms

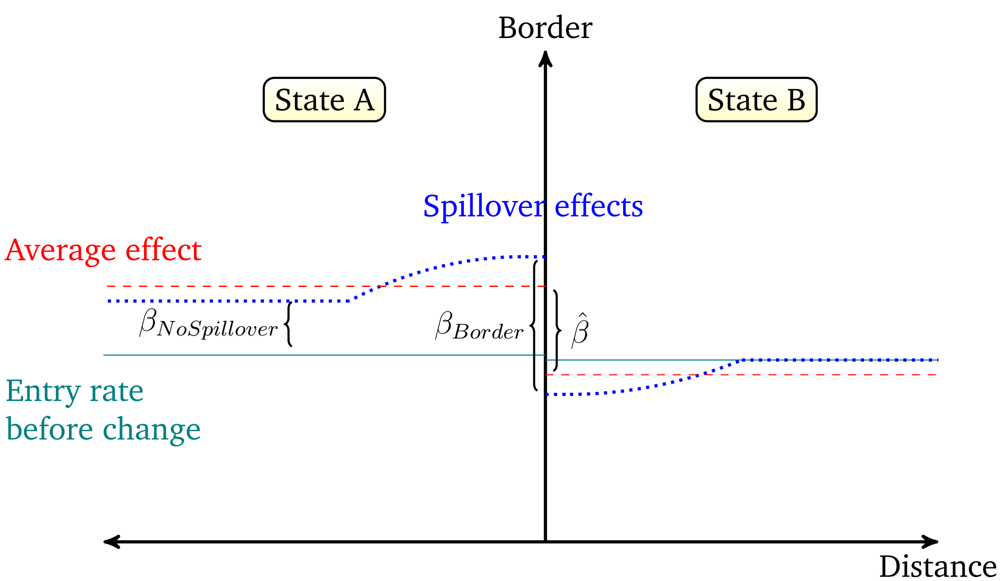


(d) Total number of firms

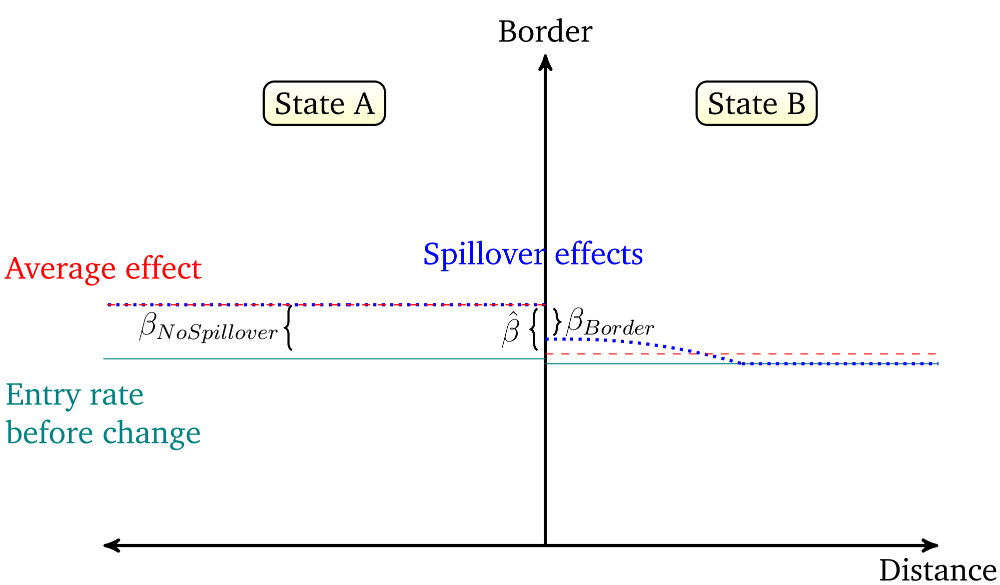
In this figure I show the results for the change in entry and exit rate, as well as average firm size and total firms in the market following a change in the tax rate on business income. General equilibrium computes optimal business decisions taking into consideration input prices adjustment (wages in the model as the price of capital is normalized to 1).

Figure A.5: Estimated coefficients and spillovers near the border

Tax cut in state A - negative spillovers



Tax cut in state A - positive spillovers



These two figures depict what happens near a state border when one state cuts the corporate income tax. I assume that the outcome variable of interest, here entry rate, goes up in the treated state and look at what happens to the estimated coefficient $\hat{\beta}$ on the tax rate differential in the presence of negative or positive spillovers.

A.3 Data

A.3.1 Important corporate tax reforms

this section I provide more information on major tax reforms and tax changes in the datasets. I focus on reforms covering the sample period (1997-2017). Unless otherwise noted, when I describe periods of taxation, I assume the starting year to be the sample start (i.e. 1997).

Ohio corporate tax reform

Until 2005, Ohio had a corporation franchise tax which taxed both the firm's net worth and the firm net income. In 2005, the net worth rate was 0.4% based on the company's equity valuation with a maximum tax bill capped at $150,000. The income tax rate worked similarly to a corporate income tax, with a rate of 5.1% on the first 50,000 of income, and a rate of 8.5% on the remaining income. Ohio decided to move to a commercial activity tax (CAT) in 2005, with a 0.26% rate on annual gross receipts over 1 million, and a minimum tax of 150 for receipts bewteen 150k and 1 million. Business with revenues lower than 150k are not taxed. The old franchise tax was phased out between 2005 and 2010, where businesses had to pay 80% of their tax liability in 2006, 60% in 2007, 40% in 2008, 20% in 2009, until the full phase out in 2010, where they only paid the CAT.

Michigan corporate tax reform

Until 2012, Michigan had a dual tax system taxing both profits and gross receipts at rate 4.95% and 0.8% respectively, with an additional 21.99% surcharge on total tax liability. In 2012, they switched to a flat net income tax rate of 6%, which was roughly similar to the previous system in terms of average tax liability.

Texas corporate tax reform

Texas uses a franchise tax on total business revenues, which varies by industries (1% for most firms, 0.5% for retailers and 0.575% for small businesses with less than 10 million in revenue in 2015). Prior to 2005, Texas had a franchise tax based on annual receipts, in addition to a surplus based on the federal taxable income plus executive compensation and taxed at 4.5%. There was an additional property tax on capital of 0.25%. Following a large decline in the tax base in the 1990s due to a loophole allowing pass-through businesses to avoid the tax, Texas passed a large reform in 2005 which went into effect in 2008.

They expanded the tax base to most pass-through entities (such as LLCs), increased the minimum threshold to pay the tax from 150k to 300k and introduced the ”margin” tax concept, where the tax base was calculated by multiplying a firm’s tax margin, defined as revenues minus one of four possible deductions, with the firm’s revenues in Texas.

A.3.2 List of corporate tax reforms 1978-2017

States with 1 corporate tax change

Alabama

- Tax hike 1.5pt in 2001

Arkansas

- Tax hike 0.5pt in 1991

Delaware

- Tax hike 1.5pt in 1978

Florida

- Tax hike .5pt in 1985

Iowa

- Tax hike 2pt in 1983

Maryland

- Tax hike 1.25pt in 2008

Mississippi

- Tax hike 1pt in 1983

South Carolina

- Tax cut -1pt in 1989

Tennessee

- Tax hike .5pt in 2003

States with 2 corporate tax changes

Alaska

- Tax cut -.4 in 2017
- Tax hike .4 in 2018

Maine

- Tax cut -.7pt in 1979
- Tax hike 2pt in 1983

Minnesota

- Tax cut -2.5pt in 1987
- Tax hike 0.3pt in 1990

Oklahoma

- Tax hike 1pt in 1985
- Tax hike 1pt in 1991

Utah

- Tax hike .35pt in 1983
- Tax hike .65pt in 1984

States with 3 corporate tax changes

California

- Tax hike .6pt in 1980
- Tax cut -.3pt in 1988
- Tax cut -.46pt in 1997

Kansas

- Tax hike .6pt in 1993
- Tax cut -.3pt in 2008
- Tax cut -.05pt in 2011

Massachusetts

- Tax cut -.7pt in 2010
- Tax cut -.55pt in 2011
- Tax cut -.25pt in 2012

Missouri

- Tax hike 1.5pt in 1990
- Tax cut -.5pt in 1992
- Tax cut -.25pt in 1994

States with 4 corporate tax changes Idaho

- Tax hike 1.2pt in 1983
- Tax hike 0.3pt in 1988
- Tax cut -.4pt in 2001
- Tax cut -.2pt in 2013

Oregon

- Tax hike .5pt in 1978
- Tax cut -.9pt in 1987
- Tax hike 1.3pt in 2009
- Tax cut -.3pt in 2011

States with 5 corporate tax changes

Pennsylvania

- Tax cut -1pt in 1985
- Tax cut -1pt in 1987
- Tax hike 3.75pt in 1991
- Tax cut 0.26pt in 1994
- Tax cut -2pt in 1995

Vermont

- Tax hike 1.5pt in 1985
- Tax cut -.75pt in 1988
- Tax hike 1.5pt in 1997
- Tax cut -.85pt in 2007
- Tax cut -.4pt in 2008

States with 6 corporate tax changes

Arizona

- Tax cut -1.2pt in 1990
- Tax cut -.3pt in 1994
- Tax cut -1.03pt in 1999
- Tax cut -1pt in 2001
- Tax cut -.47pt in 2014
- Tax cut -1.6pt in 2017

Kentucky

- Tax hike .2pt in 1981
- Tax hike 1.25pt in in 1985
- Tax hike .75pt in 1991
- Tax hike .25pt in 1992
- Tax cut -1.25pt in 2005
- Tax cut -1pt in 2007

New Mexico

- Tax hike 1pt in 1981
- Tax hike 1.2pt in 1983
- Tax hike .4pt in 1987
- Tax cut -.3pt in 2014
- Tax cut -1.1pt in 2017
- Tax cut -.3pt in 2018

Rhode Island

- Tax hike 1pt in 1983

- Tax cut -1pt in 1984
- Tax hike 1pt in 1989
- Tax hike .99pt in 1991
- Tax cut -.99pt in 1994
- Tax cut -2pt in 2017

States with 7 corporate tax changes

District of Columbia

- Tax hike .6pt in 1985
- Tax cut -.25pt in 1987
- Tax hike .25pt in 1989
- Tax cut -.25pt in 1993
- Tax cut -.275pt in 1995
- Tax cut -.975pt in 2017
- Tax cut -.75pt in 2018

Illinois

- Tax cut -.35pt in 1981
- Tax hike .8pt in 1983
- Tax cut -.8pt in 1985
- Tax hike 0.8pt in 1989
- Tax hike 2.2pt in 2011
- Tax hike -1.75pt in 2017
- Tax hike 1.75pt in 2018

Indiana

- Tax hike 1pt in 1983
- Tax hike .9pt in 1987
- Tax hike .6pt in 2003
- Tax cut -.5pt in 2012
- Tax cut -.5p in 2014
- Tax cut -1.25pt in 2017
- Tax cut -.25pt in 2018

New Jersey

- Tax hike 1.5 pt in 1981
- Tax hike .375pt in 1989
- Tax hike 0.05pt in 1990
- Tax cut -0.05pt in 1991
- Tax cut -.375pt in 1994

- Tax hike .36pt in 2006
- Tax cut -.36pt in 2010

States with 8 or more corporate tax changes

<u>Colorado</u>

- Tax hike 1pt in 1987
- Tax cut -.5pt in 1989
- Tax cut -.1pt in 1990
- Tax cut -.1pt in 1991
- Tax cut -.1pt in 1992
- Tax cut -.1pt in 1993
- Tax cut -.1pt in 1994
- Tax cut -.25pt in 1999
- Tax cut -.12pt in 2000

<u>Connecticut</u>

- Tax hike 1.5pt in 1983
- Tax cut -.25pt in 1995
- Tax cut -.5pt in 1996
- Tax cut -.25pt in 1997
- Tax cut -1pt in 1998
- Tax cut -1pt in 1999
- Tax cut -1pt in 2000
- Tax hike 1.5pt in 2012
- Tax cut -1.5pt in 2017

<u>Nebraska</u>

- Tax cut -.55pt in 1978
- Tax hike .55pt in 1979
- Tax cut -.825pt in 1980
- Tax hike 2.175pt in 1982
- Tax hike .7pt in 1983
- Tax cut -.35t in 1984
- Tax hike .35pt in 1985
- Tax cut -.35pt in 1986
- Tax hike .59pt in 1990
- Tax hike .57pt in 1991

<u>New Hampshire</u>

- Tax hike 1pt in 1978

- Tax hike 1.08pt in 1982
- Tax hike .48pt in 1983
- Tax cut -1.31pt in 1985
- Tax cut -2.5pt in 1987
- Tax cut -.5pt in 1993
- Tax cut -.5pt in 1995
- Tax hike 1pt in 1999
- Tax hike .5pt in 2001
- Tax cut -.3pt in 2017

New York

- Tax cut -1pt in 1987
- Tax hike 1.35pt in 1990
- Tax cut -.225pt in 1994
- Tax cut -.45pt in 1995
- Tax cut -.45pt in 1996
- Tax cut -.225pt in 1997
- Tax cut -.5pt in 2000
- Tax cut -.5pt in 2001
- Tax cut -.5pt in 2002
- Tax cut -.4pt in 2008
- Tax cut -.6pt in 2017

North Carolina

- Tax hike 1pt in 1987
- Tax hike 1.06pt in 1991
- Tax cut -.0775pt in 1992
- Tax cut -.0775pt in 1993
- Tax cut -.0775pt in 1994
- Tax cut -.0775pt in 1995
- Tax cut -.25pt in 1997
- Tax cut -.25pt in 1998
- Tax cut -.25pt in 1999
- Tax cut -.1pt in 2000
- Tax cut -.9pt in 2014
- Tax cut -3pt in 2017

North Dakota

- Tax hike 2.5pt in 1978
- Tax cut -1.5pt in 1981

- Tax hike 3.5pt in 1983
- Tax cut -3.5pt in 2005
- Tax cut -.5pt in 2008
- Tax cut -.1pt in 2010
- Tax cut -1.2pt in 2012
- Tax cut -.05pt in 2013
- Tax cut -0.62pt in 2014
- Tax cut -.22pt in 2017

West Virginia

- Tax hike 2.05pt in 1983
- Tax cut -1.05pt in 1986
- Tax hike 2.75pt in 1987
- Tax cut -.15pt in 1989
- Tax cut -.15pt in 1990
- Tax cut -.15pt in 1991
- Tax cut -.3pt in 1993
- Tax cut -.25pt in 2008
- Tax cut -.25pt in 2009
- Tax cut -.75pt in 2012
- Tax cut -.75pt in 2013
- Tax cut -.5pt in 2014

A.3.3 Matching and additional analysis

In this section I present additional results at the census tract level using a matching estimations.

Census tract level

The main matching techniques uses observable characteristics to combine tracts that are most similar. I create an similarity index based on both demographics (population, share of black, white, college educated, and 20-59 year old inhabitants) and economic characteristics (total firms, firm entries, firms exits, employment in new firms). I find the average of each characteristics for years 1997-1999 and then subtract the national mean and divide by the standard error of each characteristics across all tracts in the same period. I then define the similarity index between two tracts as

$$I_{c1,c2} = \sum \left(\frac{\bar{y}_{c1} - \bar{y}}{\sqrt{var(y)}} - \frac{\bar{y}_{c2} - \bar{y}}{\sqrt{var(y)}} \right)^2$$

which is essentially the sum of the squared difference between the tracts. I then match each tract to the 10 closest tracts according to $I_{c1,c2}$. I define 3 indexes, one based on demographic characteristics, one based on economic characteristics, and the combination of the two. For all indexes I use population as a parameter. Given the large potential of tracts, I restrict the potential matching sample to the 500 closest tracts (the average number of pairs by tract when restricting to areas within 50 miles of the border and tracts within 50 miles of each other is close to 700).

The second matching technique is based on distance between census tracts. For each tract I find the closest 10 tracts across the border. I then compute the difference in outcomes across tracts. Second, I perform the same matches but limiting the sample to tracts in border counties.In areas with small counties, it is not unusual to have the majority of potential tract matches to not be located in a border county.

The last matching technique randomizes the choice of matches within specific subsets. Within each particular subset, I randomly select 10 matching tracts for the analysis. One particular subset is limiting matches to tract in border counties. The main reason is so that I can compare the results to the county border differential estimates. The second subset uses the 100 closest tracts by distance, or the 100 closest tracts by the overall index.

