The Pricing of Property Tax Revenues*

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Abstract

Suppose a local government collects 3% of the market price of regional real estate in taxes each year. We show that this tax payment stream is equivalent to a stream of claims to future rent flows: the government owns 3% of this year's rent, approximately 6% in two years, 9% in three years, and so on. This result implies that seemingly small property taxes extract a large fraction of the value of future rents; that tax revenues are very sensitive to changes in interest rates; and that governments funded by tax revenues have future-biased incentives to invest in public goods.

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1 Introduction

Homeowners in the US pay *property taxes* equal to a percentage of the assessed value of their houses to state and local governments each year.[1] Roughly 20% of the own source revenues of US state and local governments come from these property taxes. Many other countries have analogous systems. This paper asks: What fraction of the value of the US housing stock is extracted through property taxes? Is this fraction sensitive to changes in economic conditions, such as interest rates, and how might the current property tax system affect local governments' incentives?

We answer these questions by developing a new way to think about the net present value of a stream of property taxes. An untaxed house can be thought of as a claim to an infinite sequence of future rents; its price is thus the sum of the discounted values of future rents. Intuitively, an annual 3% property tax can be thought of as a claim to 3% of the house's price in each future year; the tax should in some sense also be a claim to future rents, but this is complicated by the fact that taxation lowers the price of the house, since taxation encumbers the owner with tax payments in current and future years. What is the nature of the rent claim implicit in a sequence of property taxes, and how does taxation influence the price of the taxed house?

Our core contribution is to show that property taxation can be thought of as dividing the stream of future rents – equivalently, the hypothetical price of an untaxed house – into two separate assets: a taxed house, and the NPV of the stream of property taxes paid by the homeowner. These two assets represent different sets of claims to future rents. A stream of annual property taxes at rate τ represents a claim to a fraction $1 - (1 - \tau)^t$ of rent flows $t - 1$ years into the future; correspondingly, the owner of the taxed house owns a claim to $(1 - \tau)^{t-1}$ of rent flows $t - 1$ years into the future. Rent flows in the future are effectively taxed more heavily: a larger fraction of rents accrue to the government in property taxes, and thus a smaller fraction accrues to the homeowner. In other words, a 3% property tax can be thought of as a claim to 3% of rent flows in the first year, 6% next year, 9% in two years, and so on; property taxes extract a larger fraction of rent flows further in the future. Correspondingly, the owner of a taxed home residually owns roughly 97% of rent services generated in the present year, 94% the next year, and so on; with property taxes, rent flows further in the future thus impact taxed prices less, since a larger fraction of their value is captured by property taxes.

Our characterization has three useful implications.

[1] For example, homeowners in Camden County, New Jersey, must pay approximately 3% of the assessed value of their houses to the county government each year. See the New Jersey Treasury website.

First, seemingly small property taxes appropriate a very large fraction of rent flows. If rental services are constant over time, then the NPV of tax revenues as a fraction of all rental service flows – which is equal to one minus the ratio of taxed house prices to hypothetical untaxed house prices – is $\frac{\tau}{r+\tau}$, where τ is the tax rate and r is the discount rate. Suppose the discount rate is 5%: a seemingly small 2.5% annual property tax thus extracts *one third* of the entire value of rental service flows generated by the house. Equivalently, house prices would be 50% higher if the 2.5% annual property tax were removed.

We also show that there is a simple empirical approach to estimating the fraction of rental flows which is extracted through property taxation: this fraction is simply equal to the tax rate multiplied by the price-rent ratio. Using this approach, we estimate the tax extraction fraction for US states. Across states, taxes appear fairly low, with a median of 1.43%, 25th percentile of 1.07% and a 75th percentile of 2.26%. But the tax extraction fraction is very large in almost all states: the median is 26.09%, and the 25th and 75th percentiles are 18.13% and 37.54%, respectively. In other words, the median US state would have 35.3% higher house prices, in the absence of property taxes. As another illustration of how large these taxes are, if the property tax were abolished and replaced with a tax on rental services, applied equivalently to owner-occupants, the government would need to impose an annual 26.09% tax on rent services to raise as much tax revenue as they currently raise through property taxes.

Beginning with George (1884), a large literature has normatively argued that it is efficient to fund local governments through land taxation. Our contribution is to positively argue that US state and local governments are, quantitatively, already Georgist to a degree that we believe is larger than the literature previously believed: local governments already appropriate 26.09% of future rent flows in taxes, in the median US state.

Second, since property tax revenues are very backloaded, the present value of property tax revenues is very sensitive to fluctuations in interest rates. The concept of *duration* measures the average maturity of an asset, and thus also its sensitivity to interest rates. At a 5% discount rate, and assuming rents do not grow over time, we find that the duration of property tax revenues is 33.48; that is, tax revenues are as sensitive to interest rates as a *33.48 year zero-coupon bond.*

State and local governments are adversely affected by declines in interest rate through their pension obligations: since defined-benefit pensions are fixed and long-duration nominal liabilities, their present value increases as interest rates decrease. However, using data and estimates from the pension literature, we find that property tax revenues are around three times higher-duration, and twice as large in flow dollar terms, as pension liabilities. In a back-of-envelope calculation, we find that when interest rates decrease, property tax revenues increase by around \$6.89 for each dollar that pension liabilities increase. Thus, after taking property taxes into account, almost all state and local governments in our data on net *benefit* fiscally from a fall in interest rates.

