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Can Property Taxes Reduce House Price Volatility?
Evidence from U.S. Regions

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Can Property Taxes Reduce House Price Volatility? Evidence from U.S. Regions

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Abstract

We use a novel dataset on effective property tax rates in U.S. states and metropolitan statistical areas (MSAs) over the 2005–2014 period to analyze the relationship between property tax rates and house price volatility. We find that property tax rates have a negative impact on house price volatility. The impact is causal, with increases in property tax rates leading to a reduction in house price volatility. The results are robust to different measures of house price volatility, estimation methodologies, and additional controls for housing demand and supply. The outcomes of the analysis have important policy implications and suggest that property taxation could be used as an important tool to dampen house price volatility.

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I. Introduction

Housing market has important implications for macroeconomic stability through its impact on aggregate demand and supply (OECD, 2011).[2] On the demand side, housing wealth is an important part of the net worth of the private sector and housing-related expenses (e.g., mortgage payments, rents) represent a major part of household expenditure. Hence, changes in house prices may affect aggregate demand through various channels, including spending on residential construction and spending on non-residential consumption (wealth effect). On the supply side, house prices have implications for labor mobility and property assets of businesses contribute to the production process. Volatile housing market can also raise systemic risks due to the high mortgage exposure of the banking sector.

Developments in the housing market have been at the heart of the global crisis, prompting a debate on alternative policy responses. The discussion so far has mainly focused on employing monetary policy tools and macro prudential regulation to dampen house price volatility and prevent the buildup of housing bubbles. However, both have drawbacks (Crowe et al., 2013). Monetary policy is considered a too blunt instrument, as it affects the entire economy and may be too costly if the boom is limited to the housing market. Moreover, this tool is not available for members of a monetary union. Macro prudential regulation is more targeted and relatively more flexible,[3] but it may be too invasive to the operation of markets and market participants may find ways to circumvent them. A natural question arises – can tax policy help?

In recent years, a number of countries used tax instruments to curb excessive house price fluctuations (Lim et al., 2011; He, 2014; Darbar and Wu, 2015). There has been also increased interest in using property taxation as an efficient tool to bolster public revenues (IMF, 2013; Norregaard, 2015). While there is large literature assessing the impact of macro prudential regulation on house prices (Kuttner and Shim, 2013; Claessens, 2014; Cerutti et al., 2016), evidence on the impact of property taxes is scant.

Van Den Noord (2005) develops a simple theoretical framework showing that demand shocks to house prices tend to amplify if property taxes are low, inducing excessive volatility. He supports the theoretical prediction of a negative association between property tax rates and house price volatility using a simple scatterplot analysis. Crowe et al. (2013) run cross-sectional regressions using a sample of 243 U.S. metropolitan statistical areas (MSAs) and show that property taxes are negatively associated with house price volatility. However, the paper does not assess whether the causality runs from property tax rates to house price volatility. Using a panel of OECD countries over 1980-2005, Andrews (2010) also finds that more generous taxation of property (mortgage interest deductibility, recurrent property taxes) could lead to larger house price volatility. Similarly, OECD (2011) argues that reducing the tax relief on mortgage debt financing costs from the level observed in

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[2] Some empirical studies suggest that a significant fall in housing prices is even more important for the economy than an equivalent fall in stock prices (Case et al., 2001).

[3] For instance, the recently created European Systemic Risk Board (ESRB) will be in charge of providing macro prudential policy recommendations in Europe.

Netherlands to the level in Sweden can reduce house price volatility by 11 percent. By contrast, Aregger et al. (2013) study the impact of transaction and capital gains taxes in 21 Swiss cantons over 1985-2009 but find mixed evidence on their ability to deter speculation and reduce volatility. Keen et al. (2010) also argue that the ability of transaction taxes to deter housing speculation in the longer term is ambiguous. Ultimately, the extent to which house prices adjust to accommodate demand shocks driven by property tax changes is affected by the responsiveness of housing supply and regulatory arrangements (Saiz, 2010; Andrews et al., 2011; Gattini and Ganoulis, 2012; Hilber and Vermeulen, 2016).