Under the assumptions that spillover will be larger as firms are closer to the border, I look at the effect of changes in corporate tax rates based on distance between the census tract and the closest border. I categorize spillover effects into two main categories. The

first one is
I evaluate the following model

$$\ddot{y}_{c_1c_2t} = \beta\ddot{\tau}_{s(c_1)s(c_2)t} \times Dist + \Theta\ddot{X}_{c_1c_2t} + \lambda_{c_1c_2} + \varepsilon_{it} \tag{A.1}$$

where $x_{\ddot{c_1c_2}} = x_{c1} - x_{c2}$ is the average difference between matched census tracts.

Table A.5: State taxes - effect on *log entry rate*

Index		20 full index			20 dem	20 bus	10 all	10 dem	10 closest
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Corp rate	-0.67^b		-0.75^b	-0.71^b	-0.74^b	-0.63^b	-0.69^b	-0.70^b	-0.82^a
	(0.32)		(0.31)	(0.30)	(0.30)	(0.27)	(0.29)	(0.28)	(0.41)
Pers rate		0.06	0.73	1.04	1.12	1.10	1.13	1.15	1.22
		(0.75)	(0.80)	(0.84)	(0.85)	(0.82)	(0.87)	(0.88)	(0.89)
Weighted	✓	✓	✓	✓	✓	✓	✓	✓	✓
Other policy				✓	✓	✓	✓	✓	✓
R^2	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
N (in 1000s)		891		860	840	879	817	798	797

^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

A.4 Theory

A.4.1 General Equilibrium Model

I use a general equilibrium model with heterogeneous firms in perfect competition and a representative household. Household utility is given by $U(C, N) = \log C - vN$, where v represents the disutility of labor. Household discount the future at rate β. Firms produce a homogeneous good according to the production function $y = f(z, k, l)$, where z represents a the firm's total factor of productivity, and k and l are capital and labor inputs respectively. Productivity follows a Markov process which implies that the firm's output each period is uncertain. Firms also face a random cost of production c_f, which is a fixed cost for remaining operational. Each period firms decide how much to invest and how many people to hire. Investment is denoted as $i = k - (1 - \delta)k_{-1}$, where δ is capital depreciation, and k_{-1} is stock of capital from the previous period. Firms pay a capital income tax τ on profits. Firms also face a cost of capital adjustment specified as $\phi(k, k_{-1})$ and labor can be adjusted without any costs.

At the beginning of each period, firms decided whether to continue operating or exit the market.[1] Continuing firms then learn their productivity draw z and their profit is $\pi = y - wn - i - c_f - \phi(k, k_{-1})$. If a firm exits they sell their remaining capital and make a profit of $\pi = (1 - \delta)k_{-1} - \phi(0, k_{-1})$. Entry in the market is free but firms must pay an entry cost of c_e. Entrants know their lagged productivity z_{-1} and decided whether to enter or not based on their expected value function. As such they behave as incumbents where the main difference is that they do not pay adjustment cost for their initial capital investment upon entering.

Firms are taxed at rate τ on their economic profit. Firms can deduct labor costs, the fixed cost of production and the capital adjustment cost. Entrants cannot deduct the entry cost. Investment can be expensed gradually as was the case in the United States until 2017. I assume that tax depreciation is the same as economic depreciation, which implies firms can deduct δk from their tax bill. I assume that firms exiting the market do not pay taxes on selling the remaining capital (which is equivalent to a negative investment).[2] The tax bill is then $T_c = \tau(\pi_c + i - \delta k)$ for continuing firms, and $T_x = \tau(\pi_x + i) = -\tau\phi(0, k_{-1})$. Importantly, I assume that firms can carryback their operating loss when they exit, hence making tax bill is negative for exiting firms.[3] I assume the government runs a balanced

[1] One could model the firm's decision after observing their productivity draw. However, this specification makes solving the model more tractable, as discussed in Hopenhayn and Rogerson (1993)

[2] Some states have capital income gains taxes in place. The model assumes a constant price of capital so capital gains taxes would not affect firms decisions.

[3] Firms could carry back losses up two years until 2017 federally. Several states allow carrybacks between

budget and returns tax collections in the form of a negative lump sum tax to households.

We can now turn to the value function. Given that households own the firms and discount the future, the implied interest rate in a stationary equilibrium is $r = 1/(\beta - 1)$. The firm value function before making the exit decision is

$$V(z_{-1}, k_{-1}) = \max \left\{ \underbrace{\mathbb{E}\{\max_{k,l} \pi_c - T_c + \frac{1}{1+r} V(z,k)\}}_{\text{Continuation value}}, \underbrace{\pi_x - T_x}_{\text{Exit value}} \right\}$$

We can now define a productivity value z^*_{-1} at which the firm is indifferent between continuing and exiting. The cutoff is increasing in input prices (namely the wage rate) and production costs, as they lower the present value of the firm and drive out lower productivity firms. I assume that there is a positive mass of entrants in equilibrium, which implies that the cost of entry is equal the the expected value of entrants, $c_e = \mathbb{E}[V_e(z_{-1})]$. The value for new firms is also declining in the wage rate and production cost c_f. Note that it is also declining in the cutoff level, since it increases the likelihood a firm will exit in the future, and reduces its expected value.

Total labor demand, investment (including fixed costs and adjustment costs) and capital are denoted by L, I and K, total output by Y. The price of goods is normalized to 1. I can define the equilibrium as

- Optimal decision rule by firms for labor (n), investment (i) and exit (z^*_{-1})
- Optimal decision rule by household for consumption (C) and labor supply (N)
- Government tax rate (τ)
- Mass of entrant M_e and wage rate w which clear the labor and goods market.

which solve the household and the firms objective function, satisfy the free entry condition, balance the government's budget, and clear the labor market. While I cannot derive close-formed predictions, in the next section I discuss the effect of tax changes qualitatively and focus on the direct and indirect effects. I then simulate the model and derive the new exit and entry rates, as well as firm size and optimal labor and capital.

Calibration Following Sedlacek and Sterk (2019) I parametErize the fixed operational cost c_f as stochastic following a logistic distribution with mean μ_f and standard deviation $_f$. This implies that all firms have a positive probability of continuing, regardless of their

2 and 3 years (e.g. California, Idaho, Missouri, Oklahoma, Mississippi, Georgia, West Virginia, Virginia, Delaware and Maryland had a 2-year carryback provision, while Montana, Wyoming, Utah, South Dakota and New York had a 3-year provision in 2017.) In the simulation, I also look at the effect of tax reform on entry and exit without carryback rules.

productivity draw. The discount factor β is set to 0.96 (roughly equivalent to a 4% interest rate). The production function is $y = z(k^{\alpha}l^{1-\alpha})^{\theta}$, with the share of capital income $\alpha = 0.35$, and the span of control θ=0.9.[4]. The capital depreciation rate is set to $\delta = 0.08$. Productivity follows a log normal distribution $\log z = \mu_z + \rho_z log z_{-1} + \epsilon$, with $\epsilon \sim N(0, \sigma_z^2)$. The remaining parameters (mean of TFP shocks - μ, dispersion of TFP shocks - , auto correlation of TFP shocks - ρ_z, mean of cost shocks - μ_f, the adjustment costs parameters ζ_0 and ζ_1) are set such that the model matches specific statistics from the data. Note that the disutility of labor v is set so that the wage rate is normalized to 1, and the entry cost c_e is set to normalize the mass of new firms to 1.The calibration process and specific matching moments is described in the appendix. Parameter values and the statistics targets in the model are shown and discussed in the appendix. I calibrate the model with a starting tax rate of 41.6%, which is equivalent to the sum of the statutory federal tax rate of 35% between 1993 and 2017, and the average state corporate income tax between 1997 and 2017 (6.6%).

The target parameters and outputs from the calibration are shown on the following table:

[4]These values are standard in the macroeconomics literature, and span of control being in the range documented by Basu and Fernald (1997)

Parameters		Value
r	Discount rate	0.04
α	Capital share	0.35
θ	Span of control	0.90
δ	Depreciation rate	0.08
ρ_z	Autocorrelation of TFP shocks	0.38
σ_z	Standard Deviation of TFP shocks	0.19
μ_z	Mean of TFP shocks	0.26
μ_H	Mean of cost shocks	2.20
σ_H	Dispersion of cost shocks	2.95
ζ_0	Non-convex adjustment costs	0.001
ζ_1	Convex adjustment costs	0.27
c_e	Entry cost	1.55
υ	Disutility of labor	0.01
τ	Tax rate	0.416

Parameter values

Target	Data	Model
Investment rate mean	0.12	0.10
Investment rate standard deviation	0.34	0.41
Investment autocorrelation	0.06	0.05
Inaction rate	0.08	0.07
Average exit rate	0.09	0.10
Relative exit rate	2.2	2.2
Average size	21	19

Targets: data and model

APPENDIX B

Chapter II Supporting Material

B.1 Additional Tables

Table B.1: Data description for selected variables

Variable	Description
HPI	Average house price index at the county level
Nav	Net assessed value of properties at the county level
Mill rate	Property tax on $\$1,000$ of assessed value averaged at the county level
Aggregate levy limit	Limit on the growth of levy at the jurisdiction level
Jurisdiction rate limit	Limit on the growth of mill rate at the jurisdiction level
Assessment limit overall	Presence of assessment limit in the county
Demographic controls	Share of white population, share of black population share of population age 20-29, share of population age 30-39 share of population age 40-49, share of population age 50-59 share of college educated population, share of urban area in county unemployment rate
Public finance controls	Fraction of own source revenues Fraction of property tax on total revenues Fraction of other taxes on total revenues Fraction intergovernmental revenues on total revenues
Income controls	Personal income, employment income, wage income

Table B.2: Summary Statistics: limits by state

	Assessment limit	Rate limit on property	Rate limit for jurisdiction	Levy limit on property	Levy limit in aggregate
Alabama			✓	✓	
Alaska					✓
Arizona	✓	✓		✓	✓
Arkansas	✓		✓		✓
California	✓	✓		✓	
Colorado	✓	✓	✓		✓
Connecticut	✓				
Delaware			✓	✓	
District of Columbia	✓				✓
Florida	✓		✓		
Georgia	✓		✓		
Hawaii	✓				
Idaho			✓		✓
Illinois	✓		✓		✓
Indiana		✓			✓
Iowa	✓	✓	✓		
Kansas					✓
Kentucky			✓		✓
Louisiana			✓		✓
Maine					✓
Maryland	✓				
Massachusetts			✓		✓
MichigaObservations	✓		✓		✓
Minnesota					✓
Mississippi					✓
Missouri			✓		✓
Montana	✓				✓
Nebraska			✓		✓
Nevada		✓		✓	✓
New Hampshire					
New Jersey					✓
New Mexico	✓	✓	✓		✓
New York	✓		✓		✓
North Carolina			✓		
North Dakota			✓		✓
Ohio		✓	✓		✓
Oklahoma	✓	✓			
Oregon	✓	✓	✓		
Pennsylvania			✓		✓
Rhode Island					✓
South Carolina	✓		✓		
South Dakota					✓
Tennessee					✓
Texas	✓		✓		✓
Utah			✓		✓
Vermont					
Virginia					✓
Washington		✓	✓		✓
West Virginia		✓	✓		✓
Wisconsin			✓		✓
Wyoming			✓		

Notes: Data from Paquin (2015) and Lincoln Institute and of Public Policy (2021*b*)

Table B.3: Summary Statistics: by local property tax limits

	No levy limits					Aggregate levy limit				
$\Delta Year$	Mean	p50	p25	p75	sd	Mean	p50	p25	p75	sd
%Δ HPI	0.33	0.29	-3.00	3.44	6.49	0.41	0.28	-2.34	2.87	4.83
%Δ NAV per cap	1.91	0.69	-1.78	4.58	8.13	1.43	0.14	-2.07	3.38	7.73
%Δ Levy per cap	1.94	1.30	-1.44	4.61	7.37	2.42	1.54	-0.94	4.85	8.30
%Δ Mill rate	0.11	0.00	-1.26	1.79	6.23	1.28	0.45	-1.57	3.66	8.95
Observations	11884					26501				
	No levy limits					Aggregate levy limit				
$\Delta 2007-2012$	Mean	p50	p25	p75	sd	Mean	p50	p25	p75	sd
%Δ HPI	-23.62	-20.87	-32.55	-13.17	13.88	-14.85	-13.50	-22.32	-7.46	12.08
%Δ NAV per cap	-0.56	-1.24	-12.18	10.41	21.71	5.33	0.90	-8.56	13.57	21.69
%Δ Levy per cap	3.11	3.65	-5.75	13.10	17.18	11.50	8.64	0.32	18.69	17.90
%Δ Mill rate	4.95	2.76	-0.75	9.57	11.97	7.39	4.00	-3.20	16.25	18.01
Observations	713					1556				
	No levy limits					Aggregate levy limit				
$\Delta 2007-2015$	Mean	p50	p25	p75	sd	Mean	p50	p25	p75	sd
%Δ HPI07_15	-19.85	-20.08	-27.51	-12.39	11.31	-12.18	-13.11	-21.24	-4.72	13.78
%Δ NAV per cap	3.80	-0.59	-15.49	14.10	32.50	11.33	2.27	-11.34	18.51	38.53
%Δ Levy per cap	6.75	6.39	-6.78	17.02	22.37	18.19	12.87	0.55	29.34	27.07
%Δ Mill rate	5.56	3.49	-0.57	12.53	14.98	9.57	6.56	-3.49	21.33	25.07
Observations	714					1536				
	No rate limits					Juris. rate limit				
$\Delta Year$	Mean	p50	p25	p75	sd	Mean	p50	p25	p75	sd
%Δ HPI	0.60	0.31	-2.85	3.61	6.32	0.28	0.28	-2.42	2.85	5.06
%Δ NAV per cap	2.55	0.69	-1.50	5.07	9.38	1.15	0.12	-2.19	3.28	7.05
%Δ Levy per cap	2.63	1.74	-0.67	5.17	7.19	2.11	1.37	-1.30	4.59	8.36
%Δ Mill rate	0.39	0.10	-1.43	3.05	7.76	1.15	0.26	-1.46	3.04	8.41
Observations	11633					26752				
	No rate limits					Juris. rate limit				
$\Delta 2007-2012$	Mean	p50	p25	p75	sd	Mean	p50	p25	p75	sd
%Δ HPI	-19.92	-17.22	-27.45	-10.64	14.53	-17.03	-15.69	-24.77	-7.99	12.77
%Δ NAV per cap	7.45	3.70	-5.55	15.49	22.72	1.73	-1.59	-10.32	11.21	21.24
%Δ Levy per cap	11.41	8.94	1.82	17.90	16.18	7.77	5.77	-2.98	16.46	18.79
%Δ Mill rate	5.85	4.27	-2.70	13.43	15.97	6.99	3.15	-1.96	14.17	16.60
Observations	707					1562				
	No rate limits					Juris. rate limit				
$\Delta 2007-2015$	Mean	p50	p25	p75	sd	Mean	p50	p25	p75	sd
%Δ HPI	-17.42	-17.54	-26.02	-10.08	12.96	-13.72	-15.26	-22.84	-5.20	13.54
%Δ NAV per cap	11.70	5.39	-6.67	19.55	32.68	7.64	-1.48	-14.06	16.31	38.60
%Δ Levy per cap	17.58	13.63	4.76	25.90	20.47	13.13	8.41	-4.52	23.46	28.36
%Δ Mill rate	8.90	6.68	-0.60	19.20	19.29	8.00	4.16	-2.55	17.03	23.72
Observations	704					1546				

All values are adjusted for inflation with 2000 as the base year. Jurisdiction rate limits are limits on what mill a local jurisdiction can impose. Aggregate levy limits are limit on the maximum growth in tax levy.

Table B.4: The tax base: Home price index and assessed values 2

Dep. var: Δ ***Log NAV per capita***	(1)	(2)	(3)	(4)	(5)	(6)
Years	All	All	< 2008	$\geq$2008	< 2008	$\geq$2008
$(\log HPI_t - \log HPI_{t-3}) > 0$	0.17^c	0.15^c	0.19^c	0.13^c	0.18^c	0.09^c
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
$\lvert(\log HPI_t - \log HPI_{t-3}) < 0\rvert$	-0.18^c	-0.19^c	0.66^b	-0.18^c	0.28^c	-0.19^c
	(0.01)	(0.02)	(0.29)	(0.01)	(0.05)	(0.02)
Weighted		✓			✓	✓
R^2	0.14	0.30	0.22	0.10	0.39	0.26
Observations	23,814	23,814	7,487	16,327	7,487	16,327

Standard errors are clustered at the county level to take into account county level policy and serial correlation. All variables except for the mill rate are adjusted for inflation using the GDP deflator and using 2000 as the reference year. HPI denotes the home price index and is provided by the Federal Housing Finance Agency. NAV refers to Net Assessed Value and represents the tax base on which is levied ad valorem property taxes. Weights are based on the average national share in the county population between 2000 and 2010.The independent variables are the three year first difference in home prices between 2002 and 2015.