Third, since property taxes represent backloaded rent claims, property taxes give state and local governments very *future-biased* investment incentives. Suppose the government holds a local festival which provides amenities that raise rents by \$1 in $t = 0$, with no effect thereafter; house prices and thus property taxes thus increase for a single period. If instead the government commits to running a festival in $t = 5$, house prices will *immediately* increase today, allowing the government to collect increased property taxes for the five years, until the event is actually realized. Fiscally, the government experiences a much greater property tax increase in the latter case. Another perspective is that a stream of 3% annual property taxes represents a 3% stake in rents this year, compared to a roughly 18% stake in rents in five years; since local governments have higher fiscal exposure to future rents than present rents, governments have a greater incentive to invest in public goods providing value further in the future. This perspective also illustrates that the magnitude of this distortion is very large: under realistic discount rates and tax rates, the government collects more than *four times* more tax revenue in the $t = 5$ case relative to the $t = 0$ case.

A common view is that governments funded by property taxes have an incentive to maximize property prices. Our result points to a subtle flaw in this logic. A government which maximizes *property prices* invests more or less to maximize the present value of future rent flows, with some distortions towards near-term payoffs due to tax capitalization into prices. But a government which maximizes the *present value of future tax revenues* has very different, and substantially future-biased incentives, to a government maximizing property prices. Separately, a variety of arguments have been put forwards discussing why governments and politicians often have incentives to be less patient than the representative voter; our results suggest that, interestingly, the structure of property taxes generates strong fiscal incentives for governments to be *more* patient than voters.

In summary, we show in this paper how viewing property taxes as a stream of claims to future rental incomes sheds new light on the magnitude of property tax revenues, the interest rate sensitivity of tax revenues, and the impacts taxes have on local governments' investment incentives. Our work contributes to several related strands of literature.

We relate to a recent, mainly empirical literature analyzing property taxes. Avenancio-León and Howard (2022*b*) find evidence that property taxes are systematically higher for racial and ethnic minorities, for similar properties, and Avenancio-León and Howard (2022*a*) show that legislative caps on assessment growth are associated with reduced racial inequality.

Amornsiripanitch (2020) and Berry (2021) show that property taxes are typically regressive, with low-priced properties being taxed more heavily; this finding is also discussed in McMillen and Singh (2023). The "capitalization" effect, where taxes lower house prices, is often not discussed in empirical analyses of property taxes. Our results suggest this is a potentially very important omission: seemingly small shifts in tax rates can dramatically affect property values. Our paper contributes a very simple, but novel and quantitatively realistic, model of the net present value of property tax flows, and how property taxes influence house prices. The "capitalization" effect could also contribute to explaining the "regressivity" of taxation documented in Amornsiripanitch (2020) and Berry (2021): low-priced properties may seem to have higher tax rates because higher tax rates *cause* lower house prices. Note also that, since our main goal is to characterize aggregate property tax exposures, our model is stylized and ignores many of the empirically documented differences between tax rates on different groups.

Our paper is also related to Giesecke, Mateen and Sena (2022), who empirically analyze the fiscal position of US municipal governments. As part of their analysis, Giesecke, Mateen and Sena empirically estimate how property tax revenues relate to a number of economic factors, including interest rates. In principle such an approach could find, complementary to our theoretical results, that property tax revenues are very sensitive to interest rates; in practice, however, house prices and thus property tax revenues are very slow-moving, hence we believe the estimated high-frequency responsiveness of property tax revenues to short-term interest rates likely understates the long-run effect of rates on property tax revenues.

Aiello et al. (2018), using a state-border design, show that pension shortfalls appear to lower house prices. This relates to an important shortcoming of our analysis: we assume property tax rates are fixed and unchangeable, whereas in practice local governments may adjust property taxes depending on future fiscal conditions. House prices in reality should reflect not only current tax rates, but the market's beliefs about future tax rates. We disregard this for simplicity, and because we think there are substantial insights from the simple constant-tax case.

The paper proceeds as follows. Section 2 contains our model and main result. Section 3 discusses the magnitude of property tax revenues, and Section 4 discusses interest rate risk exposures. Section 5 discusses how the structure of property taxes influences state and local governments' investment incentives . We discuss our results and conclude in Section 6.

2 Model

Time is discrete, $t = 0, 1 \ldots \infty$. There is no uncertainty, all agents discount at the common rate r, and have utility quasilinear in money. All houses are identical. Houses are valuable because they deliver rental services to the homeowner at the end of each time period; let ψ_t be the value of nominal rent in period t, in terms of dollars in period t. Each time period has three stages.

1. All "incumbent" homeowners – that is, any agent who was a homeowner at the end of period $t-1$ – simultaneously put their houses up for sale, for identical buyers. Since all agents and houses are identical, and there is no uncertainty, each period-t market clears at some unique price p_t, which we will characterize below.

2. Incumbent homeowners, regardless of whether they sell or keep their houses, pay property tax τp_t to the government, where τ is the tax rate.

3. Homeowners – either incumbent homeowners who have not sold, or non-incumbent buyers who successfully purchased houses from incumbents – collect ψ_t in dollar-equivalent rental services, and become incumbent homeowners in $t+1$.