The purpose of our analysis is to contribute to this literature by providing a more detailed assessment of the relationship between property tax rates and house price volatility.[4] Similar to Crowe et al. (2013), the analysis employs data on property tax rates from U.S. regions (states and MSAs),[5] but extends it for the period 2005-14. Another difference is that we are trying to establish a causality in the relationship between property tax rates and house price volatility.

Estimation results support the theoretical prediction of Van Den Noord (2005) on the negative impact of property tax rates on house price volatility. A 0.5 percent increase in property tax rates (one standard deviation in the total sample) leads to 0.5-5.5 percent decline in house price volatility depending on the empirical specification and the measure of volatility. Instrumental variable and GMM regressions suggest that this relationship is causal, which increases in property tax rates leading to a reduction in house price volatility. The results are supported by the difference-in-difference regressions exploring the exogenous variation in housing supply due to the geographical location and regulatory constraints and are are robust to different measures of house price volatility and estimation methodologies. The key policy implication is that property taxation could usefully complement other tools, including monetary and macro prudential, in reducing house price volatility.

The remainder of the paper is structured as follows. Section II outlines the theoretical framework underpinning the empirical analysis. Section III describes the data and provides descriptive statistics. Section IV presents estimation results. The last section concludes.

II. Theoretical Framework

Tax policy tools can influence housing markets through affecting demand for housing. There is a wide range of property taxes and subsidies, with the main being: mortgage rate deductibility, tax on imputed rents, capital gains tax, recurrent taxes on land and buildings,

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[4] The paper does not attempt to assess the extent to which higher house price volatility induced by property taxation can ultimately result in financial instability.

[5] An MSA is a geographical region with a relatively high population density and close economic ties throughout area. Such regions are not legally incorporated (like a city or a town) and not considered legal administrative divisions (like counties). Some MSAs contain more than one large city (e.g., Norfolk-Virginia Beach, Minneapolis-Saint Paul). MSAs are used by the Census Bureau and other federal government agencies for statistical purposes and their definition can vary over time. As of 2014, there have been close to 400 MSAs in the U.S.

wealth tax, inheritance tax, VAT, and stamp duties (or acquisition taxes). These could be grouped into three broad categories: (i) transaction taxes, (ii) recurrent property taxes, and (iii) mortgage interest deductibility.

The starting point of the theoretical framework of Van Den Noord (2005) that underpins our empirical analysis is the assumption of an equilibrium relationship between homeowners' return on housing investment and on other assets (see also Poterba, 1992; Poterba and Sinai, 2008). This requires an equality between the marginal value of rental services from owner-occupied housing and marginal user cost of housing capital:

$$R_t(H) = P_t \cdot [r \cdot (1 - \tau_m) + \tau_p - \pi^e (1 - \tau_c) + \delta] \quad (1)$$

where R is the marginal value of rental services, H is the housing stock, r is the nominal interest rate, τ_m is the marginal effective tax rate on interest income (normally, marginal income tax rate), τ_p is the property tax rate, τ_c is the capital gains (transaction) tax rate, δ is the property depreciation rate, P is the price of owner-occupied housing, and π^e is the expected rate of house price inflation ($E[dP_t/dt]/P_t$). As shown in (1), the user cost of owning a house is distorted by the favorable tax treatment of owner-occupied housing (transaction taxes, recurrent property taxes, and mortgage interest deductibility). Given that the marginal value of rental services is a negative function of the total housing stock H ($dR/dH<0$), equation (1) can be interpreted as a downward-slopping *demand function* for housing.

The *supply function* relates the total stock of housing to the flow of net construction, which depends on the ratio of house prices and construction costs (C):

$$H_t = (1 - \delta) \cdot H_{t-1} + \varphi \cdot \left(\frac{P_t}{C_t}\right) \quad (2)$$

where φ is the positive short-run price sensitivity of supply. This sensitivity is typically small and short-run supply tends to be steep. However, the long-run price sensitivity (φ/δ) is considerably larger than the short-run sensitivity for relatively small values of δ.

Figure 1 provides graphical illustration of how demand shock affects house prices in the presence of different property tax systems. Panel I shows the results for less generous tax treatment of housing (flatter demand curve), while Panel II depicts the case of a more generous tax treatment (steeper demand curve). Given the inelastic short-term supply curve (horizontal line S_{SR}), the equilibrium initially moves from A to B. Over time, the supply would expand (upward-slopping line S_{LR}) and equilibrium would be set at C. Overall, prices first go up and then come down, settling at a higher level than that prior to the shock. The key implication is that the volatility of house prices (or overshooting) during this transition is larger in the presence of a more generous tax treatment.