Table B.5: The policy effect: the tax base and property tax revenues - 2

	(1)	(2)	(3)	(4)
	$\Delta \log mill$		$\Delta \log levy\ cap$	
$(\log HPI_t - \log HPI_{t-3}) > 0$	-0.09^c	-0.07^c	0.07^c	0.05^c
	(0.01)	(0.02)	(0.01)	(0.01)
$\lvert(\log HPI_t - \log HPI_{t-3}) < 0\rvert$	0.05^c	0.06^c	-0.12^c	-0.09^c
	(0.01)	(0.02)	(0.01)	(0.02)
Weighted		✓		✓
R^2	0.05	0.09	0.11	0.24
Observations	22,534	22,534	22,534	22,534

	(1)	(2)	(3)	(4)
	$\Delta \log mill$		$\Delta \log levy\ cap$	
Years	< 2008	$\geq$2008	< 2008	$\geq$2008
$(\log HPI_t - \log HPI_{t-3}) > 0$	-0.14^c	-0.04^c	0.08^c	0.07^c
	(0.01)	(0.01)	(0.01)	(0.01)
$\lvert(\log HPI_t - \log HPI_{t-3}) < 0\rvert$	-0.47^b	0.06^c	0.57^c	-0.12^c
	(0.22)	(0.01)	(0.22)	(0.01)
R^2	0.07	0.04	0.18	0.10
Observations	7,087	15,447	7,087	15,447

Standard errors are clustered at the county level to take into account county level policy and serial correlation. All variables except for the mill rate are adjusted for inflation using the GDP deflator and using 2000 as the reference year. HPI denotes the home price index and is provided by the Federal Housing Finance Agency. NAV refers to Net Assessed Value and represents the tax base on which is levied ad valorem property taxes. Weights are based on the average national share in the county population between 2000 and 2010. The independent variables are the three year first difference in home prices between 2002 and 2015.

Table B.6: The Great Recession: disentangling the tax base and policy effect - Pop Weighted

Dep. var: Δ ***Log levy per capita***	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta \log NAV$	0.37^c		0.33^b		0.29^a	
	(0.13)		(0.12)		(0.17)	
$\Delta \log NAV > 0$		0.54^c		0.48^c		0.59^c
		(0.15)		(0.15)		(0.16)
$\|\Delta \log NAV < 0\|$		-0.30		-0.30^b		-0.23
		(0.20)		(0.14)		(0.21)
R^2	0.24	0.26	0.25	0.26	0.16	0.20
Observations	2,176	2,176	2,205	2,205	2,161	2,161

Dep. var: Δ ***Log mill rate***	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta \log NAV$	-0.55^c		-0.63^c		-0.65^c	
	(0.14)		(0.13)		(0.18)	
$\Delta \log NAV > 0$		-0.35^c		-0.35^c		-0.24^c
		(0.12)		(0.10)		(0.09)
$\|\Delta \log NAV < 0\|$		0.65^c		0.67^c		0.74^c
		(0.22)		(0.16)		(0.22)
R^2	0.39	0.42	0.55	0.56	0.48	0.52
Observations	2,175	2,175	2,204	2,204	2,160	2,160

Standard errors are clustered at the county level to take into account county level policy and serial correlation. This table presents results from table 2.6 weighting outcomes. Weights are based on the average national share in the county population between 2000 and 2010.

Table B.7: The Great Recession: The role of rate and levy limits 2007-2012 (by jurisdiction)

Dep. var: Δ ***Log levy per capita***	(1)	(2)	(3)	(4)
Years	Yearly Δ for years 2007-2012			
$\Delta \log NAV_t > 0$	0.70^c	0.63^c	0.76^c	0.42^c
	(0.02)	(0.02)	(0.06)	(0.07)
$\|\Delta \log NAV_t < 0\|$	-0.33^c	-0.42^c	-0.51^c	-0.42^c
	(0.03)	(0.02)	(0.07)	(0.03)
$\Delta \log NAV_t > 0 \times jurisd.\ rate\ limit$	-0.08^c		-0.36^c	
	(0.03)		(0.07)	
$\|\Delta \log NAV_t < 0\| \times jurisd.\ rate\ limit$	-0.16^c		0.06	
	(0.04)		(0.09)	
$\Delta \log NAV_t > 0 \times ind.\ property\ levy\ lim.$		0.22^c		0.47^c
		(0.03)		(0.07)
$\|\Delta \log NAV_t < 0\| \times ind.\ property\ levy\ lim.$		-0.29^c		-0.24^b
		(0.03)		(0.05)
R^2	0.38	0.38	0.41	0.43
Observations	12,877	12,877	12,877	12,877

Dep. var: Δ ***Log mill rate***	(1)	(2)	(3)	(4)
Years	Yearly Δ for years 2007-2012			
$\Delta \log NAV_t > 0$	-0.29^c	-0.30^c	-0.24^c	-0.52^c
	(0.02)	(0.02)	(0.06)	(0.07)
$\|\Delta \log NAV_t < 0\|$	0.66^c	0.52^c	0.49^c	0.52^c
	(0.03)	(0.02)	(0.07)	(0.03)
$\Delta \log NAV_t > 0 \times jurisd.\ rate\ limit$	0.00		-0.28^c	
	(0.02)		(0.07)	
$\|\Delta \log NAV_t < 0\| \times jurisd.\ rate\ limit$	-0.21^c		0.03	
	(0.04)		(0.09)	
$\Delta \log NAV_t > 0 \times ind.\ property\ levy\ lim.$		0.06^c		0.29^c
		(0.02)		(0.07)
$\|\Delta \log NAV_t < 0\| \times ind.\ property\ levy\ lim.$		-0.04^c		-0.04^c
		(0.03)		(0.09)
R^2	0.20	0.20	0.35	0.41
Observations	12,877	12,877	12,877	12,877
Pop. Weighted			✓	✓

Standard errors are clustered at the county level to take into account county level policy and serial correlation. This table presents results from table 2.7 using jurisdiction rate limits rather than overall rate limits. Jurisdiction rate limits are specified as limits on the mill rate a local jurisdiction can impose. Levy limits on individual property are limits that restrict the maximum effective tax rate on a property to a certain percentage, either based on market value or assessed value. See text and appendix for more details on the data sources and which states have such limits.

Table B.8: The Great Recession: the role of limits - long differences - Pop Weighted

Dep. var: Δ ***Log levy per capita***	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta \log NAV > 0$	0.47^{c}	0.92^{c}	0.53^{c}	0.85^{c}	0.65^{c}	1.08^{c}
	(0.09)	(0.22)	(0.12)	(0.22)	(0.13)	(0.18)
$\|\Delta \log NAV < 0\|$	-0.03	-0.60^{c}	0.01	-0.62^{c}	0.11	-0.70^{c}
	(0.11)	(0.06)	(0.05)	(0.13)	(0.09)	(0.06)
$\Delta \log NAV > 0 \times rate\ lim$	0.12		-0.08		-0.08	
	(0.24)		(0.24)		(0.25)	
$\|\Delta \log NAV < 0\| \times rate\ lim$	-0.30		-0.35^{b}		-0.36	
	(0.24)		(0.16)		(0.24)	
$\Delta \log NAV > 0 \times agg\ levy\ lim$		-0.52^{b}		-0.45		-0.58^{b}
		(0.25)		(0.27)		(0.24)
$\|\Delta \log NAV < 0\| \times agg\ levy\ lim$		0.75^{c}		0.54^{c}		0.77^{c}
		(0.18)		(0.18)		(0.16)
r2	0.27	0.44	0.28	0.41	0.21	0.43
N	2,176	2,176	2,205	2,205	2,161	2,161

Dep. var: Δ ***Log mill rate***	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta \log NAV > 0$	-0.54^{c}	-0.09	-0.47^{c}	-0.15	-0.35^{b}	0.07
	(0.09)	(0.22)	(0.11)	(0.22)	(0.13)	(0.18)
$\|\Delta \log NAV < 0\|$	0.94^{c}	0.32^{c}	1.00^{c}	0.33^{b}	1.08^{c}	0.23^{c}
	(0.11)	(0.07)	(0.05)	(0.15)	(0.10)	(0.08)
$\Delta \log NAV > 0 \times rate\ lim$	0.31^{a}		0.18		0.14	
	(0.17)		(0.18)		(0.17)	
$\|\Delta \log NAV < 0\| \times rate\ lim$	-0.32		-0.37^{b}		-0.37	
	(0.26)		(0.17)		(0.26)	
$\Delta \log NAV > 0 \times agg\ levy\ lim$		-0.36		-0.25		-0.38^{a}
		(0.24)		(0.24)		(0.20)
$\|\Delta \log NAV < 0\| \times agg\ levy\ lim$		0.82^{c}		0.58^{c}		0.84^{c}
		(0.19)		(0.19)		(0.17)
r2	0.43	0.57	0.58	0.66	0.53	0.68
N	2,175	2,175	2,204	2,204	2,160	2,160

This table presents weighted results for table 2.8. Weights are based on the average national share in the county population between 2000 and 2010.

Table B.9: Tax base versus policy effect: taking stock - Limited sample

Dep. var: Δ ***Log NAV per capita***	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta \log HPI$	-0.01		0.16^c		0.21^b	
	(0.09)		(0.06)		(0.09)	
$\Delta \log HPI > 0$		-0.02		0.18		0.37
		(0.42)		(0.25)		(0.69)
$\lvert\Delta \log HPI < 0\rvert$		0.01		-0.16^c		-0.21^b
		(0.09)		(0.06)		(0.10)
R^2	0.00	0.00	0.06	0.06	0.04	0.04
Observations	1,686	1,686	1,713	1,713	1,686	1,686

Dep. var: Δ ***Log levy per capita***	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta \log NAV$	0.46^c		0.42^c		0.47^c	
	(0.08)		(0.09)		(0.10)	
$\Delta \log NAV > 0$		0.57^c		0.65^c		0.64^c
		(0.09)		(0.11)		(0.10)
$\lvert\Delta \log NAV < 0\rvert$		-0.22		-0.17		-0.18
		(0.18)		(0.15)		(0.20)
R^2	0.31	0.35	0.26	0.35	0.31	0.39
Observations	1,686	1,686	1,713	1,713	1,686	1,686

The top panel of this table presents results from table 2.9 limiting the sample where both levy and assessed values are available for the years evaluated (2007-2015). The bottom panel estimates the top panel of table 2.6, limiting the sample where the Home Price Index is available.

Table B.10: Tax base versus policy effect: taking stock - Weighted results

Dep. var: Δ ***Log levy per capita***	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta \log HPI$	-0.00		0.10		0.09	
	(0.08)		(0.07)		(0.13)	
$\Delta \log HPI > 0$		1.47^c		1.46^c		1.11^c
		(0.35)		(0.38)		(0.14)
$\lvert\Delta \log HPI < 0\rvert$		0.00		-0.10		-0.08
		(0.08)		(0.07)		(0.14)
R^2	0.00	0.01	0.08	0.09	0.02	0.07
Observations	1,686	1,686	1,713	1,713	1,686	1,686

Dep. var: Δ ***Log mill rate***	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2010		2007-2012		2007-2015	
$\Delta \log HPI$	-0.13^c		-0.24^c		-0.34^c	
	(0.05)		(0.08)		(0.11)	
$\Delta \log HPI > 0$		0.37		0.28		2.41^c
		(1.46)		(1.28)		(0.86)
$\lvert\Delta \log HPI < 0\rvert$		0.13^c		0.24^c		0.39^c
		(0.05)		(0.08)		(0.11)
R^2	0.11	0.12	0.27	0.27	0.17	0.39
Observations	1,685	1,685	1,712	1,712	1,685	1,685

This table presents weighted results for table 2.9. Weights are based on the average national share in the county population between 2000 and 2010.

Table B.11: Correlations between changes in income, demographics, limits and change in the home price index

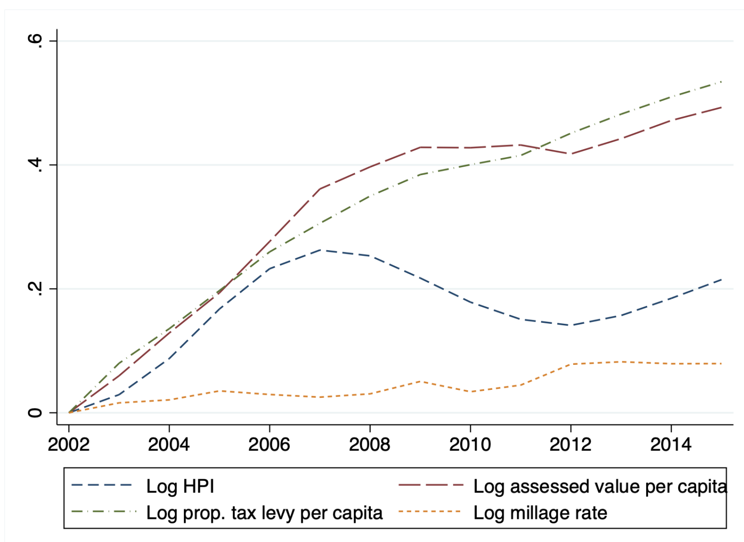
Correlation with $\Delta \log HPI_t$			
ΔShare white$_t$	-0.07^c	Fraction revenue own source	0.46^c
	(0.02)		(0.12)
ΔShare black$_t$	-0.55^c	Fraction revenue property tax	1.30^c
	(0.15)		(0.23)
ΔShare population 20-29$_t$	1.32^c	Fraction revenue other taxes	-0.43
	(0.19)		(0.44)
ΔShare population 30-39$_t$	-0.38^b	Fraction inter-gov. transfers	-0.77^c
	(0.18)		(0.13)
ΔShare population 40-49$_t$	1.67^c		
	(0.13)		
ΔShare population 50-59$_t$	2.95^c	Some rate limit	1.72^c
	(0.15)		(0.14)
ΔShare college$_t$	-0.90^c	Rate lim. on jurisdiction	-1.48^c
	(0.05)		(0.13)
ΔShare urban$_t$	-0.13^c	Rate lim. on property	-0.15^b
	(0.02)		(0.06)
ΔUnemployment rate$_t$	-1.21^c	Some levy limit	-1.03^c
	(0.05)		(0.11)
ΔLog income per cap$_t$	-0.03^b	Levy lim. - aggregate	0.90^c
	(0.01)		(0.10)
ΔLog employment$_t$	0.41^c	Levy lim. on property	0.27^b
	(0.03)		(0.12)
ΔLog wage per cap$_t$	0.05^c		
	(0.01)		

This table reports coefficient from four separate regressions to find the correlation between the yearly change in log home price index and the relevant variables reported. The data covers yearly changes between 2000 and 2016. Standard errors are clustered at the Each horizontal separation denotes a separate regression.

