Commuting and Taxes: Theory, Empirics, and Welfare Implications

Short title: Commuting and Taxes

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Abstract

We examine the effect of interstate differences in income taxes on commuting times. Our theoretical model introduces a border into a model of an urban area and shows that differences in average tax rates distort commuting patterns, but the sign of the effect depends on whether taxes are residence-based or employment-based. Empirically, tax differentials have a large effect on commuting times for affluent households and mobile households. We show that commuting times are a sufficient statistic to measure the spatial welfare effects of tax policy. The model and empirical design can be used by economists to study other policy differences.

Urbanization provides many benefits such as improved economic mobility and opportunity, agglomeration and productivity gains, environmental benefits from density, and cultural and

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educational amenities. Not surprisingly, urbanization also comes with substantial costs. One of the most significant costs is associated with work-related travel. In 2011, the average one-way commute in the U.S. was 25.5 minutes for all workers and 44.8 minutes for workers commuting across state lines. Eight percent of workers have one-way commutes of over one hour. In many European countries, average commutes exceed twenty minutes. With the value of time associated with commuting estimated to be in the range of $20.00 to $40.00 an hour (Brownstone and Small 2005), commuting entails substantial costs.

Can government policy affect commute times and patterns? Glaeser and Kahn (2004) argues that government policies, including "bad" urban planning, play a limited role in generating urban sprawl. However, Baum-Snow (2007), Baum-Snow (2010) and Duranton and Turner (2012) find evidence that the development of the interstate highway system increased employment and suburban populations at the expense of populations in central cities. Shoag and Muehlegger (2015) shows that land use regulations increase commuting times and, consistent with our results, that the effects are largest for highly educated individuals. In addition to these studies, a small theoretical literature examines the impact of tax policies on the spatial structures of cities. Wildasin (1985), Brueckner and Kim (2003), and Voith and Gyourko (2002) argue that increases in marginal income tax rates (that change the opportunity cost of time), property tax rates, and the mortgage interest deduction might lead to an expansion of the city.[1] While these studies show how tax policies can change the spatial structure of a city, they assume uniform tax policies within the metropolitan area, ignoring the heterogeneity of tax policies within metropolitan areas.

Our interest is not in the impact of *uniform* government policies on sprawl and commuting costs, but rather on the effect of policy *discontinuities.* These discontinuities result from multiple jurisdictions and multiple levels of government within metropolitan areas (Calabrese *et al.* (2012), Calabrese *et al.* (2002), and Brülhart *et al.* (2015)). Metropolitan areas in the United States are composed of multiple municipalities, counties, school districts, and, for

[1] Distortions to city shapes result from the transportation network (Anas and Moses 1979). For a discussion of commuting subsidies, see Wrede (2001), Borck and Wrede (2005) and Borck and Wrede (2009).

some of the largest metropolitan statistical areas (MSAs), multiple states. As each of these multiple jurisdictions set different policies, policy discontinuities may result in the spatial mismatch of jobs and increased commuting costs. We focus on MSAs that cross state borders and have different state income tax policies. Understanding the effect of policy differentials in these areas is important because 75 million Americans reside in multi-state MSAs.

Our model represents the first unifying framework to study the location effects of both residence and employment-based tax policies. Using a model of an MSA divided by a state border, we study the effect of state income tax differences on the MSA's shape and the location of employment and households. In the process, we are able to contribute to the literature on endogenous city structure (Fujita and Ogawa 1982; Lucas and Rossi-Hansberg 2002). Our predictions depend on whether state income taxes are based on the state of residence of the household or on the state of employment. When state income taxes are *strictly* based on the state of residence, states are said to have reciprocity agreements. In MSAs where this is not the case (no reciprocity), the structure of tax credits makes tax liability for interstate commuters a function of the tax system in both the state of residence and state of employment. In MSAs where states have reciprocity agreements, tax differentials will influence the location of population. For high-income households, we show that in multi-state MSAs with reciprocity agreements, the high-tax [low-tax] side will have fewer [more] interstate commutes and, under reasonable assumptions, shorter [longer] commutes. In MSAs where states do not have reciprocity agreements, tax differentials affect both population and employment. On the high-tax [low-tax] side, the number of interstate commutes and commute times will increase [decrease] if employment is more responsive to a tax increase than population. As we demonstrate, the effect on commuting times is a sufficient statistic for measuring the spatial welfare cost associated with interjurisdictional tax differentials.

The goal of our empirical analysis is to obtain estimates that can be used to measure the welfare costs of interstate tax differentials resulting from the spatial relocation of employment and people. We test the model's predictions using household-level data and tax rates, controlling for other policies that may affect commuting such as infrastructure, property taxes, and state spending. We identify the effect of taxes on commuting by exploiting the discontinuous change in the tax system at geographic borders along with the heterogeneous effects in MSAs with and without reciprocity.[2] The results are robust to panel data approaches in the spirit of Zidar (2015) where we exploit state-level (statutory) tax rate changes at different points of the income distribution. Among low-income households, the response to tax differentials is small. But, the effect on commute times increases substantially with income, a finding consistent with these households having larger absolute tax differentials. In states with reciprocity, for households in the top 10% of the income distribution a one percentage point change in the tax differential can affect commute times by up to 0.85 minutes per one-way trip or 3 percent of the average commute. At \$30 an hour, the monetary value of this longer commute time in the lower-tax state is \$300 per year per household; using an hourly wage more appropriate for these households yields estimates near \$900 a year per household. This is a large fraction of the hypothetical change in the taxes due on labour earnings. Using the sufficient statistic for welfare changes derived from our theoretical model, we show that some of the \$900 worth of losses realised by households with longer commutes is offset by gains from shorter commutes on the other side of the MSA. However, significant welfare costs persist because of initial asymmetries in the population distribution.

Our paper makes three additional contributions. First, we show that to a first order approximation, commuting times are a sufficient statistic to measure welfare changes resulting from changes in location decisions. Changes in commute times capture the welfare changes across geographic space that are a result of the movement of jobs and people, a change in welfare not captured in estimates of the elasticity of taxable income (Saez *et al.* 2012). Second, we provide strong evidence that researchers seeking to identify migration resulting from government policies should focus on the responses of both employment and population. A literature estimates whether individuals migrate in response to state tax dif-

[2]Exploiting policy differentials was pioneered by Holmes (1998) and used within MSAs in Pence (2006).

ferentials (Young and Varner 2011). However, at the vast majority of state borders, income is partially taxed in the state where it is earned and not necessarily based on the state of residence. Thus, our results suggest that direct tests of the local responses at these borders should look for migration of both jobs and households. A small migration elasticity is not sufficient to show that there is little distortion of location decisions.

Finally, our paper provides a unifying framework for studying both residence-based and employment-based policies that are relevant for public, labour, IO, health and urban economics. For example, following the passage of the Affordable Care Act, some states elected to expand Medicaid while others did not. Given that this policy is residence-based, we would expect migration of eligible households to the states where Medicaid expanded resulting in spatial distortion. In contrast, a number of states and cities recently increased minimum wages. As this policy is employment-based, we would expect migration of employment to states which have not increased minimum wages, again creating a spatial distortion.

Our results are important for understanding cross-border commuting flows in Europe. The phrase "frontaliers" is used to refer to individuals who live in one country and work in another country. In 2007, approximately 800,000 people (or 1.45% of total employment) engaged in cross-country commuting in the European Union – up from 500,000 in 2000. Cross-border commuters are especially important in small countries such as Luxembourg and Liechtenstein where "in-commuting" represents 43% and 48% of domestic employment, respectively. Even in many larger European countries, cross-border commuting is substantial: in-commuting represents 6% of employment in Switzerland and 10.5% in Ireland while out-commuting from the country of residence is 7% of domestic employment in France and 7.4% in Ireland. To get a sense of how important cross-country commuting could become as the European Union integrates, in the United States, 5.3 million individuals (or 3.70% of total employment) worked outside of their state of residence in 2007. As in Europe, substantial heterogeneity exists among American states. For example, in California the number of out-commuters is less than 1% of the state's domestic employment while in Maryland the number of out-commuters is 16%. In Europe, tax treaties – similar to reciprocity agreements – determine place of taxation. Historically, frontaliers have been taxed in the country of residence, in the country of work or in both countries.[3]

In the next section we develop a simple theoretical model of multi-state urban areas and use it to highlight the effect of tax differences between the states on commuting times. In Section 2 we discuss the data used in the analysis and in Section 3 we discuss our empirical design. Our results utilizing tax discontinuities are found in Section 4 and our results using statutory tax changes are in Section 5. We provide estimates of the spatial welfare effects of tax differences in Section 6. Section 7 concludes.

1 Theory: Multi-State Urban Areas

We consider a spatial general equilibrium model of a closed[4] monocentric metropolitan area (MSA) located in two states ($i = 1, 2$).[5] We define r as the distance from the Central Business District (CBD). We assume that all employment in both states is located in the CBD, a mass point located at $r = 0$ that is also the state border. Although a mass point, the allocation of employment between the two states is endogenously determined and how much is in each state depends on the states' tax policies.[6] Thus, some share of employment is allocated to state 1 with the remainder allocated to state 2. The length of the MSA within state i, denoted by $\overline{r}^i$, is endogenous. Each state is composed of two areas, a central city and suburbs, denoted by C and S respectively. The terminus of the central city is at $\overline{r}^i_C$ and the suburbs run from $\overline{r}^i_C$ to $\overline{r}^i$. While the boundary of the MSA is endogenous, the boundaries of

[3]See "Frontier Workers in the European Union" and "Scientific Report on the Mobility of Cross-Border Workers within the EU-27/EEA/EFTA Countries."

[4] An alternative modelling strategy would be to have a system of cities in which residents are mobile among the cities. This case is discussed in Appendix A.4.

[5]Our model is not structural (Ahlfedlt *et al.* (2015), Fajgelbaum *et al.* (2015), or Monte *et al.* (2015)) because we wish to derive analytic comparative statics to study small changes in tax rates empirically. Our model is spatial as agents are heterogeneous with respect to distance and is general equilibrium because prices and government spending adjust endogenously. We differ from Ahlfedlt *et al.* (2015) and Monte *et al.* (2015) by focusing on taxes and from Fajgelbaum *et al.* (2015) by focusing on commuting.

[6]We can allow the CBD to take on an exogenous amount of area in each state and the results remain unchanged. This changes the bounds of integration in the formulas, so the mass point CBD is a normalization.

the central cities are fixed due to historical invariance.[7] Figure 1 illustrates this geography.

The MSA has a fixed but completely mobile[8] population that consists of two types of individuals indexed $k = C, S$ with N_C workers of type C and of N_S workers of type S where N_k^i individuals live in state i. For reasons discussed shortly, we assume that type C individuals outbid type S individuals for land in the city, which explains our notation. Utility for both types of workers is defined over the private good (x), a public service (g), and land (l) by the utility function $U = u(x, l) + m(g)$ with the standard assumptions.[9] Each individual provides a single unit of labour.[10] Individuals of type C receive utility from an amenity ϕ that only exists in the cities; it captures a relative preference of these individuals for the amenities associated with city dwelling.[11] Then, we can express utility at distance r in state i by the indirect utility function $V\left[w_k^j - \gamma r - \sigma - T,\, g(T^i),\, p^i(r)\right] + z\phi$, $i, j = 1, 2$; $k = C, S$ of an individual working in state j where $p^i(r)$ is the price of land at distance r, w_k^j is the wage rate, and the price of x is normalised to one. The cost of commuting to work is $\gamma r + \sigma$ where γ is the marginal cost of commuting distance r and σ is a cost incurred only for interstate commutes.[12] The term z equals 1 for type C only when residing in the city and $z = 0$ for type S regardless of residential location. For an individual residing in state i at distance r the demand for land is given by $l\left[p^i(r)\right]$ and we normalise the supply to one unit

[7] This fixed boundary might be explained by fiscal zoning, existing housing stocks, or a failure to assemble parcels (Brooks and Lutz 2016). Furthermore, Epple and Romer (1989) do not finding evidence supporting the flexible municipal boundary hypothesis. In our model, we think of the suburbs boundaries as being flexible because unincorporated areas at the fringe of the MSA can be incorporated as a new municipality. However, the model could be extended to incorporate a flexible boundary between the suburb and city. While this is possible, we chose the more tractable model given the literature discussed.

[8] The assumption of costless mobility across jurisdictions is in Roback (1982) and Albouy (2009). If mobility were costly, individuals would need larger tax differentials to induce mobility.

[9] The separability of the public service from the private good and land means that changes in the public service do not affect the choice between the private good and land; this simplifies the analysis.

[10] As our focus is on the distortion to location and space, we assume that labour is inelastically supplied by individuals. Recent estimates of labour supply responses to changes in after-tax wages are, on the intensive margin, quite small (Ziliak 2010). The assumption of inelastic labour supply is also found in Roback (1982).

[11] See Brueckner and Rosenthal (2009), Brueckner *et al.* (1999), and Glaeser *et al.* (2001) for explanations of the amenities that may result in a variety of spatial outcomes.

[12] For a given r, an interstate commute is always more costly than a commute within the state of residence. Thus σ captures the additional distance to travel to the other state's CBD or may be thought of as the cost of crossing a river. Note that as labour is inelastically supplied in our model, commuting costs are independent of the wage rate because w is not the opportunity cost of time. In our welfare analysis, Section 6, we allow the commuting cost to be proportionate to wages.

at each r.[13] T is a lump-sum tax and $g(T)$ reflects that the public service consumed by residents of the state is a function of tax revenues with $g'(T) > 0$. To close the model, we assume that all land rents and profits are distributed to absentee owners of land and capital.