Assuming that the expected house price inflation is a linear function of the observed price change in the previous period ($E[dP_t/dt]=a*[P_{t-1}-P_{t-2}]$, with $a>0$)[6] and abstracting away from capital gains taxes (τ_c=0), equation (1) can be rewritten as:

$$P_t = \frac{a}{r\cdot(1-\tau_m)+\tau_p+\delta}\cdot(P_{t-1}-P_{t-2}) + \frac{R_t}{r\cdot(1-\tau_m)+\tau_p+\delta} \quad (3)$$

where $r\cdot(1-\tau_m)+\tau_p+\delta > 0$ and $a>0$.

Specification (3) indicates that after an initial demand shock to *R*, the accelerator mechanism sets in assuming unchanged supply. This mechanism will be stronger for lower property tax rates (smaller τ_m). The equation will produce an oscillating development of the price level and its rate of change, with the amplitude greater for higher values of the ratio $a/[r\cdot(1-\tau_m)+\tau_p+\theta+\delta]$.

In sum, this simple theoretical model suggests that *lower property tax rates will lead to higher volatility of house prices* following an exogenous demand shock. In the *long-run* (equilibrium), the property tax rate itself does not induce the price volatility, but can exacerbate or dampen the impact of shocks. In the *short-run*, property tax rate changes can contribute to house price volatility directly as prices adjust to the new equilibrium.

Figure 2 illustrates the dynamics of house prices in response to a permanent demand shock. As expected, the volatility of house prices in response to a shock is higher for lower levels of property taxes. We test the empirical validity of this theoretical prediction below.

III. Data and Descriptive Statistics

A. Data

Our database covers the period 2005-2014. We employ separately data on 51 U.S. states and 77 MSAs in two sets of regressions. Table 1 lists variables and their sources.

House price data are taken from the Federal Housing Finance Agency. Annual house prices are estimated as averages of four quarters within a year. *Macroeconomic variables*, including nominal and real GDP, GDP deflator, per capita GDP, and population are taken from the Bureau of Economic Analysis. *Effective property tax rates* are measured as the ratio of the median annual property tax payment to the median property value for owner-occupied housing units. Both series are taken from the American Community Survey maintained by the Census. The advantage of this measure is that it accounts for differences in property tax rates across counties within the state and property tax exemptions/adjustments. Unfortunately, the survey data do not extend back beyond 2005, so the series are restricted to the 2005-2014 period.

[6] This assumption suggests that after a positive demand shock has produced first-round effect on house prices, households may anticipate further price increases. It also implies that property taxes do not directly affect expected house price changes.

(continued…)

The *volatility of house prices* is estimated using 5-year backward moving window. We use the following alternative measures of real house prices for estimating volatility: (i) annual growth rates, and (ii) percentage deviations from the HP-filtered value.[7]

B. Descriptive Statistics

Table 2 presents descriptive statistics of all variables used in the analysis. The panel is balanced, with 510 state-year and 770 MSA-year observations. The average effective property tax rate in the sample is 1 percent, with standard deviation of 0.5 percent. The average volatility of house prices is 5-6 percent, depending on the measure.

Figure 3 presents the dynamics of house price growth rates and property taxes across 51 U.S. states over 1995-2014. Two observations are worth noting. *First*, the median house price growth rate has switched from positive to negative during the crisis period (2007-11). For each year, the real growth rates varied widely across states, with 25-75 interquartile range of up to 8 percent depending on the year. The variation across states was largest at the height of the crisis in 2009, when some states have experienced positive growth rates despite the negative median. This suggests that some states managed to weather the demand shock better than others and property tax rates could have played a role here. *Second*, the median effective property tax rate has increased from 0.8 percent before the crisis to 1 percent now. This was in part driven by the large deficits run by local governments requiring them to look for alternative revenue sources to meet their balanced budget targets (Gracia et al., 2014). Similar to house prices, effective property tax rates vary widely across states and this variation did not change following the crisis. In some states, property tax rates are approaching 2.5 percent level, with the 25-75 interquartile range reaching up to 1 percent depending on the year.