An incumbent homeowner in period t who chooses not to sell collects ψ_t in rental services, owes τp_t to the government, and becomes an incumbent homeowner in $t+1$. An incumbent who sells receives p_t from the buyer and owes τp_t to the government, for a net payment $(1-\tau)\, p_t$, and does not receive ψ_t in services. A new homebuyer pays p_t to the seller, collects ψ_t in services, and becomes an incumbent homeowner in $t+1$. Agents who do not purchase housing receive nothing; alternatively, we can think of them as paying ψ_t in cash to purchase ψ_t in rental services, for 0 net utility.

Before we characterize the general case, note that when $\tau = 0$, houses are an unencumbered claim to the stream ψ_t of rental flows; prices in each period p_t are thus simply the sum of discounted future payoffs:

$$p_t^{\tau=0} = \sum_{s=t}^{\infty} \frac{\psi_s}{(1+r)^{s-t}} \tag{1}$$

Intuitively, taxes impose costs on holding houses, which should make house prices lower than (1).

Note also that our goal is to characterize the net present value of the stream of government tax revenues. Since the government collects τp_t in period t, the NPV of the government's expected future tax revenues stream, during period t and expressed in period-t dollars, is:

$$PVT_t = \sum_{s=t}^{\infty} \frac{\tau p_s}{(1+r)^{s-t}} \tag{2}$$

Expression (2) states that PVT_t represents a stream of claims to a fraction τ of the house's price p_s in each future period $s \geq t$. Houses themselves can be thought of as tax-encumbered claims to future rents, ψ_t. PVT_t thus is essentially a compound claim to future rents, and a natural conjecture is that it should be possible to express PVT_t directly in terms of the future rents ψ_t.We do this in the following proposition.

Proposition 1. *Under a tax rate of τ, period-t prices are:*

$$p_t = \sum_{s=t}^{\infty} \left(\frac{1-\tau}{1+r}\right)^{s-t} \psi_s \tag{3}$$

PVT_t is:

$$PVT_t = \sum_{s=t}^{\infty} \left(\left(\frac{1}{1+r}\right)^{s-t} \left(1 - (1-\tau)^{s-t+1}\right) \right) \psi_s \tag{4}$$

Proof. Prices can be calculated using a simple cost-of-carry approach. Consider two agents in period t who wish to obtain rental services; they must be indifferent between purchasing a house in period t and selling in $t+1$, and simply paying rent. The renter pays ψ_t in period-t dollars. The homeowner pays p_t in period-t dollars, pays taxes τp_{t+1} in the next period, and sells the house for p_{t+1}, both in period $t+1$ dollars; hence, her cost in period t dollars is:

$$p_t - \frac{p_{t+1}}{(1+r)} + \frac{\tau p_{t+1}}{(1+r)} \tag{5}$$

Equating (5) to ψ_t and rearranging, we have:

$$p_t = \psi_t + p_{t+1} \frac{1-\tau}{1+r} \tag{6}$$

Expression (6) can then be recursively substituted into itself, for example:

$$p_t = \psi_t + \left(\psi_{t+1} + p_{t+2} \frac{1-\tau}{1+r}\right) \frac{1-\tau}{1+r}$$

Expanding to $t \to \infty$, we get expression (3).

Given (3), we could then calculate PVT_t simply by plugging (3) into (2) and simplifying the double sum; we do this in Appendix A.1. However, as a more intuitive appraoch, consider the two agents who wish to purchase rental services at period t. The first agent purchases a house in period t for p_t, and is a homeowner forever after; she thus pays:

$$p_t + \sum_{s=t+1}^{\infty} \frac{\tau p_s}{(1+r)^{s-t}} = p_t + PVT_{t+1}$$

that is, her total payment is the price p_t plus the government's entire tax stream PVT_{t+1} beginning from period $t+1$. The second agent simply rents forever, paying ψ_s each period $s \geq t$, for a total present value of $p_t^{\tau=0}$. Agents must be indifferent between these two choices, implying:

$$p_t + \frac{PVT_{t+1}}{1+r} = p_t^{\tau=0} \tag{7}$$

Plugging in p_t and $p_t^{\tau=0}$ from (3) and (1), we have:

$$\sum_{s=t}^{\infty} \left(\frac{1-\tau}{1+r}\right)^{s-t} \psi_s + \frac{PVT_{t+1}}{1+r} = \sum_{s=t}^{\infty} \frac{\psi_s}{(1+r)^{s-t}} \tag{8}$$