Taxes depend on place-of-taxation rules. In the case of reciprocity, income taxes are residence-based; an interstate commuter residing in state i always pays T^i. In the absence of reciprocity, the extent to which taxes have an employment-based component depends on the tax credits applied. To simplify, we focus on the case in which tax payments in the state of employment receive a full credit.[14] Details on partial credits are found in Appendix A.3.[15] Then, in the absence of reciprocity, the tax payment to state i for a resident of state i employed in state j is $T^i - T^j$ if $T^i \geq T^j$ or 0 if $T^j > T^i$, $i \neq j$. Combined with the taxes paid in state j, total taxes are T^i if $T^i \geq T^j$ or T^j if $T^j > T^i$. If the tax in the state of residence exceeds the tax in the state of employment, then tax liability is effectively residence-based. Otherwise, it is source-based. The tax liability for a resident of state i working in state j is

$$(1 - I_k)T^i + I_k T^j \tag{1}$$

where $I_k = 1$ if $T^j > T^i$, $i \neq j$, with no reciprocity. Or $I = 0$ with reciprocity or with no reciprocity and $T^i \geq T^j$.

Each state has a fixed number of many identical firms.[16] Let the production function for a firm in state i be given by $f^i(e^i_C, e^i_S, E^i_C, E^i_S, E^j_C, E^j_S)$, where e^i_k is firm-level employment of type k workers in state i, E^i_k is the total employment of type k in state i and E^j_k is the total

[13] The demand for land is a function of income that is affected by tax changes. See Appendix A.2.4.

[14] Until recently, a number of states did not fully credit resident tax payments to other states. For example, the tax credit was partial in the states of Maryland, North Carolina, Wisconsin and in cross-border cities such as New York, Philadelphia, and St. Louis, but mainly for local income taxes we do not observe. In 2015, the Supreme Court ruled (*Comptroller of the Treasury of Maryland v. Wynne*) that such double-taxation of income is unconstitutional and that states should provide a full credit from income earned outside the state of residence. See "Supreme Court: Two states can't tax the same income," *USA Today*, May 18, 2015.

[15] In the absence of reciprocity, under partial tax credits, the tax payment to state 2 for a resident of state 2 employed in state 1 is $T^2 - \theta T^1$ where $\theta \in [0, 1]$ reflects the fraction of taxes eligible for the credit. Then, total taxes are $T^2 + (1 - \theta)T^1$ if $\theta T^1 < T^2$. If $\theta T^1 \geq T^2$ then total taxes are simply T^1.

[16] While we assume firms are not mobile, employment is mobile. As there are additional costs associated with interstate commutes, interstate changes in employment will generate some spatial distortions.

employment of type k in the other state in the MSA. We assume that $\partial f^i/\partial e^i_k > 0$, $\partial^2 f^i/\partial {e^i_k}^2 < 0$, and the standard Inada conditions apply. The Inada condition will guarantee that in equilibrium production occurs in both states. In general, type C and S will have differences in productivity and can be complements or substitutes to each other. Total employment of both types of workers in each state enters the production function of the individual firms. This reflects agglomeration economies that we assume have positive impacts on both marginal and total productivity of firms with the impact of increases in total employment in the state in which the firm is located being greater than the impacts of employment in the other state. This is consistent with Arzaghi and Henderson (2008) and Rosenthal and Strange (2008) that suggest spillovers are localised.[17]

1.1 *Equilibrium Conditions*

In equilibrium, firms in both states will employ both types of workers. We assume that the amenity, ϕ, is sufficiently large to ensure that type C workers outbid type S for land in the city and, in equilibrium, live there. We study the empirically-relevant equilibrium with non-zero interstate commuting of both types.[18] As individuals are perfectly mobile between the two states, all individuals of the same type receive the same utility regardless of where they live or work. To preview the equilibrium we study, type C workers will only commute from state 1 to state 2 and type S workers will only commute from state 2 to state 1.

In equilibrium, type S individuals residing at the termini of both states will be employed in their state of residence. Then equal utility between the two states requires

$$V\left[w^1_S - \gamma\bar{r}^1 - T^1,\, g(T^1),\, p^*\right] = V\left[w^2_S - \gamma\bar{r}^2 - T^2,\, g(T^2),\, p^*\right], \tag{2}$$

[17] Agglomeration may reduce the sensitivity to tax differentials (Brülhart *et al.* 2012). Knowledge spillovers positively affect agglomeration at the local level (Rosenthal and Strange 2001).

[18] We assume that the distribution of employment and population is such that there will be interstate commuting and changes in taxes are not enough to fully eliminate it. This is likely to occur if the city, with its amenities, is much smaller in one state than the other, resulting in more of type C individuals residing in that state than are employed there and more type S workers living in the other state (where they have shorter commutes as a result of the smaller city) than employed there. Technically, there could exist an equilibrium in which there is no interstate commuting. However, the data indicate an equilibrium with interstate commuting and we focus on this more complex equilibrium.

where p^* is the value of land at the termini of each state as determined by its value in non-residential use. The equal utility condition for type C at their municipal border is

$$V\left[w_C^1 - \gamma \bar{r}_C^1 - T^1,\, g(T^1), p^1\left(\bar{r}_C^1\right)\right] + \phi = V\left[w_C^2 - \gamma \bar{r}_C^2 - T^2,\, g(T^2),\, p^2\left(\bar{r}_C^2\right)\right] + \phi, \tag{3}$$

where, again, the state of residence and state of employment are the same.[19]

Without loss of generality, we assume that the number of type C workers residing in state 2 is less than the number employed there so some type C workers commute from state 1 to state 2. Analogously, we assume that the number of type S workers residing in state 1 is not sufficient to ensure that all type S workers employed in state 1 reside there, thereby generating an equilibrium with interstate commuting in both directions. Then equal utility condition for type S interstate commuters is

$$\begin{gathered} V\left[w_S^2 - \gamma r - T^2,\, g(T^2), p^2\left(r\right)\right] = \\ V\left\{w_S^1 - \gamma r - \sigma - \left[(1-I_S)T^2 + I_S T^1\right],\, g(T^2),\, p^2\left(r\right)\right\},\ r \in (\bar{r}_C^2, \tilde{r}_S^2], \end{gathered} \tag{4}$$

where the indicator $I_s = 1$ with no reciprocity and $T^1 \geq T^2$; $I_S = 0$ with reciprocity or with no reciprocity if $T^2 > T^1$. The interstate commuters from state 2 to state 1 reside between the city border and $\tilde{r}_S^2$. The equal utility condition for type C interstate commuters is

$$\begin{gathered} V\left[w_C^1 - \gamma r - T^1,\, g(T^1), p^1\left(r\right)\right] + \phi = \\ V\left\{w_C^2 - \gamma r - \sigma - \left[(1-I_C)T^1 + I_C T^2\right],\, g(T^1),\, p^1\left(r\right)\right\} + \phi,\ \ r \in (0, \tilde{r}_C^1], \end{gathered} \tag{5}$$

where the indicator $I_C = 1$ with no reciprocity and $T^2 > T^1$; $I_C = 0$ with reciprocity or with no reciprocity if $T^1 \geq T^2$. The interstate commuters from state 1 to state 2 reside between the CBD and $\tilde{r}_C^1$.[20]

[19] The equilibrium is not a corner solution, that is, both types of workers live in both states.

[20] In equilibrium, all type S [C] individuals are indifferent between any suburban [city] location in the MSA as they have identical utility functions and costless mobility. While someone living in state i and working in state j need not live closer to the CBD than someone living in state i and working there, assigning them the location nearest the CBD allows for clearer statements about the impacts of tax policies on commutes.

Equal utility within a state implicitly defines the bid-rent gradient as well as the population distribution in the state. In a market equilibrium, the wage in each state must equal the marginal product of labour. A necessary condition of equilibrium, due to the Inada conditions, is that both types of workers are employed in both states. Furthermore, in equilibrium, interstate commuting must only go in one direction for each type of worker.[21] The only assumption we place on commuting patterns is that a non-zero mass of each type of worker has an interstate commutes in opposite directions, which adds to the empirical applicability of the model by allowing for interstate commutes in both directions. The equilibrium of the model is depicted in Figure 2. In the figure, we depict the termini, city boundary and the boundary for interstate commutes $(\overline{r}^1, \overline{r}^1_C, \widetilde{r}^1_C; \overline{r}^2, \overline{r}^2_C, \widetilde{r}^2_S)$ along with the bid-rent curves where $(\overline{r}^1, \widetilde{r}^1_C, \overline{r}^2, \widetilde{r}^2_S)$ are endogenous. Note that the bid-rent function is discontinuous at the city boundary because of the discrete change in amenities valued by type C individuals.

1.2 *Comparative Statics: An Increase in T^1*

Our interest is in how a change in the difference, $T^1 - T^2$, between the two states' taxes affects commuting times. We consider a change in this differential via an increase in T^1. In Appendix *A.2* we explicitly solve for effects of this tax increase on the endogenous variables – wages, employment, population, rents, the termini of the MSA, and commuting patterns. Here we offer an intuitive explanation.

Define the net benefit associated with the tax increase as $\Delta NB^1_k \equiv MRS^1_k g'(T^1) - 1$ where $MRS^1_k \equiv {}^{\partial U^k}\!/\!_{\partial g^1} / {}^{\partial U^k}\!/\!_{\partial x^1_k}$ is the marginal rates of substitution between the public and private good. The sign of ΔNB^1_k will influence the effect of the tax change. Going forward we assume that the net benefit from the tax increase is negative for both types of workers ($\Delta NB^1_k < 0$), that is, the tax cost of an increase in public services is greater than

[21] With reciprocity, the equal utility condition for interstate commuters from state 1 to state 2, equation (5), implies $w^2_c - \sigma = w^1_c$. Then analogously for workers commuting from state 2 to 1 to have equal utility it must be the case that $w^1_c - \sigma = w^2_c$. Both cannot hold simultaneously and therefore commuting can only be in one direction. As noted previously, we assume this commuting is from state 1 to state 2. A similar argument applies for type S , which we assume commute from state 2 to state 1. The no reciprocity case is discussed in Appendix A.1.

the benefit from the public service increase. We make this assumption because our empirical analysis focuses on high-income households.

1.2.1 *Reciprocity*

Consider when states have a reciprocity agreement, making the tax residence-based. For the equal utility condition of type S interstate commuters, (4), to be satisfied, it must be the case that $w_S^1 - \gamma\widetilde{r}_S^2 - \sigma - T^2 = w_S^2 - \gamma\widetilde{r}_S^2 - T^2$. Then if T^1 increases, any changes in the two states' wage rates must be equal. As w_S^1 and w_S^2 are inversely related given that $N_S = E_S^1 + E_S^2$, employment of type S workers in the two states is unchanged. Thus, neither w_S^1 nor w_S^2 change as a result of the increase in T^1 ($dw_S^1 = dw_S^2 = 0$). Analogously, for (5) to remain satisfied, the increase in T^1 will have no effect on wages or employment of type C workers.

For the equal utility condition at the termini, (2), to remain satisfied, the terminus of state 1 ($\overline{r}^1$) must contract while the terminus of state 2 ($\overline{r}^2$) must increase. Contractions in the terminus imply reductions in population and land prices throughout the suburbs with the converse true for expansions. While the city boundaries are fixed, with the decrease in utility for city residents in state 1, population declines and, therefore, city land prices fall. The converse is true in state 2's city. Because employment in state 1 is unchanged but its population decreases, the number of type S interstate commuters from state 2 to state 1, $\widetilde{N}_S^2$, increases and the number of interstate commuters of type C from state 1 to state 2, $\widetilde{N}_C^1$, decreases.

The change in the bid rent functions as well as the changes in the termini of the MSA and boundary for interstate commutes ($\overline{r}^1$, $\overline{r}^2$, $\widetilde{r}_C^1\,\widetilde{r}_S^2$) are illustrated in Figure 3. Denoting the new values with a prime, the figure provides the intuition for our model: when states have reciprocity agreements, migration of households occurs from the high-tax state to the low-tax state, shifting the bid-rent curves. As employment is unchanged, this implies more interstate commutes from state 2 to state 1 and fewer from state 1 to state 2.

1.2.2 *No reciprocity*

The case of no reciprocity corresponds to source-based taxation if working in the high-tax state and residence-based taxation if working in the low-tax state. The difference in tax liability for interstate commuters drives the difference between the cases of reciprocity and no reciprocity. First consider the case with $T^1 \geq T^2$. For residents of the high-tax state who commute to a low-tax state (type C), the state of residence determines the tax burden. For residents of the low-tax state who commute to the high-tax state (type S), the state of employment determines the tax burden. The equal utility condition for these interstate commuters, (4), implies that the tax difference is fully capitalised into wages, that is, $dw_S^1 - dw_S^2 = dT^1$. Employment of type S decreases in state 1 and increases in state 2; this results in wages in state 1 increasing relative to state 2.

As the tax increase is fully capitalised into the wages of type S workers, the net benefit from the public service increases for type S ($MRS_S^1 g'(T^1) > 0$), and utility from residing in state 1 increases. For the equilibrium condition (2), to be restored, $\overline{r}^1$ must increase while $\overline{r}^2$ decreases. As employment of type S workers increases in state 2 and its suburban population decreases, the number of interstate commuters from state 2 to state 1, $\widetilde{N}_S^2$, decreases.

Regardless of where they work, taxes for type C residents of state 1 increase by dT^1 with $dw_C^1 - dT^1 = dw_C^2 - dT^1$ from (5) and therefore $dw_C^1 = dw_C^2 = 0$ as in reciprocity. Then, as $\Delta NB_C < 0$ population decreases in the city of state 1 and increases in the city of state 2. While wages do not change, the distribution of employment between the two states depends on the relationship between type C and S workers in production. If complements, the increase in type S workers in state 2 will increase employment of type C workers in state 2.[22] The effect on interstate commuting depends on the magnitude of the employment versus the residence response. If the change in employment is greater than the change in population (Monte *et al.* 2015), interstate commuting from state 1 increases.