Figure 4 presents the dynamics of house price volatility using both definitions. Both measures provide a qualitatively similar picture. The median state standard deviation has increased from below 5 percent to above 5 percent during the crisis. There is wide variation across states, exceeding 15 percent in some years. The standard deviation has declined back to pre-crisis levels recently.

Figure 5 presents simple scatterplots of house price volatility and property tax rates. The slopes are negative for both definitions of house price volatility, suggesting a lower volatility in state-years characterized by high property tax rates. There is also some evidence of heteroscedasticity, with distribution of house price volatility being larger in state-years with low property tax rates. The latter suggests that robust standard errors should be used in the regressions to improve inference.

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[7] Following the established practice for annual series, the smoothing parameter of the HP filter is set to 100.

IV. Empirical Analysis

In this section, we test the theoretical prediction of the Van Den Noord (2005) model suggesting a negative association between house price volatility and the level of property tax rates. We test this prediction using several alternative empirical specifications.

A. Baseline Specification

The baseline specification takes the following form:

$$VOL_{it} = \alpha + \beta TAX_{it} + \gamma' X_{it} + u_i + \omega_t + \varepsilon_{it} \quad (4)$$

where *i* denotes state, *t* denotes time, *VOL* is the house price volatility, *TAX* is the property tax rate, *X* is a vector of control variables, *u* is the unobserved state-specific heterogeneity (state fixed effect), ω is the unobserved time-specific heterogeneity (time fixed effect), and ε is the i.i.d. error term. The Van Den Noord model predicts a *negative* slope coefficient on the property tax rate variable ($\beta<0$).

Table 3 presents estimation results from the baseline specification. Columns (I)-(IV) show results for volatility based on house price real growth rates, while columns (V)-(VIII) show results for volatility based on detrended house prices. In all specifications the slope coefficient of the property tax variable is negative (and in most cases significant), supporting the theoretical prediction of the negative association between house price volatility and property tax rates. The economic significance of the coefficients is large: a 1 standard deviation increase in property tax rates (0.48 percent) leads to 1.3-1.7 percent reduction in volatility based on the growth rate measure and 0.5-0.6 percent reduction in volatility based on the detrended measure. Figure 6 provides further evidence on the economic significance of the impact assuming a normal distribution of house price growth rates.

B. Instrumental Variables

The baseline specification assumes that the causality goes from property tax rates to house price volatility, but in practice the causality may go in both directions. Specifically, states experiencing high house price volatility may react by increasing property tax rates. This reaction will lead to a downward bias in the slope coefficient on the property tax rate variable.

To control for this endogeneity, we run two sets of instrumental variable regressions. *First*, we instrument the property tax rate variable by the average property tax rates of neighboring states. This instrument is motivated by the large literature showing existence of a strategic interaction in property tax setting by local governments competing for property tax base (see, e.g., Brueckner and Saavedra, 2001; Brueckner, 2003). *Second*, we use panel GMM estimator, using lagged values of explanatory variables as instruments.

Table 4 presents estimation results from the instrumental variable specification. F-statistics from first stage regressions are high (exceeding 10 in most cases), supporting the instrument validity. The coefficient on the property tax rate variable remains negative and significant.

As expected, its magnitude increases, suggesting a stronger impact of property tax rates on volatility: a 1 standard deviation increase in property tax rates (0.48 percent) leads to 2.3-5.5 percent reduction in volatility based on the growth rate measure and 1.0-3.2 percent reduction in volatility based on the detrended measure.

Table 5 shows the dynamic panel system GMM estimation results following Blundell and Bond (1998), which allow controlling for the endogeneity of the lagged dependent and other potentially endogenous variables. Similar to the instrumental variable regressions, the negative coefficient on the tax variable remains: a 1 standard deviation increase in property tax rates (0.48 percent) leads to 0.7-4.0 percent reduction in volatility based on the growth rate measure and 0.6-1.4 percent reduction in volatility based on the detrended measure. We also assess the validity of the GMM results by: (i) running the Arellano-Bond test of no second-order autocorrelation on the residuals, and (ii) using Sargan test to check for the misspecification of our instruments. Both statistics are reported at the bottom of the table and confirm the validity of model specification.