Rearranging (8), we have (4). □

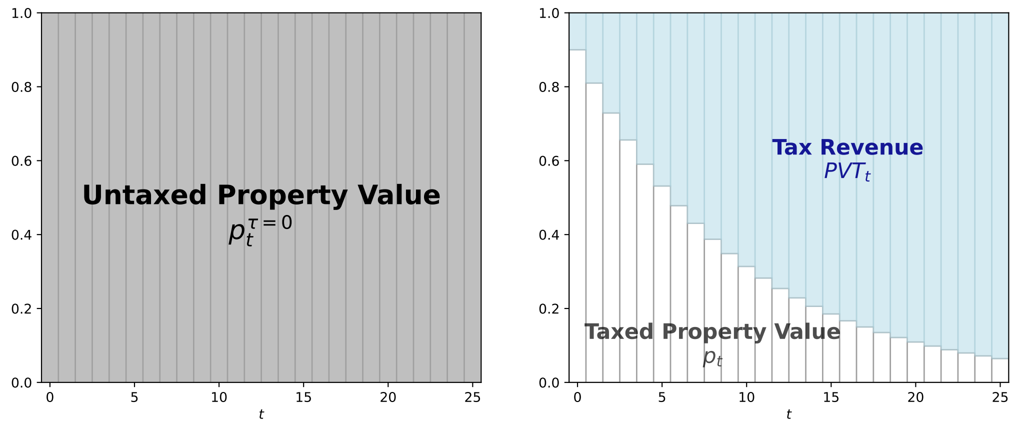
Intuitively, an untaxed house, with value $p_t^{\tau=0}$ can be thought of as a perpetuity, paying the stream ψ_t of rents in all future periods. Property taxes can be thought of as dividing $p_t^{\tau=0}$ into two claims: a taxed house of value p_t, which gives the holder a geometrically depreciating claim to rent flows, giving $(1-\tau)^{t+1}$ fraction of the rent t periods in the future; and a stream of property tax revenues with value PVT_t, which delivers the residual $1-(1-\tau)^{t+1}$ fraction of period-t rent to its holder. For example, a property tax of 3% can be thought of as the government appropriating approximately 3% of rents in the first year, 6% in the second years, and so on from the homeowner; the property title claim thus represents a claim to 97% of first year rents, 94% of second year rents, and so on. Rent flows in the future are effectively taxed more heavily: a larger fraction of rents further into the future accrues to PVT_t, and a smaller fraction accrues to p_t.

We show a stylized depiction of this decomposition in Figure 1. The x-axis represents t, and the bar heights on the right panel represent the claim fractions $\left(1-(1-\tau)^{t+1}\right)$ and $(1-\tau)^{t+1}$ respectively. This illustrates how p_t is a frontloaded set of rent claims, and PVT_t is a backloaded set of rent claims, such that through (7), PVT_t and p_t add up to the value of the untaxed house, $p_t^{\tau=0}$, represented by the gray area on the left plot.

Proposition 1 has a number of implications, which we discuss in the following sections.

Figure 1: Stylized Depiction of Untaxed Property Value, Taxed Value, and Tax Revenue NPV

This figure depicts how property taxes can be thought of as dividing an untaxed property worth $p_t^{\tau=0}$ – the gray bars on the left – into the two assets on the right plot: PVT_t in blue, which represents a backloaded set of claims to future rents, and p_t in white, which represents a frontloaded set of claims to future rents. The x axis represents time t. The bar heights represent the claim fractions, $\left(1-(1-\tau)^{t+1}\right)$ for PVT_t, and $(1-\tau)^{t+1}$ for p_t. We use $\tau = 0.1$.



3 The Magnitudes of Value Extraction through Property Taxation

Proposition 1 implies that seemingly small property taxes extract a large fraction of the value of future rental services. To illustrate this, we show expressions for prices and tax revenues when ψ_t grows at a constant rate.

Proposition 2. *Suppose $\psi_t = (1+g)^t \psi_0$ with $g < r$. We then have:*

$$p_t = \frac{\psi_t (1+r)}{(1+r) - (1-\tau)(1+g)} \tag{9}$$

$$PVT_t = \frac{\psi_t (1+r)^2 \tau}{(r-g)\left((1+r) - (1-\tau)(1+g)\right)} \tag{10}$$

$$PVR_t = p_t^{\tau=0} = \sum_{s=t}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} (1+g)^s \psi_0 = \frac{\psi_t (1+r)}{r-g} \tag{11}$$

$$\frac{PVT_t}{PVR_t} = \frac{\tau (1+r)}{(1+r) - (1-\tau)(1+g)} = \frac{\tau p_t}{\psi_t} \tag{12}$$

$$\frac{p_t}{p_t^{\tau=0}} = \frac{r-g}{(1+r)-(1-\tau)(1+g)} \tag{13}$$

We define the *extraction ratio* $\eta_t \equiv \frac{PVT_t}{PVR_t}$ as the fraction of the present value of rents, PVR_t, which is collected in taxes, PVT_t. If r, g, τ are all small, we can disregard the $(1+r)$ in the numerator of (12) and a τg term in the denominator, so (12) and (13) simplify to:

$$\eta_t = \frac{PVT_t}{PVR_t} \approx \frac{\tau}{\tau+(r-g)}, \frac{p_t}{p_t^{\tau=0}} \approx \frac{r-g}{\tau+(r-g)} \tag{14}$$

Expression (14) states that the ratios $\frac{PVT_t}{PVR_t}$ and $\frac{p_t}{p_t^{\tau=0}}$ depend on the relative size of taxes and the real interest rate, $r-g$. If the real interest rate is 5%, a seemingly small 5% property tax extracts *half* of the entire value of discounted rent flows PVR_t; in other words, the government collects as much revenue as if it collected a 50% tax on all rental income. From (13), another implication is that if the 5% property tax were removed, property prices would *double*. An intuition for this seemingly puzzling magnitude is that, from (4) and Figure 1, property taxes apply cumulatively to future rents: rent flows $N-1$ years in the future are effectively taxed N times at 5%, so the total fraction of the NPV of rents extracted by taxes is much higher than the tax rate τ. Expression (14) also implies that the fraction of present value extracted by property taxes is larger when the discount rate is lower: at, say, a 1% discount rate, a 4% property tax extracts a massive 80% of rent flow value.