Next, briefly consider an increase in T^1 when $T^1 < T^2$. The equal utility condition for type C interstate commuters, (5), is relevant and requires that $w_c^1 - T^1 = w_c^2 - T^2 - \sigma$. Then

[22] If type C and S workers are substitutes in production then the reverse holds.

with an increase in T^1 we have $dw_c^1 - dT^1 = dw_c^2$. This implies that the employment of type C workers in state 1 decreases and thus their wages increase; the reverse is true in state 2. As the benefits from the public service changes ($MRS_C^1 g'(T^1) > 0$), the city population in state 1 increases and decreases in state 2. Therefore interstate commuting of type C workers from state 1 to state 2 increases. While the increase in T^1 has no effect on the wages of type S workers, it will reduce their population in state 1 and, if type C and S workers are complements in production, will reduce employment there as well. Then, the effect on interstate commuting of type S workers from state 2 to state 1 depends on the relative changes in population and employment.

Figure 4 depicts the effects of the tax increase in the case of no reciprocity with $T^1 \geq T^2$. As the figure shows, the limits of the MSA do not change but interstate commuting will change. Again, denoting the new values with a prime, the figure shows there are both changes in interstate commuting and population. Figure A.1 shows the case when $T^1 < T^2$.

1.3 *The Effect of a Tax Increase on Commuting Times*

Given these results, we can now study the effect on commuting times. We define the average commuting time (AC^i) as the sum of state i residents' commuting times divided by state population. Commuting times depend on the length of the city, the distribution of residents, and the number of interstate commuters. Average commuting cost in state 1 is

$$AC^1 = \frac{1}{(N_C^1 + N_S^1)} \left[\int_{\overline{r}_C^1}^{\overline{r}^1} \gamma r N_S^1(r)\, dr + \int_0^{\overline{r}_C^1} \gamma r N_C^1(r)\, dr + \int_0^{\widetilde{r}_C^1} \sigma N_C^1(r)\, dr \right], \qquad (6)$$

with the expression for average commuting cost in state 2 analogous but with type S workers on the interval $(\overline{r}_C^2, \widetilde{r}_S^2]$ incurring the interstate commuting costs rather than type C workers on the interval $(0, \widetilde{r}_C^1]$. Appendix A.5.2 shows that differentiating with respect to T^1 yields

$$\frac{dAC^1}{dT^1} = \frac{1}{(N_C^1 + N_S^1)} \left[\begin{array}{c} \underbrace{N_s^1 \left(\overline{r}^1\right) \left(\gamma \overline{r}^1 - AC^1\right) \frac{d\overline{r}^1}{dT^1}}_{(a)} + \underbrace{\sigma \frac{d\widetilde{N}_C^1}{dT^1}}_{(b)} + \\ \underbrace{\int_{\overline{r}_C^1}^{\overline{r}^1} N_S^1(r) \left(\gamma r - AC^1\right) \widehat{N_S^1(r)} dr + \int_0^{\overline{r}_C^1} N_C^1(r) \left(\gamma r - AC^1\right) \widehat{N_C^1(r)} dr}_{(c)} \end{array} \right], \quad (7)$$

where $\widehat{N_k^1(r)}$ is the percentage change in the population for type k at distance r. The effect of a tax increase on average commuting time can be decomposed into three components. Term (a) is the change in average commuting time as a result of a change in the termini of the city – under reasonable conditions, commuters at the termini will have longer than average commutes $(\gamma \overline{r}^1 - AC^1 > 0)$. A second component, (b), is the change in interstate commuters. The sign of term (c) depends on how equilibrium changes in land prices affect the distribution of the population. Specifically, in percentage terms, are the increases in population greater near the CBD, where commuting costs are less than average, or near the fringe of the MSA, where commuting costs are higher? Based on empirical evidence, we assume that they are approximately the same regardless of distance from the CBD. In this case term (c) equals zero.[23]

1.3.1 *Reciprocity*

Recall that in the case of reciprocity, the terminus of state 1 contracts and the terminus of state 2 expands with an increase in T^1. As a result, average commuting times are reduced in state 1 but increased in state 2 (term (a)). The decrease in the number of type C interstate commuters also reduces commuting times in state 1 while in state 2 the number of type S interstate commuters increases, increasing commuting times there (term (b)). Then, as the

[23]As shown in Appendix A.5, if the Marshallian elasticity of demand of land, $\epsilon = -\frac{dl[p(r)]}{dp} \frac{p}{l[p(r)]}$ is equal to unity then $\widehat{N_k^1(r)}$, is a constant. This implies there are proportionate increases in population at all r. Concerning the empirical evidence, Cheshire and Sheppard (1998) cannot reject a (land) elasticity of one; Albouy *et al.* (2016)find an uncompensated (housing) elasticity closer to one than zero.

empirical evidence suggests that term (c) is negligible, after aggregating the effects, average commuting times are reduced in state 1 and increased in state 2.

1.3.2 *No reciprocity*

In the absence of reciprocity and $T^1 \geq T^2$, for type C workers the effect on commuting times entirely depends on the impact on interstate commuting. The impact is, a priori, ambiguous because it depends on the extent that firms relative to residents respond through interstate moves following the tax change. However, as discussed, empirical evidence suggests that employment will be more responsive than residents. If so, interstate commutes and commuting times for type C residents in state 1 increase. There will be no impact on commuting times of type C residents in state 2. As state 1's terminus increases, then from term (a), commuting times of type S workers increase. In state 2, the terminus contraction reduces commuting times (term (a) for state 2) and the decline in interstate commuting also decreases commuting times (term (b) of state 2). Aggregating the effects on commuting times in each state, we find commuting times increase in state 1 and decrease in state 2.

If $T^1 < T^2$, the effect on commuting times in state 1 is ambiguous – interstate commuting of type C workers will increase but $\overline{r}^1$ also decreases, shortening the average commutes of type S workers in the state. In state 2, there will be no impact on the commuting costs of type C workers residing in the state. For type S workers, the impact is ambiguous – the increase in $\overline{r}^2$ will lengthen their commutes, but if type S and C workers are complements, employment of type S in state 1 decreases and interstate commuting decreases. Thus in both states the impact on average commuting times depends on the impact on interstate commuting relative to expansion of the termini.

1.3.3 *Summary of results*

PROPOSITION 1. *With full tax credits, an increase in the tax differential,* $T^1 - T^2$*,*

1) with reciprocity and $\Delta NB < 0$*, will decrease commute times in state 1 and increase commute times in state 2.*

2.i) without reciprocity and $T^1 \geq T^2$*, will decrease average commute times in state 2. The* *impact on average commuting times in state 1 is ambiguous but will increase if the response of employment exceeds that of residents.*

2.ii) without reciprocity and $T^1 < T^2$, will have ambiguous impacts on commuting times. It will increase in state 1 and decrease in state 2 if the effect on interstate commuting is large relative to the effect of changes in the termini on commuting costs.

Proof. See Appendix A.5.2. □

1.4 *Spatial Welfare Effects: Commuting as a Sufficient Statistic*

We now consider the effect of this tax increase on social welfare. As the analysis suggests, the tax increase will potentially affect wages, land values, the level of public services, commutes and the termini of the MSA. While our analysis is couched in terms of a model with absentee land and firm owners, to fully consider the welfare effects of the tax increase, the impacts on profits and land rents need to be considered. Social welfare is defined as

$$W = N_C^1 U_C^1 + N_S^1 U_S^1 + N_C^2 U_C^2 + N_S^2 U_S^2 + \pi + P \tag{8}$$

where U_k^i is the (monetary) utility of type k worker residing in state i, π is total firm profit, and P is total land rent less the opportunity cost of land (p^*) in the city.

As shown in Appendix A.6, given the assumption of an inelastic labour supply, the impact of the tax increase on wage rates has no welfare effects – the change in earnings to residents offsets the change in profits. However, when employment moves, there are changes in welfare due to changes in agglomeration across the two states. In addition, the change in land rents paid by residents offsets the change in land rents received by the landowners resulting in no welfare effects. Marginal expansions or contractions in the termini only affect welfare through changes in commuting but not directly as land rent at the termini is equal to the opportunity cost of land (p^*). Finally, given equal utility across states for each residential type in equilibrium, residential relocation between the two states only affects welfare through changes in commuting costs. Thus, the tax increase affects social welfare through three channels: commuting costs, agglomeration, and public service levels. However, our focus is not on whether public services are efficiently provided, but on the changes in commuting costs due to differences in taxes between states. And if marginal agglomeration effects are similar across both states, the change in welfare is approximated by

$$\frac{dW}{dT^1} \approx -N^1\frac{dAC^1}{dT^1} - N^2\frac{dAC^2}{dT^1}. \tag{9}$$

where ${}^{dAC^i}/{}_{dT^1}$ is the change in AC^i for residents of state i. Furthermore, our model predicts that ${}^{dAC^1}/{}_{dT^1}$ and ${}^{dAC^2}/{}_{dT^1}$ will be opposite signs. In reciprocity states where there are no changes in employment, equation (9) holds with equality. In states without reciprocity, the sign of this approximation depends on which state has the greatest marginal agglomeration economies.

1.5 *Implications for Empirics*

As shown in Section 1.4, the change in commuting is a sufficient statistic for the spatial-welfare effects of tax differentials. This naturally leads us to focus our empirical analysis on the effect of state income tax differentials on commute times rather than the components that affect commute times (interstate commutes, sprawl, place of residence, place of employment), some of which have been extensively studied in the prior literature.

We summarise the predictions of our model in Table 1. Underlying the results in this table is the condition that $\Delta NB < 0$ for MSA's with reciprocity, that is, the net benefit from a tax increase is negative. Under this condition, with reciprocity, we expect a negative relationship between commuting times and tax differentials (the tax in state of residence minus the tax in other state in MSA). To the extent that we observe no effect of tax differentials on commuting at different points in the income distribution, this could be explained by $\Delta NB \approx 0$ for those income groups; significant negative effects on commuting are consistent with $\Delta NB < 0$. Thus, our model provides us with a test of which income-groups benefit from tax-financed public service increases, analogous to the relationship between property value and public service provision examined in Brueckner (1979) and Brueckner (1982).

With no reciprocity, we expect a positive relationship between commute times and tax differentials. An important condition needed to derive this result is that employment is more responsive to tax changes than households. Thus, an empirical positive effect of tax differentials on commuting times in no-reciprocity MSAs helps inform us of the relative response of employment and households to changes in state income tax rates.

Finally, although our model considers a common tax rate for both types of individuals, the model can be generalised to different tax rates for each type of individual. For example, in the case of reciprocity if one state increases the tax rate only on the suburban residents, it will decrease their commuting times in that state and increase suburban commute times in the other state in the MSA, but have no impact on the commute times of city residents. Thus, person-specific tax differentials are relevant for our empirical analysis.

2 Data

We use household data from the IPUMS-USA (Ruggles *et al.* 2010). The IPUMS-USA provides a 1% national random sample of the American Community Survey (ACS). We use data from the 2005 though 2011 ACS, creating a repeated cross-section of seven years. We only use households residing in a Combined Statistical Area (CBSA) crossing state lines.

The United States government defines CBSAs on the basis of commuting patterns such that individuals in the CBSA share a common market. Figure 5 shows CBSAs that cross state borders along with their reciprocity status. Sixty-one CBSA's cross state borders although some of the smaller contiguous CBSAs are merged together in our analysis because some Public Use Microdata Areas (PUMAs) that provide geographical identification in the ACS do not allow us to identify the specific CBSA in which they are located. In the Appendix, Table A.1 provides the descriptive statistics for the CBSAs (henceforth referred to as MSAs) used in the analysis. For the MSAs that cross into three or more states, we use the two most populated sides of the MSAs. With the exception of Washington DC, the population and employment in the smallest portion of the MSA is trivial. We use the data in Rork and Wagner (2012) to determine if the states have reciprocity agreements.

To estimate tax rates within the MSAs, we calculate the federal plus state average tax rate and the marginal tax rate using the NBER's TAXSIM program (Feenberg and Coutts 1993). When doing this exercise, for MSAs with reciprocity agreements we calculate the tax rate conditional on income being taxed in the state of residence. We then calculate the tax rate conditional on the household's residence being in the other state of the MSA. For MSAs with no reciprocity agreements, we first calculate the tax rate conditional on all income being earned in the state of residence and then calculate the tax rate if all income were earned in the other state in the MSA. We calculate the sum of the federal and state rate to allow for the deductibility of tax payments at the other level government. Appendix A.7 describes the details of the tax calculations, sample restrictions and the procedure for matching Census data to MSAs. As can be seen in Table 2, the mean combined federal and state average tax rate across all years in the sample is 8.75% and the average commute time is just over twenty-five minutes.[24] Approximately 7% of households have an interstate commute.

3 Research Design

We exploit policy discontinuities that arise at state borders *within* a MSA to identify the effect of tax differences on commuting patterns and times; we focus on testing Proposition 1 because commuting represents a sufficient statistic to conduct welfare analysis. Discontinuous changes in taxes at borders have been used to study tax evasion and avoidance, migration decisions (Coomes and Hoyt 2008), firm location decisions (Holmes 1998; Rohlin *et al.* 2014) and tax competition (Agrawal 2015).