C. Difference-in-Difference Regressions

To provide further insights on the relationship between property tax rates and house price volatility, we adopt a difference-in-difference approach proposed by Rajan and Zingales (1998). We exploit variation in house price volatility across metropolitan statistical areas (MSAs) within states by using an interaction of state tax rates with MSA-specific supply restriction indicators. The empirical specification takes the following form:

$$VOL_{mt} = \alpha + \beta TAX_{it} + \lambda(TAX_{it} * SUPPLY_m) + \gamma' X_{it} + u_m + \omega_t + \varepsilon_{mt} \tag{5}$$

where *i* denotes state, *m* denotes MSA, *t* denotes time, and $SUPPLY$ is the supply restriction indicator. The dataset covers 77 MSAs located in 29 U.S. states.

We use two supply-restriction indicators: (i) geographical - the share of undevelopable land area as of percent total (Saiz, 2010), and (ii) regulatory - the index of property regulation (Wharton Regulation Index) (Gyourko et al., 2008). Higher level of both variables indicates less responsive supply of housing to demand shocks. The interaction term of each supply-restriction indicator with effective property tax rates at the state level shows the extent to which the difference in house price volatility in MSAs with varying degrees of supply restrictions and located within the same state responds to differences in property tax rates across states (difference-in-difference effect). The null hypothesis is $\lambda < 0$, which implies that a higher property tax at the state level would reduce house price volatility in MSAs with more rigid housing supply at a faster rate compared to states with less rigid supply.

Tables 6-7 present estimation results for each supply-restriction indicator. The results support the null hypothesis, as the coefficient on the interaction term is negative and significant. The economic significance measured for the 25-75 interquartile range of property tax rates and supply restriction indices results in a difference-in-difference effect of 1.1-2.0 percent for the geographical supply restriction indicator, and 2.6-3.2 percent for the regulatory supply restriction indicator.

V. CONCLUSIONS

House price volatility is important contributor to macro financial stability. Following the global crisis, the discussion of policy tools to dampen house price volatility ranks high on the policy agenda. While the effectiveness of macro prudential measures to curb house price volatility has been analyzed extensively (Kuttner and Shim, 2013; Claessens, 2014; Cerutti et al., 2016), evidence on the effectiveness of property taxes is scant.

In this paper, we assess the relationship between property tax rates and house price volatility using U.S. state and MSA level panel data for the period 2005-2014. Drawing on a novel dataset on effective property tax rates, we show that property taxes have a negative impact on house price volatility, which is consistent with the theoretical prediction of Van Den Noord (2005). The impact is causal, with increases in property tax rates leading to a reduction in house price volatility. Specifically, a 0.5 percent increase in property tax rates (one standard deviation in the total sample) leads to 0.5-5.5 percent decline in house price volatility depending on the empirical specification and the measure of volatility. The results are supported by the difference-in-difference regressions exploring the exogenous variation in housing supply due to the geographical location and regulatory constraints and are robust to different measures of house price volatility and estimation methodologies.

The key policy implication is that property taxation could be used as an effective tool to dampen house price volatility. However, using transaction taxes in a countercyclical fashion may not be the best option given that they tend to thin the markets and discourage transactions that would allocate properties more efficiently. In addition, unlike macroprudential tools, transaction taxes cannot be changed very frequently and implementation lags can be too long given the need to amend legislation. Finally, they could adversely impact labor mobility by increasing the cost of changing property.

Instead, reforms could target recurrent property taxation and mortgage interest deductibility, with the objective of ensuring tax neutrality between investment in housing and other types of capital. The objective is to reduce incentives for debt-financed home ownership permanently. One possibility is to tax imputed rents (Linden and Gayer, 2010; OECD, 2011). The practical issue with this approach is that these rents are difficult to measure. Hence, increasing recurrent and transaction property taxes could be used as an alternative. Another possibility is: (i) not to allow mortgage interest deductibility, and (ii) to levy a lower recurrent tax on property. In this way, housing investment would still be taxed and the tax system would not favor debt. Both options would reduce incentives for debt-favored house financing.

