Taxes and Telework: The Impacts of State Income Taxes in a Work-from-Home Economy

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Abstract

This paper studies the interstate effects of decentralized taxation and spending in a world where fully remote work is possible for all workers. When WFH is fully remote, a state's population and employment levels are decoupled, and this decoupling makes the impact of state tax differentials radically different than when individuals must live and work in the same state. Our main findings show that a shift from a non-WFH economy to WFH reduces employment and raises the wage in high-tax states, with larger effects under source taxation. Once WFH is established, an increase in a state's tax rate either reduces employment further while raising the wage (source taxation) or leaves the labor market unaffected (residence taxation). We show that the residence-taxation equilibrium is efficient.

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David R. Agrawal[†] and Jan K. Brueckner[*‡]

1. Introduction

State and local governments are limited to taxing people living, or activities occurring, within their borders. With the exception of a relatively small share of workers commuting between states in multi-state metro areas such as New York and Chicago, people have tended to live and work in the same state. But telework fundamentally severs the geographic link between the locations of the employer and the worker, in a more fundamental way than for physical interstate commuters. In particular, workers may relocate to more-affordable cities while keeping their original jobs via telework. After such relocations, the place of work is no longer transparent for tax purposes but will depend critically on state or local tax rules. As a result, standard models that assume people live where they work must be modified under WFH to analyze the effects of state taxes on migration, labor flows, wages, and housing prices.

In this paper, we show how the economy's locational equilibrium is affected by decentralized taxes and spending when an individual can work for an out-of-state employer from the convenience of his or her home. To do so, we adapt the highly stylized model of Brueckner, Kahn and Lin (BKL, 2022), who analyze the effect of decoupling residence and work locations in a work-from-home (WFH) economy where intercity telework is feasible, showing how telework alters the equilibrating role of wages and housing prices.[1] Our model adds differential

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[1] Their model relied on foundational contributions of Rosen (1979) and Roback (1982). In an extension,

state taxes and public services (an endogenous amenity) to BKL's framework. This extension requires specifying which state (the employment or residence state) has taxing rights over the income of a teleworker. To gain intuition, we consider two polar cases, where teleworkers are taxed only by the source (employment) state or taxed only by the state of residence. In the absence of WFH, these tax regimes are equivalent since people work where they live, but their effects differ under WFH. Since actual tax sourcing rules vary across state pairs, these polar cases may pertain only to subsets of US households in a complex fashion. We show these polar cases can be extended to shared tax apportionment between the employment and residence state. More generally, although we refer to jurisdictions in our model as "states," they could just as well be countries or cities that levy their own income taxes.

Interstate telecommuting, the focus of this paper, coexists with a more familiar telecommuting pattern, which occurs within and not between cities. In the latter case, employees continue to live and work in the same city with the emergence of WFH but make fewer office visits per week, while possibly moving farther into the suburbs in response to lower commuting costs. This "hybrid" WFH pattern is more common than intercity or interstate telework, the present focus, and although data on the precise number of intercity teleworkers is unavailable, Barrero, Bloom, and Davis (2021) estimate that as of 2020, 14.1 percent of college graduates were in fully remote work arrangements that potentially allow for interstate telework.[2] Furthermore, substantial anecdotal evidence indicates that interstate telework may be substantial.[3] This evidence is strengthened by the empirical findings of BKL, who show that

Brueckner and Sayantani (2023) show that allowing for both remote and non-remote worker types does not change the main qualitative implications of BKL's model. Although such an extension in our context would allow for state taxes to potentially influence an additional margin, the added complexity is unlikely to be worthwhile in the current setting.

[2] In his March 2023 video interview, "The Future of Remote Work," Nick Bloom gave more recent estimates, saying that 12% of job are fully remote and 29.3% involve hybrid WFH. See `https://www.brookings.edu/events/the-future-of-remote-work-a-fireside-chat-with-nick-bloom/`.

[3] Intercity WFH has received considerable media attention (see Bindley, 2020, 2021; Buhayar, 2020; Coy, 2021; Dillon, 2021; Kamp, 2021). Even the University of Kentucky recently announced that it has registered with 17 states for tax withholding purposes because remote employees owe taxes there. In addition, some tech firms appear to be adopting a "work from anywhere" approach in hiring. In an online statement, the real-estate data firm Zillow says that if "you work for Zillow, your long-term earning potential is determined by how you perform, and will not be limited by where you live" (`https://www.zillowgroup.com/news/why-zillow-group-is-de-emphasizing-location-as-a-component-of-compensation-making-it-easier-for-employees-to-move/`). Several other tech firms, such as Automatic or DuckDuckGo, have signaled a willingness to

populations, housing prices and rents fell between 2019 and 2020 in US counties containing high-productivity jobs that have high work-from-home potential, a pattern that is consistent with intercity relocation by remote workers. Intercity and interstate telework thus appears to be happening on a scale sufficient to affect housing markets, calling for an analysis of how the phenomenon interacts with state income taxation and tax rules.

It is important to note, however, that because fully remote work is not allowed for the majority of jobs, our model does not give a completely accurate picture the existing economy. Therefore, it would be excessive to expect the model to fully replicate tax-related impacts from the emergence WFH. This cautionary view is heightened by the model's omission, for tractability reasons, of some important real-world features, such as worker productivity differences across cities and states, which were a focus of BKL. Therefore, it is best to view our analysis mainly as a conceptual exercise that shows how taxation can affect labor and housing markets in a highly stylized setting without any restrictions on fully remote work. The exercise should thus be viewed as the first foundational analysis of the interaction between WFH and local public finance, an exercise which is critical to pointing the way toward other, even more realistic investigations of tax effects in a WFH economy. Our simple model yields sharp insights and clear intuition, and while further enhancements may make the signs of our comparative-static results ambiguous, it is likely that the core message—that the effects of state taxes under WFH are radically different from a world without WFH—will likely remain.

With a few exceptions, the sourcing rules for taxing teleworkers that are fundamental to our analysis are ignored in the current literature on personal income taxation, recognizing that most workers lived and worked in the same place prior to the recent pandemic. Although these rules have been a major focus in the analysis of corporate and commodity taxes,[4] we have a limited understanding of how state income tax systems and the public services they finance will affect where people live and work in a WFH economy. In our model, unlike those in the corporate and commodity tax setting, public services play a critical role. We show the

allow employees to work from anywhere by not having much physical office space in any state. See Felicity Hannah, "The Firm with 900 Staff and No Office." BBC (July 5, 2019), https://www.bbc.com/news/business-48879976.

[4] Where profits should be taxed in the corporate income-tax context has gained much more attention (see, for example, Auerbach and Devereux, 2018 and Suárez Serrato and Zidar, 2018).

importance of tax sourcing rules in this new telework era, which Barrero, Bloom and Davis (2021) argue is here to stay.

The appropriate taxation of teleworkers is also controversial. A recent Supreme Court lawsuit filed by the state of New Hampshire challenged the ability of Massachusetts to tax individuals working for Massachusetts employers from their New Hampshire homes. Given that the Court declined to hear this case, we are left with a hodgepodge of sourcing rules that differ across states, with legal uncertainty on the power to tax teleworkers expected for the foreseeable future (see Agrawal and Stark, 2022). Such controversies, combined with limited economic models, mean that there is little guidance on the economic consequences of various sourcing rules, which this paper seeks to provide.[5]

The purpose of the paper is to develop a model that is rich enough to capture the central features of decentralized taxation of teleworkers, but that is simple enough to deliver clear insights on the central policy questions. The model adds to BKL's framework a public good financed by state-specific ad valorem taxes on earnings. Consumer utility then depends on housing and non-housing consumption, the public good, and amenities, with the latter element differing between the two states that comprise the stylized economy. Amenities are high in state h and low in state l.[6] In the absence of WFH, workers work where they live, and the single equilibrium condition requires equal utilities between states h and l, determining the division of population between them. Under WFH, residential utilities must again be equalized, but because workers can be employed anywhere, they must be indifferent between working in state h or l, which requires that net-of-tax wages must be equal across the states.[7] The utility- and net-wage-equalization conditions provide two equations to determine two unknowns: population and employment in state h, which are disconnected under WFH instead of taking values that are identical in the absence of WFH. State-l values are determined by the population constraint.

Tax rules are important. The form of the net-wage-equalization condition depends on

[5] These issues raise challenges for other federal systems such as Canada and Switzerland and within supranational institutions such as the European Union. At the international level, bilateral tax treaties often determine whether teleworkers are taxed at source or residence.

[6] BKL analyze a model where locations differ either in amenities or worker productivity, but we focus on the first case for simplicity.

[7] As in trade models, costless telecommuting equalizes factor prices.

whether taxes are paid in the state where the firm is located (source taxation) or in the state of residence (residence taxation). Under residence taxation, because the same (residential) tax rate is applied to wage income regardless of where it is earned, the tax rate drops out of the net-wage-equalization condition, which reduces to a requirement that wages are equalized across states. Under source taxation, by contrast, the tax rate applied to the wage differs by the state of employment and thus does not cancel from the equalization condition.

The paper first asks how a switch from the non-WFH regime to one of the WFH regimes affects employment and population in the two states. This question is answered under the assumptions taxes are set optimally in the absence of WFH and remain at these values after the switch. Non-WFH optimality implies a higher tax rate in h, the high-amenity state. With tax rates held fixed at these non-WFH values, as they would be in the short run, we show that the shift to WFH reduces employment in state h relative to the no-WFH equilibrium while increasing it in state l, doing so under both WFH tax regimes. These employment effects raise (lower) the wage in state h (state l). Notably, the employment and wage changes are larger under source taxation than under residence taxation. While the effects of WFH on state populations, and thus on housing prices, are ambiguous under source taxation, WFH leads to an increase in state h's population and housing price under residence taxation, with the reverse effects in state l. Thus, high-tax states are predicted to unambiguously lose employment under WFH while also gaining population when taxation is residence-based.

Then, following the switch to WFH, we consider a widening of interjurisdictional tax differentials resulting from state h increasing its tax rate. We show that, under WFH with source taxation, the tax increase reduces employment and raises the wage in state h. But under WFH with residence taxation, employment and wage effects are strikingly absent, a consequence of wage (as opposed to net-wage) equalization. The tax increase's effects on populations and housing prices are ambiguous in general, a consequence of the endogenous public-spending amenity, but they can be signed under certain natural assumptions.