Seemingly small property tax rates have large effects on revenues and prices because property taxes apply to houses, which are a *stock* quantity. A perpetual 5% tax on labor income each period would extract 5% of the NPV of labor income flows in each period. If all houses were rented, a 5% tax on rents would extract 5% of the NPV of the entire housing stock each period. But a 5% property tax extracts some fraction of *house prices*, which reflect all future rents, as well as the expected value of future tax payments, and thus is equal in present value to a much larger flow tax on rents.

Expression (12) also implies that there is a very simple way to measure the extraction ratio $\frac{PVT_t}{PVR_t}$ empirically: it is simply equal to the tax payment τp_t divided by rental flow ψ_t, which can alternatively be thought of as the tax rate τ multiplied by the price-rent ratio $\frac{p_t}{\psi_t}$. [2]Using data from 2011 to 2015 on county level tax rates as a fraction of the dollar value of houses from Baker, Janas and Kueng (2023), and median home values and median gross rents from the ACS, we characterize the extraction ratio of property taxes. In Figure 2, we plot the cross-sectional distribution of property tax rates on the left panel, and extraction ratios

[2] One caveat to this characterization is that the construction of price-rent ratios typically don't use comparable houses. We temporarily set aside this concern as correcting for this measurement error would be unlikely to qualitatively undermine the fact that property taxes have high extraction ratios.

on the right panel. Details on how we construct the figure are described in Appendix A.3.

The left panel shows that annual property tax rates in the US appear fairly low on average. The population-weighted median value of τ is 1.43%, the 25th percentile is 1.07% and the 75th percentile is 2.26%. However, these seemingly small tax rates lead to fairly large extraction ratios. On the right panel, the population-weighted median extraction ratio is 26.09%; the 25th percentile is 18.13%, and the 75th percentile is 37.54%. Population-weighted percentiles are somewhat higher than equal-weighted percentiles, since tax rates tend to be somewhat higher in high-population counties: the unweighted quartiles of the extraction ratio across counties are 18.52%, 23.86%, and 27%.[3]

Real estate in the US is sometimes thought, in a simplified way, to be owned by private individuals under perpetual and mostly unencumbered use licenses. Figure 2 quantitatively challenges this view: we show that the median US household makes tax payments to local governments equal to roughly 26.1% of what they would pay in rents in the same areas. Put another way, the NPV of taxes is as large as if state and local governments imposed a 26.1% tax on rents; or as if governments conducted a one-time seizure of 26.1% of the housing stock, sold this to buyers, and charged no taxes thereafter.

4 Duration

Expression (4) shows that property taxes are very backloaded, representing larger claims to rent flows further into the future. An asset's value is more sensitive to interest rates the further in the future its payoffs are; thus, property tax revenues have very high sensitivity to interest rates. The following proposition characterizes the interest rate exposures of property tax revenues.

Proposition 3. *The percentage duration of tax flows is:*

$$D = -\frac{1}{PVT_0} \cdot \frac{\partial PVT_0}{\partial r} = \frac{1}{1+r} \frac{\sum_{s=0}^{\infty} \frac{s}{(1+r)^s} \left(1 - (1-\tau)^{s+1}\right) \psi_s}{\sum_{s=0}^{\infty} \frac{1}{(1+r)^s} \left(1 - (1-\tau)^{s+1}\right) \psi_s}.$$

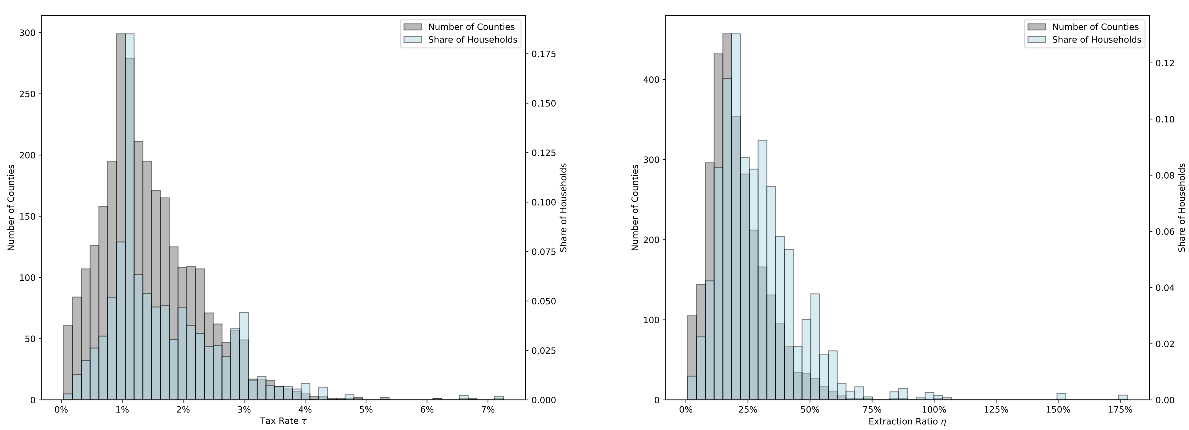
Assuming $\psi_t = (1+g)^t \psi_0$ with $g < r$, the above formula simplifies to

$$D = \frac{1}{(1+r) - (1-\tau)(1+g)} + \frac{1}{r-g} - \frac{2}{1+r}. \tag{15}$$

[3]The magnitude of extraction ratios is robust to using alternative measurements of tax rates, for example, measuring tax rates as the county-level median tax payment over median home value, based on American Community Survey 5 year estimates.