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Table 1. Variables and Data Sources

Variable	Definition	Frequency	Geography	Source
	House prices			
House prices	Weighted repeated-sales indices of single family house prices (seasonally adjusted and non-adjusted)	Quarterly	State, MSA	Federal Housing Finance Agency
	Property tax rates			
Property tax rate	Effective rate = 100*Property taxes paid/Assessed value of the house (state median)	Annual	State, MSA	Census bureau
	Macro variables			
Nominal GDP	Value added of all industries (current prices)	Annual	State	Bureau of Economic Analysis
Real GDP	Value added of all industries (constant prices)	Annual	State	Bureau of Economic Analysis
GDP deflator	Ratio of nominal and real GDP	Annual	State	Bureau of Economic Analysis
Real per capita GDP	Value added of all industries (constant prices)/Population	Annual	State	Bureau of Economic Analysis
Population	Number of state residents	Annual	State	Bureau of Economic Analysis
	Housing Supply Restrictions			
Geographical restrictions index	Share of undevelopable geographical area	Annual	MSA	Saiz (2010)
Regulatory restrictions index	Index measuring zoning regulations or project approval practices that constrain new residential real estate development	Annual	MSA	Gyorko et al. (2008)

Table 2. Descriptive Statistics

	Obs.	Mean	Median	St. Dev.	10th percentile	90th percentile	25th percentile	75th percentile
Hose price growth rate (%)	510	-1.30	-0.95	7.42	-9.67	6.94	-5.57	2.98
Effective property tax rate (%)	510	1.04	0.91	0.48	0.52	1.75	0.65	1.35
House price volatility (%, growth-based)	510	5.13	4.18	3.90	1.55	10.28	2.47	6.28
House price volatility (%, HP-based)	510	6.39	4.92	4.93	1.96	12.85	3.16	8.15
Real GDP per capita growth (%)	510	1.27	1.40	2.66	-1.69	4.16	0.16	2.54
GDP deflator growth (%)	510	2.23	2.10	1.88	1.09	3.50	1.67	2.84
Population growth (%)	510	0.84	0.75	0.75	0.11	1.73	0.35	1.24
Supply restrictions index (Saiz, 2010)	770	27.94	23.29	22.32	3.12	64.01	9.28	40.50
Regulatory restrictions index (Wharton)	770	0.10	0.03	0.69	-0.81	0.94	-0.38	0.61

Table 3. Baseline Regressions

	Volatility (house price growth)				Volatility (detrended house prices)			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Property tax rate	-3.542***	-2.784***	-3.210***	-2.802***	-1.283**	-1.111	-1.347**	-1.177
	[0.674]	[0.884]	[0.789]	[0.893]	[0.610]	[0.750]	[0.626]	[0.746]
Lagged dependent variable	0.579***	0.551***	0.497***	0.526***	0.466***	0.462***	0.465***	0.474***
	[0.022]	[0.033]	[0.042]	[0.046]	[0.033]	[0.041]	[0.035]	[0.047]
Real GDP per capita growth			-0.239***	-0.048			-0.052	-0.038
			[0.064]	[0.052]			[0.053]	[0.057]
Inflation (GDP deflator growth)			-0.067	0.023			-0.048	0.091*
			[0.050]	[0.041]			[0.039]	[0.049]
Population growth			-0.165	-0.363*			-0.026	0.069
			[0.209]	[0.208]			[0.160]	[0.120]
Constant	6.186***	4.122***	6.792***	6.952***	4.861***	5.734***	5.113***	5.971***
	[0.699]	[0.880]	[0.976]	[1.002]	[0.602]	[0.895]	[0.721]	[0.800]
Economic significance	-1.7	-1.3	-1.5	-1.3	-0.6	-0.5	-0.6	-0.6
Time FE	No	Yes	No	Yes	No	Yes	No	Yes
# observations	459	459	459	459	459	459	459	459
# states	51	51	51	51	51	51	51	51
R^2	0.365	0.588	0.434	0.598	0.215	0.460	0.219	0.465