The main positive conclusions of the analysis thus pertain to the employment and wage effects of WFH. A shift to WFH from a non-WFH regime reduces employment and raises the wage in high-tax states. Once WFH is established, an increase in a state's tax rate further reduces employment and raises the wage if taxes are source based or leaves the labor market unaffected if residence taxation is present. In addition to these results, the paper also derives an important normative conclusion by showing that the residence-taxation equilibrium under WFH is efficient when the tax rate is set optimally, a conclusion that does not arise under source taxation. Intuitively, the residence principle efficiently equates workers' marginal products across states while effectively converting the labor tax into an efficient head tax. As a result, the federal government would want to induce states to choose the residence principle for state income taxes under WFH.

We also consider several extensions to the model. One extension derives further tax impacts by considering a group of (affluent) workers who pay taxes but do not benefit from the public good they finance, while operating in labor and housing markets. In a second extension, we apply the model to hybrid WFH. Work is split between home and office locations in nearby jurisdictions (now cities) that levy separate income taxes, which are apportioned according to time spent in the two locations. In this hybrid case, the employment effects of WFH lie between those under pure residence and source taxation. A third extension pertains to a mixed system that combines both the residence and source-taxation regimes while giving remote workers a residence-tax credit for source taxes paid to the work state. A fourth extension considers a mixed system without tax credits, where double taxation occurs.

We make several contributions to the public finance literature. First, in relaxing the common assumption that workers live where they work (Gordon and Cullen, 2012; Lehmann, Simula and Trannoy, 2014),[8] we show that where people are taxed is critical. Under certain taxing rules, our model implies that migration elasticities are no longer sufficient to determine the spatial distortions from taxes, with researchers also needing to estimate employment elasticities.[9] Second, by showing the importance of tax sourcing rules, we buttress Slemrod and Gillitzer's (2014) concern that tax analysis too often ignores the effects of legal rules that make

[8] The exceptions include papers that have studied the presence/lack of reciprocity agreements on interstate commuting or interjurisdictional mobility (Rork and Wagner, 2012; Coomes and Hoyt, 2008; Rohlin, Rosenthal and Ross, 2014; Agrawal and Hoyt, 2018; Agrawal and Tester, 2022). See also Osmundsen, Schjelderup, and Hagen (2000).

[9] For papers on tax-induced residential mobility in the US, see Agersnap and Zidar (2021), Moretti and Wilson (2017), and Young et al. (2016).

up our tax systems, while also showing that the resulting distortions are quite different from those in the corporate tax literature (Auerbach and Devereux, 2018). Third, in contrast to the literature focusing on high-income workers (Kleven et al., 2020), we show that the tax-induced migration of individuals who value public services shows a richer pattern of responses.

We also make several contributions to the urban economics literature. First, we extend spatial equilibrium models to study questions in public finance related to locational sorting across cities due to decentralized taxation.[10] Second, by showing how both public spending and taxes can affect work and residence locations, we add to the literature that has emphasized the role of endogenous amenities in reinforcing sorting across jurisdictions (see Brueckner, Thisse, and Zenou 1999; Diamond, 2016; Couture, 2019; Almagro, 2019). Finally, by studying how public policies interact with telework, we contribute to the recent set of theoretical papers that, along with BKL, have analyzed how telework shapes urban form (Behrens, Kichko and Thisse, 2021; Delventhal, Kwon and Parhomenko, 2022; Delventhal and Parkhomenko, 2021; Gokan, Kichko and Thisse, 2021; Kyriakopoulou and Picard, 2022; Larson and Zhao, 2017).

We proceed as follows. Section 2 presents the model, while section 3 makes comparisons under the three regimes. Section 4 derives the efficiency analysis, while section 5 presents the comparative-static results. Section 6 presents extensions, and section 7 offers discussions.

2. Model

2.1. The setup

The economy has two states[11] with fixed unitary land areas but different amenity levels, containing a total population of $2\overline{N}$. The wage earned by workers employed in a state is given by $w(L)$, where L is the employment level and $w' < 0$. The underlying production function is $f(L)$, with $w = f'$ and $f'' < 0$, and it implicitly depends on a fixed factor such as immobile capital or a fixed business land area. The wage is the same for resident and remote workers,

[10] See, Suárez Serrato and Zidar (2016) and Fajgelbaum, Morales, Suárez Serrato, and Zidar (2019). Albouy (2009) shows that even federal taxes can have the mobility impacts of decentralized taxes via their failure to account for cost-of-living differences.

[11] Although we refer to the jurisdictions as states, the model also could apply to countries or to localities within states that are allowed to levy local income taxes. Local income taxes and public good differences are common in many metropolitan areas, allowing these local tax rules to interact with hybrid telework arrangements.

with no productivity loss from working remotely.[12]

States levy an ad valorem income or payroll tax t on workers employed in the state (source principle) or residing there (residence principle), with the revenue used to provide a public good z. Assuming that z is a publicly produced private good produced at unitary cost, then $z = tB/N$, where B is the tax base and N is the state population. The expression for the tax base B depends on whether taxation uses the source principle or the residence principle, as seen below. Because z then depends on the tax rules along with a state's wage, employment, and population levels, the level of this publicly-provided good is endogenous, in contrast to the exogenous amenity A.

In addition to depending on A and z, consumer utility is determined by consumption of land (housing), denoted q, and a numeraire non-land good, denoted e. The utility function is assumed to take a quasi-linear form:

$$A \ + \ e \ + \ V(tB/N) \ + \ U(q) \ \ = \ \ A \ + \ (1-t)w \ + \ V(tB/N) \ + \ U(q) \ - \ pq, \qquad (1)$$

where the equality uses the budget constraint $e = (1-t)w - pq$. Note that the increasing functions $U(\cdot)$ and $V(\cdot)$ satisfy $U'', V'' < 0$, and that the coefficients of A and e are identical and equal to unity through choice of units of measurement.

Using the housing first-order condition $U'(q) = p$, the terms $U(q) - pq$ in (1), which give "net housing utility," can be written as $U(q) - U'(q)q \equiv X(q)$, where $X'(q) = -U''(q)q > 0$. But with a state's land area fixed at unity, housing consumption is given $q = 1/N$. Net housing utility can then be written as $X(1/N) \equiv H(N)$, with H decreasing in N because $X' > 0$. This decrease in net housing utility arises because the housing price p, which can be written as $p(N) \equiv U'(1/N)$, is increasing in N given $U'' < 0$ (making X' positive from above and hence $H' < 0$).

[12] While in BKL's model and the present one, worker utility-equalization plays a key role, the models do not explicitly incorporate firm mobility (and hence an equal-profit condition), an important additional feature of the Rosen (1979)-Roback (1982) framework (whose approach partly motivated BKL). Firm mobility in the sense of Rosen and Roback is only tractable in a model with constant returns to scale, and adopting this assumption would obscure the link between wages and employment levels that lies at the heart of our analysis. A different mobility notion would apply to capital, a possible fixed factor in state production. However, capital mobility would cause the wage function to shift as capital relocates, altering the marginal product of labor. Such an extension would complicate the analysis.

Rewriting utility using the H function, it becomes[13]

$$A \ + \ (1-t)w(L) \ + \ V(tB/N) \ + \ H(N). \tag{2}$$

This framework implicitly treats a state as a single residence and work location, when in fact cities are the relevant housing and labor markets. To make the model more realistic in this regard, we could assume that population and employment in each state are equally divided among a common number of identical cities, each subject to the state's tax rate. We can assume that this common number of cities is normalized to 1.

2.2. Equilibrium conditions

As explained in the introduction, a state's employment level equals its population ($L = N$) in the absence of WFH. As a result, the source and residence principles yield the same expression for the tax base B, which equals $w(N)N$, or total wages earned in the state by its residents, all of whom are employed there. Thus, $z = tB/N = tw(N)N/N = tw(N)$, which equals the tax payment of an individual worker. Substituting this expression in the V function, the single non-WFH equilibrium can be stated, which requires populations to adjust so as to equalize utilities. Adding state subcripts in (2), this condition is

$$\begin{aligned} A_h \ + \ (1-t_h)w(N_h^*) \ + \ V(t_h w(N_h^*)) \ + \ H(N_h^*) \ \ &= \\ A_l \ + \ (1-t_l)w(N_l^*) \ + \ V(t_l w(N_l^*)) \ + \ H(N_l^*)&, \end{aligned} \tag{3}$$

where asterisks denote non-WFH equilibrium values. Substituting $N_l^* = 2\overline{N} - N_h^*$ in (3), the condition then determines the equilibrium value of N_h^*, with N_l^* determined residually.

[13] Two types of income, land rent and profit (or income to the fixed factor, equal to $f(L) - f'(L)L$) are not captured in this utility expression. Although it could be assumed that this non-wage income flows to absentee owners, this assumption is not tenable in a model that is intended to portray an entire economy. Instead, we assume that the total income across both states from these two sources is equally shared among workers, and that this income is not subject to state taxes, so that the utility expression in (3) is then augmented by this non-wage income share (possibly reduced or entirely eliminated by a federal tax that finances a nationally uniform public good). Importantly, since this quantity (which is endogenous) does not depend on the state of residence of the worker, it cancels in all the utility-equalization conditions presented below, which equate worker utilities across states. Non-wage income can thus be ignored since it plays no role in the derivation of the results of the analysis.

WFH breaks the equality between a state's employment and population. Equilibrium under WFH is thus determined by two conditions: a utility-equalization condition, which makes workers indifferent as to the state of residence, and a net-wage-equalization condition, which makes them indifferent to the state of employment. The form of these conditions depends in part on whether taxation is source or residence based. With source based taxation, the net-wage-equalization condition is

$$(1 - t_h)w(\widetilde{L}_h) \quad = \quad (1 - t_l)w(\widetilde{L}_l), \tag{4}$$

where tildes denote WFH-equilibrium values under source taxation, and where the wage now depends on employment, not population. Note that, with source taxation, the tax rate is the rate for the state where employment occurs. The tax base of a state is now total wages paid to workers employed there, given by $B = tw(L)L$. As a result, $z = tw(L)L/N$, with z equal to total taxes collected from workers *employed* in the state divided by the number of workers *residing* in the state.