B.2 Additional Figures

Figure B.1: Changes in HPI, Assessed values, property tax levy and mill rate - 2

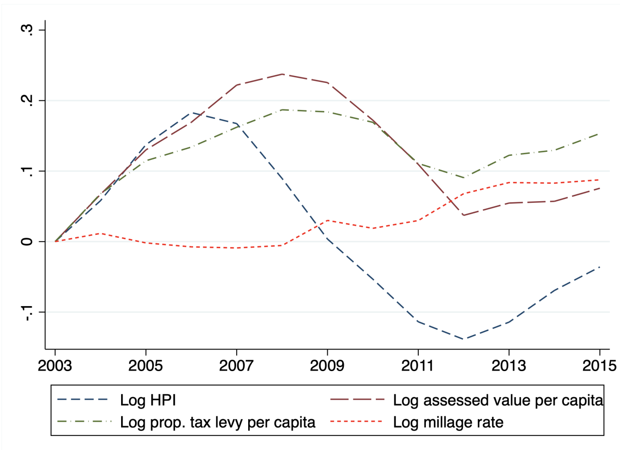
(a) U.S. average change 2000-2015 - population weighted full sample



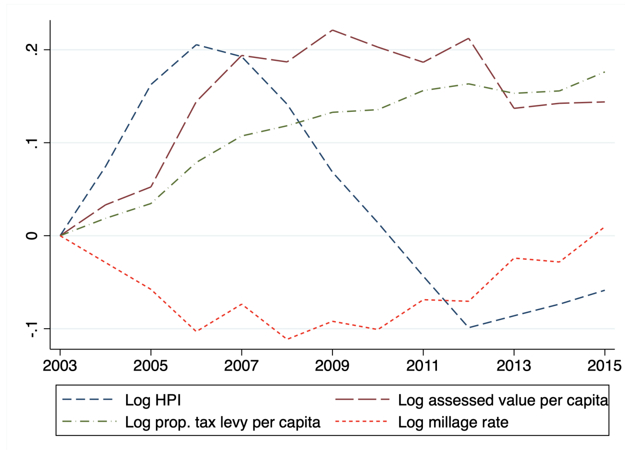
(b) U.S. average change 2000-2015 - full sample unweighted / non adjusted for inflation

The top figure plots the county weighted US average change in the four denominated variables starting in year 2002. The bottom figures plots the unweighted US average change of the four denominated variables not adjusted for inflation. Values are standardized from base year 2002. See text and appendix for more details on how variables are computed.

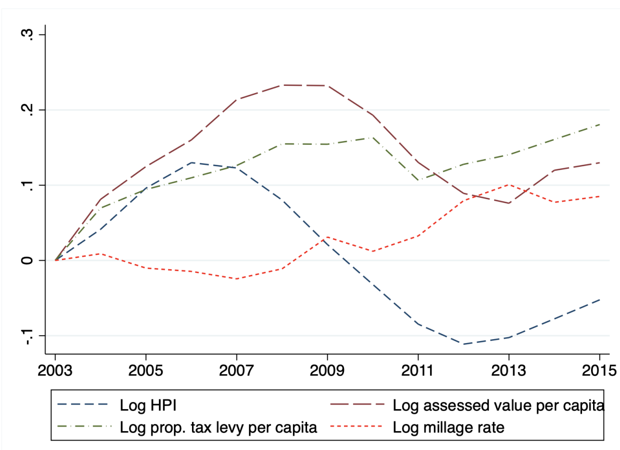
Figure B.2: Changes in HPI, Assessed values, property tax levy and mill rate - subsamples Weighted



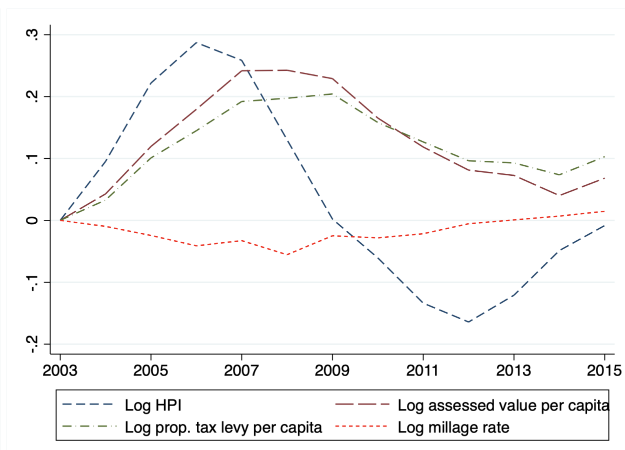
(a) Counties with some rate limits



(b) Counties without some rate limits



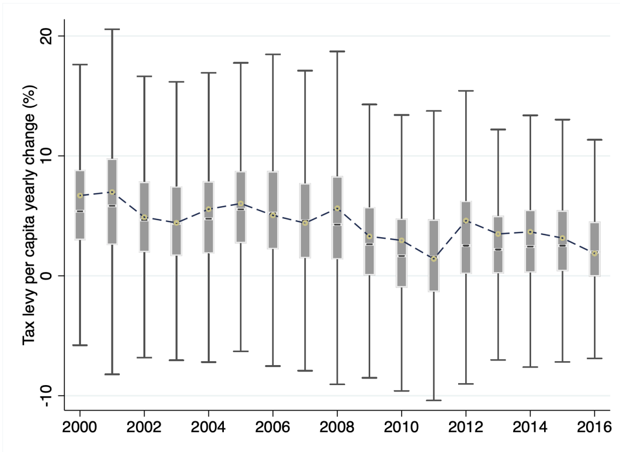
(c) Counties with aggregate levy limits



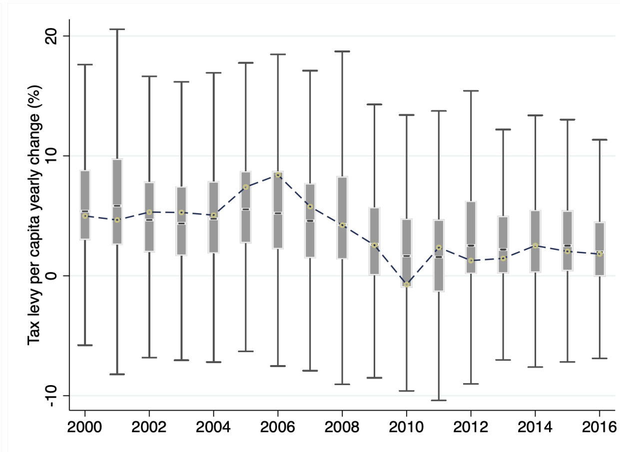
(d) Counties without aggregate levy limits

The top figure plots the county weighted US average change in the four denominated variables starting in year 2003, by whether counties are in a state with or without any rate limit, or with/without any aggregate levy limit. Refer to previous tables and text for exact definition of rate and aggregate levy limits. See text and appendix for more details on how variables are computed.

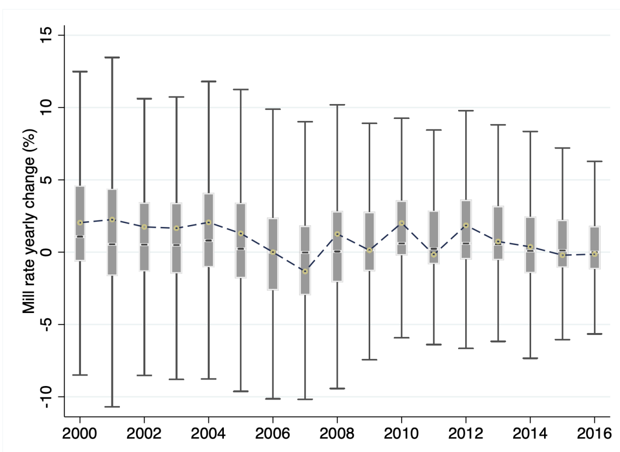
Figure B.3: Median and inter-quartile range of yearly changes 2000-2016 - By rate limits



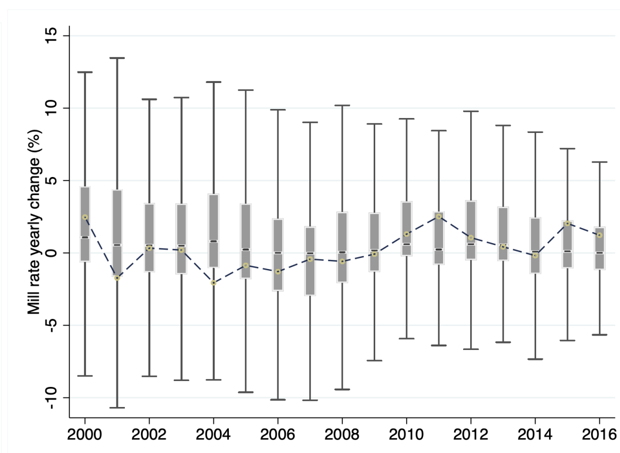
(a) % Change in property tax levy - aggregate levy limit



(b) % Change in property tax levy - NO aggregate levy limit



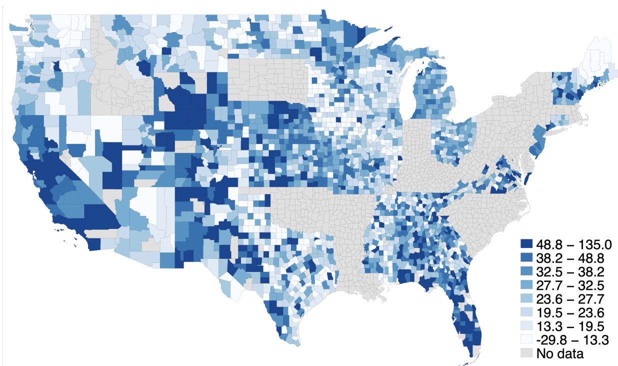
(c) % Change in mill rate - rate jurisdiction limit



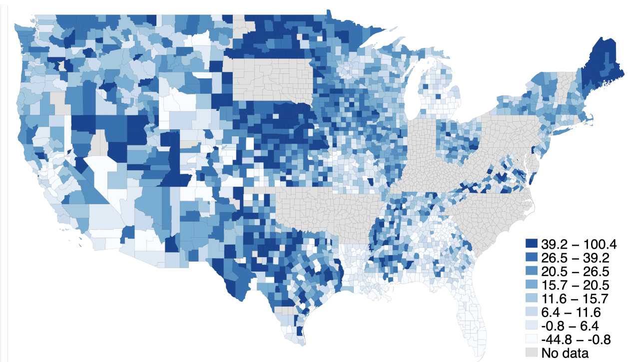
(d) % Change in mill rate - NO rate jurisdiction limit

Our baseline mill rate is computed as the total tax levy divided by the taxable assessed value $\times$ 1000. The column ”Mill avg.” indicates whether the mill rate was computed by finding an average of the mill rate for multiple jurisdictions in the county. When both are available, we use the baseline mill rate. The column Aggregated indicates whether the data was collected at the county level or for at the taxing district level, and then aggregated for all counties.

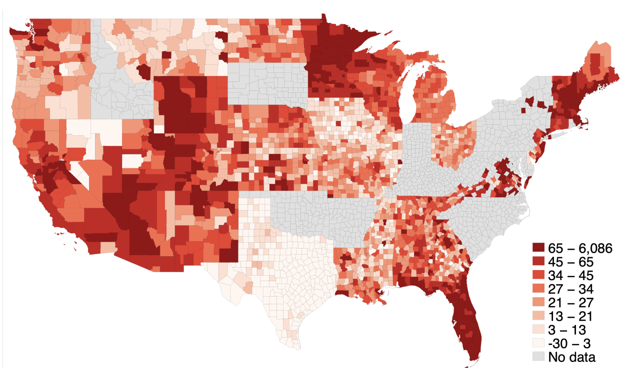
Figure B.4: County level 5-year %Δ change



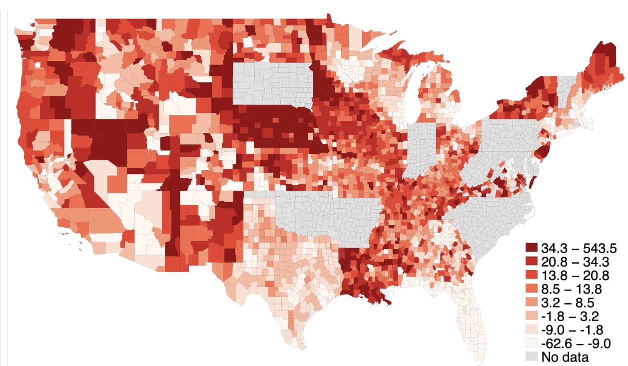
(a) Change in levy per capita 2002-2007



(b) Change in levy per capita 2007-2012



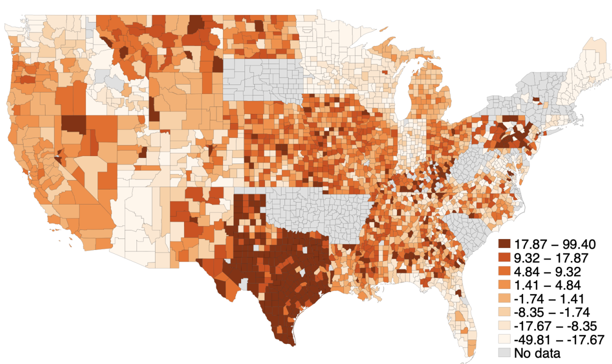
(c) Change in nav per capita 2002-2007



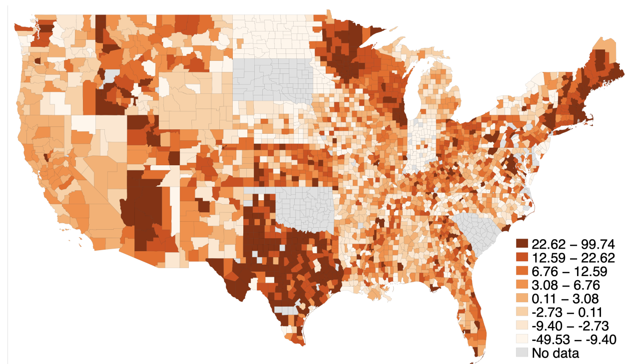
(d) Change in nav per capita 2007-2012

These maps show the 5-year percentage change in levy per capita and assessed value per capita between 2002 and 2007, and between 2007 and 2012. All values are adjusted for inflation.

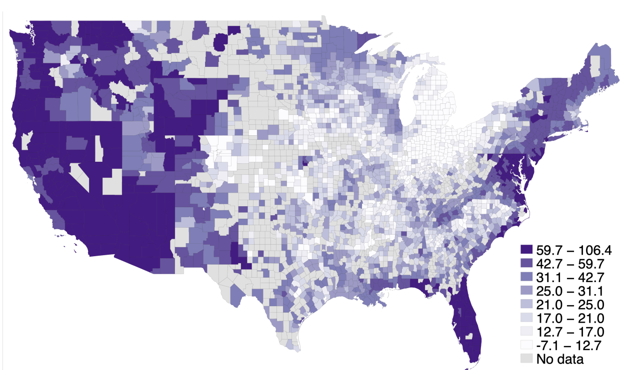
Figure B.15: County level 5-year $\%\Delta$ change



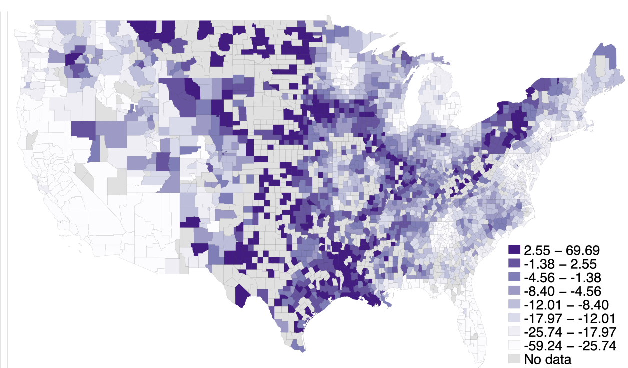
(a) Change in mill rate 2002-2007



(b) Change in mill rate 2007-2012



(c) Change in HPI2002-2007



(d) Change in HPI 2007-2012

These maps show the 5-year percentage change in mill rate and county home price index (HPI) between 2002 and 2007, and between 2007 and 2012. All values are adjusted for inflation.

B.3 Property tax variables and data collection procedure

This document explains the data collection and cleaning process for all states. We include documentation on the variables collected and used. The first section describes the typical format for the collected property tax data, as well as specific issues related to the data collection and cleaning. Section 2 summarizes the data collected. Section 3 includes information on the data collected in each state, as well as important details or potential issues specific to that state. Finally, the last section discusses the sources used to collect data on property tax limitations and discusses specific issues.

County level mill rate

We determine the mill rate from three different methods

1. Dividing levy by total net taxable assessed value $\times$ 1000

2. Using the average county mill rate given directly in tax reports (assumed to be calculated as 1), unless stated otherwise). When both 1) and 2) are available, we check they are the same.

3. Using the average county level mill rate calculated from the average of all sub jurisdictions within a county. For instance, average county mill rate = county rate + average city rate + average school rate.

1) is our preferred option when others are available. When computing 3), we typically don't include special districts. Special districts (e.g. fire departments, library, etc.) only make up a tiny fraction of property tax levy. The main issue is that because not every property in the state will be subject to a levy from a special district, a simple average will cause an upward bias in the mean county mill rate.