We naturally focus on how state income taxes would differ between the states within the MSA given the household's reported income and its current employment. The identifying

[24]We check our average tax rate calculations from TAXSIM with statistics released by the CBO. We underestimate the average tax rate in the full population. This underestimate is likely a result of the top coding of income data available to us, measurement error of income resulting from the Census survey, and an inability to correctly classify some income or deductions.

variation comes from person-specific differences in the average tax rate differential and marginal tax rates. To test how commute times vary as a function of the tax rate for household i living in metropolitan area m and state s in year t of the ACS, we estimate

$$C_{i,m,s,t} = \begin{array}{c} \beta_1 \triangle atr_{i,m,s,t} + \beta_2 \triangle atr_{i,m,s,t} R_{m,t} + \gamma_1 mtr_{i,m,s,t} + \gamma_2 mtr_{i,m,s,t} R_{m,t} \\ + \varrho X_{i,m,s,t} + \zeta_{m,t} + \theta_{s,t} + \epsilon_{i,m,s,t}, \end{array} \tag{10}$$

where $C_{i,m,s,t}$ is the average commute time per member of the household in the labour force,[25] $\triangle atr_{i,m,s,t}$ is the difference in average tax rates for the household, $mtr_{i,m,s,t}$ is the marginal tax rate paid, $X_{i,m,s,t}$ are controls listed in Appendix A.9 including a series of occupation dummies for the primary and secondary earner and other policy differentials, $R_{m,t}$ is a dummy variable that equals one if the states in the MSA have a reciprocity agreement. We include MSA by year dummies denoted $\zeta_{m,t}$ and state by year dummies denoted $\theta_{s,t}$, which account for specific economic or policy shocks to a particular area. The state by year dummies control for all other policy changes that affect all households identically. Let

$$\triangle atr_{i,m,s,t} = \begin{cases} atr_{i,m,s,t} - atr_{i,m,-s,t} & \text{if two state MSA} \\ atr_{i,m,s,t} - \overline{atr_{i,m,-s,t}} & \text{if more than two state MSA} \end{cases} \tag{11}$$

where $atr_{i,m,s,t}$ is the average tax rate (federal plus state) of household i living in state s of MSA m in Census year t and $atr_{i,m,-s,t}$ is the average tax rate for that same household in the other state (denoted $-s$) of the urban area. Define $\overline{atr_{i,m,-s,t}}$ as the average (for that household) across the other states in the MSA for three-state areas. The idea behind using the average of all other states in the MSA is that even though the third state is less populated, it is within the common labour market and thus households can choose it as a location. Thus, $\triangle atr_{i,m,s,t}$ is the average tax rate in the household's state of residence

[25]In the ACS, respondents are asked "How many minutes did it usually take this person to get from home to work last week?" Although a survey question, we believe that systematic measurement error concerns are limited given that the question asks respondents to specifically draw on recent commuting experience.

relative to the rate in the counter-factual (non-residence) portion of the MSA. We follow the convention in the theoretical model and determine the tax impact on commute times on the basis of the state of residence. A state border through a common labour market is useful to construct a household's counter-factual tax rate. The counterfactual is what the household would pay to the other state given its income and other characteristics determining tax liability; it is not based on what a representative (average) household would pay to the other state. The variable $\triangle atr_{i,m,s,t}$ is negative on the low-tax side and positive on the high-tax side. A one percentage point increase in $\triangle atr_{i,m,s,t}$ corresponds to a widening of the tax gap on the high-tax side, but a narrowing of the tax gap on the low-tax side, which has the same theoretically signed effect. The specification assumes that the effect of a change in the own-tax rate and the neighbouring-tax state are equal in magnitude, but opposite in sign ($\beta_1 \triangle atr_{i,m,s,t} = \beta_1 atr_{i,m,s,t} - \beta_1 atr_{i,m,-s,t}$). We relax this assumption later.

An implicit identifying assumption for $\triangle atr_{i,m,s,t}$ is that we can accurately measure the counter-factual tax rate when we only observe wages from one state. If wages differ across states, we will mismeasure the counter-factual. In MSAs with reciprocity, this amounts to assuming that if the household changed residences because of a change in their tax liability in one state, their gross wages would remain similar. In MSAs without reciprocity, this amounts to assuming that the difference in average tax rates attributable to additional taxes associated with any wage capitalization are relatively small if a household changes its state of employment.[26] We rely on the MSA being a local labour market and thus, the wages available to a household of a particular ability level are independent of the particular state.

To account for marginal tax rates (Wildasin 1985), we use the marginal tax rate paid. The marginal tax rate paid by a household living in state l and working in state w is

$$mtr_{i,m,s,t} = \begin{cases} mtr_{i,m,l,t} & \text{if } R_{m,t} = 1 \\ mtr_{i,m,w,t} & \text{if } R_{m,t} = 0 \end{cases}. \tag{12}$$

[26]Derivation of the difference between the measure of $\Delta atr_{i,m,s,t}$ we use and the theoretically-consistent measure is found in Appendix A.7. The comparison found there suggests this difference is small.

The value depends on whether the states in the MSA have a reciprocity agreement. In words, $mtr_{i,m,s,t}$ equals the marginal tax rate in the state of residence if the states have reciprocity and equals the tax rate in your state of work if no reciprocity agreement exists. The marginal tax rate is based on the tax rate that you actually pay because, as in Wildasin (1985), the marginal tax rate influences commuting through the opportunity cost of your time.

To address the possibility of confounding factors, we employ a battery of controls within the X vector. The set of controls can be decomposed into several parts. The first set includes economic and demographic characteristics (both characteristics common to the household and each individual) that are designed to control for preferences for public services and locations. These controls include marital status, race, income, house or apartment characteristics, gender, the number of children, citizenship, age, employment status, education status, a dummy variable if the household resides in the state containing the first named city in the MSA and the method of transportation to work. As we realise the relationship between commutes and incomes may be non-linear, we include a flexible polynomial in income as a control. Because the analysis is done at the household level, we also include person-specific variables for the second person after interacting them with a variable that equals one if it is a two person household.[27] The second set of controls includes public policy differences across states, which may influence sorting behaviour, including but not limited to gas taxes, sales taxes, education spending, and highway spending. Finally, we also control for time-varying MSA by state aggregated characteristics that are designed to capture possible sorting across the border.

In addition, we include a series of occupation dummy variables for each person. These dummy variables control for the fact that certain occupations may cluster on one side of a state border. One may worry, however, that the distribution of occupations is endogenous to taxes, which could arise if high-income occupations cluster in low-tax states. To test for this possibility, we calculate for each state by MSA the fraction of primary workers in a particular

[27]Inclusion of both person's characteristics is common for joint decisions (e.g., McGeary 2009).

occupation. We then conduct a test of differences in means between the high-tax and low-tax side of the border and fine a statistical difference for some, but not all, occupations. A list of all occupation dummies, person, household, policy, or MSA-state controls is in Appendix A.9.

3.1 *Reciprocity Agreements*

Reciprocity status is a key source of identifying variation because our theoretical model predicts opposite-signed effects. Where does this variation come from and is it correlated with unobserved determinants of commute times? To address possible concerns regarding reciprocity status, we first note that most reciprocity agreements were implemented in the 1960s and 1970s. The most recent reciprocity agreement was implemented in 1992. Only two reciprocity agreements have ever been abolished after their initial agreement and only one state-border changed its reciprocity status in our sample. Although reciprocity agreements were historically drawn, they will have a relationship to current commuting if factors that influenced the determination of reciprocity status also persist today and influence commute times. Because reciprocity agreements apply to the entire state border, they may not be targeted at a particular MSA if states have multiple (large) MSAs crossing the state border. Many of the states in our sample have multiple cross-border MSAs at the same state border (for example, the West Virginia-Ohio border). Thus, although reciprocity agreements likely target cross-border activity, many states need to be concerned about multiple points of cross-border economic activity.

To verify this claim, we run a regression of the form: $r = \alpha + \varsigma Z + \epsilon$, where r is a reciprocity dummy variable and where Z is an observable characteristic in 2011. We run two types of regressions: (1) a state level regression where r takes on the value of one if the state has at least one reciprocity agreement and (2) a border analysis where we pair adjoining states in our sample and let r equal one if that pair of states has a reciprocity agreement. Table A.2 shows the results. None of the variables included offer a statistically significant explanation of the reciprocity variable. Acknowledging that this may remain a concern, in subsequent sections we show that the results are robust to an instrumental variable (IV) strategy.

4 Results

In all models presented, standard errors are clustered at the MSA-state level. In Table A.4 we present the baseline results of estimating (10) for the full population of taxpayers. No economically-meaningful effects arise. This null result is not surprising considering that this sample includes many households that pay no state taxes and that are likely to consume public services in excess of tax costs. We next proceed by disentangling the effects by income group with a focus on incomes where we expect $\Delta NB < 0$.

4.1 *The Role of Income*

We expect that higher income households are more responsive to average tax rate differentials. For a given difference in the average tax rate differential, the absolute difference in total taxes is proportional to household income. Then, if the benefits from the associated public service increase are less than proportional to income, net benefits are decreasing with income and likely to be strongly negative for the highest-income households. We also expect tax differentials to be most salient for high income earners and the firms that employ them. To test this theory, we cut the sample based on various percentiles of the income distribution. Formally, we construct income groupings $\iota \in [1, 2, ...20]$, based on the percentiles of total income where each group corresponds to five percentiles of the income distribution such that $\iota = 1$ are households in the bottom 5% of the income distribution and $\iota = 20$ are households in the top 5%.[28]

[28] We define the thresholds for each group using the distribution in the mid-year of our sample and then allocate a household to income percentile ι if its total income falls within the defined thresholds in any year t. We do this to hold the income thresholds for each group fixed over time. Table A.3 shows the thresholds.

We first run a triple interaction model that expands equation (10) to include:

$$\beta_1 \triangle atr_{i,m,s,t} + \sum_{y=2}^{20} \eta_y \triangle atr_{i,m,s,t} 1(\iota = y) + \beta_2 \triangle atr_{i,m,s,t} R_{m,t} + \sum_{y=2}^{20} \lambda_y \triangle atr_{i,m,s,t} R_{m,t} 1(\iota = y) \tag{13}$$

where $1(\cdot)$ is an indicator variable that equals one for the income percentile when index $y = \iota$. We also include the dummies $1(\iota = y)$ separately in the regression and we interact MSA dummies and state dummies with the income group dummies to control for economic or policy shocks that affect each income group. In this way, the coefficients η_y indicate the effect of the tax differentials (relative to the omitted category $\iota = 1$) for income group ι in no reciprocity states while λ_y indicate the additional effect in reciprocity states for each income group. Given the omitted category corresponds to the bottom five percent of the income distribution, β_1 and β_2 are approximately equal to zero implying that the effect of tax differentials is approximately equal to η_y for income group ι in no reciprocity states and $\eta_y + \lambda_y$ in reciprocity states. In Figure 6, we plot the coefficients η_y and λ_y separately. The figure indicates that tax differentials do not appear to influence the bottom 75% of the income distribution. Around the 75th percentile, the coefficients begin to diverge away from zero and move in opposite directions in reciprocity and no reciprocity states. At about the 85th percentile of the income distribution, these coefficients become statistically different from zero. This figure provides a test of when tax differentials start to matter and suggests that the effects are most important for households in the top of the distribution.

Thus, we focus on selected percentiles of the income distribution in Table 3. In this table, we estimate equation (10) for non-overlapping income groups. We estimate equation (10) using a split sample approach, which improves identification by allowing the state-by-year and MSA-by-year dummies to be specific for each income group. This controls for state policy and economic shocks that affect that particular income group. If $\Delta NB < 0$, our theory predicts that $\beta_1 > 0$ and if employment is more sensitive than residence then $\beta_2 < 0$. Thus, any omitted variable that threatens identification would likely need to have opposite effects in reciprocity and no reciprocity MSAs.

To interpret the magnitudes, consider households in the top five percent of the income distribution – column (7). If this household resides in an MSA without reciprocity, a one percentage point increase in the average tax differential increases one-way commuting times by 1 minute per person or over a 3.5% increase relative to the average commute time in this group. Given Proposition 1, this positive effect suggests that the employment elasticity is greater than the migration elasticity. In a MSA with reciprocity, a one percentage point increase in the tax differential lowers commuting times by 1.24 $(-2.23 + 0.99)$ minutes or a 4.4% decline of the average commuting time. All magnitudes can be interpreted in this same manner although marginal effects in reciprocity states are only statistically significant for the very top of the income distribution. For the top 5% of households, a one percentage point increase in the marginal tax rate has no significant effect in no-reciprocity MSAs, but raises commutes by 0.24 minutes in MSAs with reciprocity. In general, although the effect of mtr is often statistically significant, the economic effect of marginal tax rates on the shape of the MSA is relatively small. These effects may be small because marginal tax rates may not be salient.

Moving from column (1) to (7) in Table 3, the effect of the average tax rate differential is increasing across the income distribution except for a slight decline at the very top. In MSAs with reciprocity [no reciprocity], the effects among households in the top 5% are 6.0 [3.6] times larger than for those in the top 20-25%. This generally monotonic property is consistent with the theoretical model if the net benefit from tax increases is declining with income. Although splitting the sample into non-overlapping income groups is appealing to see how the effects change across the income distribution, in Table 4 we allow for the income groups to overlap. This table is useful for two reasons: (1) the overlapping categories will be useful for the welfare analysis given that a policymaker likely cares about the effects across several income groups and not just within a narrow income group and (2) because we shall subsequently focus on the top 10% and 25%. Results increase monotonically, but slower than in Table 3 because the all columns in Table 4 include people at the top.

Dividing the sample on the basis of homeownership status, Table 4 shows mixed results for the relative magnitudes among homeowners and renters. This is likely due to homeowners having a longer tenure at a location in the MSA that makes them more responsive, but also have higher moving costs, making them less responsive.

4.2 *The Role of Children and Singles*

In Table 5, we show the results conditional on having children and conditional on being a single-person household. Households without children are likely to be more mobile than households with children and are less likely to care about school quality. Further, married households are likely to contain multiple workers. This joint decision may result in smaller commuting coefficients simply because the household may not have the flexibility to optimally decide its commuting patterns for both workers.

From column (1) of Table 5, it is apparent that with reciprocity, the results for the married households in the top 25% with no children are more negative than those for all households (column (2) of Table 4). However, the effects are even larger in absolute value for households that are single with no children. For them, a one percentage point increase in the tax differential lowers commuting times by approximately 0.91 minutes, an effect that is over five times larger than for the same income group for the full sample in Table 4. In no reciprocity states, results are smaller for those without children, which is consistent with the change in population being closer to the change in employment (muting the effects in proposition 1 part b). Columns (3) to (5) demonstrate that single households in MSAs with reciprocity are highly responsive regardless of their income percentile. We conclude that marital status seems to be very important, which is consistent with needing to consider a joint-maximization problem that is likely to arise for high-income households.