With the employment choice independent of the residence choice under WFH, and with net wages equalized across states, the net-wage terms drop out of the utility-equalization condition.[14] Inserting the new expression for z and adding state subscripts, this condition is

$$A_h \ + \ V(t_h w(\widetilde{L}_h)\widetilde{L}_h/\widetilde{N}_h) \ + \ H(\widetilde{N}_h) \quad = \quad A_l \ + \ V(t_l w(\widetilde{L}_l)\widetilde{L}_l/\widetilde{N}_l) \ + \ H(\widetilde{N}_l). \tag{5}$$

Conditions (4) and (5) along with $\widetilde{N}_h = 2\overline{N} - \widetilde{N}_l$ and $\widetilde{L}_h = 2\overline{N} - \widetilde{L}_l$ determine the equilibrium values of population and employment in the two states.

Using hats to denote equilibrium values under WFH with residence taxation, the net-wage-equalization condition for workers living in state h is $(1 - t_h)w(\widehat{L}_h) = (1 - t_h)w(\widehat{L}_l)$, with the

[14] In other words, the utility from living in state h (state l) is given by the LHS of (5) (RHS of (5)) plus either $(1 - t_h)w(\widetilde{L}_h)$ or $(1 - t_l)w(\widetilde{L}_l)$, depending on where employment occurs. Since these two terms are equal, they cancel from the two sides of (5), regardless of which one is relevant for a particular worker. Stated differently, the equilibrium conditions (4) and (5) are equivalent to a single condition requiring utilities to be equal for four different combinations of residence and workplace locations: live in h, work in h; live in h, work in l; live in l, work in l; live in l, work in h.

state-h tax rate applying to income regardless of whether it is earned in state h or state l. Similarly, the condition for workers living in state l is $(1-t_l)w(\widehat{L}_h) = (1-t_l)w(\widehat{L}_l)$. Since the $1-t$ expression cancels in each equation, they reduce to the single condition

$$w(\widehat{L}_h) \quad = \quad w(\widehat{L}_l), \tag{6}$$

which requires wage equalization across the states. This condition in turn implies $\widehat{L}_h = \widehat{L}_l = \overline{N}$, so that employment is equalized between the states. As a result, the net wage for a resident of state h equals $(1-t_h)w(\overline{N})$ regardless of the work location, with $(1-t_l)w(\overline{N})$ giving the corresponding net wage for a state-l resident. Note that net wages *are not* equalized across states despite equalization of wages themselves.

The state tax base under residence taxation equals the total wages earned by its residents regardless of the place of employment. To write the appropriate expression for state h, let $\widehat{N}_h^h$ and $\widehat{N}_h^l$ denote the number of state-h residents employed in states h and state l, respectively. Then, the state's tax base is given by $B_h = \widehat{N}_h^h w(\widehat{L}_h) + \widehat{N}_h^l w(\widehat{L}_l)$. Since $\widehat{L}_h = \widehat{L}_l = \overline{N}$, this expression reduces to $(\widehat{N}_h^h + \widehat{N}_h^l)w(\overline{N}) = \widehat{N}_h w(\overline{N})$. Then $\widehat{z}_h = t_h \widehat{N}_h w(\overline{N})/\widehat{N}_h = t_h w(\overline{N})$, so that the public good level under residence taxation reduces to the tax payment of a worker employed in state h.

Substituting this $\widehat{z}_h$ expression and a parallel one for $\widehat{z}_l$ into the V function, and using the net wage expressions from above, the utility-equalization condition under residence taxation can be written:

$$A_h + (1-t_h)w(\overline{N}) + V(t_h w(\overline{N})) + H(\widehat{N}_h) \quad = \quad A_l + (1-t_l)w(\overline{N}) + V(t_l w(\overline{N})) + H(\widehat{N}_l). \tag{7}$$

This condition along with $\widehat{N}_l = 2\overline{N} - \widehat{N}_h$ determines the equilibrium state populations. Note that condition (7) resembles the non-WFH utility-equalization condition (3), except that employment in the two states equals $\overline{N}$, with wages also equalized.

It is important to note that, because workers are indifferent to their place of employment under both WFH regimes, the model does not actually pin down the volume of remote work flows, but only determines the net flows. To understand this point, consider the source-taxation regime, and suppose that $\widetilde{N}_h > \widetilde{L}_h$ and $\widetilde{N}_l < \widetilde{L}_l$ hold, a pattern that will be shown below to emerge under a particular natural assumption. With population exceeding employment in state h and the reverse in state l, it is natural to imagine that the remote workers in the economy consist only of the excess state-h residents (who number $\widetilde{N}_h - \widetilde{L}_h$ and would work in state l), with all state-l residents working where they live (and none thus working remotely in state h). However, suppose that an additional F state-h residents also worked remotely in state l, bringing the total to $\widetilde{N}_h - \widetilde{L}_h + F$, while F state-l residents also start working remotely in state h. With this change, total employment in both states remains the same (along with populations), so that the new allocation of workers to jobs thus continues to satisfy the WFH equilibrium conditions. The crucial point, however, is that the net flow of remote work in the direction of state l equals $\widetilde{N}_h - \widetilde{L}_h + F - F$ (with the negative l to h flow subtracted), which reduces to the original net flow of $\widetilde{N}_h - \widetilde{L}_h$ that was based on a zero remote flow from state l to state h. Therefore, the model pins down the net flow of remote work, it does not pin down gross flows between the states.

3. The effects of shifting to a WFH regime

3.1. The non-WFH equilibrium

To derive the effects of shifting to one of the WFH regimes from the non-WFH regime, it is first necessary to characterize the non-WFH equilibrium. The first conclusion is that, under the non-WFH regime, state h has the greater population, with $N_h^* > N_l^*$. To establish this conclusion, we assume that non-WFH state tax rates are set optimally, with the rates chosen treating populations as parametric (without considering responses to tax changes). Referring to (3), the first-order conditions for choice of the two tax rates are then $V'(t_h w(N_h^*)) = V'(t_l w(N_l^*)) = 1$, with the wage canceling. Further analysis then shows that $N_h^* > N_l^*$ must hold, so that state h has the higher population.[15] As a result, state h has a lower wage and

[15] Let the amenity levels A_h and A_l start out equal, implying that $N_h^* = N_l^*$ holds in (3). Then let A_h increase (yielding $A_h > A_l$ as assumed), a change disrupts the equality in (3), making the LHS larger. With H' and w' negative, an increase in N_h^* and a corresponding decrease in N_l^* then reduce the LHS and increase the RHS of (3), restoring the equality and yielding $N_h^* > N_l^*$. Note that the effects of changing A_h that operate through the tax rates vanish by the envelope theorem, since the rates are set optimally.

a higher housing price, with $w_h^* \equiv w(N_h^*) < w(N_l^*) \equiv w_l^*$ and $p_h^* > p_l^*$. Finally, because the wage is lower in state h, the tax first-order conditions from above imply that the tax rate is higher in that state, with $t_h^* > t_l^*$. Summarizing yields

Proposition 1. *In the absence of WFH, the differences in populations, housing prices, wages, and tax rates between states h and l are as follows:*

$$N_h^* \ > \ N_l^*, \quad p_h^* \ > \ p_l^*, \quad w_h^* \ < \ w_l^*, \quad t_h^* \ > \ t_l^*.$$

The wage and price differences between the high- and low-amenity state match the pattern in the typical equilibrium of the Rosen (1979)-Roback (1982) model. But the present framework differs from that model because of taxes and public goods and because a locational equilibrium for firms is not imposed. In addition, the higher tax rate in state h is consistent with models showing that bigger jurisdictions set higher taxes (Bucovetsky, 1991; Keen and Konrad, 2013).

3.2. Shifting to a WFH regime

In moving from the non-WFH regime to one of the two WFH regimes, we assume that state tax rates are fixed at their non-WFH values t_h^* and t_l^*, thus being higher in state h. This assumption will be realistic at least in the short run, before the states have had a chance to adjust their tax rates. Later on in the discussion, we carry out a comparative-static analysis assuming the tax rates under WFH are initially set at arbitrary levels, and we also investigate the efficiency of the WFH regimes, with taxes then set optimally in each regime.

The first observation is that the employment-indifference conditions (4) and (6) are not satisfied at the non-WFH employment levels given $L_h^* = N_h^* > N_l^* = L_l^*$ and $t_h > t_l$:

$$(1 - t_h)w(L_h^*) \quad < \quad (1 - t_l)w(L_l^*) \qquad (\textit{source taxation}) \tag{8}$$

$$w(L_h^*) \quad < \quad w(L_l^*) \qquad\qquad (\textit{residence taxation}) \tag{9}$$

To satisfy these conditions given $w' < 0$, employment under WFH must fall in state h and rise in state l, and the presence of the tax terms in (8) makes the required changes larger under source taxation. These conclusions are partly evident from the fact that employment is equalized under residence taxation, as seen above. In addition, the net-wage equalization condition (4) under source taxation implies $\widetilde{L}_h < \widetilde{L}_l$ and thus a drop in state-h employment relative to the non-WFH equilibrium, with the reverse outcome in state l. Summarizing:

Proposition 2. *Under either residence or source taxation, a shift to WFH with tax rates held fixed at non-WFH levels reduces employment in state h while increasing employment in state l. The wage rises in state h and falls in state l. The magnitudes of these effects are larger under source taxation than under residence taxation. Formally,*

$$L_h^* \;=\; N_h^* \;>\; \overline{N} \begin{cases} > \widetilde{L}_h \\ = \widehat{L}_h \end{cases} \qquad\qquad L_l^* \;=\; N_l^* \;<\; \overline{N} \begin{cases} < \widetilde{L}_l \\ = \widehat{L}_l \end{cases}$$

$$w_h^* \;<\; \widehat{w}_h \;<\; \widetilde{w}_h \qquad\qquad w_l^* \;>\; \widehat{w}_l \;>\widetilde{w}_l.$$

To explore the population effects of shifting to WFH, the first step is to note that the residential-indifference condition (7) under residence taxation is not satisfied when evaluated at the non-WFH populations:[16]

$$A_h + (1-t_h)w(\overline{N}) + V(t_h w(\overline{N})) + H(N_h^*) \;>\; A_l + (1-t_l)w(\overline{N}) + V(t_l w(\overline{N})) + H(N_l^*). \quad (10)$$

With (10) holding, population must rise in state h and fall in state l, starting at non-WFH levels, to achieve equality, given $H' < 0$. Housing prices then move in step. Intuitively, starting at the non-WFH equilibrium, the wage increase in state h under residence taxation leads to both a higher net-of-tax wage and a higher z level in state h, with opposite effects in state l. These changes then lead to an equilibrating population shift toward state h.