Table 4. Instrumental Variable Regressions

	Volatility (house price growth)				Volatility (detrended house prices)			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Property tax rate	-5.260***	-11.081***	-4.855***	-11.598***	-2.113***	-6.205**	-2.369***	-6.677**
	[0.740]	[3.570]	[0.831]	[3.806]	[0.622]	[3.003]	[0.700]	[3.136]
Lagged dependent variable	0.599***	0.557***	0.518***	0.525***	0.466***	0.453***	0.462***	0.469***
	[0.022]	[0.038]	[0.045]	[0.052]	[0.031]	[0.039]	[0.033]	[0.045]
Real GDP per capita growth			-0.238***	-0.075			-0.044	-0.063
			[0.062]	[0.057]			[0.053]	[0.058]
Inflation (GDP deflator growth)			-0.035	0.100***			-0.075	0.151**
			[0.042]	[0.031]			[0.063]	[0.063]
Population growth			-0.311	-0.42			-0.143	0.08
			[0.250]	[0.292]			[0.192]	[0.194]
Constant	7.931***	11.883***	8.489***	15.903***	5.755***	11.293***	6.375***	11.516***
	[0.763]	[3.348]	[1.019]	[3.599]	[0.638]	[3.471]	[0.933]	[3.134]
Economic significance	-2.5	-5.3	-2.3	-5.5	-1.0	-3.0	-1.1	-3.2
Time FE	No	Yes	No	Yes	No	Yes	No	Yes
# observations	441	441	441	441	441	441	441	441
# states	49	49	49	49	49	49	49	49
R^2	0.347	0.462	0.426	0.467	0.206	0.421	0.210	0.422

Note: Coefficients are obtained from panel IV regressions with state fixed effects. The dependent variable is the house price volatility, measured as a 5-year backward moving window standard deviation of: (i) house price real growth rates (columns I-IV), and (ii) deviation of real house prices from their HP-filtered values (columns V-VIII). The instrument for the property tax rate variable is the average property tax rate of neighboring states.
Economic significance measures the response of house price volatility to a 1 standard deviation (0.48%) increase in property tax rates.
Robust standard errors are in brackets. *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 5. Dynamic Panel GMM Regressions

	Volatility (house price growth)				Volatility (detrended house prices)			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Property tax rate	-8.410***	-3.083***	-3.121***	-1.538***	-2.704***	-2.874***	-2.136***	-1.162***
	[0.318]	[0.611]	[0.136]	[0.205]	[0.083]	[0.229]	[0.087]	[0.236]
Lagged dependent variable	0.825***	0.949***	0.697***	0.898***	0.740***	0.823***	0.731***	0.798***
	[0.004]	[0.016]	[0.004]	[0.013]	[0.003]	[0.007]	[0.003]	[0.007]
Real GDP per capita growth			-0.251***	-0.016***			-0.095***	-0.070***
			[0.003]	[0.006]			[0.004]	[0.010]
Inflation (GDP deflator growth)			-0.011	0.028***			-0.022***	0.145***
			[0.008]	[0.005]			[0.004]	[0.009]
Population growth			0.233***	-0.072			0.057*	0.294***
			[0.029]	[0.047]			[0.034]	[0.082]
Constant	9.811***	2.198***	5.235***	2.768***	4.497***	4.340***	4.145***	3.646***
	[0.238]	[0.707]	[0.136]	[0.242]	[0.098]	[0.282]	[0.118]	[0.391]
Economic significance	-4.0	-1.5	-1.5	-0.7	-1.3	-1.4	-1.0	-0.6
Time FE	No	Yes	No	Yes	No	Yes	No	Yes
# observations	459	459	459	459	459	459	459	459
# states	51	51	51	51	51	51	51	51
Sargan test (p-value)	0.1293	0.1632	1.0000	1.0000	0.1021	0.2834	1.0000	1.0000
AR(2) test (p-value)	0.0660	0.0807	0.0789	0.0804	0.0533	0.0572	0.0500	0.0543

Note: Coefficients are obtained from system GMM regressions with state fixed effect (Arellano-Bover). The dependent variable is the house price volatility, measured as a 5-year backward moving window standard deviation of: (i) house price real growth rates (columns I-IV), and (ii) deviation of real house prices from their HP-filtered values (columns V-VIII).
Economic significance measures the response of house price volatility to a 1 standard deviation (0.48%) increase in property tax rates.
Robust standard errors are in brackets. *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 6. Difference-in-Difference Regressions: Geographical Supply Restrictions Index