Assessed value

There are two main issues to consider. The first one is that some states report the net taxable value, which is used to determine the tax rate based on the required levy. Some states may report assessed value before exemptions. Unless specifically stated, we assume that assessed values reported in annual property tax reports are the net taxable value. Some states are not specifically reporting assessed values before exemptions, in that case we assume they report the taxable value only.

The second issue with assessed value is that it can be different for counties and school districts. While most states order assessment to be made at the county level (sometimes at the state level), school district and counties may have different exemption levels, implying a different net taxable assessed value at the county level for either jurisdictions. When multiple assessed values are reported, our preferred choice is the county assessed value, as some school district borders cross county limits. In states where school districts do not cross county limits, we can also compute the average of the two to find the average taxable value at the county level.

Tax levy

Tax levies are rather straightforward and typically reported at the county level for the total of all sub jurisdictions within a county, or by jurisdictions. When reported individually, we compute the county level total of each sub-jurisdiction (e.g. county total from all levies by school districts), and the county total for all jurisdictions.

Type of property considered

In many cases the disaggregated values for different types of property are not available, and the data reported refers to all property tax categories. Usually, personal property constitutes only a fraction of real property. Therefore, as standard, we will use the Total Residential Land, Improvements & Personal Property valuation.

Year vs Fiscal year

In some cases, data is reported according to the fiscal year and not the calendar year. In addition, different states have different definitions of fiscal year, for example New York's state fiscal year begins April 1 and ends on March 31, while Michigan's begins October 1 and ends September 30. In the majority of cases, we follow the state reports in assigning data to the calendar year in which taxes are levied.

B.4 Cleaning log

The following list details for each state the source of the data, the variables collected and / or computed, the years available and specific issues if present. In addition to the state-specific sources referenced, materials from the Lincoln Institute have been used in producing this section[1].

B.4.1 Alabama

- Source of data: Lincoln Institute for mill rates, and Alabama Department of Revenue for Annual Reports.
- Data available:
  - Net taxable assessed valuation by county (Including Real, Business Personal, and Motor Vehicle Property (State))
  - Net collections (levy) after all exemptions by State, Counties, Municipalities and Schools at the County level.
  - Mill rates: Millage available by county as imposed by the state, the county, the school districts within the county and the municipalities within the county
- Computed variables: County level millage is computed by summing the total state and county-wide mill rates to the average of the mill rates for municipalities and school districts within the county.
- Years: Data for assessment collected from 1997-2019, for levies collected for 2000-2019. The data on levy is based on year the levy is determined. Taxes are collected the following year. The data on millage rates is available from 2000-2019, but missing for 2013 and 2015. Alabama begins the fiscal year on October 1st. Assessment data reported by fiscal year.

[1] Significant Features of the Property Tax. https://www.lincolninst.edu/research-data/data-toolkits/significant-features-property-tax/access-property-tax-database/property-tax-rates Lincoln Institute of Land Policy and George Washington Institute of Public Policy. (Property Tax Rates; accessed: 05/19/2021 09:26:50 PM)

State-by-State Property Tax at a Glance. https://www.lincolninst.edu/research-data/data-toolkits/significant-features-property-tax/state-state-property-tax-glance. Significant Features of the Property Tax. Lincoln Institute of Land Policy and George Washington Institute of Public Policy. (Property Tax at a Glance; accessed: 10/31/2017 4:41:21 PM)

Retrieved May 12, 2021, from https://revenue.alabama.gov/category/publications/annual-reports/

- Assessment and levy data includes Real, Business Personal, and Motor Vehicle Property.

B.4.2 Alaska

No data is available for Alaska.

B.4.3 Arizona

- Source of data: Arizona Department of Revenue Annual Reports, available at the Arizona Department of Revenue for years 2008-2020, and Lincoln Institute for years 1999-2019.
- Data available:
  - Asssessed value computed using the primary limited property value (LPV) and the secondary full cash value (FCV). LPV is always lower or equal to full market value and has limits placed on how much it can increase.
  - Primary and secondary Levies by jurisdictions (state, county, municipality, school districts, community colleges, and all other jurisdictions)
  - Primary and secondary mill rates.
- Computed variables: We compute the total levy at the county level by summing primary and secondary levy for all jurisdictions within a county. Using the secondary net assessed value and the computed total levy, we obtain a measure of county-level mill rate.
- Years: We collected data from 1999 to 2017. Data in Arizona is given based on the fiscal year. The fiscal year is the 12-month period beginning on July 1 and ending June 30 of the following year.
- Property Classification: In Arizona property is categorized into 9 different groups. Each classification is assigned a specific assessment ratio prescribed by law which is then multiplied by the full cash and limited values to produce an assessed value. Properties in all classes are subject to the same tax rate.

Retrieved May 14, 2021 from https://azdor.gov/reports-statistics-and-legal-research/annual-reports

- Other: Beginning in Tax Year 2015, both primary and secondary taxes are levied against the limited (primary) value.

B.4.4 Arkansas

- Source of data: Lincoln Institute for levies by class, assessed values by class and effective rates by class between 1995 and 2005, and average county mill rates for 2005-2018. Arkansas department of property tax through direct contact for assessed values at the county level between 2012 and 2018.
- Data available:
  - Mill rates by class at the county level between 1995-2005.
  - Mill rates by jurisdiction (school district, cities, county) between 2005-2018.
  - Assessed values by class at the county level between 1995-2005
  - Levies by class at the county level between 1995-2005
  - Assessment at the county level between 2012-2018
- Computed variables: For years 1995-2005, compute mill by dividing total levy across classes over total assessed value across classes. For 2006-2018, average mill rate at the county level already provided in the data.
- Years: 1995-2018 for mill rates, 1995-2005 for levies, 1995-2005 and 2012-2018 for assessed values. Data in Arkansas is reported for years levied. Taxes reported would be collected the following year. Data in Arkansas is based on levy, the year of collection is the following year. The Fiscal Year begins in July in Arkansas.
- Property Classification: Real property is assessed at 20% of true and full market values, whereas personal property is assessed at 20% of value.

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https://www.arkansasassessment.com/media/1354/faqs-update-final-2021.pdf

B.4.5 California

- Source of data: Lincoln Institute for years 1999-2016. Data also available from the California State Board of Equalization for 2012-2019
- Data available:
  - Net taxable assessed value at the county level
  - Levies by jurisdiction (city, county, school, and other districts)
  - Average tax rate at the county level
- Computed variables: The mill rate is computed by dividing the sum of the levies within a county, over the overall net taxable assessed value in the county.
- Years: Data collected from 1999-2016. The year refers to when the tax is levied (not collected). The fiscal year in California start on July first.
- Property Classification: California does not have a statewide classification of real property.
- Other: The assessment of property in California is regulated by Proposition 13.

B.4.6 Colorado

- Source of data: Annual reports available from the Department of Local Affairs and from the Lincoln Institute.
- Data available:
  - Assessed valuation at the county level
  - Total levy raised at the county level
  - Mill rate by jurisdiction (county, average municipal, average school district, average special district) and average by county
- Computed variables: Average mill rate by county already provided in the raw data

https://www.boe.ca.gov/dataportal/dataset.htm?url=PropTaxGenPropTaxLevies; accessed: 05/12/2021 07:42:20 PM

https://cdola.colorado.gov/publications/annual-reports

- Years: Data collected from 2001-2018. The fiscal year in Colorado runs from July to July. The year reported in the data refers to when taxes are levied, which are payable the following year.

- Property Classification: Colorado has a statewide classification of property. Property in different classes is assessed at different ratios.

- Other: Assessment is done at the county level, and the State Board of Equalization has the task to make sure the burden is equally distributed.

B.4.7 Connecticut

- Source of data: Mill rates from direct contact with the Connecticut Office of Policy and Management. Assessment data available on the Office of Policy and Management's website

- Data available
  - Mill rates at the municipality level
  - Assessed value at the municipality level: listed as Net Grand List, or the assessed value of all taxable property within a municipality net of exemptions

- Computed variables: we compute the average mill rate at the county level by averaging out the mill rates in the municipalities within the county. We compute the county level net assessed value by summing the total assessed values of the municipalities within the county. We compute the levy using the county level mill rate and net assessed value.

- Years: Mill rates data collected from 1991-2017, assessed values data collected from 1996-2018. The fiscal year in Connecticut begins on July 1st. The Grand List is certified before the fiscal year, so a Grand List for 2019 is certified in February 2020 and is used for taxes in Fiscal year June 2020-June 2021, while taxes are due January 2021. The year thus refers to when taxes are levied, not collected.

- Property Classification: Connecticut does not have a statewide classification of real property.

https://portal.ct.gov/OPM/IGP-MUNFINSR/Municipal-Financial-Services/Municipal-Fiscal-Indicators

B.4.8 Washington DC

No data is available for Washington DC

B.4.9 Delaware

- Source of data: Mill rates from the Lincoln Institute
- Data available:
  - Mill rates at the county and municipality level, by jurisdiction within municipality (County rate, school rate, city rate, library rate, others)
  - Taxable values at the county level (incomplete - available only for two counties)
  - Levy: incomplete, only for one county
- Computed variables: we compute the average mill rate at the county level by averaging out the municipality-level mill rates within the county.
- Years: Data on average mill rate collected from 2005 to 2015. Partial assessment data collected from 1997 to 2017.
- Property Classification: Delaware does not have a statewide classification of real property.
- Other: The three Delaware counties have different dates of assessment; they tax a different proportion of that assessment, and they tax at different rates. Municipal and school district rates also vary throughout the state.

B.4.10 Florida

- Source of data: We obtain data on mill rates, levies and taxable value from the Lincoln Institute and from the Florida Department of Revenue
- Data available
  - Taxable value and just value, where just value represents the market value of the property, and taxable value represents the just value minus exemptions.

https://floridarevenue.com/property/Pages/DataPortal.aspx

  - Millage rate at the county level by function and jurisdiction (County, School, Special Districts, Municipal and others)
  - County-wide levy (total and by jurisdiction / function)

- Computed variables: County-wide totals are already available in the raw data

- Years: Data collected from 1999-2019. Data for a year is based on assessments made on January 1st. Tax collection is determined mid-year, and taxes are collected the following year. The state tax year runs June-June but local tax years follow calendar years.

- Property Classification: Florida does not have a statewide classification of real property.

B.4.11 Georgia

- Source of data: Information on mill rates, levies and taxable values is available on the Georgia's Department of Revenue Website

- Data available

  - Mill rate at the jurisdiction level
  - Levy at the jurisdiction level
  - Assessed value and taxable value at the jurisdiction level for different property classes.

- Computed variables: we use the net taxable value reported at the county level (schools net taxable value is reported as well, the two differ slightly due to different exemptions), and compute the sum of all levies of jurisdictions within the county. We compute the average county level mill rate using the total levy and taxable value.

- Years: We use data from 1994-2018. Local policymakers determine the millage rate around July, and they do so based on an estimated assessed value based on the previous year's value.

- Property Classification: Georgia has a statewide classification of real property.

https://dor.georgia.gov/local-government-services/digest-compliance-section/digest-consolidated-summaries

- Other: In Georgia property is required to be assessed at 40% of the fair market value unless otherwise specified by law.

B.4.12 Hawaii

No data is available for Hawaii

B.4.13 Idaho

- Source of data: Assessed values, levies, and millage rates can be accessed through the Idaho State Tax Commission's website
- Data available:
  - Taxable value by property type at the county level
  - Levy by property type at the county level
  - Average property tax rate in urban and rural areas within the county, and overall.
- Computed variables: Years 2001 and 2003 only report separate urban and rural data for tax rates. For these years, we get the mill rate as the avg between urban and rural times the ratio between the true average and calculated (urban and rural) average for years 2002 and 2004. We compute the total levy by summing the levies on different types of property. The total value at the county level is already provided in the data.
- Years: Data for levies collected for 2004-2012 (2010 missing), data for values collected from 2004-2020, data for mill rate collected from 2001-2017.
- Property Classification: Idaho does not have a statewide classification of real property.
- Other: In FY 2007, a change was implemented in the funding of schools. Thus, property taxes were reduced dramatically starting in calendar year 2006, FY 2007.

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https://tax.idaho.gov/search-reports.cfm

B.4.14 Illinois

- Source of data: Data available on the Illinois Department of Revenue's Website
- Data available
  - Equalized assessed value at the county level. The equalized assessed value is computed multiplying the assessed value of property times the state equalization factor and subtracting exemptions.
  - Taxes levied at the county level
- Computed variables: the average mill rate at the county level is computed using the equalized assessed value and the total levy.
- Years: data collected from 1990-2018.
- Property Classification: Illinois does not have a statewide classification of real property.
- Other: The equalization is required so that counties have a median level of assessment at 33% of fair market value. This is necessary since some counties assess property at different ratios of market value.

B.4.15 Indiana

- Source of data: Lincoln Institute.
- Data available:
  - Gross millage rates by municipalities and property type. The gross tax rate is applied to the net taxable value of a property. After that, properties may receive a credit, to which a homestead credit may be added.
- Computed variables: the tax rates available are gross tax rates. We take the average at the county level of tax rates imposed within the county.
- Years: data collected for years 1999-2016.
- Property Classification: Indiana does not have a statewide classification of real property.

https://www2.illinois.gov/rev/research/taxstats/PropertyTaxStatistics/Pages/default.aspx

- Other: In 2002, there was a change in the assessment method, from a formula based one to a market value-in-use assessment practice. This change was accompanies by increased deductions for homeowners. This explains a sharp decrease in effective tax rates between 2001 and 2002: due to the new rules on assessment, the gross value of real property grew at a faster rate than levies.

B.4.16 Iowa

- Source of data: Lincoln Institute
- Data available
  - Taxable value by jurisdiction
  - Levy by jurisdiction and function
- Computed variables: We compute the levy at the jurisdiction level using jurisdiction level taxable value and mill rate. We then use total levy and total taxable value at the county level, and compute the average mill rate at the county level.
- Years: Data collected for 2000 to 2017. In the reported data, the tax rate applied for a fiscal year is based on the taxable value of the previous year. For example, the assessed value as of January 2011 is used to calculate the tax liability in summer 2012. Taxes are due in September 30th and March 30th. In our data, year 2011 refers to the fiscal year 2011-2012. The fiscal year for the state starts on July 1st and ends on the following June 30th.
- Property Classification: Iowa has a statewide classification of real property.

B.4.17 Kansas

- Source of data: Annual reports from the Kansas Department of Revenue's website
- Data available
  - Average mill rate by county
  - Property taxes levied by county

https://www.ksrevenue.org/prannualreport.html

- Computed variables: we compute the net assessed value from the mill rate and the levy.
- Years: We have data from 2004-2018.
- Property Classification: Kansas has a statewide classification of real property
- Other

B.4.18 Kentucky

- Source of data: Kentucky Department of Revenue for Property values, Lincoln Institute for mill rates
- Data available
  - Mill rates by jurisdiction and type of property
  - Full value of property subject to local taxes
- Computed variables: We compute the average county level mill rate by summing the county level rate to the average city rate. In this case, we exclude school district rates because the data is incomplete. In Kentucky, the average mill rate for counties is 2.5 times as large as for school districts, and the average city mill rate is 2 times as large as school districts.
- Years: Assessment data collected from 2007-2020. Data on mill rates collected from 1999-2018.
- Property Classification: Kentucky has a statewide classification of real property.

B.4.19 Louisiana

- Source of data: Louisiana Tax Commission
- Data available
  - Assessed value by type of property

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https://revenue.ky.gov/Property/Pages/default.aspx
https://www.latax.state.la.us/Menu$_{A}nnualReports/AnnualReports.aspx$

  - Levy by function/jurisdiction (parish levy, road levy, school levy, levee levy, drainage levy, other levy)
  - Millage rate by function/jurisdiction

- Computed variables: The millage rate is equivalent to the rate obtained by dividing the total levy collected within the jurisdiction and the total assessed value exclusive of Homestead Exemption within the parish.

- Years: Data for assessments and levies collected for 2004-2017. Data for millage rates collected for 2002-2017.

- Property Classification: Louisiana has a statewide classification of real property.

- Other: In Louisiana, assessed value is supposed to be 10% of the market value for land and residential property, 15% for commercial and movable personal property, and 25% for public service property.

B.4.20 Maine

- Source of data: State of Maine Department of Administrative and Financial Services

- Data available

  - Mill rates derived by dividing the levy at the municipal level by the state equalized valuation of property (excluding homestead adjustments and exemptions).
  - State equalized valuation of municipal assessments: the state certifies the full equalized value of property reported by municipalities.

- Computed variables: We compute the levy at the county level by multiplying the mill rate times the net assessed value.