However, the direction of the analogous inequality in the case of source taxation cannot be established in general:

$$A_h \;+\; V(t_h w(\widetilde{L}_h)\widetilde{L}_h/N_h^*) \;+\; H(N_h^*) \;>(<)\; A_l \;+\; V(t_l w(\widetilde{N}_l)\widetilde{N}_l/N_l^*) \;+\; H(N_l^*). \qquad (11)$$

The obstacle is that the z arguments of V have different forms in the source-taxation and non-WFH cases. This difference prevents a repetition of the previous logic (see footnote 15),

[16] To establish (10), the inequality is rearranged so that $H(N_l^*) - H(N_h^*)$ is by itself on the RHS. Using (3) to substiture for this expression, the inequality becomes

$$A_h + (1-t_h)w(\overline{N}) + V(t_h w(\overline{N})) - [A_l + (1-t_l)w(\overline{N}) + V(t_l w(\overline{N}))] \;>$$
$$A_h + (1-t_h)w(N_h^*) + V(t_h w(N_h^*)) - [A_l + (1-t_l)w(N_l^*) + V(t_l w(N_l^*))],$$

which holds given $N_h^* > \overline{N} > N_l^*$. Given $w' < 0$, these inequalities make the first expression on the LHS larger than the corresponding expression on the RHS and the second (bracketed) expression on the LHS smaller than the corresponding bracketed expression on the RHS.

which relies on the arguments' common form (tax rate times wage) in the residence-taxation and non-WFH cases. Summarizing yields

Proposition 3. *A shift to WFH under residence taxation increases state h's population and housing price, with the reverse effects in state l. Population and housing-price changes are ambiguous under source taxation.*

With population and the housing price already larger in state h than in state l in the absence of WFH, their increases in shifting to WFH under residence taxation imply $\widehat{N}_h > \widehat{N}_l$ and $\widehat{p}_h > \widehat{p}_l$. Thus, state h continues to have a higher population and housing price under WFH in this case. Despite the ambiguity in Proposition 3, this same conclusion comparing population sizes of the jurisdictions is true under source taxation provided that labor demand is inelastic.[17] Inelastic demand implies $w(\widetilde{L}_h)\widetilde{L}_h > w(\widetilde{L}_l)\widetilde{L}_l$ given $\widetilde{L}_h < \widetilde{L}_l$, and since $t_h > t_l$, state h then has more tax revenue than state l. For utilities to be equalized in (5), $\widetilde{N}_h > \widetilde{N}_l$ is then required to offset state h's amenity and tax-revenue advantages, also implying $\widetilde{p}_h > \widetilde{p}_l$.

The results in Propositions 2 and 3 are summarized in the first panel of Table 1.

3.3 Tax exporting?

Although a state's residents fully pay for the public good they consume under residence taxation, tax exporting (Wildasin, 1987) is a built-in feature of the source-taxation regime. State h's resident workers help to pay for the state's public good, but remote workers from state l, who do not consume the good, also make a contribution. Similarly, state h residents working remotely in state l help to pay for that state's public good, which they do not consume. Therefore, the provision of public goods under source taxation is partly financed by outsiders.

While helping to defray costs, does the tax contribution of outside remote workers actually subsidize the public consumption of resident workers, making it less than the cost of provision? Or do resident workers pay more than cost? When labor demand is inelastic, per-capita

[17] Empirical evidence suggests that inelastic labor demand may be a reasonable assumption. Hamermesh (1993) indicates that the range of constant-output elasticities of labor demand is $[-.75, -.15]$. A recent meta-analysis (Lichter, Peichl, and Siegloch, 2015) of hundreds of micro-level estimates of the elasticity of labor demand shows that the median is -0.420, with 83% of estimates falling within the interval $[-1, 0]$. Given that telework may change these elasticities, our analysis suggests a need for more estimates of this demand elasticity in the context of the WFH economy.

expenditure on the public good is less than the taxes paid by resident-workers in state h, while expenditure exceeds taxes paid by resident-workers in state l. Thus, resident workers are subsidized in state h, while the reverse is true in state l. This result follows because $\widetilde{N}_h > \widetilde{N}_l$ (a consequence of inelastic demand) and $\widetilde{L}_h < \widetilde{L}_l$ imply $\widetilde{L}_h < \widetilde{N}_h$ or $\widetilde{L}_h/\widetilde{N}_h < 1$. As a result $\widetilde{z}_h = t_h w(\widetilde{L}_h)\widetilde{L}_h/\widetilde{N}_h < t_h w(\widetilde{L}_h)$. So the per-capita cost of the public good (equal to $\widetilde{z}_h$ itself) is less than the tax paid by a resident worker (last term in the previous inequalities), with the reverse relationship holding in state l.

4. Efficiency analysis

A natural question is whether any of the three regimes is efficient when tax rates are chosen optimally conditional on the regime. As shown in the Appendix, efficiency requires equalization of the marginal products of labor across the states and equality in each state between the marginal benefit of z and its unitary marginal cost, both natural conditions. In addition, efficiency requires adjustment of the populations so that the amenity plus net housing utility is equalized across states.

These conditions are not satisfied in the non-WFH case. With the tax-rate optimality condition satisfied in both states, the previous analysis established $N_h^* > N_l^*$, implying that wages, and hence labor's marginal products, are unequal across the states. The result is an inefficient non-WFH equilibrium.

However, it is easy to see that the optimality conditions from above are satisfied under residence taxation when the tax rates in both states are chosen optimally conditional on this regime. Wage equalization across states implies equality of employment and thus marginal products. Public goods are paid for entirely by residents, and their tax payments are equal regardless of place of employment (thus being head taxes) given wage equalization. With tax rates set optimally, yielding $V'(t_i w(\overline{N})) = 1$ for $i = h, l$, these head taxes become efficient benefit taxes that are equal across states, with V' equaling z's unitary marginal cost in both states. With the tax rates and z levels equalized, the net wage and V terms on both sides of the utility equalization condition (7) then cancel, so that the condition requires equality of the amenity plus net housing utility across states, as required for an efficient allocation of population. Efficiency emerges because of WFH's decoupling of work and residence locations.[18]

The source-tax equilibrium is, by contrast, inefficient. While marginal products would be equalized across the states if tax rates were equal, satisfying one efficiency condition, states will not choose equal tax rates given the form of the optimality condition for rates.[19] This inefficiency implies that workers are better off under residence taxation, an important conclusion. As a result, the federal government would want to induce states to adopt the residence principle over the source principle in a WFH economy. Summarizing yields

> **Proposition 4.** *While the non-WFH equilibrium or the WFH equilibrium with source-taxation are inefficient, the equilibrium under residence taxation satisfies the social planner's optimality conditions when tax rates are set optimally. The efficiency of residence taxation means that workers are better off under this regime than under source taxation or the non-WFH regime.*

An important implication of the proposition is that the emergence of WFH is welfare improving as long as the residence-taxation regime is adopted.[20]

Although a public good is absent in BKL, their WFH equilibrium leads to equalization of marginal products along with equalization of amenities plus net housing utility across locations, which are the conditions for efficiency in that model regardless of whether locations differ by amenities or productivity. If states differed by productivity instead of amenities in the current

[18] The efficiency result can be related to Wildasin's (1980) condition for efficient interstate locational equilibrium, which governs the location of the population holding public-good levels constant. His condition requires that the sum of labor's marginal product plus public-good benefits minus public-sector congestion costs should be equalized across states. As we have seen, the first two elements in this sum are equalized given equality of wages and the z's. To induce individuals to account for congestion costs, a public-good congestion tax must be levied, and in the case of a publicly produced private good, this charge amounts to a head tax. With wages fixed at $w(\overline{N})$, the labor tax in our model is effectively a head tax, and with the z's equal, the level of this tax is the same across the states, implying that all three elements in Wildasin's locational equilibrium condition are the same across states, guaranteeing its satisfaction. See also Boadway and Flatters (1982) and Boadway and Tremblay (2012).

[19] The source-based taxation regime also offers other sources of inefficiency that we do not model. Source-based taxation combined with remote work offers potential arbitrage opportunities for multi-state firms. In particular, the source regime may facilitate tax avoidance strategies where multi-state firms allocate their payroll of remote workers to low-tax states. This avoidance strategy has parallels to income shifting by multinational companies in the international corporate tax setting, and given that it is well-documented in that setting, we have abstracted away from its implications here.

[20] Albouy (2012) shows that federal transfers that make household residential decisions efficient should offset any local taxes levied on nonresidents. The residence-based regime taxes residents and nonresidents working in the same jurisdiction equally.

model, residence-taxation would again be efficient.

5. The comparative-static effects of state income taxes

5.1. Main analysis

This section derives the effects of an increase in state h's tax rate on populations, employment levels, wages and housing prices in both states, with and without WFH. The tax rates start at some arbitrary levels, and we derive the effect of an exogenous increase in the tax differential by raising t_h.

In the absence of WFH, an increase in t_h has no effect if the rate is initially set optimally. If the tax rate is below optimal, then an increase makes state h more attractive, raising its population and hence employment and thus raising the housing price and reducing the wage, with the reverse outcomes if t_h is above optimal.

Tax impacts are radically different under WFH because employment and population are decoupled. With residence taxation, a higher t_h has no effect on employment or wages in either state because wage equalization fixes both employment levels at $\overline{N}$. Evaluating the effect of t_h on population in this case raises the same issues as in the absence of WFH. In particular, from (7), the increase in t_h makes state h more (less) attractive as the initial value is below (above) the optimal t_h, which satisfies $V'(t_h w(\overline{N})) = 1$. Therefore, an increase in t_h raises population $\widehat{N}_h$ and the housing price $\widehat{p}_h$ if the initial rate is suboptimal, reducing population and the housing price when the initial rate is super-optimal (no effect arises when the tax rate is initially optimal). The opposite impacts are felt in state l.

Turning to WFH with source taxation, an increase in t_h reduces employment in state h while raising it in state l, given (4). If labor demand is realistically inelastic, this increase in employment $\widetilde{L}_h$ raises state h's tax base, $w(\widetilde{L}_h)\widetilde{L}_h$, with tax revenue then rising given the higher t_h. As before, state h then becomes more attractive, leading to an increase in its population and housing price.