Figure 2: Magnitudes of County Level Extraction Ratios (2011 ~ 2015)

This figure depicts the magnitude of property tax extraction ratios. Extraction ratios are computed at the county level, according to $\eta = \frac{\text{Median Home Value}}{\text{Annualized Median Gross Rent}} \times \text{tax rate}$. Median home value and median gross rent are taken from the American Community Survey 5 year estimates from 2011 to 2015. County-level property tax rates as a fraction of the dollar value of houses are computed as the average property tax rate of each county over 2011 to 2015, given by Baker, Janas and Kueng (2023). Number of households is taken from the ACS, and share of households is computed as the number of households in a county as a share of total number of households summed across counties in our data. $n = 2885$ after dropping counties with missing values.



When $g = 0$, we have $D = \frac{1}{r+\tau} + \frac{1}{r} - \frac{2}{1+r}$.

As a simple numerical example, if $r = 0.05, g = 0$, the duration of a 30-year outstanding 2% coupon bond is 19, and the duration of a 30-year zero coupon bond is 30. The duration of PVT at $\tau = 0.015$, approximately the median tax rate in the US, is 33.48: that is, the stream of property tax flows is to first-order as sensitive to interest rates as *a 33.48 year zero-coupon bond*. At a lower discount rate of $r = 0.02$, the duration of property tax revenues is 76.61. Thus, at realistic tax rates, property tax revenues are more sensitive to interest rate changes than most common financial assets.

An intuition for why PVT has such long duration is that PVT can be thought of like a perpetuity on a perpetuity. If rents are expected to be constant at ψ, a house is a perpetuity paying ψ each period; PVT is an asset which pays fractions of a house each period. The resultant security has nominal payoffs which *increase* over time, and is thus more backloaded – and more sensitive to rate changes – than a perpetuity. Equivalently, PVT is a perpetuity which pays $p\tau$ in each future period; when interest rates decrease, the rate at which the $p\tau$ payments are discounted to the present decreases, and each nominal payment $p\tau$ also increases, since house prices rise when interest rates fall.

A number of papers have noted that state and local governments fiscally suffer from falls in interest rates because of their *pension obligations*, which are long-duration nominal liabilities. But Proposition 3 implies that the value of governments' property tax revenues increases substantially when rates decrease, and property tax revenues are on average both higher-duration, and much larger in present value, than pension obligations. We show this using a simple back-of-envelope comparison, in which we compare the size of duration weighted pension expenses to property tax revenue flows.[4] Previous literature estimates the duration of public (state and local combined) pension liabilities to be approximately 11 in 2022.[5] The service costs of public pensions, that is, the flow expense of public pensions, account for about 8.8% of own source revenue in the same year.[6] We can thus approximate the dollar

[4]The ideal exercise that showcase governments' interest rate exposure is to compare the duration weighted present value of pension liabilities to property tax revenue. However, the value of property tax revenue is hard to estimate because it requires a strong stance on future tax revenue flow projections. Therefore, we compare the duration weighted flows of pensions and property taxes, which is informative under the assumption that the ratio of these two cash flows remain somewhat stable over time.

[5]Estimates of pension duration are sensitive to the measurement of pension liabilities, i.e., whether to include only accrued or also projected liabilities, and the discount rate used in valuation. Estimated duration typically falls between 10 to 15, under a wide range of measurement and discount rate assumptions (Novy-Marx and Rauh, 2011; Giesecke and Rauh, 2023*b*). A recent updated estimate by Giesecke and Rauh (2023*b*) suggest that the liability-weighted average duration of public pensions (state and local combined) is 11.3 in 2022.

[6]Formally, service cost is defined as the present value of future pension benefits that employees earn in a fiscal year, and it is a flow variable that reflects the yearly accruing expense of the pension provider paying

sensitivity of local governments' property tax revenues and pension liabilities to interest rates through the ratio:

$$\frac{\text{Property Tax Duration} \times \text{Property Tax Flow as \% of Own Source Revenue}}{\text{Pension Duration} \times \text{Service Cost as \% of Own Source Revenue}} \tag{16}$$

This calculation is very approximate, and does not take into account any possible nonstationary dynamics of revenues or liabilities, but serves to give an approximate sense of the relative size of the dollar rate exposures of property tax revenues versus pension liabilities.

At the national median property tax rate $\tau = 0.015$, assuming $g = 0$, and discounting at $r = 0.05$, we find that the ratio (16) is 6.89. In other words, when interest rates fall slightly, the present value of governments' property tax revenues rises by \$6.89 for each dollar increase in the value of governments' pension liabilities. This is because, under these assumptions, PVT has approximately three times higher duration than pension liabilities, and is roughly twice as large in flows as a fraction of revenues. Thus – considering only property tax revenues and pension liabilities and ignoring other components of governments' balance sheets – state and local governments fiscally *benefit* on net from a fall in interest rates.

5 Investment Incentives

State and local governments make investments to influence local economic conditions, which affect current and future rents. The structure of state and local governments' revenues can conceivably influence their investment decisions. Since property tax revenues represent very backloaded claims to future rents, state and local governments operating to maximize the value of property tax revenues have *future-biased* investment incentives.