The effects are larger in reciprocity states for recent single movers compared to households that have not moved in more than ten years.[29] Again, this is consistent with theory: recent

[29]We do not identify an effect for recent movers when the households contain married couples, perhaps

movers are most likely to have optimised their commutes with respect to current day tax policy differentials. Movers from a different state have the largest effects, but the sample size becomes too small to do formal inference. Recent home movers are not very different in no reciprocity states, consistent with job changes mattering more.

4.3 *Own-State Tax Rate vs. Other-State Tax Rate*

Recall that the use of $\triangle atr_{i,m,s,t}$ constrains the effect of an increase in the tax rate of the state of residence to be equal but opposite in sign to the effect of an increase in the tax rate of the other state in the MSA. In this section, we relax this assumption to allow the own-state and other-state tax rate to have effects that differ in their magnitude. Splitting the sample by reciprocity status in this exercise, the estimating equation becomes

$$C_{i,m,s,t} = \begin{array}{c} \beta_{own} atr_{i,m,s,t} + \beta_{other} atr_{i,m,-s,t} + \gamma_1 mtr_{i,m,s,t} \\ + \varrho X_{i,m,s,t} + \zeta_{m,t} + \theta_{s,t} + \epsilon_{i,m,s,t} \end{array} \tag{14}$$

where the variables are defined previously. Holding constant $atr_{i,m,-s,t}$, an increase in the tax rate in the state of residence will decrease commuting times in the presence of reciprocity agreements; it will increase commute times when no reciprocity agreements are in place if the employment response is large relative to the residence response. Similarly, holding constant $atr_{i,m,s,t}$ an increase in the tax rate in the other state of the MSA will increase commuting times in the presence of reciprocity agreements; it will decrease commuting times in the absence of reciprocity agreements and a large employment response.

In Table 6 we report the results of this exercise. In general, the statistical significance of the effects becomes stronger when they are entered separately in the regression. The effect of the tax rate in the state of residence is usually slightly larger than the effect of taxes in the other state (in absolute value) in the absence of reciprocity agreements. The result is reversed for reciprocity states suggesting that pull factors may be more important. However, the effect of the own-state tax rate and other-state tax rate are not statistically different from

because of the joint location issue.

each other in absolute value, suggesting that the use of the tax differential is appropriate.[30]

4.4 *Identification*

In terms of identification, we address several challenges. For example, tax rates might be higher in places with less mobile residents. Or MSAs with lower population densities might have lower tax rates to compensate residents for the longer commutes. As a response to these concerns, note that we focus on state income tax rates that apply uniformly across the state and multiple metropolitan areas. As a result, it is unlikely that the states create tax policy to target a particular MSA, especially given that the median voter in the state is likely quite different from the median voter in the MSA. Thus, commuting times in one specific MSA are likely not co-determined with state income tax rates.

Second, one concern may be the endogeneity of the average tax rate differential. Although we observe wages in the Census, we do not observe the counter-factual wages that the person would obtain in the other state of the MSA. Until now, our identifying assumption has been that the counter-factual wages are similar – in fact the same – across all states in the MSA. Given that MSAs are defined as common commuting and labour markets, this seems like a reasonable assumption. However, as noted in Kleven *et al.* (2013) the counter-factual average tax rate will be over-estimated (if the tax systems are progressive) if households are more likely to select the side of the MSA where they can obtain the highest wages. To address this, we show in Appendix A.8, that the bias is theoretically likely to be small. In particular, many state tax systems are much less progressive than the federal tax schedule because they have top marginal tax rates that go into effect at relatively low levels of income. For example, in 2007, only 6 states in our sample had top tax brackets greater than $75,000 and in 3 of those states the difference in the top and bottom marginal tax rate was less than or equal to 2 percentage points. The first two columns of Table A.5 also show that the results are robust to using a dummy variable for high-tax, which does not suffer from this problem.

Third, residents on the high-tax side may differ on unobservables from those on the

[30] In Appendix A.11 and Table A.6 we allow the effects to differ by high- and low-tax sides of the border.

low-tax side of metro areas because of sorting. To address this issue, we present several robustness checks. In the last two columns of Table A.5 we show that the results are robust – and stronger – when we restrict the sample to the residents living in the state containing the principal (first named) city in the MSA. Thus, we move away from the two-state design and exploit variation in tax differentials within a particular part of the MSA. As an alternative response, in Table 7 we show that sorting based on unobservables does not appear to be a concern. To do this, we start with a baseline specification containing only MSA, state and year dummies and then sequentially we add various controls. Relative to the specification in column 1, the coefficient estimates are similar. Adding family and individual controls shows a dramatic increase in the R^2 of the regression from 0.06 to 0.27. This pattern is consistent across the income distribution (see Table A.7). This suggests that the person specific controls explain a large amount of variation in commuting, but they have little effect on the estimates. It would be difficult (but not impossible) to imagine that unobservables – if similar to the observables – would have a large enough effect to erode the effects we demonstrate.

4.4.1 *Instrumenting for reciprocity status*

Fourth, although we have argued that reciprocity agreements were historically decided, it is possible that unobserved location fundamentals that determine reciprocity status could persist and may be related to commuting times today. To address this concern, we construct instruments for reciprocity status in a similar spirit to Rork and Wagner (2012) based on historical participation in interstate compact agreements. Interstate compacts signal that states are willing to cooperate. Voit and Nitting (1999) identify interstate compacts by the type of agreement.[31] From this database of compacts, for every state border pair in our sample, we calculate the number of interstate compacts between the two states in each category of compacts. We then identify categories of compacts that are positive and sig-

[31] We do not use recent compacts as we wish to exploit the historical nature of interstate compacts as well. We throw out all compacts related to taxation, commuting, bridges, or any other aspect that directly relates to our analysis and all compacts where more than a majority of states are signatories because these compacts are likely to be national in scope and not predictive of bilateral reciprocity agreements.

nificantly correlated with reciprocity status: compact agreements on water, child welfare, lottery, pests, insurance, health and planning. We calculate the number of compacts in each category that are ratified prior to 1999 for each state-pair combination.

We instrument for $\triangle atr_{i,m,s,t}R_{m,}$ with the interaction of $\triangle atr_{i,m,s,t}$ and the number of interstate compact agreements in each of the categories above; we also construct instruments in a similar manner for $mtr_{i,m,s,t}R_{m,}$. We then estimate (10) with these instrumental variables excluding the one borderpair that changes reciprocity status because our instruments are not time varying. The instruments are relevant (they are strongly correlated because cooperation on these topics signals a willingness to cooperate on taxes) and they are valid given it is unlikely that historical agreements on topics like pest control directly influence commuting today. We present the results of this exercise as a robustness check in Table 8. It become clear that after instrumenting for reciprocity status with compacts signed prior to 1999, that the effects of tax differentials generally increase slightly in absolute value suggesting that any endogeneity concerns about reciprocity status will bias the estimates presented throughout this paper towards zero. One concern with the instruments is that there may be unobserved location fundamentals correlated with individual commuting times that affect both whether a state currently has a reciprocity agreement in place and whether a state previously signed an interstate compact. To reduce the possibility, we use only interstate compact agreements that were signed prior to 1970. These interstate compact agreements occurred in the more distant past and therefore are less likely to be correlated with commuting times today, although the correlation with reciprocity status remains strong.[32] When using these earlier compacts, the results remain close to the OLS results.

5 Tax Changes

[32]Even with historical compact agreements, various unobserved location fundamentals may persist or be path dependent (Bleakley and Lin 2012). These unobserved location fundamentals may be correlated with historical compact agreements, reciprocity agreements today, and commuting times today. However, we believe the presence of MSA by year dummies and state by year dummies reduces this concern.

Although the various cuts on the sample provide convincing results, in the cross-sectional setting we cannot rule out confounding unobservables. To address this issue, we show that our results are robust to exploiting state-level tax changes over time. To do this, we create panel data at the income percentile p for each MSA-state by year. We wish to isolate tax changes due to statutory changes in state tax codes. Simply aggregating individual tax rates to percentile p would result in taxes changing for two reasons: state tax rate changes and income changes. We first divide our sample into 100 percentiles indexed by p using the national averages for each percentile of the income distribution in the middle year of our sample (as described in Section 4.1 except instead of using groups of 5 percentiles, we create a group for each percentile). To identify purely statutory changes that are independent of secular changes in income, in the spirit of Zidar (2015), we construct tax rates for each percentile by holding income and all other characteristics *fixed* at the averages for each percentile but changing the tax year and state in TAXSIM.[33] By holding income and characteristics that matter for determining tax liability fixed, we are able to isolate purely statutory changes in tax rates over time. By using the national rather than state-specific averages, we avoid confounding our tax rate estimates by the responses of individuals to their state tax systems. Although tax rates are calculated by holding income and characteristics fixed at the national average, we allow averages of all other variables for our regressions including commuting times (and all controls) to vary at the income group by MSA-state by year level. We exploit aggregated panel data by estimating:

$$C_{p,m,s,t} = \begin{array}{c} \beta_1 \triangle atr_{p,m,s,t} + \beta_2 \triangle atr_{p,m,s,t} R_{m,t} + \gamma_1 mtr_{p,m,s,t} + \gamma_2 mtr_{p,m,s,t} R_{m,t} \\ + \vartheta R_{m,t} + \varrho X_{p,m,s,t} + \delta_t + \omega_{p,m,s} + \epsilon_{p,m,s,t}, \end{array} \tag{15}$$

[33] To formally implement this, we calculate averages of variables necessary for TAXSIM at their national average. When a characteristic takes on a non-integer value on average – such as the number of children – we round it to the nearest integer to enter into TAXSIM. Further, with regard to filing status (single, married, head of household), we cannot average this characteristic and feed it into TAXSIM. Thus, for each income percentile, we simulate tax rates using fixed characteristics separately for single, married, and head of households. This yields three tax rates for each income percentile, which we consolidate to a single measure by calculating the weighted average across single, married, and head of households.

where percentile p in state s of MSA m is the cross-sectional unit and t indexes the time dimension. Thus δ_t are time dummies and $\omega_{p,m,s}$ are the cross-sectional unit fixed effects.

Figure 7 provides a nonparametric way of visualizing the regressions; as expected, results are opposite in sign for MSAs with and without reciprocity and the largest effects are found for the largest changes in tax differentials. Table 9 presents the results for various sample restrictions. For example, columns (1), (2), and (3) are comparable to columns (2), (4), and (5) of Table 4. The results exploiting statutory tax changes are very similar to those exploiting our border design. Exploiting tax change for households in the top 10% of the income distribution, a one percentage point increase in the average tax differential increases commute times by 1.01 minute in no reciprocity states and decreases times by 0.85 (= 1.01 − 1.86) minutes in reciprocity states. The border analysis found an effect of 1.24 minutes in no reciprocity states and -0.84 minutes in reciprocity states. For the top 5% of the income distribution the effects in the panel data regression are 0.90 [-1.45] and in the border design are .99 [-1.24] in no reciprocity [reciprocity] places. The similarity of the results, especially at the top of distribution, gives us confidence that the results we identify are being driven by the tax system. Appendix Table A.8 shows the results are robust to studying only observations that experience a large change in the tax differential. Finally, Table 10 shows the results instrumenting for reciprocity status using historical interstate compact agreements; generally, the results are larger in absolute value.

6 Empirical Estimates of Spatial Welfare Effects

To obtain estimates of the magnitude of the spatial distortion, we apply equation (9) to our empirical estimates from Table 4. Appendix A.13 details the assumptions needed to calculate the annualised welfare effects per household. We present the measures of welfare impacts in minutes and dollars. To calculate the dollar values of welfare changes, we use both the hourly wage and estimates of the value of time from Brownstone and Small (2005), which estimates the median willingness to pay to reduce commute times at thirty dollars an hour. Given we are the first paper to test Wildasin (1985), we also present measures of the spatial distortion from increases in marginal tax rates. Table 11 presents the effects from the average tax rate and Table 12 presents the effects from the marginal tax rate.

Households that realise declines in commutes experience a welfare gain, while households that realise increases in commutes experience welfare losses. Although the distortions for a particular person who has a longer commute may be large, the distortions for the average person within the MSA might be small because another person realises a shorter commute.

Consider the average household living in a MSA with reciprocity. For this household, a one percentage point change in the tax differential corresponds to a change in taxes of approximately \$640. Accounting for differences in the number of workers per household in high- and low-tax states, this corresponds to a 20 minute increase *per year* in commuting times on the low-tax side of the MSA and a 19 minute decline in commuting times on the high-tax side of the MSA per household per year. Factoring in the populations on each side of the MSA, the weighted average implies a total decline in welfare of approximately 5 minutes per household. This last number is the one presented in Table 11. Thus, it is clear that the changes in welfare are larger in absolute value if measured conditional on a specific side of the MSA than if averaged across both sides of the MSA. To calculate the total change in welfare, these household estimates can be scaled by the total number of working persons displayed in Table 11.[34] Next, consider a high-income household with income in the top 10% of the sample. In reciprocity MSAs, the average earnings in the top 10% is approximately \$219,000 so that a one-percentage point change in the average tax rate is approximately \$2190. For these households, that change in taxes corresponds to commutes that are 611 minutes longer on the low-tax side and 502 minutes shorter on the high-tax side (per household, per year). If valuing time at an hourly wage, this corresponds to a welfare loss of \$899 (41% of a one percentage point tax change) and a welfare gain of \$740 (34% of the tax change), respectively. Aggregating across the high-tax and low-tax sides –

[34]One must adjust for the fact that the average household has approximately 1.15 workers.

accounting for the shares of the population on each side – yields a net decline in welfare per household of 341 minutes, which is valued at $503 per year. Similar calculations yield welfare effects that are smaller in no reciprocity states given the initial population distribution – but that are positive because more people realise declines than increases in their commute.[35]

As a comparison, it is useful to understand the distortion from marginal tax rates. Here, increases in the marginal tax rate will increase commuting times on both sides of the border, so welfare will be unambiguously negatively affected according to theory. Table 12 shows that a one percentage point change in the marginal tax rate increases commutes by 17 minutes in reciprocity states and 20 minutes in no reciprocity states on average. For high-income individuals, the effects are larger in no reciprocity states.[36]

The results suggest that income taxes induce a welfare change resulting from the spatial distribution of population and employment that is not captured by standard estimates of behavioural responses of taxable income. The welfare change is driven by differences in average tax rates, although marginal tax rates slightly amplify these effects.