It is important to note that, in contrast to the non-WFH case and the WFH case with residence taxation, tax impacts under WFH with source taxation are fully independent of the initial level of the tax rate. This independence arises due to the absence of a net-wage term in the equal-utility condition (5), which means that the relationship between the tax burden and the benefits from the public good is immaterial, in contrast to the two other cases, where the sub- or super-optimality of t_h matters for incidence.[21]

Summarizing for the WFH regimes yields

Proposition 5. *Under WFH , an increase in the tax rate in state h has the following effects on population, housing prices, employment levels, and wages in state h, with the reverse effects felt in state l.*

(i) Residence taxation:

$$\widehat{N}_h: +/- , \quad \widehat{p}_h: +/-, \quad \widehat{L}_h: 0, \quad \widehat{w}_h: 0,$$

where the + (−) effects arise if the tax rate is initially below (above) optimal.

(ii) Source taxation with inelastic labor demand:

$$\widetilde{N}_h: + , \quad \widetilde{p}_h: +, \quad \widetilde{L}_h: -, \quad \widetilde{w}_h: +$$

The results in Propositions 5 are summarized in the second panel of Table 1.

Given the highly stylized nature of the model and its omission of elements such as interstate productivity differences, there is little hope of crafting a numerical simulation that matches real-world patterns. But a numerical example using arbitrary parameter values can give some sense of the quantitative effects implied by the model. Accordingly, Figure 1 graphs the equilibrium solutions under source taxation for t_h values between 0.1 and 0.9 under particular functional-form and parameter-value assumptions.[22] Where they touch the vertical axis, the (colored) curves, highest to lowest, show $\widetilde{L}_h$, $\widetilde{N}_h$, $\widetilde{p}_h$, and $\widetilde{w}_h$, respectively. As can be seen, the responses of population and the house price to the tax increase are more muted that those of employment and the wage.

The radical difference between tax impacts with and without WFH is clearest in the case of employment. While employment (= population) can either rise or fall in the absence of WFH depending on whether the initial tax rate is sub- or super-optimal, employment under

[21] Under residence taxation, this dependence is only present for population and the housing price since the employment and wage effects are always zero.

[22] The assumptions are: $w(L) = L^{-1.5}$, $U(q) = q^{0.5}$, $V(z) = z^{0.5}$, $A_l = 1.0$, $A_h = 1.2$, $t_l = 0.5$. To plot all the solutions on the same diagram, the $\widetilde{w}_h$ value is divided by 10.

WFH is either *unaffected* by the tax increase (under residence taxation) or *decreases* as t_h rises (under source taxation). These radically different employment effects are due, of course, to the decoupling of residence and employment locations. In addition, population increases under WFH with source taxation when labor demand is inelastic, in contrast to the possible positive or negative movements in the absence of WFH.[23]

As for the net flow of remote work, by increasing $\widetilde{N}_h$ and decreasing $\widetilde{L}_h$ under source taxation, the tax increase raises the net flow toward state l. The ambiguity of the population effect under residence taxation, however, means that the net flow could shift in either direction as t_h increases.

5.2. Empirical considerations

Proposition 5 has important implications for empirical researchers seeking to study the effect of state tax changes. First, the impact of taxes is dramatically different in the presence of telework. Wages may move in opposite directions in response to a tax increase when workers can work remotely compared to when they cannot, which suggests the need to estimate heterogeneous tax effects in the pre- and post-WFH eras. In addition, although the burden of state taxes was born by resident-workers prior to WFH, the wage burden of source-based taxes post-WFH is born both by residents and non-residents, as seen in Proposition 5. As a result, empirical research must exploit information on the location of work to estimate wage incidence.

Second, because telework decouples residential and employment locations, researchers must distinguish between tax-induced residential relocations and tax-induced employment shifts.

[23] It is interesting to note that impacts like those in Proposition 5 can arise from a change in the federal tax rate holding state tax rates fixed. Suppose that federal taxes are levied through a flat rate t_f and that the revenue is spent on a public good consumed equally across states (and valued in an additional subutility function). State taxes are deductible in paying federal taxes, so that net income in state h equals $(1-t_h-t_f(1-t_h))w(L_h) = (1-t_h-t_f+t_ft_h)w(L_h)$. Now consider the effects of an increase in the federal tax rate. The state public-good levels are unaffected, and because the federal subutility function cancels from the equal-utility conditions, no federal public-consumption effects appear either. Just as in the case of rich workers discussed subsequently, the only effect arises in the net-wage expressions, where the state plus federal tax rate on wage income rises. As the combined rate rises less in state h than in state l because of federal deductibility, the federal tax-rate change has the same effect as a simultaneous increase in t_h and t_l, with t_h rising by less. Under the federal change, it is as if t_h falls relative to t_l, which leads to results opposite to those in Proposition 5. However, if the federal rate were to fall instead of rise, the effects would parallel those in the proposition. This extension makes it clear that, a federal tax change can spur interstate mobility because it interacts with state tax rates.

The latter are especially important in the case of source-based taxation, where changes in jobs by remote workers (holding constant their residence) can be viewed as spatial tax arbitrage. If labor demand is inelastic, employment and population in the high-tax state may move in *opposite* directions in response to a tax increase, suggesting that residential relocations are no longer sufficient to determine the pattern of spatial distortions from taxation.

Finally, our analysis points to the importance of sourcing rules on outcomes and incidence. Our model is flexible enough to encompass residence-based tax systems, such as those in the European Union but also in the hodgepodge of rules in the United States, where teleworkers can be taxed in the source state if convenience of the employer rules are adopted or in the residence state if states rely on physical presence rules for determining tax liability. Given ample variation in the tax rules in the United States, and given a sufficient number of state tax-rate changes in the coming years, the empirical predictions of our model could be tested. Unfortunately, in the initial year after COVID-19, the sourcing rules by US states were unclear with many states making court challenges or temporarily pausing existing rules, thus currently preventing a formal empirical analysis. In the meantime, our theoretical model is valuable for both researchers seeking to assemble datasets necessary to study tax arbitrage with telework and for policymakers seeking to determine the consequences of taxing remote workers.

5.3. Relation to corporate and commodity taxes

The study of sourcing rules has a long history in the commodity (Lockwood, 1993; Lockwood, 2001; Kanbur and Keen, 1993; Haufler, Schjelderup, Stähler, 2005) and corporate (Auerbach and Deverexu, 2018; Griffith, Hines, Sorensen, 2010; Huizinga and Nielsen, 1997) tax literatures, but is limited in the personal income tax setting. Although there are similarities, our setting differs in important ways from those in the corporate and commodity tax literature. First, in contrast to models of commodity and capital taxation, where labor or households are treated as immobile resource, telework makes employment and population both mobile. Second, mobility implies that local public services are critical, unlike in the other literatures. Third, unlike much of the income shifting responses in the corporate tax literature, telework allows for real responses of households.

The most direct parallel to this literature, however, relates to the efficiency of residence taxation in Proposition 4. With capital mobility and cross-country tax differentials, capital taxes either distort international savings (when residence-based) or international production (when source-based). Thus, the international version of the production efficiency theorem states that, in the absence of pure profits and with a full set of taxes, only residence-based taxes are used, with source taxes zero at the optimum. This conclusion is true not only in a small open economy (Gordon, 1986), but also for a set of symmetric countries that are all "large" (Eggert and Haufler, 1999).

6. Extensions

6.1. Focusing on high-income households

A recent literature has explored the effects of taxes on superstars and other high-income individuals (Scheuer and Slemrod, 2020; Scheuer and Werning, 2016), and empirical evidence suggests that the impacts on these groups differ from those on the less well-off (Zidar, 2019). To explore this possibility, suppose that the economy consists of a second type of household that receives no benefit from the public goods financed by the taxes it pays. These households might be high-income households that are unlikely to consume state public goods or, in a less extreme variant, households that are net-payers into the tax system due to progressivity. Data from the Current Population Survey indicate that high-income households also have the highest propensity to work remotely, thus being most affected by the decoupling of residence and employment. To simplify the analysis, we assume that both the housing and labor markets are segmented, with the housing prices paid by the rich depending only on the rich population, and the wages earned by the rich depending only on their own employment. In this section, we focus solely on the effect of tax changes on rich populations and employment and on the wages earned and housing prices paid by this group.[24]

The equal-utility condition for the rich is characterized by a modified variant of (3), (5)

[24] The effects on low-income households depend on whether the tax changes affect the rates they pay or only alter top marginal rates. In the latter case, a tax change will affect low-income households only through the level of the public good, leading to changes in their employment levels and populations that we do not analyze. Without further changes to the setup, such an analysis would need to assume that, although the rich do not value the public good, they still create congestion in its consumption (reflected in the $1/N$ factors in the z expressions). This assumption would be valid, for example, if the police force patrols rich neighborhoods (expending resources) even though rich households mainly rely on private security services.

or (7) that excludes the $V(\cdot)$ terms and where all quantities and prices correspond to those of the rich. The net-wage equalization conditions given by (4) and (6) are unchanged, except that they involve wages for rich workers.

In the absence of WFH, an increase in the tax rate t_h decreases the LHS of the modified version of (3), requiring an offsetting decrease in the rich population (equal to employment) in state h, which reduces the rich housing price and raises their wage (opposite effects are felt in state l). This outcome is similar to the effects of a decrease in state-h amenities in the standard Rosen (1979)-Roback (1982) framework, although the model structures are different.

With WFH and residence taxation, an increase in t_h has no effect on rich employment or the wage, given that tax rates are absent from (6). While V does not appear, the presence of the net-wage term in (7) means that the tax increase reduces the attractiveness of state h for the rich, so that their population and the housing price they pay fall.

With WFH and source taxation, an increase in t_h reduces the net wage in (4). As a result, employment of the rich falls in state h and their wage rises, with opposite effects felt in state l. But because the modified equal-utility condition (now (5)) is again unaffected by the tax increase, the population of the rich in state h and the housing price they pay are unchanged, reflecting their zero valuation of public services.

Summarizing yields:

Proposition 6. *Tax-induced changes in high-income wages and employment are in the same direction as in the previous cases. The population and housing-price effects in state h from an increase in its tax rate are as follows (with the reverse effects in state l):*

$$\widehat{N}_h : \; - \; , \; \widehat{p}_h : - \;\; \textit{with residence taxation}; \qquad \widetilde{N}_h : \; 0 \; , \; \widetilde{p}_h : 0 \;\; \textit{with source taxation}$$

Clear population effects emerge in the high-income case because endogenous public goods are not a complicating factor in determining the residential locations of rich workers. Note the stark contrast between the tax effects in Proposition 6 and those from the basic model, shown in the second panel of Table 1.

While the assumption of segmented housing and labor markets underlying Proposition 6 is stylized (ignoring, for example, labor complementarity across income groups), it allows us to build clear intuition. Moreover, empirical researchers studying the effect of top tax-rate changes usually invoke these assumptions to identify mobility effects, using lower-income households as a comparison group.