Consider a government that can influence rents ψ_t in any given future period t, by paying a convex cost $c(\psi_t)$ in $t = 0$ dollars. A local government which tries to maximize the present value of future property tax revenues solves:

$$\max_{\psi_0, \psi_1 \ldots} \sum_{s=0}^{\infty} \left(\left(\frac{1}{1+r} \right)^s \left(1 - (1-\tau)^{s+1} \right) \right) \psi_s - c(\psi_s)$$

out the contracted benefits to current pension beneficiaries. The literature uses service cost as a percentage of own source revenue to estimate the cost of the current pension contractual terms. Giesecke and Rauh (2023*b*,*a*) show that service costs on average account for 8.8% of own source revenue, and this ratio ranges from 3.1% to 20.9% across different states.

The first-order condition for this problem is, for any t:

$$c'(\psi_t) = \left(\frac{1}{1+r}\right)^t \left(1 - (1-\tau)^{t+1}\right) \tag{17}$$

Intuitively, (17) states that local governments capture a share $\left(\frac{1}{1+r}\right)^t \left(1 - (1-\tau)^{t+1}\right)$ of any changes in ψ_t, so governments optimally invest until the marginal cost of investment, $c'(\psi_t)$, is equal to the RHS of (17). (17) is strongly increasing in t, when t is not very large, due to the $\left(1 - (1-\tau)^{t+1}\right)$ term. Thus, governments have a much stronger incentive to invest in increasing rents further in the future, since they capture a larger fraction of these value increases in property taxes. For example, at $r = 5\%, \tau = 2\%$, the RHS of (17) is 0.02 at $t = 0$ and 0.089 at $t = 5$; thus, local governments have *more than four times higher* fiscal incentives to invest in increasing rents 5 years in the future, relative to rents today.

As another intuition for this result, suppose the government considers holding a local festival, which would raise rent by \$1 at $t = 0$: this would increase taxes collected by only \$0.02. However, if the government commits to holding a festival in $t = 5$, which similarly increases rent at $t = 5$ by \$1, prices will increase from now until $t = 5$, allowing the government to collect increased property taxes for 5 years before the festival realizes; expression (17) shows that the government collects \$0.089 in present value of increased taxes by raising rents by \$1 in $t = 5$, giving the government more than four times higher incentives to invest.

To further illustrate the nature of future-bias generated by property tax revenues, we compare investment incentives under property taxes to a number of benchmarks.

Flow taxes. Consider a local government which taxes rents – or, more realistically, suppose ψ_t represents labor income and the government charged a flat tax rate of τ. If the government maximizes the NPV of taxes, it solves:

$$\max_{\psi_0, \psi_1 \dots} \sum_{s=0}^{\infty} \tau \left(\frac{1}{1+r}\right)^s \psi_s - c(\psi_s)$$

and the corresponding FOC is:

$$c'(\psi_t) = \tau \left(\frac{1}{1+r}\right)^t \tag{18}$$

The RHS of (18) is smoothly decreasing in t: governments are slightly more willing to invest in near-term payoffs, simply because of discounting.

House prices. Consider a government which invested to maximize (taxed) *house prices*.

From (3) of Proposition 1, this government would have the FOC:

$$c'(\psi_t) = \left(\frac{1-\tau}{1+r}\right)^t \tag{19}$$

Such a government would have lower incentives to increase ψ_t further in the future: in fact, investment incentives would decrease in t even faster than in (18), since future rents affect prices less under property taxes. In contrast, (17) tends to *increase* over time. Expressions (19) and (17) thus show that a government which maximizes *property taxes* in fact has very different incentives from a government which maximizes *prices*. A price-maximizer has decreasing stakes in rents further in the future; in fact, the time decay rate of investment incentives is even faster than in (18), due to the price distortions generated by taxes. A tax maximizer has increasing stakes in rents further in the future, and correspondingly increasing investment incentives.

Social Planner. Finally, suppose the social planner chose $\psi_0, \psi_1 \ldots$ to maximize the representative consumer's welfare net of investment costs. The investment FOC would instead be:

$$c'(\psi_t) = \left(\frac{1}{1+r}\right)^t \tag{20}$$

All of the benchmarks we have analyzed have investment incentives which differ from (20), but the distortions are slightly different. (18) shows that flow taxes distort investment incentives most uniformly: incentives are too low by a uniform factor of τ throughout time. (19) has a similar pattern, but discounts future payoffs slightly too much. Property taxes, (17), have the interesting feature of having smaller distortions further in the future. Since the entirety of rents in the distant future accrues to the government, the government's investment incentives are perfectly aligned with the representative consumer's as $t \to \infty$.

A number of papers in political economy analyze various distortions in governments' incentives relative to voters; interestingly, the majority of arguments suggest that local governments are too present-biased relative to the social planner.[7] We have shown that property taxes give local governments extremely future-biased investment incentives, relative to flow taxes; property taxes thus have some potential to counteract these various forces producing present-bias in governments' investment decisions. Moreover, the heuristic that a government whose revenue derives from property taxes has incentives to maximize property values is incorrect; the government instead has strongly future-biased incentives, since the government collects taxes more times on rent flows that accrue further in the future.

[7] See, for example, Alesina and Tabellini (1990).