7 Conclusion

Our model shows that changes in commute times are a sufficient measure of the welfare cost associated with the spatial distortions created by inter-jurisdictional tax differentials. We present robust evidence that differences in average tax rates distort commute times. The mechanism by which average tax rates have such an effect is through changes in the location of residents and employment. When taxes are strictly-based on the location of residence (reciprocity), our results are driven by residential mobility, that is, people moving to the lower tax side of the MSA. In the absence of reciprocity, the structure of tax credits makes taxes a function of the state of residence and state of employment. In this case, the relative responses of employment and population to the tax increase are critical. In our empirical

[35]Recall that we do not attempt to capture the direct effect of public services on welfare but only the welfare changes associated with commuting. Thus, the aggregate reduction in commuting costs may be more than offset by a reduction in welfare associated with public services and amenities.

[36]For the top of the income distribution in reciprocity states, our coefficients suggest declines in commuting times resulting in welfare gains, but these estimates are not statistically significant.

application, our results are consistent with employment being more responsive in the absence of reciprocity. Effects are most pronounced at the top of the income distribution, suggesting that tax increases exceed the value of any increases in public services consumed by this group.

Given that commuting is a sufficient statistic, we do not separately identify whether commutes are longer because of interstate commutes, changes in employment, or changes in population, which have been studied previously.[37] Future research might study the incidence on wages relative to housing prices.

This paper suggests that policy discontinuities *within* a MSA have important implications for the efficient spatial allocation of jobs and people. As policies, regulations, and spending vary not only *across* cities, but *within* cities, this paper expands our understanding of the effects of decentralised governance in urban areas and could be applied to consider inter-jurisdictional policies other than taxes. While our focus is on state borders, the framework is useful to study all borders – school districts, townships and international borders for which we might reasonably expect more cross-border mobility in the future.

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[37]To attempt to address this issue, we tried to test the effect of tax differentials on a binary variable for whether the household had an interstate commute. Given that the sample is mostly composed of zeros and because some households had an interstate commute for only one spouse, we were unable to identify any effects. In fact, observable non-tax variables had very little predictive power.

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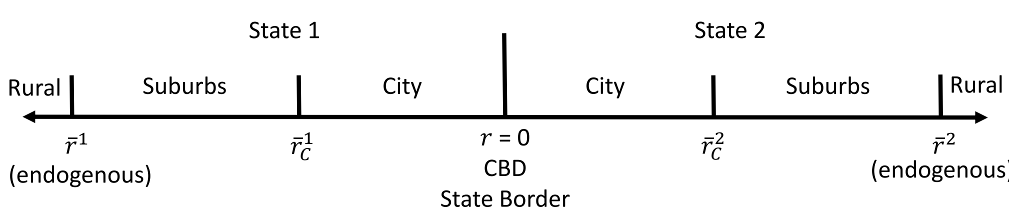
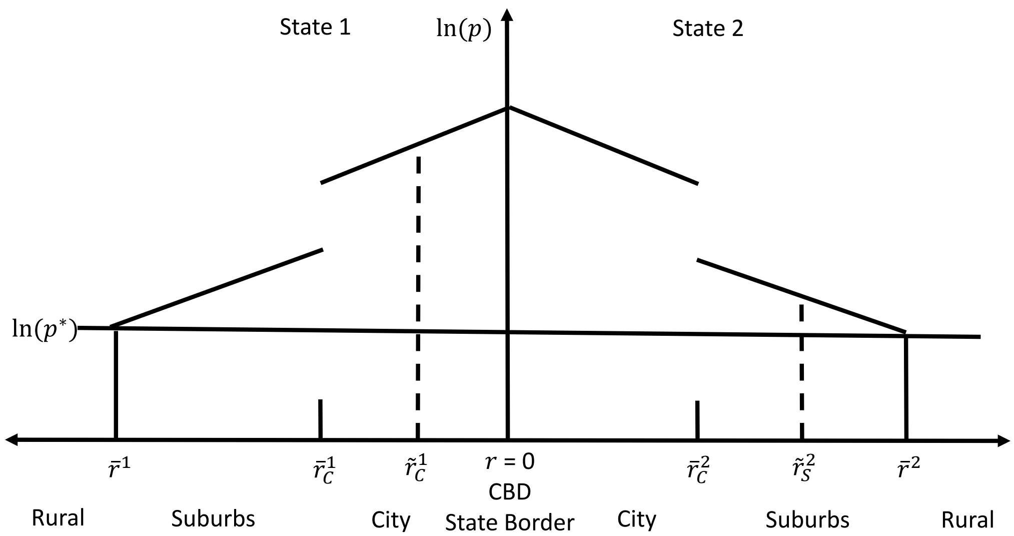
Figure 1: *Geography*



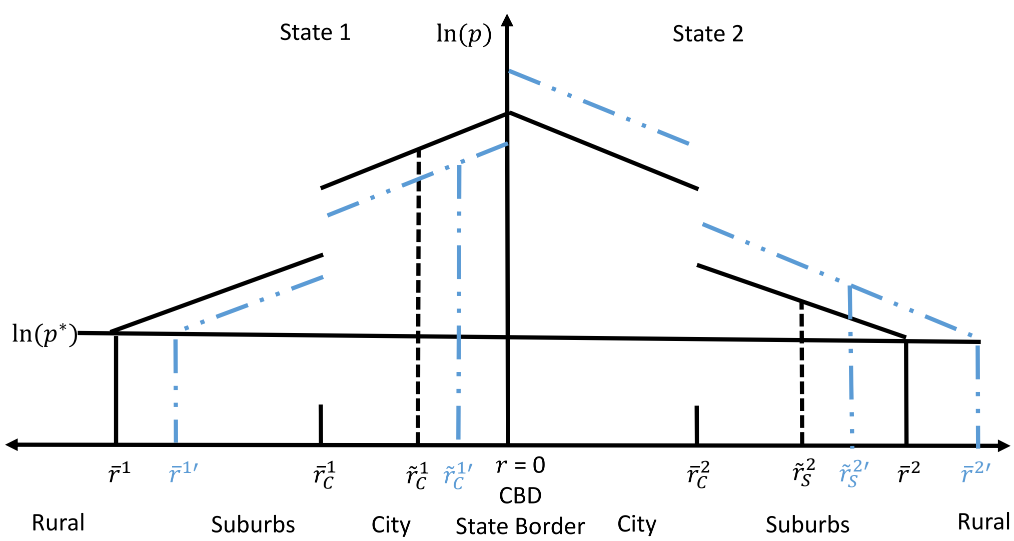
This figure presents the geography of a single cross-border metropolitan area (MSA) in the model. The line segment is partitioned into two states, indexed $i = 1, 2$. The state border is at $r = 0$ where r denotes the distance from the CBD (Central Business District). Each state is partitioned into a city and a suburb with the (exogenously given) border between the two at a distance of $\overline{r}_C^i$ from the CBD. The termini of the MSA in each state is given by the endogenously-determined distance $\overline{r}^i$. Land outside of the MSA boundary is rural with no commuters to the CBD.

Figure 2: *Equilibrium*



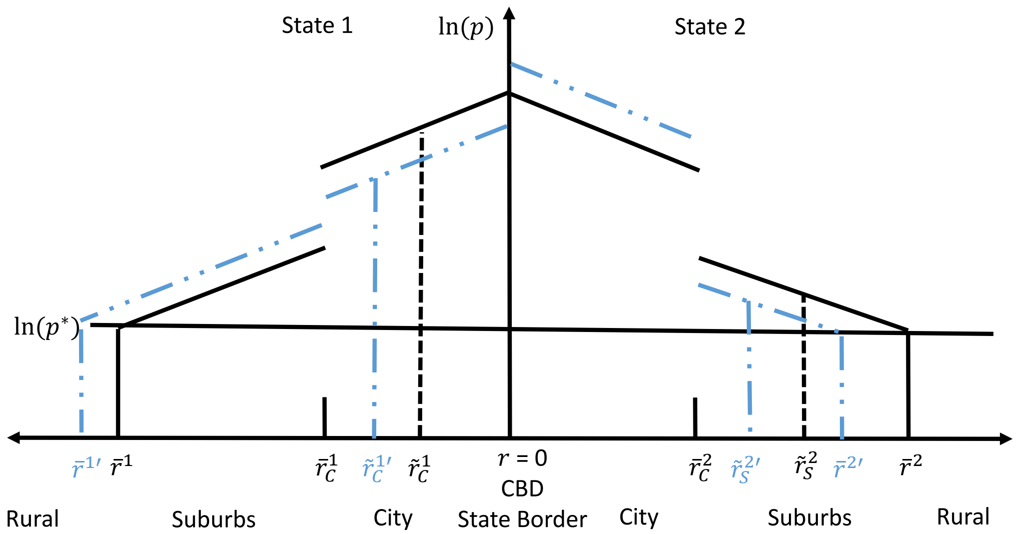
This figure presents a sketch of a possible equilibrium for the model. To summarise the notation: r denotes the distance from the CBD , $\bar{r}_C^i$ is the exogenously-determined boundary between the city and the suburb, and $\bar{r}^i$ is the endogenously-determined MSA termini. Residents of state 1 with an interstate commute reside on the interval $(0, \tilde{r}_C^1]$ and residents of state 2 with an interstate commute reside on the interval $(\bar{r}_C^2, \tilde{r}_S^2]$. The log of land prices (p) is on the vertical axis, where the horizontal line $ln(p^*)$ corresponds the land price outside of the MSA.

Figure 3: *An Increase in State 1's Tax with Reciprocity*



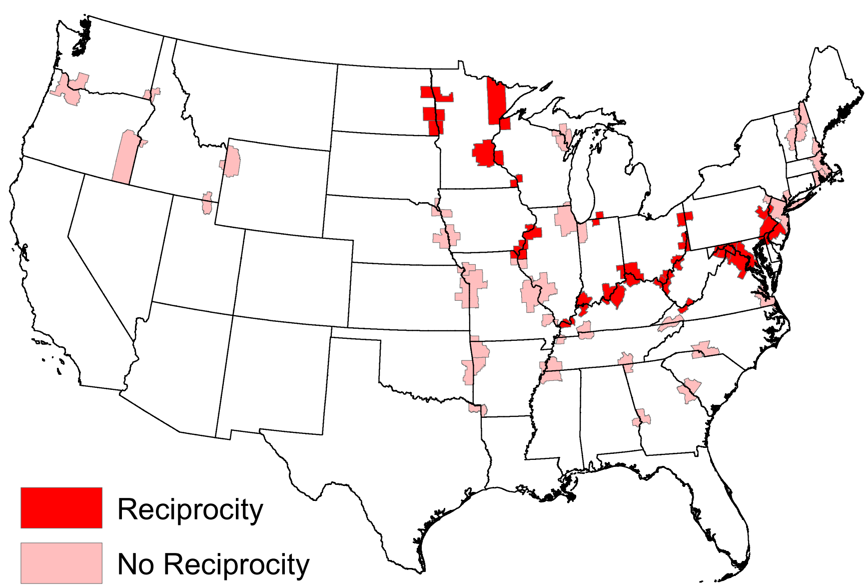
This figure presents a sketch of an increase in T^1 when the two states have a reciprocity agreement. The equilibrium values for the endogenous variables following the tax increase are denoted with a prime ($'$) and the pre-reform values have no prime. Further, the values following the reform are given by $\cdot\cdot-$ (dot dot dash). To summarise the notation: r denotes the distance from the CBD , $\bar{r}_C^i$ is the exogenously-determined boundary between the city and the suburb, and $\bar{r}^i$ is the endogenously-determined MSA termini. Residents of state 1 with an interstate commute reside on the interval $(0, \tilde{r}_C^1]$ and residents of state 2 with an interstate commute reside on the interval $(\bar{r}_C^2, \tilde{r}_S^2]$. The log of land prices (p) is on the vertical axis, where the horizontal line $ln(p^*)$ corresponds the land price outside of the MSA.

Figure 4: *An Increase in State 1's Tax with No Reciprocity and $T^1 \geq T^2$*



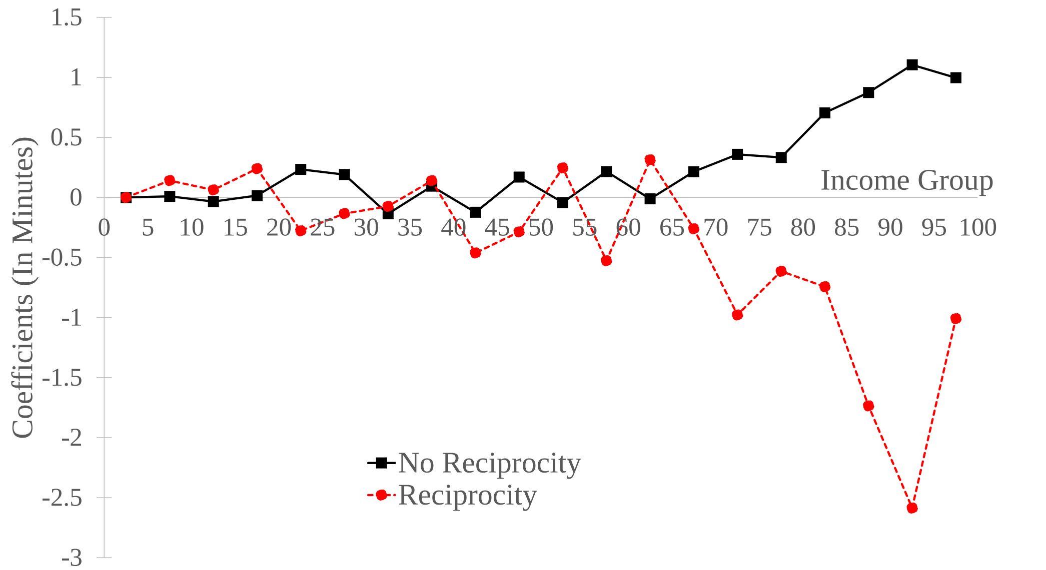
This figure presents a sketch of an increase in T^1 when the two states do not have a reciprocity agreement and $T^1 \geq T^2$. We assume that the two types of workers are complements in production and the response of employment exceeds the response of population. The equilibrium values for the endogenous variables following the tax increase are denoted with a prime ($'$) and the pre-reform values have no prime. Further, the values following the reform are given by $\cdot\cdot -$ (dot dot dash). To summarise the notation: r denotes the distance from the CBD , $\tilde{r}_C^i$ is the exogenously-determined boundary between the city and the suburb, and $\bar{r}^i$ is the endogenously-determined MSA termini. Residents of state 1 with an interstate commute reside on the interval $(0, \tilde{r}_C^1]$ and residents of state 2 with an interstate commute reside on the interval $(\tilde{r}_C^2, \tilde{r}_S^2]$. The log of land prices (p) is on the vertical axis, where the horizontal line $ln(p^*)$ corresponds the land price outside of the MSA.