6.2. Applying our approach to hybrid WFH

Throughout the paper, we have focused on jurisdictions as states, but they could equally well be countries or cities that levy their own local income taxes. While the international interpretation of our analysis is straightforward, the application to cities allows us to relate our model to the case of hybrid WFH in a situation where both the home and work jurisdictions levy separate income taxes. Such local taxes are common around the world, including in countries such as the United States, Denmark, Switzerland, Finland and Italy, and their levels can vary substantially within metropolitan areas.[25] Critically for our purposes, localities (like states) differ in how they tax interjurisdictional workers. For example, in the US, some cities levy local payroll taxes that act as source-based taxes for teleworkers. Other cities acknowledge that these taxes fund public services primarily for residents and thus apply local income taxes only to resident-workers or let nonresident workers pay a preferential tax rate.

To analyze the hybrid WFH case, consider two cities sufficiently close to one another to allow commuting between them, which is assumed to be costless. Suppose that a worker is employed in city h, but spends a fraction θ of work hours telecommuting from home, which is located in jurisdiction l, with a fraction $1-\theta$ of work hours spent at the office. Moreover, suppose that jurisdiction h levies an income tax at rate t_h on the portion of income generated at the office, while jurisdiction l levies an income tax at rate t_l on the portion of income generated at home. In effect, taxes are prorated across the locations where the work is done.

Total employment in jurisdiction h is L_h, which counts the total time spent regardless of whether workers are present in the office or are telecommuting. Therefore, the net income of a worker who works in h, partially telecommuting from l, equals

$$(1-t_h)(1-\theta)w(L_h) \; + \; (1-t_l)\theta w(L_h). \tag{12}$$

[25] Prior to the emergence of telework, several studies found that municipal income taxes are important for the residential location decisions of individuals (Rubolino, 2022; Schmidheiny, 2006).

Similarly, a worker employed in jurisdiction l who partly telecommutes from jurisdiction h has net income of

$$(1-t_l)(1-\theta)w(L_l) \ + \ (1-t_h)\theta w(L_l), \tag{13}$$

while workers living and working in city i have net incomes of $(1-t_i)w(L_i),\ i=1,2$.

For this setup to be viable, the fraction θ cannot be a choice variable of the worker but must be institutionally fixed, possibility being dictated by firms so as to match their prior leasing of office space to the home/office division of work. Otherwise, a worker would set $\theta = 1$ $(= 0)$ in (12) if $t_l < (>)\ t_h$. Under an alternative interpretation, θ is an exogenously given apportionment fraction set by the federal government that allocates income taxes of intercity workers to the employment and residence cities.

Worker indifference between living and working in city l and living in l but partly telecommuting to h requires equality between $(1-t_l)w(L_l)$ and (12). Similarly, worker indifference between living and working in city h and living in h but partly telecommuting to l requires equality between $(1-t_h)w(L_h)$ and (13). While both conditions imply $w(L_h) > w(L_l)$ when $t_h > t_l$, they require different proportional relationships between the two wages and thus cannot both be satisfied. Therefore, only one condition can hold, implying that remote work flows in only one direction. However, it can be shown that, regardless of which condition is satisfied, the value of L_h exceeds the source-taxation value $\widetilde{L}_h$ and is smaller than the residence taxation value $\widehat{L}_h = \overline{N}$ as long as $0 < \theta < 1$.[26]

Computing a jurisdiction's tax revenue is complex in this setting because revenue no longer simply depends on employment and the local tax rate, but also depends on where the employees live. Nevertheless, a utility equalization condition can be derived, and when combined with the one of the workplace indifference conditions, an equilibrium is determined. Our focus, however,

[26] Letting $L_h^{\#}$ denote state h's employment level in the hybrid case (with $L_l^{\#} = \overline{N} - L_h^{\#}$), the workplace indifference condition based on (12) reduces to $w(L_h^{\#})/w(\overline{N}-L_h^{\#}) = (1-t_l)/[(1-t_h)(1-\theta)+(1-t_l)\theta]$ while the indifference condition based on (13) reduces to $w(L_h^{\#})/w(\overline{N}-L_h^{\#}) = [(1-t_l)(1-\theta)+(1-t_h)\theta]/(1-t_h)$. Since these RHS expressions are equal only by accident, both conditions cannot in general be satisfied. But since the RHS expressions are both greater than 1 when $t_h > t_l$, it follows that $w(L_h^{\#}) > w(\overline{N}-L_h^{\#})$ in both cases. Furthermore, since both RHS expressions are less than $(1-t_l)/(1-t_h)$ for interior values of θ, the RHS expression applicable under source taxation, it follows that $L_h^{\#} > \widetilde{L}_h$ in both also holds. Also, $L_h^{\#} < \widehat{L}_h = \overline{N}$ follows because both RHS expressions are greater than one, the RHS value under residence taxation.

is to link this hybrid model to the previous analysis. The following important conclusion can be stated:

Proposition 7. *The hybrid equilibrium reduces to the residence-taxation equilibrium when $\theta = 1$, and it reduces to the source-taxation equilibrium when $\theta = 0$. Moreover, when $0 < \theta < 1$, the value of L_h lies between the source- and residence-taxation values of $\widetilde{L}_h$ and $\widehat{L}_h = \overline{N}$, thus representing an intermediate case.*

The first part of the proposition follows because both of the indifference conditions reduce to $w(L_h) = w(L_l)$ when $\theta = 1$, while reducing to $(1 - t_h)w(L_h) = (1 - t_l)w(L_l)$ when $\theta = 0$. Therefore, we can view our polar cases of residence (source) taxation as limiting cases of the hybrid model when work is done entirely at home (entirely in the office). The second part of the proposition follows from the previous analysis.

6.3. A mixed system with tax credits

The previous focus on source- and residence-based taxation masks the actual variability across U.S. states in the tax treatment of interstate teleworkers.[27] Under one possible alternate case, the tax regime is a mixture, with the two states both levying source-based taxes on teleworkers as well as residence-based taxes, but with tax credits limiting the double taxation of teleworkers. In particular, a worker living in the first state and teleworking in the second state would pay a source-based tax to the second state. The residence state would then give a tax credit to the worker equal to source-based taxes already paid, reducing the worker's residence-based tax liability (although it cannot become negative).[28]

To show how this mixed system works, we first derive the net wage for different combina-

[27] In the pre-WFH era, some adjacent states that contain parts of a large metro area straddling their border (Pennsylvania and New Jersey, for example) adopted reciprocal agreements. These agreements allow income earned by workers commuting across the state border to the other state's part of the metro area to be taxed in the state of residence, agreements that now presumably apply to remote workers. In effect reciprocity makes it so these states bilaterally are operating under the residence-taxation regime.

[28] This mixed system would pertain to actual pairs of states where state T's tax rules include a source-based tax on teleworkers (there are 7 such states), where state R levies a residence-based tax (only the 9 states without income taxes do not), and where state R offers tax credits for all source-based taxes paid to another state. Since not all states with income taxes fall into this latter group and because not all states tax nonresident teleworkers, the mixed system cannot be viewed as broadly representative of current practice, which is actually better approximated by the residence-based system (though there is substantial uncertainty over tax rules in the future). Nevertheless, the following analysis formalizes the mixed system and derives some of its properties.

tions of residence and work locations, assuming that $t_h > t_l$. For state-h residents who work in that state, their tax is $t_h w(L_h)$, yielding a net wage of $(1 - t_h)w(L_h)$. Workers living in h and working in l pay a tax of $t_l w(L_l)$ to state l, and they pay state h a tax on remote income at the local rate t_h less a credit for taxes already paid to state l. The state-h tax liability then equals $\max\{0, t_h w(L_l) - t_l w(L_l)\} = t_h w(L_l) - t_l w(L_l)$, where $t_h > t_l$ is used and the max operator captures non-refundability of credits (ruling out negative taxes). Summing the tax payments to the two states yields $t_h w(L_l)$ and a net wage of $(1 - t_h)w(L_l)$. For state-h residents to be indifferent to their place of employment, this net wage must equal the one from living and working in state h, yielding:

$$(1 - t_h)w(L_h) \quad = \quad (1 - t_h)w(L_l), \qquad (14)$$

which replicates the requirement under residence taxation.

Now consider workers who live in state l. For those also working in state l, the net wage is $(1 - t_l)w(L_l)$. Those working in state h pay $t_h w(L_h)$ to that state while paying $\max\{0, t_l w(L_h) - t_h w(L_h)\} = 0$ to state l. This expression is zero because the state-h tax payment exceeds the local payment, meaning that no additional tax is paid to state l. The result is a net wage of $(1 - t_h)w(L_h)$. For state-l residents to be indifferent to their place of employment, these two net wage expressions must again be equal:

$$(1 - t_h)w(L_h) \quad = \quad (1 - t_l)w(L_l), \qquad (14)$$

which replicates the requirement under source taxation.

Inspection of (14) and (15) shows that both equations cannot be satisfied. The implication is that, as in the hybrid case, telecommuting cannot occur in both directions in the mixed model, with telecommuters living only in one state or the other (but not both).[29] When

[29] This discussion raises the possibility that the wage-equalization condition in the WFH models without tax credits may not hold as an equality, as has been assumed so far. In this case, all workers in the economy, regardless of their residence state, would work in just one of the two states, the one with the higher net wage. However, here and above, we consider only those equilibria where both states contain jobs.

equality holds in (15) rather than in (14), the mixed equilibrium would appear to match the previous one with source-based taxation, while the equilibrium would appear to coincide with the residence-based equilibrium when (14) holds as an equality. However, to verify these claims, it must be checked that the utility-equalization condition remains the same as before, which requires the same expressions for z_h and z_l. Online Appendix A.1 shows that this coincidence of equilibria occurs only in the case when (14) holds as an equality. Thus,

Proposition 8. *Under WFH with a mixed tax regime in which each state contains jobs, residents of one of the two states work only in that state, ruling out bi-directional telework. If residents of state l work in both states, then the mixed equilibrium coincides with the equilibrium under source taxation, having the same comparative-static properties. But if residents of state h work in both states, the mixed equilibrium is different from those considered so far.*

Note that, because it appears impossible to rule out one of the two cases delineated in the proposition, a WFH economy under a mixed regime evidently can have multiple equilibria.