- Years: Data on millage rates collected from 2001-2016, and data on state equalized value from 1986-2017. The state valuation lags the values assessed by municipalities by almost two years.

- Property Classification: Maine does not have a statewide classification of real property.

https://www.maine.gov/revenue/taxes/property-tax/municipal-services and https://www.maine.gov/revenue/taxes/property-tax/state-valuation

B.4.21 Maryland

- Source of data: Lincoln Institute and Maryland Department of Assessment and Taxation
- Data available:
  - Tax rates by jurisdiction and by type of property
- Computed variables: we compute the mill rate by first computing the sum of county and municipality/district rate imposed in jurisdictions within the county on real property, and then taking the average at the county level.
- Years: Data for mill rates collected for 2002-2017. Data for every year refers to mill rates imposed on July 1st. For example, data for 2002 refers to mill rates imposed on July 1st.
- Property Classification: Maryland does not have a statewide classification of real property.
- Other:In Maryland, all property is assessed at the fair market value. The assessments are done by the state and not by the county and reevaluated every three years.

B.4.22 Massachusetts

- Source of data: Lincoln Institute and Massachusets Department of Revenue Division of Local Services
- Data available:
  - Mill rates by municipality and type of property
  - Tax levy by municipality and type of property
  - Assessed values by municipality and type of property

https://dat.maryland.gov/Pages/Tax-Rates.aspx
https://dat.maryland.gov/realproperty/Pages/HomeOwners-Guide.aspx
https://www.mass.gov/service-details/property-tax-related-data

- Computed variables: We compute the average mill rate by county by dividing the levy from the total assessed value. We compute the total assessed value and levy at the county level by summing assessed values and levies of the jurisdictions within the municipality
- Years: Data collected from 2003-2019 for tax levies and assessed values, and from 1981-2017 for tax rates. The data is presented for fiscal years. Fiscal years in Massachusetts the fiscal year runs from July 1st to June 30th.
- Property Classification: Massachusetts does not have a statewide classification of real property.

B.4.23 Michigan

- Source of data: Michigan Department of Treasury
- Data available
  - County level total taxable valuation
  - Total taxes levied in the county
  - average tax rage within the county
- Computed variables: All variables provided in the raw data
- Years: 2002-2018. The information is reported for tax years.
- Property Classification: Michigan does not have a statewide classification of real property
- Other: The information is based on all classes of property (real and personal). Michigan relies on an equalization process.

B.4.24 Minnesota

- Source of data: Minnesota Department of Revenue

https://www.michigan.gov/taxes/0,4676,7-238-43535$_4 3925 - 540359 - -, 00.html$

https://www.revenue.state.mn.us/sites/default/files/2011-11/ptbulletin$_0 1.pdf andhttps : //www.revenue.state.mn.us/property - tax - history - data$

- Data available:
  - Estimated market value
  - Tax exemptions
  - Taxable market value
  - Net tax capacity
  - Tax levies
  - Tax credits
  - Net tax payable.
- Computed variables: We use net tax payable for levy, which includes property taxes paid for jurisdictions within the county excluding credits, and taxable market value, which is defined as the assessed value of the property minus exemptions. We compute the average tax rate at the county level by dividing the total levy over the net assessed value.
- Years: We have data from 2001 to 2018. The year indicated in the reports is the year in which property taxes are paid. Property taxes paid in the current year use property valuations (assessments) from January 1 of the previous year. For example, property taxes paid in 2018 are based on the assessment from January 1, 2017. In our dataset, we use the year for which property was assessed and taxes levied (the previous year).
- Property Classification: Minnesota has a statewide classification of real property.
- Other: In Minnesota, there is a referendum market value (RMV), which is applied to property tax levied through referendum. It is similar to the taxable market value minus agricultural land. Although RMV may be different than TMV, we combine all levies (including referendum levies) when calculating payable taxes. We then compute the effective mill rate by dividing the net tax payable by the taxable market value. In Minnesota, the assessment ratio varies across counties, which implies the effective rate on property will differ across jurisdictions.

B.4.25 Mississippi

- Source of data: State tax office and annual reports

https://www.dor.ms.gov/Property/Pages/default.aspx
https://www.dor.ms.gov/Statistics/Pages/Annual-Reports.aspx

- Data available
  - Total assessment by county and type of property
  - Mill rate by county and function (schools, colleges, roads, fire and police and other county level operations). The county mill rate does not include city level mill rates.
- Computed variables: We estimate the county levy using the data on assessed value and millage rates at the county level.
- Years: We have data from 1995-2018. The fiscal year runs from July to July in Mississippi. Data are given for fiscal years. E.g. we define data for fiscal year 2004-2005 as data for year 2004, since mill rates and assessed values are determined based on 2004 data.
- Property Classification: Mississippi has a statewide classification of real property.

B.4.26 Missouri

- Source of data: The office of Missouri State Auditor
- Data available
  - Assessed value by jurisdiction and function
  - Mill rate ceiling
  - Mill rate actually levied
- Computed variables: Using the jurisdiction level assessed value and mill rate, we compute the levy for each jurisdiction. Since assessed values are reported multiple times within a county for different taxes (e.g. General Revenue, Fire, Debt Service), we use the assessed value used by the county for General Revenues. We calculate the effective average mill rate by dividing the total aggregate levy at the county level by the total county level assessed value.
- Years: We have data from 2000-2018. The fiscal year in Missouri runs from June to June. Property tax bills are sent out in November each year and are to be paid by the end of the year. The data covers years based on regular calendar year, which corresponds to the year when property taxes were decided and levied.

https://auditor.mo.gov/AuditReport/Reports?SearchLocalState=31

- Property Classification: Missouri has a statewide classification of real property.

B.4.27 Montana

- Source of data: Annual reports retrieved from the Lincoln Institute
- Data available
  - Mill rate by jurisdiction at the county level (state, county, schools, other districts)
  - Levy by jurisdiction at the county level (state, county, schools, other districts)
- Computed variables: Taxable value computed at county level using the given mill rates and levies' values. Average mill rate at the county level computed using total county level assessed value and levy.
- Years: The data is available from 1999-2016. The fiscal year in Montana runs from July to July. The year defined in the data is the base in the fiscal year, e.g. for FY2003-2004 we indicate 2004.
- Property Classification: Montana has a statewide classification of real property.
- Other: Properties are assessed at the state level in Montana.

B.4.28 Nebraska

- Source of data: Lincoln Institute and Nebraska Department of Revenue
- Data available
  - Total taxable value by county
  - Total property taxes levied by county
  - Average tax rate at the county level
- Computed variables: Variables reported as in the raw data
- Years: Data collected for 1997-2020

https://revenue.nebraska.gov/PAD/research-statistical-reports/average-tax-rates-county

- Property Classification: Nebraska has a statewide classification of real property
- Other: In Nebraska the assessed value is computed differently for agricultural property and other property. It is assessed at full market value by all counties for non agricultural property, and 75% of market value for agricultural property.

B.4.29 Nevada

- Source of data: State of Nevada Department of Taxation
- Data available
  - Total assessed value by county
  - Levies by taxing jurisdictions within county (schools, county, cities, towns, special districts, state)
  - Average county wide tax rate
- Computed variables: All variables are already available in the raw data
- Years: Data collected from 2000-2017. Data is presented in fiscal years, we attribute data to the second part of the fiscal year, so data for fiscal year 2016-2017 is attributed to year 2017. The fiscal year in Nevada runs from July 1 through June 30.
- Property Classification: Nevada does not have a statewide classification of real property.
- Other: In Nevada property is assessed at 35% of the taxable value. Taxable value is not equal to market value, but follows different determination rules for real and personal property.

B.4.30 New Hampshire

- Source of data: Lincoln Institute and Department of Revenue Administration through direct contact
- Data available

https://tax.nv.gov/LocalGovt/PolicyPub/ArchiveFiles/Redbook/

- Municipality level valuation
- Municipality level rates by function / jurisdiction (Town, Local Education, State Education, County)
- Total tax commitment / levy

- Computed variables: We compute the total valuation and levy at the county level by summing municipality-level valuation and levy. We compute the average mill rate at the county level using the computed total valuation and levy.

- Years: Data is available for years 2000-2017.

- Property Classification: New Hampshire does not have a statewide classification of real property.

- Other: The tax rates presented represent the estimated tax rate for a municipality if all the taxable property was assessed at 100%.

B.4.31 New Jersey

- Source of data: New Jersey Division of Taxation

- Data available
  - Net Valuation Taxable
  - Net valuation on which county taxes are apportioned (or net equalized valuation)
  - Total tax levy on which tax rate is computed

- Computed variables: Using the total net taxable value and the total levy at the county level we compute the average mill rate at the county level

- Years: Data collected from 1995-2015. Data is reported following the timing on the annual reports, which assigns data for (for example) the fiscal year ending on June 30 1996 to 1995. The New Jersey fiscal year begins on July 1st and ends on June 30th.

- Property Classification: New Jersey does not have a statewide classification of real property.

https://www.nj.gov/treasury/taxation/annual.shtml

B.4.32 New Mexico

- Source of data: Property tax facts reports of the New Mexico Taxation and Revenue Department, sourced from the Lincoln Institute and New Mexico Department of Finance and Administration
- Data available
  - Net taxable value at the county level by type of property (residential vs nonresidential)
  - Property tax obligations at the county level by type of property (residential vs nonresidential)
- Computed variables: Using the county level net taxable values and property tax levies, we are able to compute the average tax rate at the county level.
- Years: Data collected from 2003-2020. The fiscal year runs from July to July in New Mexico. The data reported for fiscal year 2020, e.g. refers to fiscal year 2019-2020. As such, we define the year as 2019 for data from fiscal year 2020.
- Property Classification: New Mexico has a statewide classification of real property.

B.4.33 New York

- Source of data: New York State
- Data available
  - Tax levy by jurisdiction
  - Rate by jurisdiction (for years until 2011, not equalized)
  - Equalization rates by jurisdiction

https://www.nmdfa.state.nm.us/local-government/budget-finance-bureau/property-taxes/property-tax-facts/

https://data.ny.gov/Government-Finance/Real-Property-Tax-Rates-Levy-Data-By-Municipality-/iq85-sdzs

- Computed variables: Using the equalization rates, we compute full tax rates (meaning tax rates that apply to the full value of the property, not to the assessed value which is computed differently in different jurisdictions in New York) for all years. Using full tax rates and levies at the jurisdiction level, we compute taxable values. Using the computed taxable values and the levies, we obtain average municipality rates and average school district rates per county. We compute the average rate imposed at the county level as the sum of the average county, municipality and school district rates imposed within a county.
- Years: The data collected for 2003-2018. We use the roll year, which is identified as the year in which taxes are levied.
- Property Classification: New York does not have a statewide classification of real property/
- Other: In New York, different jurisdictions may determine different levels of assessment. Therefore, in order for rates to be comparable within the state, there is an equalization rate which allows to compare the rates on the full values of properties, rather than on the assessed value.

B.4.34 North Carolina

- Source of data: Lincoln Institute and North Carolina Department of Revenue
- Data available
  - County and Municipality millage rates (not equalized) by county and municipality
- Computed variables: We compute the average rate at the county level by first computing the mean rates by county and municipality at the county level, and then summing them.
- Years: We use data from 1999 to 2017. The data for a year refers to the fiscal year starting in that year, e.g. data for fiscal year 2009-2010 is attributed to 2009. The fiscal year in North Carolina starts on July 1st and runs until June 30th.
- Property Classification: North Carolina has a statewide classification of real property.

https://www.ncdor.gov/news/reports-and-statistics/county-and-municipal-effective-tax-rates

- Other: In North Carolina, property is assessed at the county level. In addition, property has to be reappraised at least once every eight years.

B.4.35 North Dakota

- Source of data: Lincoln Institute
- Data available
  - Taxes raised at the county level (Ad Valorem Taxes)
  - Taxable value at the county level
  - Average mill rate at the county level
- Computed variables: The variables are used as presented in the raw data
- Years: Data is available from 2000-2017. The fiscal year in North Dakota runs from July to July. Property taxes are mailed to individuals in December of the calendar year and are then payable the following January. Property tax reports are published in June and report taxes from the previous year. We compute the year as published in the reports since it matches when property taxes are decided and levied.
- Property Classification: North Dakota has a statewide classification of real property.
- Other: In North Dakota, the assessed value is 50% of the market value, and then each class of property has a different assessment ratio. The assessment ratio is multiplied by the assessed value to obtain the taxable value. In 2009, North Dakota used revenues from oil taxes to reduce school district mill levies. This resulted in a sharp drop in average rates from 2008 to 2009.

B.4.36 Ohio

- Source of data: Ohio Department of Taxation
- Data available
  - Taxable value by type of property and county

https://tax.ohio.gov/wps/portal/gov/tax/researcher/tax-analysis/tax-data-series/property+tax+-+all+property+taxes

- Gross taxes levied by type of property and county
- Net taxes charged by type of property and county

- Computed variables: We compute the average county rate using the total net taxes levied at the county level and the total taxable value at the county level.
- Years: The data is available between 1990 and 2019. The data is presented by the calendar year in which taxes are levied (they are collected in the following calendar year).
- Property Classification: Ohio does not have a statewide classification of real property.
- Other: In Ohio, most real property has a common assessment ratio of 35%.

B.4.37 Oklahoma

No data is available for Oklahoma.

B.4.38 Oregon

- Source of data: Oregon Department of Revenue
- Data available
  - Real Market Value of Property by county
  - Net Assessed Value of Property by county
  - Property Tax Imposed by county
  - Average tax rate (computed with net assessed value and levy)
- Computed variables: The variables used are as presented in the raw data
- Years: Data collected for 2001-2016. Data reported for fiscal years, and attributed to the base year (e.g. data for fiscal year 2011-2012 recorded as data for 2011.
- Property Classification: Oregon does not have a statewide classification of real property

https://www.oregon.gov/dor/programs/gov-research/Pages/research-property.aspx

B.4.39 Pennsylvania

- Source of data: Pennsylvania Department of Community Economic Development
- Data available
  - Tax rates by municipality, county, and function
- Computed variables: We compute the average tax rate at the county level by first computing the average real estate tax rate of municipalities within a county, and then summing the the average municipality real estate tax and the county real estate tax.
- Years: Data collected from 1988-2018. The data is attributed to the year reported in the raw data.
- Property Classification: Pennsylvania does not have a statewide classification of real property.
- Other: In Pennsylvania the assessment ratio may vary at the county level.

B.4.40 Rhode Island

- Source of data: State of Rhode Island Division of Municipal Finance
- Data available
  - Municipality level property tax rates for different classes of property (residential real estate, commercial real estate, personal property, motor vehicles)
- Computed variables: We use the municipal level property tax rate for residential real estate to compute the average mill rate imposed in a county (note that this does not include the fire districts rates).
- Years: Data available from 2000-2018. The data is presented by tax roll year.
- Property Classification: Rhode Island has a statewide classification of real property.
- Other: All real property is assessed at 100 percent of full fair market value (with some minor exceptions as farmland and forests).

http://munstats.pa.gov/Public/Default.aspx
http://www.municipalfinance.ri.gov/data/tax-rates/

B.4.41 South Carolina

We do not have data for South Carolina.

B.4.42 South Dakota

We do not have data for South Dakota.

B.4.43 Tennessee

- Source of data: Data from tax aggregate reports available from the Tennessee Comptroller of the Treasury (older years obtained through direct contact via email)
- Data available
  - County level and municipality level mill rates by counties and municipalities
  - Assessed values by counties and municipalities by type of property (not including utilities).
- Computed variables: We take the average of the total rate imposed in municipalities within the county to obtain the average rate imposed at the county level. Using the total county assessed value and the county-level average rate, we estimate the total tax levied.
- Years: Data collected for 2000-2017.
- Property Classification: Tennessee has a statewide classification of real property.
- Other: Property is divided in 6 classes in Tennessee, each with different assessment rules (public and personal 55%, industrial and commercial real 40%, industrial and commercial personal 30%, residential at 25%, farm 25%, other personal 5%. In Tennessee the assessment is performed at the county level except for "utilities" such as railroads, buses, where it is done centrally.