Figure 5: *Multi-State MSA's by Reciprocity Status*



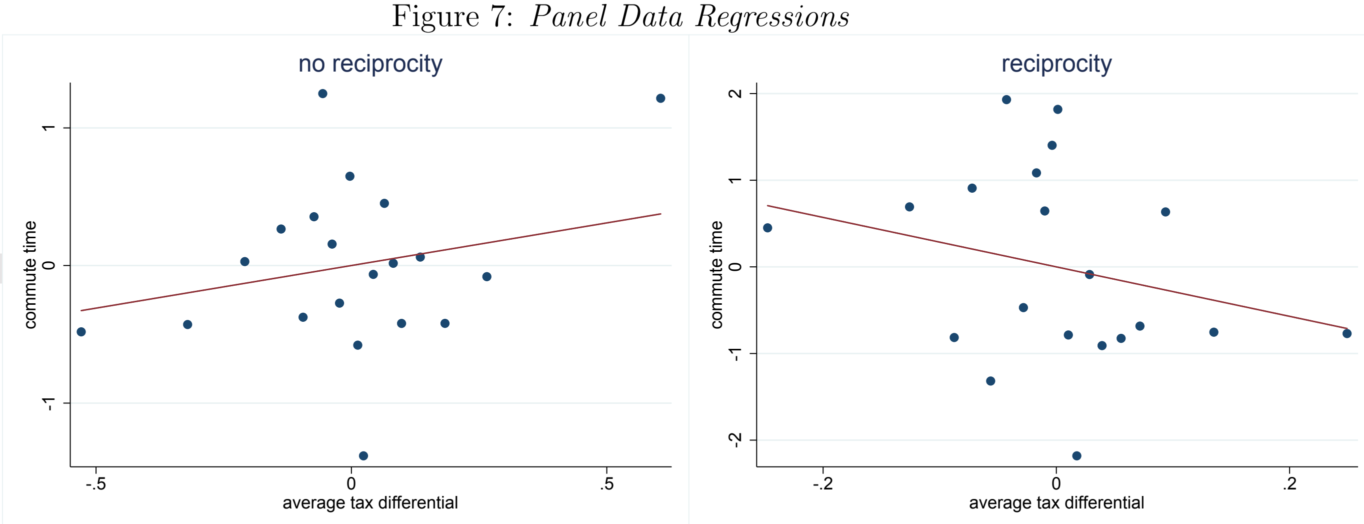
The map shows MSAs by their reciprocity status in 2009. In cases of MSAs that cross multiple states, the reciprocity status is shown between the two most populous states.

Figure 6: *Coefficients by Income Group for Reciprocity and No Reciprocity States*



The figure shows the η_y coefficients for no reciprocity jurisdictions and the λ_y coefficients for reciprocity jurisdictions given by equation (13) for each income grouping. Confidence bands are omitted, but results are only generally statistically significant for the top of the income distribution.

Figure 7: *Panel Data Regressions*



The figure shows the effect of tax differentials on commuting times using panel data for the top 10 percent of the income distribution. Each figure for no reciprocity and reciprocity jurisdictions is estimated using a separate regression. To construct this figure, we regress the commute time on controls, cross-sectional unit fixed effects and year fixed effects. The same is done for the tax variable. We weight by the number of individuals in each observation to account for the fact that some income groupings in a particular city are smaller. After each regression, residuals are binned into twenty equally sized bins and the averages within the bins are plotted and a line of best fit placed through the binned data. Note the scale of the axes are different.

Table 1: *Summary of Theoretical Results: Effect of a Tax Increase on Commute Times*

	Own Tax Rate ≥ Neighbour Tax Rate		Own Tax Rate < Neighbour Tax Rate	
	Own Tax Rate ↑ (State 1)	Neighbour Tax Rate ↑ (State 2)	Own Tax Rate ↑ (State 1)	Neighbour Tax Rate ↑ (State 2)
Reciprocity				
Type C Commute	Reduction in Interstate Commutes (↓)	Increase in Interstate Commutes (↑)	Reduction in Interstate Commutes (↓)	Increase in Interstate Commutes (↑)
Type S Commute	Contraction in Terminus (↓)	Expansion in Terminus (↑)	Contraction in Terminus (↓)	Expansion in Terminus (↑)
Overall Commute	↓	↑	↓	↑
No Reciprocity				
Type C Commute	Increase in Interstate Commutes (↑) if $\lvert\Delta E\rvert > \lvert\Delta N\rvert$	n/a	Increase in Interstate Commutes (↑)	n/a
Type S Commute	Expansion in Terminus (↑)	Contraction in Terminus (↓) & Decrease in Interstate Commutes (↓) if $\lvert\Delta E\rvert > \lvert\Delta N\rvert$	Contraction in Terminus (↓)	Expansion in Terminus (↑) & Decrease in Interstate Commutes (↓) if $\lvert\Delta E\rvert > \lvert\Delta N\rvert$
Overall Commute	↑	↓	↑ if $\left\lvert\frac{\Delta AC}{\Delta \bar{r}}\right\rvert < \left\lvert\frac{\Delta AC}{\Delta \widetilde{N}}\right\rvert$	↓ if $\left\lvert\frac{\Delta AC}{\Delta \bar{r}}\right\rvert < \left\lvert\frac{\Delta AC}{\Delta \widetilde{N}}\right\rvert$

"Overall Commute" is the effect of taxes on average commute times under the listed assumptions. Notation: $\Delta\bar{r}$ denotes a change in the terminus of the MSA, ΔE is the change in employment, ΔN is the change in population, $\Delta\widetilde{N}$ is a change interstate commuters, and ΔAC is the change in average commuting. We suppress all superscripts and subscripts as the state and type are given by column and row headings.

Table 2: *Summary Statistics*

Variable	Full Sample	No Reciprocity	Reciprocity
Average Tax Rate (Federal Plus State)	8.75	8.44	9.46
	(14.27)	(14.59)	(13.47)
Tax Differential (Absolute Value)	1.67	1.86	1.20
	(1.56)	(1.64)	(1.22)
Marginal Tax Rates (Federal Plus State)	22.27	22.12	22.53
	(15.04)	(15.33)	(14.31)
Fraction Interstate Commute	0.07	0.06	0.08
	(.26)	(.25)	(.28)
Commute Time	25.23	25.85	23.75
	(22.63)	(23.08)	(21.46)
Number	961,127	665,777	295,350

This table displays the summary statistics for the full sample and conditional on being in a reciprocity or no reciprocity MSA.

Table 3: *Commute Time Results: Heterogeneity by Income Using Distinct Groups*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Income Percentiles	≤ 50	>50 and $\leq$75	>75 and $\leq$80	>80 and $\leq$85	>85 and $\leq$90	>90 and $\leq$95	>95
$\triangle atr$	-0.041	0.067	0.274	0.503	0.784**	1.206**	0.987***
	(0.041)	(0.214)	(0.358)	(0.385)	(0.350)	(0.602)	(0.191)
$\triangle atr * R$	0.061	-0.089	-0.482	-0.631	-1.910**	-3.918***	-2.226**
	(0.055)	(0.315)	(0.642)	(0.650)	(0.780)	(1.083)	(0.973)
mtr	0.024***	0.036	0.150	0.349*	0.355**	0.213***	-0.085
	(0.004)	(0.055)	(0.148)	(0.181)	(0.139)	(0.061)	(0.079)
$mtr * R$	0.002	0.009	-0.176	-0.386***	-0.168	-0.187**	0.242*
	(0.005)	(0.070)	(0.210)	(0.146)	(0.144)	(0.079)	(0.131)
Number of Observations	490,688	239,459	46,918	47,276	46,259	45,198	45,329
R^2	0.243	0.211	0.245	0.259	0.266	0.278	0.294

The table estimates equation (10) cutting the sample by income. For example, Column (1) uses only households in the bottom 50% of the income distribution while Column (2) uses households in the 50th to 75th percentiles. The remaining columns use households in the listed percentiles. The dependent variable is the average commute time per worker in a household, the variable R is one when the MSA has a reciprocity agreement in place, mtr is the marginal tax rate paid, and $\triangle atr$ is the average tax rate in the state of residence minus the counter-factual average tax rate. All specifications include MSA by year dummies, state by year dummies, occupation dummies, household and person controls, MSA by state controls, and policy controls. All standard errors are clustered at the MSA-state level. ***99%, **95%, and *90%.

Table 4: *Commute Time Results: Heterogeneity by Income Using Overlapping Groups*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Income Heterogeneity					Homeownership			
Income Percentile	>50	>75	>80	>85	>90	>75 & Homeowner	>75 & Renter	>90 & Homeowner	>90 & Renter
$\triangle atr$	0.468**	0.826***	0.963***	1.112***	1.236***	0.682***	1.225***	1.047***	1.271***
	(0.191)	(0.278)	(0.273)	(0.299)	(0.310)	(0.244)	(0.371)	(0.279)	(0.297)
$\triangle atr * R$	-0.561*	-1.006**	-1.032**	-1.383***	-2.071***	-0.834**	-0.415	-1.808***	-3.024*
	(0.313)	(0.434)	(0.437)	(0.503)	(0.542)	(0.392)	(1.002)	(0.473)	(1.740)
mtr	0.087**	0.121*	0.131**	0.108**	0.052	0.120**	0.028	0.069**	-0.082
	(0.043)	(0.067)	(0.060)	(0.048)	(0.045)	(0.060)	(0.126)	(0.031)	(0.112)
$mtr * R$	-0.030	-0.104	-0.120*	-0.106	-0.079	-0.101	-0.107	-0.086*	-0.014
	(0.044)	(0.069)	(0.068)	(0.070)	(0.051)	(0.067)	(0.147)	(0.046)	(0.171)
Number of Observations	470,439	230,980	184,062	136,786	90,527	208,634	22,346	83,813	6714
R^2	0.230	0.254	0.261	0.267	0.277	0.264	0.256	0.289	0.294

Columns (1) to (5) cut the sample by the indicated minimum percentile of income using both homeowners and renters. Columns (6) to (9) cut the sample by homeownership status. The reason to allow for overlapping groups is that a policymaker is likely to care about the average effect among all high income households rather than a single percentile. Results for income above the 95th percentile can be seen in Table 3. Column (6) focuses on homeowners and column (7) focuses on renters above the 75th percentile. Column (8) focuses on homeowners and column (9) focuses on renters above the 90th percentile. The dependent variable is the average commute time per worker in a household, the variable R is one when the MSA has a reciprocity agreement in place, mtr is the marginal tax rate paid, and $\triangle atr$ is the average tax rate in the state of residence minus the counter-factual average tax rate. All specifications include MSA by year dummies, state by year dummies, occupation dummies, household and person controls, MSA by state controls, and policy controls. All standard errors are clustered at the MSA-state level. ***99%, **95%, and *90%.

Table 5: *No Children, Single Households and Movers*

Specific Model	(1) > 75, No Children Married	(2) Single	(3) Singles >75 and ≤85	(4) >85 and ≤95	(5) >95	(6) > 75th Percentile, Single Movers Moved 1-4 Years	(7) Moved >4 Years	(8) Different State
$\triangle atr$	0.426**	0.555*	0.625	0.478	1.264***	0.647	0.360	0.753
	(0.178)	(0.322)	(0.430)	(0.413)	(0.219)	(0.392)	(0.295)	(1.129)
$\triangle atr * R$	-1.032***	-1.461**	-2.217**	-3.592***	-2.223	-2.220***	-0.702	-5.804
	(0.324)	(0.615)	(0.937)	(1.061)	(2.607)	(0.624)	(0.638)	(4.987)
mtr	0.131*	0.009	0.203	0.117	-0.075	0.049	0.047	0.266
	(0.067)	(0.115)	(0.204)	(0.115)	(0.129)	(0.108)	(0.107)	(0.197)
$mtr * R$	-0.130*	0.032	-0.413*	-0.012	0.244	-0.053	-0.025	-0.553
	(0.067)	(0.081)	(0.210)	(0.131)	(0.324)	(0.157)	(0.102)	(0.400)
Number of Observations	81,865	37,598	23,168	15,593	6767	19,173	26,355	1292
R^2	0.249	0.261	0.280	0.290	0.296	0.267	0.291	0.340
MSA by Year & State by Year	Y	Y	Y	Y	Y	Y	Y	N

Column (1) looks at the sample of households in the top 25 percent of the income distribution with no children, but are married. Column (2) looks at households in the top 25 percent with no children, but are single. Columns (3)-(5) look at single households with incomes between the 75th and 85th, 85th and 95th and above the 95th percentile. Column (6) looks at recent movers who are single, in the top 25 percent, and moved within the last four years. Column (7) looks at long-ago movers who are single, in the top 25 percent, and moved more than four years ago. Column (7) looks at recent movers who are single, in the top 25 percent, and who moved across state lines. The dependent variable is the average commute time per worker in a household, the variable R is one when the MSA has a reciprocity agreement in place, mtr is the marginal tax rate paid, and $\triangle atr$ is the average tax rate in the state of residence minus the counter-factual average tax rate. All specifications include occupation dummies, household and person controls, MSA by state controls, and policy controls. Because of the small number of observations in column (8), the set of dummies in this regression is reduced. All standard errors are clustered at the MSA-state level. ***99%, **95%, and *90%.