6.4. A mixed system with double taxation

Given that the pure source-based equilibrium can arise under a mixed system with tax credits, one may wonder whether there exists an alternative mixed system that gives rise to the purely residence-based equilibrium. Consider the mixed system where the first state taxes its residents while also applying a source-based tax on nonresident teleworkers, while the second state levies a tax only on its residents while *refusing* to offer tax credits for those residents who telework in other states. The result is double taxation of these residents. Several states, including Vermont, do not offer tax credits for taxes paid to the seven states with source-based rules.[30]

To determine the nature of the resulting equilibrium, we follow the same steps as under the tax-credit case by first deriving the net wage equalization conditions. Again, it can be shown that the teleworkers will live in only one of the two states. With this information, we can derive tax revenues and the equal-utility condition. Online Appendix A.2 formally yields

[30] This is a case of unilateral adoption of particular tax rules. The recent corporate tax literature has considered the effects of a country unilaterally adopting a destination based cash-flow tax (e.g., Bond and Gresik 2020; Becker and Englisch 2020). See Gresik and Schjelderup (2022) for the case of universal adoption.

the following conclusions:

Proposition 9. *When one state taxes nonresident teleworkers under WFH but the other refuses to offer tax credits, residents of one of the two states work only in that state. If residents of the state taxing nonresident teleworkers work in both states, then the resulting equilibrium coincides with the equilibrium under residence taxation, having the same comparative-static properties. But if residents of the state that does not tax nonresident teleworkers work in both states, the equilibrium is different from those considered so far.*

Together, Propositions 7 and 8 imply that, under the two mixed regimes, equilibria can correspond to either of the polar cases considered previously. These alternative regimes, combined with the purely residence-based tax system studied previously, encompass the bulk of the tax regimes arising between various pairs of U.S. states. However, while the model considers only a single pair of states, thus assuming that the pair constitutes the entire economy, a fully realistic analysis would need to incorporate a larger number of states, each with potentially different tax rules. But, even in that more complex setting, the *pairwise flows* of labor and population following a tax increase would presumably show qualitative patterns similar to those in our model.

7. Conclusion

The last two years have seen a dramatic increase in WFH, which survey evidence indicates will persist into the future (Barrero, Bloom, and Davis 2021). The surge of telework has resulted in workers being able to move between metro areas without changing jobs. These structural changes in the organization of work pose important policy challenges for state and local governments that are reliant on income taxes, yet the effect of decentralized taxation in the presence of WFH is unknown. We provide the first theoretical guidance that informs policymakers on the responses to decentralized taxation and spending under WFH.

To tackle this question, we use a model that is rich enough to capture the necessary features of taxation in the presence of WFH, but simple enough to yield sharp insights into the central questions facing current policymakers. Our main positive findings, which pertain to the employment and wage effects of WFH, show that a shift from a non-WFH economy to WFH reduces employment and raises the wage in high-tax states, and that once WFH is in place, an increase in a state's tax rate either reduces employment further while raising the wage or leaves the labor market unaffected, depending on whether source or residence taxation is present. The paper also generates an important normative conclusion by showing that residence-taxation under WFH is efficient, a result of the equalization of employment and hence marginal products across states, which in turn converts the labor tax into an efficient head tax.

We see two possible extensions of the model. A first extension, which would amount to an entirely new paper, would be an analysis of tax competition using our framework. In keeping with the tradition in such models, employment and population would no longer be viewed as parametric in the choice of tax rates, but states would instead take account of tax impacts on these variables when setting tax policy.[31] While traditional models of tax competition usually assume that jurisdictions interact strategically with nearby jurisdictions (Eugster and Parchet 2019), telework makes the tax base globally mobile, meaning the competition for workers and population need not be localized.

Second, agglomeration economies, which are also absent in BKL, could be added to the model (Rosenthal and Strange, 2008). With remote work possibly lessening interactions by remote workers with their coworkers and employees in other firms, both own productivity and the extent of overall agglomeration forces could be weakened.[32] A related change would be to add innate worker-productivity differences across states to the existing amenity differences. However, BKL showed that the impacts of WFH tend to be ambiguous when both these differences are present.

Our paper provides an ambitious agenda for future empirical research. Although few major state tax reforms have occurred since the surge in telework, states will change income-tax rates and, given the lack of legal consensus on state taxing rights over teleworkers, may change the sourcing rules governing how those teleworkers are taxed. These changes, combined with the expected persistence of WFH, will provide ample variation to identify the heterogeneous effects

[31] A comprehensive model of these decisions could consider a multi-stage game where states first pick the tax regime and then pick tax rates. Researchers could also consider an additional stage where, conditional on the tax regime, states can decide whether to offer tax credits for remote workers.

[32] These individual and aggregate effects may have important implications for how employment and populations respond to taxes, as in Brülhart, Jametti, and Schmidheiny (2012).

on mobility and prices featured in our model.

The subsequent empirical analysis of interjurisdictional mobility might consider the following factors. First, researchers should allow different effects for states that tax teleworkers at their residence versus states that rely on source taxation, also taking account of any tax credits. Second, "endogenous amenities" (public goods) funded by taxes are important: the extent to which individuals value spending influences both population and employment mobility, as seen in our analysis.[33] Third, because telework decouples employment and residence, unless taxes are purely residence-based, the elasticity of residential mobility is no longer sufficient to gauge the extent of tax-related spatial distortions in the economy (employment mobility and wage impacts under WFH must also be considered). Finally, our paper provides a call for new data sources and distinct measurement of the location of the employer and whether work is done at home. While current surveys such as the Census and the Survey of Income Program Participation (SIPP) ask questions about telework, answers are potentially ambiguous in pinning down where work is actually done.[34] Researchers might instead use alternative datasets such as administrative tax data or the Longitudinal Employer-Household Dynamics (LEHD) to study the relevant locations for teleworkers.

Public-sector impacts of WFH that are not directly connected to the present model also deserve investigation. Importantly, hybrid WFH arrangements, where workers remain in the same city but commute fewer days per week, lead to a reduction commuting costs and thus create an incentive for further decentralization of cities. By putting downward pressure on residential property values in downtown areas, this decentralization is likely to depress property-tax bases in central cities across the country, creating fiscal pressure. This pressure is likely to be compounded by the falling rents (and hence values) of office buildings as commercial tenants unload unneeded space in the face of WFH (Gupta, Mittal, and Van Nieuwerburgh, 2022). Negative spillover effects for restaurants and other businesses serving downtown workers will depress rents and values for such space while also cutting sales tax revenue. All these WFH-

[33] Monte, Redding and Rossi-Hansberg (2018) estimate how migration and commuting influence the local employment elasticity in response to local demand shocks.

[34] The SIPP asks "What is the address of the main location where (person) work(s)(ed) at (employer name)?" while the American Community Survey asks "At what location did this person work last week?".

related developments could spell fiscal trouble for U.S. central cities, and they are topics ripe for further research.

Appendix

This appendix provides the efficiency analysis underlying Proposition 4. Suppose that a social planner chooses the optimal allocation of population and employment and the optimal public-good levels in our WFH economy. The problem is to maximize a common utility level u under the assumption that both states achieve this utility level, which is a horizontal equity condition that must be satisfied in any economy with free mobility. The Lagrangean expression for this problem is

$$\begin{aligned} u &+ \lambda_h(A_h + e_h + V(z_h) + U(1/N_h) - u) \\ &+ \lambda_l(A_l + e_l + V(z_l) + U(1/N_l) - u) \\ &+ \mu[N_h e_h + N_l e_l + N_h z_h + N_l z_l - (f(L_h) + f(L_l))], \end{aligned} \qquad (a1)$$

with last constraint being the economy's resource constraint.

Using $N_l = 2\overline{N} - N_h$ and $L_l = 2\overline{N} - L_h$, the first-order conditions are

$$u: \quad 1 - \lambda_h - \lambda_l = 0 \qquad (a2)$$

$$e_h: \quad \lambda_h + \mu N_h = 0 \qquad (a3)$$

$$e_l: \quad \lambda_l + \mu N_l = 0 \qquad (a4)$$

$$z_h: \quad \lambda_h V'(z_h) + \mu N_h = 0 \qquad (a5)$$

$$z_l: \quad \lambda_l V'(z_l) + \mu N_l = 0 \qquad (a6)$$

$$L_h: \quad \mu(f'(L_h) - f'(N_l)) = 0 \qquad (a7)$$

$$N_h: \quad \lambda_h U'(1/N_h)(-1/N_h^2) + \lambda_l U'(1/N_l)(1/N_l^2) + \mu(e_h - e_l + z_h - z_l) = 0 \quad (a8)$$

Eqs. $(a3)$-$(a6)$ yield $V'(z_h) = V'(z_l) = 1$, which implies $z_h = z_l = \widehat{z}^{**}$. Using $(a7)$ yields $f'(L_h) = f'(N_l)$, so that $L_h = L_l = \overline{N}$. Subtracting the utility constraints in $(a1)$ yields $e_h - e_l = A_l - A_h + U(1/N_l) - U(1/N_h)$, and inserting in $(a8)$ while canceling the z's and using

$(a3)$ and $(a4)$ to eliminate the multipliers, the condition becomes

$$A_h \ + \ H(N_h) \ \ = \ \ A_l \ + \ H(N_l). \tag{a9}$$

Thus, at the optimum, employment is equally split between the states, the z's equal $\widehat{z}$, and the state populations satisfy $(a9)$. It is easy to see that these conditions are the same as the equilibrium conditions under the residence-taxation regime when the tax rates are set optimally at the value $\widehat{t}$ in both states, which satisfies $\widehat{t}^{**}w(\overline{N}) = \widehat{z}^{**}$. Then, the V's and the net wage terms on both sides of (7) cancel, so that the equation reduces to $(a9)$, indicating that the optimal and equilibrium state populations coincide.

Inefficiency of source taxation can be seen by showing that, if some of the optimality conditions were satisfied in the equilibrium, the remaining equilibrium condition would be violated. Equality of marginal products would require $L_h = L_l = \overline{N}$, which will hold under source taxation if the tax rates are equal. The condition for optimal choice of the tax rate under source taxation is $V'(tw(L)L/N)(L/N) = 1$, which becomes $V'(tw(\overline{N})\overline{N}/N)(\overline{N}/N) = 1$. For this condition to yield equal tax rates across states, as required for equal marginal products, equalization of $\overline{N}/N$ across states is required, yielding $N = \overline{N}$ in each state. The V terms then cancel in the utility-equalization condition (5), but the resulting condition (which then matches the planner's condition) is not satisfied when populations are equal. Therefore, the planner's optimality conditions cannot be satisfied in the source-taxation equilibrium.