B.4.44 Texas

- Source of data: Texas comptroller's website and direct contact via email.

https://comptroller.tn.gov/office-functions/pa/tax-resources/reports-handbooks-reference.html
https://comptroller.texas.gov/taxes/property-tax/rates/index.php

- Data available
  - Market Value by jurisdiction (cities, counties, school districts, and special districts)
  - Taxable value by jurisdiction (cities, counties, school districts, and special districts)
  - Total rate by jurisdiction (cities, counties, school districts, and special districts)
  - Levy by jurisdiction (cities, counties, school districts, and special districts)
- Computed variables: We compute the total levy by county by summing the taxes levied in all taxing jurisdictions within a county. We then use the total assessed value at the county level and the total levy computed to get a measure of the average mill rate imposed within a county. Note that the county taxable value of a certain county and the sum of the school districts taxable values within the same county may vary slightly due to potential differences in exemptions / boundaries differences.
- Years: Data is available from 1999-2017. The year refers to when taxes are levied, not collected.
- Property Classification: Texas does not have a statewide classification of real property.
- Other: Assessed value in Texas is based on Market value. However the market assessed value has some limitations on how it can increase year to year. Second, there are exemptions that lower the taxable value.

B.4.45 Utah

- Source of data: Utah property tax division
- Data available
  - Total taxable value of all property by county (excludes total motor vehicle property)
  - Average tax rates, computed by dividing the total levies charged by total taxable value

https://propertytax.utah.gov/general/annual-report/

    - Total property tax charged by county (excluding fee for motor vehicles)

- Computed variables: All variables used are already available in the raw data
- Years: The data is available from 2000-2019. The data is attributed to the year reported, which is the tax year.
- Property Classification: Utah has a statewide classification of real property.

B.4.46 Vermont

- Source of data: Vermont Agency of Administration Department of Taxes and Lincoln Institute.
- Data available
    - Tax rate by municipality and use (state education tax rate, local share tax rate, municipal rate). From 2004 also by homestead vs non-residential.
    - Levies by municipality and use (state education tax rate, local share tax rate, municipal rate), only for 2001-2012
- Computed variables: We compute the net assessed value using the levies and rates available year by year for years 2001-2012. Specifically, when the homestead and non-residential categorization is present, we compute net assessed value as the average between the net assessed value obtained with municipal share rate and levy, and the total net assessed value from education taxes and rates (homestead plus non residential).
- Years: Data is available from 2001-2016 for mill rates, and from 2001-2012 for tax levies.
- Property Classification: Vermont does not have a statewide classification of real property.

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https://tax.vermont.gov/pvr-annual-report

B.4.47 Virginia

- Source of data: Virginia Department of Taxation
- Data available:
  - Property tax rates for every taxing jurisdiction, by type of property (real estate, tangible personal property, machinery and tools, merchants' capital).
  - Real Estate Fair Market Value, Fair Market Value, Taxable Fair Market Value and Levy by county
- Computed variables: In order to compute the total average mill rate imposed at the county level, we first take the average of the rates imposed on real estate by municipalities at the county level, then sum the county real estate rate and the average municipality rate. We use the fair market taxable value and total levy as presented by county in the raw data.
- Years: Data is available from 1998-2017. The data refers to the tax year (e.g. data for 2018 is data for the tax year 2018, fiscal year 2019) as presented in the reports.
- Property Classification: Virginia does not have a statewide classification of real property.
- Other: Cities are independent in Virginia, meaning they are not part of a county. Thus, cities' rates are not part of the computed county average rate.

B.4.48 Washington

- Source of data: Washington State Department of Revenue
- Data available:
  - Total assessed value of all taxable property by county
  - Average millage rates by county
  - Property tax levies by county
- Computed variables: All variables are available in the raw data
- Years: Data is available from 2000-2018.

https://www.tax.virginia.gov/local-tax-rates and https://www.tax.virginia.gov/annual-reports

- Property Classification: Washington does not have a statewide classification of real property.

B.4.49 West Virginia

- Source of data: Lincoln Institute and West Virginia State Auditor's Office.
- Data available:
  - Mill rates by property class and municipality level
- Computed variables: In order to compute the average total rate imposed at the county level, we take the average of the total rates imposed at the municipality level for all residential property.
- Years: Data is available from 2003-2015.
- Property Classification: West Virginia has a statewide classification of real property.

B.4.50 Wisconsin

- Source of data: State of Wisconsin Department of Revenue's website and direct contact via email
- Data available:
  - Total levy by county
  - Total equalized assessed value by county
  - Average total tax rate by county
  - Total tax credit by county
- Computed variables: We obtain the total levy by subtracting the credit from the levy.
- Years: The data is available from 1989-2018. Data for 1989-1990 attributed to 1989.
- Property Classification: Wisconsin has a statewide classification of real property.

https://www.revenue.wi.gov/Pages/Report/home.aspx

- The school credit is distributed to municipalities and reduces the individual property tax collected.

B.4.51 Wyoming

- Source of data: Wyoming Department of Revenue's website
- Data available
  - Property tax levies by jurisdiction / function (county levies, municipal levies, special district levies, education levies) at the county level
  - County level mill rate
- Computed variables: Using the county level mill rate and the total of taxes levied at the county level, we estimate the net assessed value.
- Years: We have data from 1996-2016.
- Property Classification: Wyoming has a statewide classification of real property.

https://sites.google.com/a/wyo.gov/wy-dor/dor-annual-reports

B.5 Property Tax Reforms and Tax Limits

We present results for different definitions of rate and levy limits. The majority of our results is obtained using a definition of rate and levy limits that encompasses any limit imposed. Following this definition, a locality is marked as having a rate limit if it has any type of rate limit (for example a limit on individual property, a limit on some of the taxing jurisdictions, a limit specified with a formula). Similarly, a locality is marked as having a levy limit if any type of levy limit is present. We obtain data for the definitions above from Paquin (2015)[2]. Paquin(2015) documents the limits enacted and repealed through 2013. We record for every year in our sample the active limits and use the limits as of 2007 in our analysis. It is worth mentioning that, during the period between 2007 and 2013, very few changes to limits are enacted.

In addition, we also present results for rate limits at the jurisdiction level, aggregate levy limits, and levy limits on individual properties. We complement the data from Paquin (2015) with data from the Lincoln Institute of Public Policy[3]. The Lincoln review presents the main features of states' limits as well as the relevant history. We record a locality as having rate limits at the jurisdiction level when most taxing jurisdictions within the county are subject to a rate limit. In rare cases (e.g. South Dakota), rate limits exist but are deemed not constraining (Lincoln Institute), and thus we record them as not present. We classify a rate limit on an individual property as a limit which constrains the rate to which a specific property is subject. We record a locality as having an aggregate levy limit when taxing jurisdictions within the county are subject to limits on how much the levy can grow. We also record whether there is a levy limit on individual properties, which however is far less common.

Overall, jurisdiction-rate limits set in terms of maximum rates applicable and aggregate levy limits set in terms of maximum growth rate for levies are the most common. Some states however employ different formulas to set limits, which in some cases may depend on other factors (e.g. inflation), or may combine several limits through a set process. One particular process is the "truth-in-taxation" requirement, which usually requires that higher assessed values do not automatically result in a tax increase, subjecting the increase to specific obligations such as advertising changes and notifying taxpayers. Tennessee and

[2]Paquin, B.P., 2015. Chronicle of the 161-year history of state-imposed property tax limitations. Cambridge: Lincoln Institute of Land Policy.

[3]State-by-State Property Tax at a Glance. https://www.lincolninst.edu/research-data/data-toolkits/significant-features-property-tax/state-state-property-tax-glance. Significant Features of the Property Tax. Lincoln Institute of Land Policy and George Washington Institute of Public Policy. (Property Tax at a Glance; accessed: 10/31/2017 4:41:21 PM)

Utah for example both have this type of requirement, which we categorize as an aggregate levy limit.

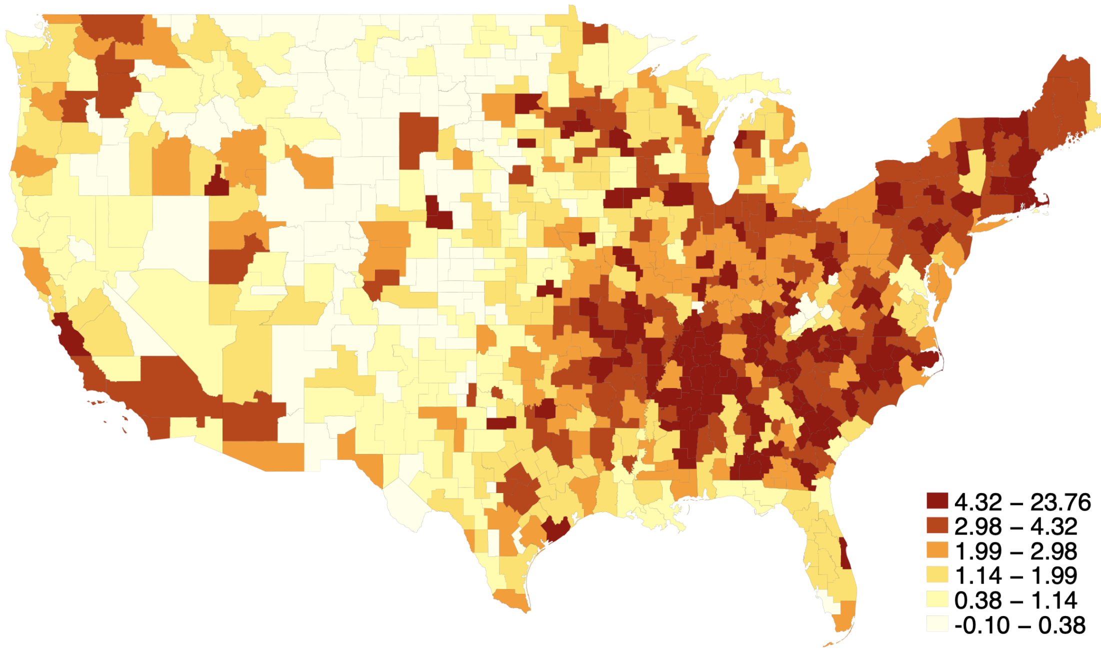
While our preferred categorization system using “any rate limit” and “any levy limit” or “aggregate levy limit” is relatively straightforward to interpret and implement, it does not allow us to differentiate between localities with stricter and looser limits.

APPENDIX C

Chapter III Supporting Material

C.1 Additional Figures

Figure C.1: Change in exposure to import Competition from China in $1000 per worker - 1990-2007



This figure displays the commuting zone exposure to the shift-share instrument for Chinese imports based on Chinese imports in several European countries between 1990 and 2007.

C.2 Additional Tables

Table C.1: Effect of shocks on wages, employment and housing market

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Log avg. wage		Log private emp. ratio		Med. home price		Home Price Index	
$\widehat{Robots}_{\Delta 10year}$	-2.21[c]	-2.09[c]	-0.53[c]	-0.63[c]	-9.14[c]	-8.80[b]	-6.49[c]	-7.23[c]
	(0.37)	(0.43)	(0.09)	(0.13)	(2.71)	(3.38)	(1.59)	(1.98)
$\widehat{Robots}_{\Delta 10year} \times HR$		-0.15		0.12		-0.40		0.90
		(0.31)		(0.09)		(2.13)		(1.28)
Dem. controls	✓	✓	✓	✓	✓	✓	✓	✓
Baseline controls	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.62	0.62	0.46	0.46	0.49	0.49	0.59	0.59
CZ-by-year	1,402	1,402	1,402	1,402	1,402	1,402	1,223	1,223

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table reports findings from equation 3.3, but focusing on log weekly wage, employment to population ratio, and local home prices (Median home price and a home price index). All controls from table 3.3 are included except for the fraction of revenues for local governments. All regressions are weighted by the national share of the population in 1990.

Table C.2: Effect of shocks on wages, employment and housing market

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Log average weekly wage				Log private employment ratio			
$\widehat{Robots}_{\Delta 10year}$	-1.93^c	-2.44^c		-2.03^c	-0.47^c	-0.53^c		-0.43^c
	(0.32)	(0.38)		(0.37)	(0.09)	(0.12)		(0.09)
$\widehat{IPW}_{\Delta 10year}$			-0.53^c	-0.33			-0.23^c	-0.18^c
			(0.12)	(0.23)			(0.03)	(0.05)
$\widehat{Robots}_{\Delta 10year} \times HR$	-0.46				-0.05			
	(0.59)				(0.11)			
$\widehat{Robots}_{\Delta 10year} \times Lim$		1.31^b				0.05		
		(0.56)				(0.20)		
$\widehat{IPW}_{\Delta 10year} \times HR$				0.04				0.00
				(0.24)				(0.05)
Demographic & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.63	0.62	0.59	0.62	0.49	0.47	0.46	0.48
CZ-by-year	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Median home price				Home Price Index			
$\widehat{Robots}_{\Delta 10year}$	-8.17^c	-9.62^c		-7.48^c	-5.84^c	-6.15^c		-5.66^c
	(1.85)	(3.43)		(2.37)	(1.17)	(1.80)		(1.41)
$\widehat{IPW}_{\Delta 10year}$			-3.22^b	-2.32			-2.09^c	-1.34
			(1.53)	(1.57)			(0.64)	(1.04)
$\widehat{Robots}_{\Delta 10year} \times HR$	0.03				-0.36			
	(2.91)				(2.00)			
$\widehat{Robots}_{\Delta 10year} \times Lim$		4.06				-1.04		
		(5.16)				(3.15)		
$\widehat{IPW}_{\Delta 10year} \times HR$				0.07				-0.07
				(1.63)				(1.00)
Demographic & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.53	0.49	0.47	0.50	0.62	0.59	0.58	0.60
CZ-by-year	1,402	1,402	1,402	1,402	1,223	1,223	1,223	1,223

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table is similar to table C.1 but including import competition from China as an additional shock, and interacting robotization with presence of local home rules and levy and rate limits. See table 3.3 for controls.

Table C.3: Effect of shocks on local revenues and expenditures - with Michigan

	Revenues		Taxes				Transfers		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total	Own	Total	Property	Other	Misc.	Total	Federal	State
$\widehat{Robots}_{\Delta 10year}$	-2.18[c]	-0.36	-0.18	0.58	-4.46[a]	-0.83	-3.39[b]	-2.33	-3.35[a]
	(0.71)	(2.34)	(3.27)	(3.70)	(2.55)	(1.41)	(1.54)	(2.08)	(1.74)
Demographic & base controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.28	0.18	0.28	0.24	0.35	0.12	0.25	0.13	0.34
CZ-by-year	1,438	1,438	1,438	1,438	1,326	1,438	1,438	1,428	1,438

State clustered standard errors in parentheses

^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

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Table C.3 – *Continued from previous page*

	Expenditures							Debt	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total	Educ.	Safety	Transport	Sanitation	Capital	Insurance	Interest	Total
$\widehat{Robots}_{\Delta 10yr}$	-2.29^{c}	-1.28^{a}	-2.15^{b}	-4.97^{c}	-0.10	-8.40^{c}	-1.78	2.24	0.74
	(0.77)	(0.65)	(0.84)	(1.65)	(1.59)	(2.85)	(1.98)	(1.76)	(1.48)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.13	0.26	0.22	0.10	0.13	0.12	0.09	0.30	0.25
CZ-by-year	1,438	1,438	1,438	1,438	1,420	1,438	1,438	1,431	1,438

State clustered standard errors in parentheses

^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table presents results similar to table 3.3, but including commuting zones in Michigan.

Table C.4: Effect of shocks on local revenues and expenditures - Unweighted

	Revenues		Taxes				Transfers		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total	Own	Total	Property	Other	Misc.	Total	Federal	State
$\widehat{Robots}_{\Delta 10year}$	-1.80^c	-2.53^b	-2.97^b	-4.22^c	3.42	-1.83	-0.27	6.21^a	-1.05
	(0.56)	(1.05)	(1.22)	(1.24)	(4.71)	(1.60)	(0.89)	(3.43)	(0.74)
Demographic & base controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.08	0.08	0.15	0.18	0.22	0.09	0.12	0.11	0.19
CZ-by-year	1,402	1,402	1,402	1,402	1,312	1,402	1,402	1,392	1,402

State clustered standard errors in parentheses

^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

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Table C.4 – *Continued from previous page*

	Expenditures							Debt	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total	Educ.	Safety	Transport	Sanitation	Capital	Insurance	Interest	Total
$\widehat{Robots}_{\Delta 10yr}$	-1.80^c	-1.24	-0.38	-0.13	1.85	-6.07^b	-3.02^a	0.03	-0.39
	(0.64)	(0.77)	(1.70)	(2.81)	(2.28)	(2.28)	(1.68)	(2.51)	(2.83)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.06	0.18	0.06	0.04	0.08	0.07	0.05	0.13	0.13
CZ-by-year	1,402	1,402	1,402	1,402	1,384	1,402	1,402	1,395	1,402

State clustered standard errors in parentheses

^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table shows the unweighted results from table 3.3.