6 Discussion and Conclusion

We have shown that the net present value of a stream of property taxes revenues can be thought of as an increasing stream of claims to future rents. Thus, property taxes extract a very large fraction of the NPV of future rents, property tax revenues are very sensitive to shifts in interest rates, and property taxes give governments very back-loaded fiscal incentives to provide public goods. While we have focused our discussion on the US, our model is not US-specific, and our results thus apply to the many other countries in which property taxes constitute a large component of government revenues. Our model is also not specific to real estate; the analysis applies to any setting in which a tax is applied on a "stock" good, whose market value shifts in response to the tax. One example is *wealth taxes*, which are used in countries such as Norway and Spain. Depending on how a wealth tax is administered, some components of our results regarding magnitudes, interest rate exposures, and investment incentives may also partially apply.

References

Aiello, Darren, Asaf Bernstein, Mahyar Kargar, Ryan Lewis, and Michael Schwert. 2018. "The economic burden of pension shortfalls: Evidence from house prices." *Wall Street Journal*, 1.

Alesina, Alberto, and Guido Tabellini. 1990. "A positive theory of fiscal deficits and government debt." *The review of economic studies*, 57(3): 403–414.

Amornsiripanitch, Natee. 2020. "Why are residential property tax rates regressive?" *Available at SSRN 3729072*.

Avenancio-León, Carlos F, and Troup Howard. 2022*a*. "Assessment caps and the racial assessment gap." *National Tax Journal*, 75(1): 169–200.

Avenancio-León, Carlos F, and Troup Howard. 2022*b*. "The assessment gap: Racial inequalities in property taxation." *The Quarterly Journal of Economics*, 137(3): 1383–1434.

Baker, Scott R, Pawel Janas, and Lorenz Kueng. 2023. "Correlation in State and Local Tax Changes." *Swiss Finance Institute Research Paper*, , (20-115).

Berry, Christopher R. 2021. "Reassessing the property tax." *Available at SSRN 3800536*.

George, Henry. 1884. *Progress and poverty: An inquiry into the cause of industrial depressions, and of increase of want with increase of wealth, the remedy.* W. Reeves.

Giesecke, Oliver, and Joshua D Rauh. 2023*a*. "State and Local Pension Funds 2022." *Available at SSRN*.

Giesecke, Oliver, and Joshua Rauh. 2023*b*. "Trends in state and local pension funds." *Annual Review of Financial Economics*, 15: 221–238.

Giesecke, Oliver, Haaris Mateen, and Marcelo Jardim Sena. 2022. *Local government debt valuation.* SSRN.

McMillen, Daniel, and Ruchi Singh. 2023. "Measures of vertical inequality in assessments." *Journal of Housing Economics*, 61: 101950.

Novy-Marx, Robert, and Joshua Rauh. 2011. "Public pension promises: how big are they and what are they worth?" *The Journal of Finance*, 66(4): 1211–1249.

Internet Appendix

A Proofs and Supplementary Material

A.1 Alternative Derivation of (4)

Observe that

$$PVT_t = \sum_{s=t}^{\infty} \frac{\tau p_s}{(1+r)^{s-t}} = \sum_{s=t}^{\infty}\sum_{j=s}^{\infty} \frac{\tau}{(1+r)^{s-t}} \left(\frac{1-\tau}{1+r}\right)^{j-s} \psi_j$$

$$= \sum_{j=t}^{\infty}\sum_{s=t}^{j} \frac{\tau (1-\tau)^{j-s}}{(1+r)^{j-t}} \psi_j = \sum_{j=t}^{\infty} \frac{\psi_j}{(1+r)^{j-t}} \left(1-(1-\tau)^{j-t+1}\right) \tag{21}$$

Note that the RHS of (21) is identical to (4) of Proposition 1.

A.2 Proof of Proposition 2

Using expression (3) for prices, we have:

$$p_t = \sum_{s=t}^{\infty} \left(\frac{1-\tau}{1+r}\right)^{s-t} (1+g)^s \psi_0 = \psi_0 \frac{(1+g)^t (1+r)}{(1+r)-(1-\tau)(1+g)}$$

Using expression (4) for PVT_t, we have:

$$PVT_t = \sum_{s=t}^{\infty} \left(\left(\frac{1}{1+r}\right)^{s-t} \left(1-(1-\tau)^{s-t+1}\right)\right) (1+g)^s \psi_0 = \psi_0 \frac{(1+g)^t (1+r)}{(1+r)-(1-\tau)(1+g)} \frac{\tau (1+r)}{r-g}$$

In addition,

$$p_t^{\tau=0} = \sum_{s=t}^{\infty} \left(\frac{1}{1+r}\right)^{s-t} (1+g)^s \psi_0 = \psi_0 \frac{(1+g)^t (1+r)}{r-g}$$

Expressions (12) and (13) immediately follow from (9), (10), and (11).

A.3 Data Details for Figure 2

To construct Figure 2, we construct extraction ratio using the following variables:

$$\eta_i = \frac{\text{Median Home Value}_i}{12 \times \text{Median Gross Rent}_i} \times \tau_i$$

where i indicates county, Median Home Value$_i$, Median Gross Rent$_i$ are taken directly from the 2011-2015 American Community Survey 5-year estimates, and τ_i is computed as the average property tax rate of county i over 2011 to 2015 from data in Baker, Janas and Kueng (2023). Baker, Janas and Kueng (2023) computes tax rates – tax payments as a fraction of the dollar value of houses – by multiplying tax rates on the assessed values of houses by the estimated average ratio of assessed prices to house transaction prices.

To construct the household share histograms, we weight county-level average tax rates and extraction ratios by the number of households in the county as a share of total number of households. Number of Households$_i$ is also taken directly from 2011-2015 ACS 5-year estimates.