Table 6: *Allowing Own-State and Other-State Effects To Differ*

Restriction	(1) No Reciprocity, Expected Signs: $\beta_{own} > 0$ & $\beta_{other} < 0$ Income> 75th	(2) Income> 90th	(3) Homeowner	(4) Single, No Children & > 75th	(1') Reciprocity, Expected Signs: $\beta_{own} < 0$ & $\beta_{other} > 0$ Income> 75th	(2') Income> 90th	(3') Homeowner	(4') Single, No Children &> 75th
$\beta_{own} : atr_{i,m,s,t}$	0.849***	0.904***	0.741***	0.581***	-0.193	-0.958**	-0.259	-0.746
	(0.236)	(0.212)	(0.212)	(0.200)	(0.339)	(0.434)	(0.349)	(0.549)
$\beta_{other} : atr_{i,m,-s,t}$	-0.706***	-0.936***	-0.560**	0.147	0.347	1.001**	0.424	1.263*
	(0.250)	(0.286)	(0.242)	(0.288)	(0.287)	(0.378)	(0.306)	(0.679)
mtr	0.097	0.028	0.094	-0.028	-0.007	0.012	-0.014	0.064
	(0.079)	(0.061)	(0.071)	(0.125)	(0.051)	(0.052)	(0.052)	(0.122)
Number of Observations	157,613	62,159	140,342	28,198	73,367	28,368	68,292	9400
R^2	(0.276)	(0.300)	(0.289)	(0.266)	(0.204)	(0.220)	(0.208)	(0.251)
Split Sample Coefficient on	0.832***	1.159***	0.662***	0.658**	-0.124	-0.962*	-0.177	-0.636
$\triangle atr$	0.261	0.267	0.222	0.308	0.325	0.512	0.345	0.466

The table allows for the average tax rate of the state of residence to have an asymmetric effect compared to the average tax rate of the other state. The first four columns correspond to no reciprocity states and the last four columns represent reciprocity pairs. Columns (1) and (1') use only households with income greater than the 75th percentile. Columns (2) and (2') use households with income above the 90th percentile. Columns (3) and (3') use only homeowners while columns (4) and (4') focus on high-income single households with no children. The dependent variable is the average commute time per worker in a household, mtr is the marginal tax rate paid, and $atr_{i,m,s,t}$ is the average tax rate in the state of residence while $atr_{i,m,-s,t}$ is the average tax rate in the other state of the MSA. The line "Split Sample Coefficient on $\triangle atr$" shows the results for when the difference in the average tax rates is used. The expected signs with no reciprocity are given for a relatively large employment response. All specifications include MSA by year dummies, state by year dummies, occupation dummies, household and person controls, MSA by state controls, and policy controls. All standard errors are clustered at the MSA-state level. ***99%, **95%, and *90%.

Table 7: *Stability of Estimates Depending on Controls*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Dummies	Family/Person Controls			Aggregate Controls			By Year Dummies	
Controls	FE	Occupation	Household (HH)	Person (P)	Policy	MSA-State	State	MSA	State & MSA
$\triangle atr$	1.503***	1.428***	1.449***	1.189***	1.197***	1.190***	1.205***	1.237***	1.236***
	(0.486)	(0.531)	(0.307)	(0.287)	(0.295)	(0.295)	(0.300)	(0.302)	(0.310)
$\triangle atr * R$	-1.684**	-1.558*	-1.792***	-1.505***	-1.812***	-1.748***	-1.860***	-2.029***	-2.071***
	(0.765)	(0.836)	(0.413)	(0.428)	(0.490)	(0.485)	(0.504)	(0.530)	(0.542)
mtr	0.102	0.097	0.097	0.049	0.050	0.050	0.051	0.052	0.052
	(0.096)	(0.080)	(0.079)	(0.045)	(0.045)	(0.045)	(0.045)	(0.045)	(0.045)
$mtr * R$	-0.135	-0.138	-0.154*	-0.065	-0.068	-0.069	-0.072	-0.079	-0.079
	(0.106)	(0.099)	(0.086)	(0.047)	(0.050)	(0.050)	(0.050)	(0.050)	(0.051)
Number of Observations	90,527	90,527	90,527	90,527	90,527	90,527	90,527	90,527	90,527
R^2	0.047	0.057	0.080	0.271	0.272	0.272	0.272	0.275	0.277
MSA, State & Year	Y	Y	Y	Y	Y	Y	Y	Y	Y
Occupation Dummies		Y	Y	Y	Y	Y	Y	Y	Y
Household/Person			HH	HH + P	Y	Y	Y	Y	Y
Policy Controls					Y	Y	Y	Y	Y
MSA_State Controls						Y	Y	Y	Y
State Controls							Y	Y	
MSA by Year Dummies								Y	Y
State by Year Dummies									Y

The table presents the results of equation (10) using various controls. The focus is on households in the top 10% of the income distribution. Column (1) includes only the tax variables, year dummies, MSA dummies, and state dummies. Columns (2)-(4) add occupation dummy variables, family controls (such as marital status, housing type, etc.), and person specific controls (such as age, race, etc.). Columns (5)-(7) add aggregate controls including policy differentials (gas tax, education spending, etc.), MSA by state controls (such as population and race on one side of the MSA, etc.), and state level controls (such as demographics at the state level). Column (8) adds MSA by year dummies and column (9) adds state by year dummies. The full list of controls in each category is given in the appendix. The dependent variable is the average commute time per worker in a household, the variable R is one when the MSA has a reciprocity agreement in place, mtr is the marginal tax rate paid, and $\triangle atr$ is the average tax rate in the state of residence minus the counter-factual average tax rate. All standard errors in ( ) are clustered at the MSA-state level. ***99%, **95%, and *90%.

Table 8: *Instrumenting for Reciprocity Status*

	(1)	(2)	(3)	(4)
Instruments	Compacts Ratified Prior to 1999		Compacts Ratified Prior to 1970	
Specific Model	Income > 75	Income > 90	Income > 75	Income > 90
$\triangle atr$	0.967***	1.316***	0.838***	1.169***
	(0.286)	(0.312)	(0.302)	(0.330)
$\triangle atr * R$	-1.773*	-2.630***	-0.941	-1.536***
	(0.993)	(0.966)	(0.718)	(0.578)
mtr	0.133*	0.055	0.114	0.051
	(0.070)	(0.048)	(0.071)	(0.048)
$mtr * R$	-0.189*	-0.127*	-0.106	-0.100
	(0.101)	(0.069)	(0.091)	(0.064)
Number of Observations	222,920	87,870	222,920	87,870
R^2	0.255	0.278	0.255	0.278

This table uses the number of interstate compact agreements across several categories as discussed in the text as instruments for reciprocity status. Columns (1) and (2) use interstate compacts ratified prior to 1999. Columns (3) and (4) only use compacts ratified prior to 1970. Column (1) and (3) is the sample of households with income greater than the 75th percentile [comparable to second column in Table 4]. Column (2) and (4) are households with income greater than the 90th percentile [comparable to fifth column in Table 4]. The dependent variable is the average commute time per worker in a household, the variable R is one when the MSA has a reciprocity agreement in place, mtr is the marginal tax rate paid, and $\triangle atr$ is the average tax rate in the state of residence minus the counter-factual average tax rate. All specifications include MSA by year dummies, state by year dummies, occupation dummies, household and person controls, MSA by state controls, and policy controls. All standard errors are clustered at the MSA-state level. ***99%, **95%, and *90%.

Table 9: *Panel Data Regressions Exploiting Statutory Tax Changes*

	(1)	(2)	(3)	(4)	(5)	(6)
		Overlapping			Non-Overlapping	
Percentiles	> 75	>85	> 90	>95	75-85	85-95
$\triangle atr$	0.592	0.867**	1.008***	0.899**	0.319	1.367
	(0.554)	(0.428)	(0.374)	(0.407)	(1.237)	(1.347)
$\triangle atr * R$	0.190	-0.884	-1.861**	-2.353	-1.272	-0.754
	(0.680)	(0.718)	(0.773)	(1.664)	(1.765)	(1.422)
mtr	-0.082	-0.089	-0.027	0.196	0.113	-0.176***
	(0.077)	(0.064)	(0.067)	(0.154)	(0.231)	(0.067)
$mtr * R$	0.046	0.002	-0.092	-0.050	-0.133	0.065
	(0.104)	(0.111)	(0.146)	(0.304)	(0.401)	(0.145)
Number of Observations	14,327	8116	5199	2520	6211	5596

We aggregate the data to the means of each income percentile by MSA-state (the cross-sectional unit) for each year. However, we calculate tax differentials holding fixed income and other characteristics in each percentile to isolate only statutory changes in the tax system. Column (1)-(4) use only percentiles above the 75th percentile, 85th percentile, 90th percentile, and 95th percentile. Columns (5) and (6) use the 75th to 85th percentile and the 85th to 95th percentile, respectively. The dependent variable is the average commute time in the percentile-state-MSA-year, the variable R is one when the MSA has a reciprocity agreement in place, mtr is the marginal tax rate paid, and $\triangle atr$ is the average tax rate in the state of residence minus the counter-factual average tax rate of the other state in the MSA; each of these tax variables is constructed using the procedure discussed in the text. All regressions are weighted by the number of ACS households in each aggregated observation. All specifications include controls, cross-sectional unit fixed effects, and year fixed effects. All standard errors in ( ) are clustered at the MSA-state level. ***99%, **95%, and *90% .

Table 10: *Panel Data Regressions: Tax Changes Using Interstate Compacts*

	(1)	(2)	(3)	(4)	(5)	(6)
		Overlapping			Non-Overlapping	
Percentiles	> 75	>85	>90	> 95	75-85	85-95
$\triangle atr$	0.984**	1.081***	1.122***	1.089***	0.069	2.089
	(0.429)	(0.381)	(0.358)	(0.325)	(1.790)	(1.360)
$\triangle atr * R$	-0.905	-1.509	-2.185**	-3.739*	-0.969	-1.581
	(1.135)	(1.064)	(1.059)	(2.126)	(3.139)	(2.193)
mtr	0.110	0.111	0.011	-0.054	-0.554	0.321
	(0.186)	(0.174)	(0.201)	(0.715)	(0.944)	(0.282)
$mtr * R$	-0.111	-0.131*	-0.066	0.210	0.230	-0.266***
	(0.096)	(0.077)	(0.080)	(0.180)	(0.292)	(0.097)
Number of Observations	13,477	7632	4887	2374	5845	5258

This table is comparable to Table 9 except that we instrument for reciprocity status using interstate compact agreements signed before 1970. We aggregate the data to the means of each income percentile by MSA-state (the cross-sectional unit) for each year. However, we calculate tax differentials holding fixed income and other characteristics in each percentile to isolate only statutory changes in the tax system. Column (1)-(4) use only percentiles above the 75th percentile, 85th percentile, 90th percentile, and 95th percentile. Columns (5) and (6) use the 75th to 85th percentile and the 85th to 95th percentile, respectively. The dependent variable is the average commute time in the percentile-state-MSA-year, the variable R is one when the MSA has a reciprocity agreement in place, mtr is the marginal tax rate paid, and $\triangle atr$ is the average tax rate in the state of residence minus the counter-factual average tax rate of the other state in the MSA; each of these tax variables is constructed using the procedure discussed in the text. All regressions are weighted by the number of ACS households in each aggregated observation. All specification include controls, cross-sectional unit fixed effects, and year fixed effects. All standard errors in ( ) are clustered at the MSA-state level. ***99%, **95%, and *90% .

Table 11: *Per Household Annual Welfare Effects from ATR Differentials*

	No Reciprocity (employment $\approx$ 23.69 m.)			Reciprocity (employment $\approx$ 10.31 m.)		
	Minutes	Hourly Wages	\$30/hour	Minutes	Hourly Wages	\$30/hour
All Incomes $\triangle atr \approx$ \$640 per HH	0.16	\$0.08	\$0.08	-5.1	-\$2.4	-\$2.6
HH Income > 75th percentile $\triangle atr \approx$ \$1490 per HH	90.6	\$103.4	\$45.3	-68.1	-\$68.8	-\$34.1
HH Income > 90th percentile $\triangle atr \approx$ \$2190 per person	84.0	\$150.3	\$42.0	-341.7	-\$503.3	-\$170.9

This table calculates the welfare effects of a one percentage point increase in the average tax rate differential using the methods described in the appendix. Positive numbers indicate welfare gain (from shorter commutes), while negative numbers represent welfare losses (from longer commutes). We present the welfare effects measured in minutes, hourly wages, and at estimates of the value of time at \$30 per hour. All estimates are per household per year. The change in the average tax payments on labour income for a one percentage point change in $\triangle atr$ is shown for reciprocity states; tax changes in no reciprocity states are slightly larger.

Table 12: *Per Household Annual Welfare Effects from MTR*

	No Reciprocity (employment $\approx$ 23.69 m.)			Reciprocity (employment $\approx$ 10.31 m.)		
	Minutes	Hourly Wages	\$30/hour	Minutes	Hourly Wages	\$30/hour
All Incomes	-20.0	-\$9.7	-\$10.0	-16.7	-\$7.7	-\$8.3
HH Income >75th percentile	-77.8	-\$88.8	-\$38.9	-12.2	-\$12.2	-\$6.1
HH Income >90th percentile	-33.0	-\$59.1	-\$16.5	18.8	\$27.7	\$9.4

This table calculates the welfare effects of a one percentage point increase in the marginal tax rate using the methods described in the appendix. Negative numbers represent welfare losses (from longer commutes). We present the welfare effects measured in minutes, hourly wages, and at estimates of the value of time at \$30 per hour. All estimates are per household per year.