Table C.5: Effect of shocks on local revenues and expenditures - w/ China shock

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total revenues		Total taxes		Property taxes		Total transfers	
$\widehat{Robots}_{\Delta 10year}$	-3.52^{c}		-5.17^{c}		-5.02^{b}		-2.21	
	(0.91)		(1.57)		(2.06)		(1.50)	
$\widehat{IPW}_{\Delta 10year}$	-0.85^{b}	-1.24^{c}	-1.02^{c}	-1.59^{c}	-1.01^{b}	-1.54^{c}	0.39	0.15
	(0.38)	(0.40)	(0.32)	(0.34)	(0.48)	(0.49)	(0.45)	(0.51)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.30	0.28	0.30	0.28	0.25	0.24	0.20	0.20
CZ-by-year	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total expenditures		Education		Safety		Capital Outlays	
$\widehat{Robots}_{\Delta 10year}$	-2.75^{c}		-1.18		-2.21^{a}		-3.21	
	(0.87)		(1.12)		(1.27)		(3.23)	
$\widehat{IPW}_{\Delta 10year}$	-0.37	-0.68^{a}	-0.52^{a}	-0.65^{a}	0.16	-0.08	-3.51^{c}	-3.87^{c}
	(0.38)	(0.40)	(0.30)	(0.35)	(0.49)	(0.50)	(0.99)	(0.98)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.12	0.11	0.25	0.25	0.22	0.21	0.09	0.09
CZ-by-year	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402

This table presents the results from table 3.3 including exposure to import competition from China as an additional shock (IPW). See table 3.3 for controls and details about estimation.

Table C.6: Effect of shocks on local revenues: with local autonomy measure - Unweighted

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total revenues		Total taxes		Property taxes		Total transfers	
$\widehat{Robots}_{\Delta 10year}$	-1.85^b	-2.10^c	-4.70^c	-2.31^b	-5.58^b	-2.56	0.82	-1.40
	(0.79)	(0.76)	(1.74)	(1.13)	(2.58)	(1.62)	(1.44)	(1.40)
$\widehat{Robots}_{\Delta 10year} \times HR$	0.06		2.34		1.84		-1.47	
	(0.71)		(1.46)		(2.23)		(1.53)	
$\widehat{Robots}_{\Delta 10year} \times Lim$		0.43		-0.96		-2.40		1.63
		(0.89)		(1.60)		(2.18)		(1.62)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.29	0.29	0.30	0.30	0.26	0.26	0.21	0.21
CZ-by-year	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total expenditures		Education		Safety		Capital Outlays	
$\widehat{Robots}_{\Delta 10year}$	-2.34^b	-2.67^c	-1.69	-1.76	-0.36	-0.96	-9.83^c	-9.07^c
	(1.11)	(0.72)	(1.08)	(1.28)	(1.54)	(1.33)	(3.62)	(2.75)
$\widehat{Robots}_{\Delta 10year} \times HR$	0.73		0.61		-0.04		5.07^a	
	(1.02)		(1.09)		(1.28)		(2.84)	
$\widehat{Robots}_{\Delta 10year} \times Lim$		1.26		0.75		0.82		4.32
		(0.99)		(1.22)		(1.85)		(3.19)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.12	0.12	0.25	0.25	0.22	0.22	0.08	0.08
CZ-by-year	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402

^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table shows the unweighted results from table 3.4.

Table C.7: Effect of shocks on local revenues: with local autonomy measure - China shock

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total revenues		Total taxes		Property taxes		Total transfers	
$\widehat{IPW}_{\Delta 10year}$	-1.53[a]	-1.22[b]	-2.49[b]	-0.82[a]	-2.50[b]	-0.27	0.90	-0.33
	(0.79)	(0.59)	(0.94)	(0.46)	(1.23)	(0.74)	(0.95)	(0.65)
$\widehat{IPW}_{\Delta 10year} \times HR$	0.40		1.21		1.30		-1.01	
	(0.70)		(1.04)		(1.44)		(0.91)	
$\widehat{IPW}_{\Delta 10year} \times Lim$		-0.02		-1.55		-2.59[a]		0.96
		(0.67)		(1.07)		(1.48)		(0.73)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.28	0.28	0.28	0.29	0.24	0.25	0.20	0.20
CZ-by-year	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total expenditures		Education		Safety		Capital Outlays	
$\widehat{IPW}_{\Delta 10year}$	-1.28[a]	-0.48	-1.28[a]	-0.70	0.40	0.17	-7.03[c]	-3.01[b]
	(0.75)	(0.57)	(0.74)	(0.45)	(0.77)	(0.57)	(1.90)	(1.14)
$\widehat{IPW}_{\Delta 10year} \times HR$	0.80		0.85		-0.65		4.26[b]	
	(0.65)		(0.76)		(0.78)		(1.82)	
$\widehat{IPW}_{\Delta 10year} \times Lim$		-0.39		0.10		-0.50		-1.74
		(0.65)		(0.64)		(0.61)		(2.00)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.11	0.11	0.25	0.25	0.21	0.21	0.10	0.09
CZ-by-year	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402

[a] $p < 0.10$, [b] $p < 0.05$, [c] $p < 0.01$

This table presents the population weighted results from table 3.4 using exposure to import competition from China as the shock (IPW). See table 3.4 for controls and details about estimation.

Table C.8: Effect of shocks on local revenues: IV estimation 1993-2007 - Unweighted

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total revenues		Total taxes		Property taxes		Total transfers	
$Robots_{\Delta 17year}$	-0.27	-0.11	-2.39^{c}	-3.20^{c}	-3.27^{c}	-3.24^{c}	1.96^{b}	2.80^{b}
	(0.58)	(0.53)	(0.88)	(1.10)	(0.83)	(0.98)	(0.90)	(1.09)
$Robots_{\Delta 17year} \times HR$		-0.35		1.74		-0.06		-1.81
		(0.70)		(1.23)		(1.35)		(1.49)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.15	0.15	0.38	0.38	0.37	0.37	0.16	0.16
CZ-by-year	722	722	722	722	722	722	722	722

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total expenditures		Education		Safety		Capital Outlays	
$Robots_{\Delta 17year}$	-0.37	-0.41	0.61	0.22	1.25	0.91	-0.30	-2.39
	(0.60)	(0.62)	(0.64)	(0.70)	(1.30)	(1.27)	(1.96)	(2.16)
$Robots_{\Delta 17year} \times HR$		0.08		0.82		0.73		4.43^{a}
		(0.82)		(0.82)		(1.30)		(2.31)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.28	0.28	0.48	0.48	0.45	0.45	0.23	0.23
CZ-by-year	704	704	704	704	704	704	704	704

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table evaluates the long-run IV model as in table 3.5 but unweighted. See table 3.5 for more details about variables and estimation.

Table C.9: Effect of shocks on local revenues: IV estimation 1993-2007 - China shock

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total revenues		Total taxes		Property taxes		Total transfers	
$IPW_{\Delta 17year}$	0.51	1.01	1.04	0.43	1.10	1.74	0.05	1.67
	(0.38)	(0.65)	(0.81)	(0.91)	(0.89)	(1.09)	(0.74)	(1.13)
$IPW_{\Delta 17year} \times HR$		-0.67		0.75		-0.85		-2.10[b]
		(0.52)		(0.72)		(1.03)		(0.89)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division FE	✓	✓	✓	✓	✓	✓	✓	✓
2	0.39	0.39	0.44	0.45	0.37	0.37	0.34	0.37
CZ-by-year	722	722	722	722	722	722	722	722

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total expenditures		Education		Safety		Capital Outlays	
$IPW_{\Delta 17year}$	0.45	0.67	0.39	-0.02	2.09[c]	2.74[c]	-0.89	-2.56
	(0.39)	(0.71)	(0.42)	(0.70)	(0.51)	(0.76)	(1.17)	(1.83)
$IPW_{\Delta 17year} \times HR$		-0.31		0.48		-0.84		2.15
		(0.58)		(0.67)		(0.74)		(1.47)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.29	0.29	0.46	0.49	0.44	0.44	0.23	0.24
CZ-by-year	722	722	722	722	722	722	722	722

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table evaluates the long-run model IV model as in table 3.5 with import competition from China as the structural shock (IPW). See table 3.5 for more details about variables and estimation.

Table C.10: Effect of shocks on local revenues: different local autonomy measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total revenues		Total taxes		Property taxes		Total transfers	
$\widehat{Robots}_{\Delta 10year}$	-3.95^b	-4.42^c	-7.50^c	-4.43^c	-8.49^b	-3.42^b	-0.68	-5.29^b
	(1.50)	(1.38)	(2.39)	(1.26)	(3.19)	(1.63)	(1.95)	(2.12)
$\widehat{Robots}_{\Delta 10year} \times HR_{city}$	-0.00		2.34		3.85		-1.67	
	(1.00)		(1.48)		(2.32)		(1.79)	
$\widehat{Robots}_{\Delta 10year} \times Lim_{levy}$		0.58		-1.61		-2.62		4.16^b
		(1.22)		(1.66)		(2.48)		(1.76)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓
2	0.29	0.30	0.30	0.30	0.26	0.26	0.21	0.22
CZ-by-year	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total expenditures		Education		Safety		Capital Outlays	
$\widehat{Robots}_{\Delta 10year}$	-2.93^b	-3.96^c	-2.21	-3.37^b	-0.92	-2.40^a	-7.94	-8.91^c
	(1.44)	(1.16)	(1.55)	(1.26)	(1.47)	(1.40)	(5.22)	(2.70)
$\widehat{Robots}_{\Delta 10year} \times HR_{city}$	-0.02		0.96		-1.50		3.62	
	(1.02)		(1.37)		(1.18)		(3.35)	
$\widehat{Robots}_{\Delta 10year} \times Lim_{levy}$		1.26		2.35^a		0.33		4.80
		(1.29)		(1.27)		(1.44)		(3.52)
Dem. & base controls	✓	✓	✓	✓	✓	✓	✓	✓
Fractions rev.	✓	✓	✓	✓	✓	✓	✓	✓
77-87 trend	✓	✓	✓	✓	✓	✓	✓	✓
Division & period FE	✓	✓	✓	✓	✓	✓	✓	✓
R^2	0.12	0.12	0.25	0.26	0.22	0.22	0.08	0.08
CZ-by-year	1,402	1,402	1,402	1,402	1,402	1,402	1,402	1,402

State clustered standard errors in parentheses
^{a} $p < 0.10$, ^{b} $p < 0.05$, ^{c} $p < 0.01$

This table evaluates our second model (table 3.4), using interactions with whether a state allows functional home rule to cities only (as opposed to cities or counties). We also interact exposure to robotization with whether a state has some levy limit, as opposed to both levy and rate limits. For details on controls and variables, refer to table 1.5. All results are weighted by the national share of population in the commuting zone.

C.3 Chinese import competition shock

Exposure to Chinese competition has become a heavily discussed topic in recent years, especially since the seminal work by Autor, Dorn and Hanson (2013a). In this paper, they use a shift-share instrument, based on the local exposure to import competition from China, where the shock is defined as the change in import from China by industry at the national level. The shock is computed by interaction the local share of employment in industry j - $\frac{L_{jct-1}}{L_{jt-1}}$, with the national change in import from China in industry j, re-scaled by the total employment in that industry at the national level - $\frac{\Delta M_{ujt}}{L_{ct-1}}$. Because of potential endogeneity between national changes in imports and local labor market conditions, Autor, Dorn and Hanson use imports from China in other rich countries as an instrument for ΔM_{ojt}. It follows that the instrument for the exposure to rising import competition is:

$$\Delta \widehat{IPW}_{oct} = \sum_j \frac{L_{jct-1}}{L_{jt-1}} \frac{\Delta M_{ojt}}{L_{ct-1}} \tag{C.1}$$

C.4 Shift-share instrument and policy - bias derivation

We will now derive analytically the intuition discussed previously. We assume that determining local policy is a function of previous policy, local economic conditions, and other local variables, such as preferences, ideology, etc.

$$\kappa_{st} = \alpha\kappa_{st-1} + \gamma f(\mathbf{y_{st}}) + g(X_{st})'\Lambda + e_{st}$$

For exposition, let's assume that the function capturing economic conditions - $f(\mathbf{y_{st}})$ - is a linear function of the share of employed individuals in the state, i.e. $f(\mathbf{y_{st}}) = \beta y_{st}$. We can then derive the change in local policy κ.

$$\begin{aligned}\Delta\kappa_{st} &= \alpha\Delta\kappa_{st-1} + \gamma\Delta\mathbf{y_{st}} + \Delta g(X_{st})'\Lambda + \Delta e_{st} \\ &= \alpha\big(\Delta\kappa_{st-2} + \gamma\Delta\mathbf{y_{st-1}} + \Delta g(X_{st-1})'\Lambda + \Delta e_{st-1}\big) + \gamma\Delta\mathbf{y_{st}} + \Delta g(X_{st})'\Lambda + \Delta e_{st} \\ &= \alpha^T\Delta\kappa_{st-T} + \gamma\sum_{t=0}^{T}\alpha^t\Delta\mathbf{y_{st-j}} + \sum_{t=0}^{T}\alpha^t\Delta g(X_{st-j})'\Lambda + \sum_{t=0}^{T}\alpha^t\Delta e_{st-j}\end{aligned} \tag{C.2}$$

The change in policy can be interpreted as a weighted sum of all the previous shocks and factors that lead to policy changes. Let's define $\beta_\mathbf{1}$ as the vector of coefficients for the included variables, and $\beta_\mathbf{2}$ as the coefficients vector for the omitted variable in the "correct" regression: $Y = X_1\beta_1 + X_2\beta_2 + \epsilon$. We know that the expected value of coefficient β_1 from the regression $Y = X_1\beta_1 + \epsilon$ can be written as

$$E[\hat{\beta}_1] = \beta_1 + [X_1'X_1]^{-1}[X_1'X_2]\beta_2$$

We can now derive the bias coming from the effect of policy on the outcome variable of interest. For convenience, let's assume that we are only regressing the outcome of interest on the economic shock, so we can rewrite the bias term as

$$E[\hat{\beta}_1] = \beta_1 + E[\Delta Shock_{st}^2]^{-1}E[\Delta Shock_{st}X_2]\beta_2$$

For exposition, we also simplify the policy function as only a function of previous policy, and economic shocks, i.e. $\kappa_{st} = \alpha\kappa_{st-1} + \gamma f(\mathbf{y_{st}}) + e_{st}$, with $y_{st} = Shock_{st}$. For exposition purposes, we have $X_1 = \Delta Shock$, the shock, $X_2 = \Delta\kappa$, the change in policy. The expected coefficient is

$$
\begin{aligned}
E[\hat{\beta}_1] &= \beta_1 + E[\Delta Shock_{st}^2]^{-1} E[\Delta Shock_{st} \Delta\kappa]\beta_2 \\
&= \beta_1 + E[\Delta Shock_{st}^2]^{-1} [\Delta Shock_{st} (\alpha^T \Delta\kappa_{st-T} + \gamma \sum_{t=0}^{T} \alpha^t \Delta \mathbf{y_{st-j}} + \sum_{t=0}^{T} \alpha^t \Delta e_{st-j})]\beta_2 \\
&= \beta_1 + E[\Delta Shock_{st}^2]^{-1} [\Delta Shock_{st} \alpha^T \Delta\kappa_{st-T}]\beta_2 \\
&+ E[\Delta Shock_{st}^2]^{-1} E[\Delta Shock_{st} \gamma \sum_{t=0}^{T} \alpha^t \Delta \mathbf{y_{st-j}}]\beta_2 + E[\Delta Shock_{st}^2]^{-1} E[\sum_{t=0}^{T} \alpha^t \Delta e_{st-j}]\beta_2 \\
&= \beta_1 + E[\Delta Shock_{st}^2]^{-1} E[\Delta Shock_{st} \gamma \sum_{t=0}^{T} \alpha^t \Delta Shock_{st-j}]\beta_2 \\
&= \beta_1 + \gamma\beta_2 \big(1 + E[\Delta Shock_{st}^2]^{-1} E[\Delta Shock_{st} \sum_{t=1}^{T} \alpha^t \Delta Shock_{st-j}]
\end{aligned}
$$

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