Table 1: Predicted effects

Effects of shift to WFH on state h

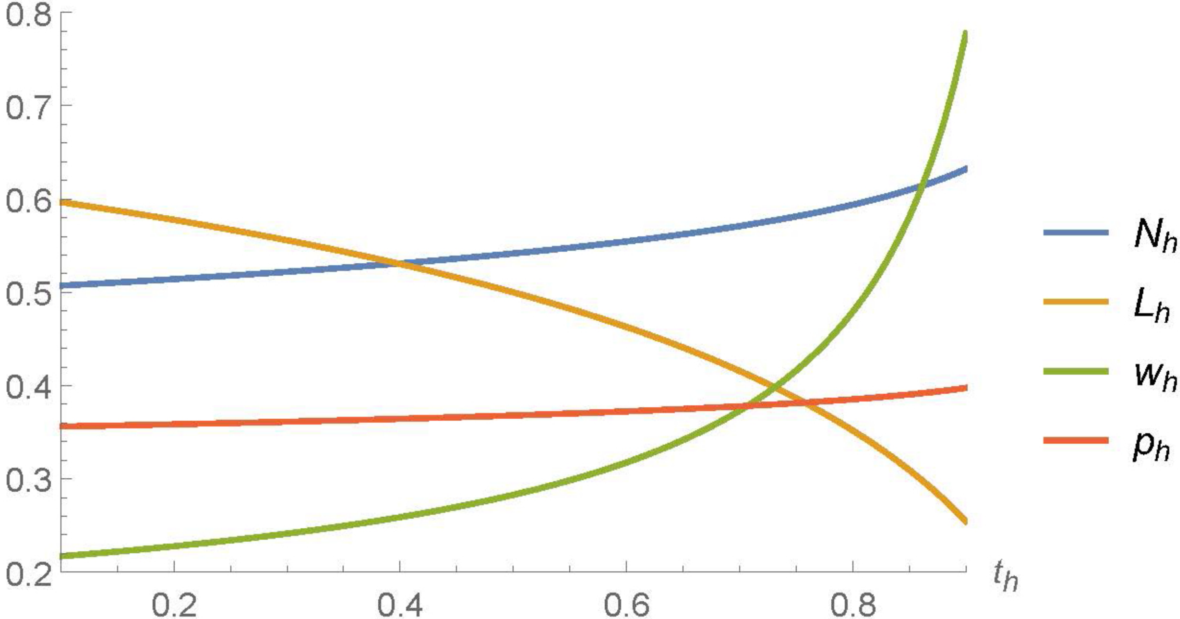
	Employment	Wage	Population	Housing price
source taxation	−	+	?	?
residence taxation	−	+	+	+

Effects of increase in t_h *on state h*

	Employment	Wage	Population	Housing price
source taxation	−	+	+*	+*
residence taxation	0	0	?	?

* Assuming inelastic labor demand

Figure 1: Illustrative solutions for source taxation



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Online Appendix

A.1. A mixed regime with tax credits

To derive tax revenues in the WFH tax-credit regime, define (as in section 2.2) N_h^h and N_h^l as the number of state-h residents employed in states h and l, respectively, and N_l^h and N_l^l as the number of state-l residents employed in states h and l, respectively. We can then write total employment in state-h as $L_h = N_h^h + N_l^h$ and total population in state h as $N_h = N_h^h + N_h^l$, with similar relationships for state l.

Tax revenues in the two states (equal to r_h and r_l) are given by

$$r_h = \theta w(L_h)N_h^h + \theta w(L_h)N_l^h + \max\{0, (\theta - t_l)w(L_l)N_h^l\} \quad (a1)$$

$$r_l = t_l w(L_l)N_l^l + t_l w(L_l)N_h^l + \max\{0, (t_l - \theta)w(L_h)N_l^h\}. \quad (a2)$$

ach equation contains three terms. Focusing on the state-h revenue, the first term in $(a1)$ is tax revenue from resident workers. The second term is revenue from state-l residents who telework in state h. The third term is revenue from state-h residents who telework in state l. Because these workers pay taxes to the source state (state l) first, the revenue they generate equals zero if $\theta \leq t_l$ and reflects the state's tax rate net of credits for state-l taxes, equal to $\theta - t_l$, if $\theta > t_l$. Revenue in state l is similarly derived.

In our model, we assume $\theta > t_l$ and, as shown in the text, only residents of one state can engage in telework. Suppose that equality holds in (12), so that state-l residents work in both states while state h residents work only there. Then, a state-l resident working in state h will pay taxes to state h but will owe no additional taxes to state l because $t_l < \theta$. Using $(a1)$ and $(a2)$, tax revenues in the two states then simplify to

$$r_h = \theta w(L_h)N_h^h + \theta w(L_h)N_l^h = \theta w(L_h)L_h \quad (a3)$$

$$r_l = t_l w(L_l)N_l^l = t_l w(L_l)L_l. \quad (a4)$$

Note that $N_l^l = L_l$ holds in $(a4)$ because $N_h^l = 0$. The tax revenue expressions in $(a3)$ and $(a4)$ are then the same as those inside the V terms in (5) (where division by population then occurs), which implies that the tax-credit equilibrium where state-l residents work in both states is the same as the source-taxation equilibrium.

Now suppose that equality holds in equation (11) in the text, so that state-h residents work in both states while state-l residents work only there. Now, tax credits matter, with the revenue expressions given by

$$r_h = \theta w(L_h)N_h^h + (\theta - t_l)w(L_l)N_h^l = \theta w(\overline{N})N_h - t_l w(\overline{N})N_h^l \quad (a5)$$

$$r_l = t_l w(L_l)N_h^l + t_l w(L_l)N_l^l = t_l w(\overline{N})(N_h^l + N_l^l) = t_l w(\overline{N})\overline{N}. \quad (a6)$$

In moving from $(a1)$ to $(a5)$, note that the second term in $(a1)$ is zero given $N_l^h = 0$ and that the second term in $(a5)$ reflects that the tax credit given by state h to its residents who work in state l, which reduces its revenue by the amount of taxes already paid to state l.

To get z values, these revenue expressions must be divided by N_h and N_l, respectively. Inspection of $(a5)$ and $(a6)$ shows that the expressions do not reduce to the z values on the two sides of (7), which equal $\theta w(\overline{N})$ and $t_l w(\overline{N})$, respectively. Therefore, the tax-credit equilibrium when state-h residents work in both states is not the same as the residence-based equilibrium analyzed above. Note that, while the analysis of residence and source taxation focused on comparative statics of an increase in θ, recognizing that equivalent results would emerge with a change in t_l, the the identity of which tax rate changes matters in this new tax-credit equilibrium, given the appearance t_l in the state-h expression $(a5)$. Given this added complexity, we leave comparative-static analysis of this equilibrium to future work.

A.2. A mixed regime with double taxation

In this section, we consider the case where one state unilaterally taxes nonresident teleworkers, but where the other state does not tax teleworkers and thus refuses to offer tax credits to its own residents who work in other states. This case is quite common in the United States, as it involves pairs of states where one state has a convenience-of-the-employer rule (7 such states) and where the other state does not have such a rule (all remaining states with income taxes) while also refusing to offer a tax credit to residents. Not all of the remaining states fall into this latter category, but there are several states that do not offer tax credits to resident teleworkers (Vermont is one).

First, we derive the net wage for different combinations of resident and work locations, assuming without loss of generality that state h taxes nonresident teleworkers, but that state l does not. Consider first workers who live in state h. For those who also work in state h, the net wage equals $(1-\theta)w(L_h)$. Workers living in h and working in l are taxed only in the resident state because state l does not tax teleworkers, receiving a net wage of $(1-\theta)w(L_l)$. For state h residents to be indifferent to their place of employment, the two net-wage expressions must be equal, yielding

$$(1-\theta)w(L_h) \quad = \quad (1-\theta)w(L_l). \tag{$a7$}$$

Now, consider workers living in state l. For those also working in state l, the net wage is $(1-t_l)w(L_l)$. Those working in state h now pay $\theta w(L_h)$ to that state because it taxes teleworkers, but they receive no credit in state l, thus owing $t_l w(L_h)$ to state l, reflecting double taxation of income. Their net wage thus equals $(1-\theta-t_l)w(L_h)$. For state l residents to be indifferent to their place of employment, these two net-wage expressions must again be equal:

$$(1-t_l)w(L_l) \quad = \quad (1-\theta-t_l)w(L_h). \tag{$a8$}$$

As before, both equations cannot be satisfied. If $(a7)$ holds, then $w(L_h) = w(L_l) = w(\overline{N})$, which means that the LHS of $(a8)$ exceeds the RHS. In this case, residents of h work in both states but residents of l do not, with uncredited taxation of teleworkers discouraging nonresidents from working in the state that adopts such a rule. Conversely, if $(a8)$ holds, then

$w(L_h) > w(L_l)$, and the LHS of $(a7)$ exceeds the RHS. Thus, residents of state l work in both states, but residents of h do not. The wage needs to be sufficiently high in the state that taxes teleworkers to incentivize nonresidents to work there, but its own residents will then not want to work in the other state.

With this information, tax revenues can easily be computed. If $(a7)$ holds, so that state-h residents work in both states, then tax revenues are given by

$$r_h = \theta w(\overline{N})N_h^h + \theta w(\overline{N})N_h^l = \theta w(\overline{N})N_h \quad (a9)$$

$$r_l = t_l w(\overline{N})N_l^l = t_l w(\overline{N})N_l, \quad (a10)$$

where the last equality holds because $N_l^h = 0$. After dividing by population, these tax revenues yield the z expressions in (7). Therefore, with the net-wage equalization condition being the same, the equilibrium and comparative statics in this case match those under purely residence-based case.

Now suppose that $(a8)$ holds with equality, so that state-l residents work in both states. Then, the expressions for tax revenue become

$$r_h = \theta w(L_h)N_h^h + \theta w(L_h)N_l^h = \theta w(L_h)L_h \quad (a9)$$

$$r_l = t_l w(L_l)N_l^l + t_l w(L_h)N_l^h. \quad (a10)$$

While state-h tax revenue in $(a9)$ matches revenue in the source-taxation case, $(a10)$ does not match the state-l revenue expression under source taxation, implying that the resulting equilibrium differs from those analyzed previously. Thus, we again leave comparative-static analysis of this case to future work.