	Volatility (house price growth)				Volatility (detrended house prices)			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Property tax rate	-2.347**	0.004	-0.699	0.083	-0.070	1.898	0.400	2.019
	[1.098]	[1.335]	[1.148]	[1.479]	[1.423]	[1.902]	[1.300]	[1.907]
Property tax rate*Geographical supply restrictions index	-0.057**	-0.074**	-0.076***	-0.068**	-0.065**	-0.078**	-0.080**	-0.093***
	[0.027]	[0.031]	[0.027]	[0.029]	[0.027]	[0.030]	[0.029]	[0.031]
Lagged dependent variable	0.614***	0.570***	0.503***	0.549***	0.439***	0.443***	0.441***	0.433***
	[0.023]	[0.030]	[0.048]	[0.030]	[0.023]	[0.026]	[0.022]	[0.025]
Real GDP per capita growth			-0.324**	-0.073			-0.079	-0.177
			[0.120]	[0.102]			[0.113]	[0.138]
Inflation (GDP deflator growth)			-0.073	0.054			-0.097	-0.086
			[0.067]	[0.048]			[0.075]	[0.063]
Population growth			-0.109	-0.380			0.139	0.184
			[0.318]	[0.361]			[0.147]	[0.176]
Constant	6.449***	3.263**	6.299***	5.893***	5.682***	4.766***	5.711***	4.468***
	[0.876]	[1.400]	[1.060]	[1.033]	[0.995]	[1.215]	[1.075]	[1.499]
Economic significance	-1.1	-1.5	-1.5	-1.3	-1.3	-1.5	-1.7	-2.0
Time FE	No	Yes	No	Yes	No	Yes	No	Yes
# observations	693	693	693	693	693	693	693	693
# MSAs	77	77	77	77	77	77	77	77
R^2	0.381	0.556	0.465	0.565	0.204	0.393	0.212	0.402

Note: Coefficients are obtained from panel OLS regressions with MSA fixed effects. The dependent variable is the house price volatility, measured as a 5-year backward moving window standard deviation of: (i) house price real growth rates (columns I-IV), and (ii) deviation of real house prices from their HP-filtered values (columns V-VIII). The geographical supply restrictions index is taken from Saiz (2010) — it measures the share of land area that is not subject to property development.
Economic significance measures the response of house price volatility to 25-75 interquartile increases in supply restrictions index and property tax rates.
Robust standard errors are in brackets. *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Table 7. Difference-in-Difference Regressions: Regulatory Restrictions Index

	Volatility (house price growth)				Volatility (detrended house prices)			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
Property tax rate	-3.524***	-1.932*	-2.339***	-1.596	-1.516**	-0.229	-1.493**	-0.484
	[0.650]	[1.011]	[0.538]	[1.231]	[0.681]	[1.301]	[0.686]	[1.132]
Property tax rate*Regulatory restrictions index	-3.747***	-4.164***	-4.602***	-4.340***	-3.710***	-3.800***	-4.087***	-4.189***
	[0.582]	[0.764]	[0.733]	[0.846]	[0.438]	[0.581]	[0.844]	[0.787]
Lagged dependent variable	0.616***	0.568***	0.502***	0.547***	0.430***	0.431***	0.430***	0.417***
	[0.022]	[0.021]	[0.044]	[0.033]	[0.024]	[0.027]	[0.023]	[0.025]
Real GDP per capita growth			-0.328**	-0.080			-0.080	-0.178
			[0.121]	[0.105]			[0.115]	[0.144]
Inflation (GDP deflator growth)			-0.082	0.050			-0.105	-0.091
			[0.071]	[0.044]			[0.076]	[0.070]
Population growth			-0.186	-0.434			0.058	0.104
			[0.306]	[0.327]			[0.134]	[0.134]
Constant	6.578***	4.514***	6.623***	6.410***	5.954***	4.747***	6.213***	5.319***
	[0.643]	[1.383]	[0.811]	[0.944]	[0.682]	[1.414]	[0.830]	[1.195]
Economic significance	-2.6	-2.9	-3.2	-3.0	-2.6	-2.6	-2.8	-2.9
Time FE	No	Yes	No	Yes	No	Yes	No	Yes
# observations	693	693	693	693	693	693	693	693
# MSAs	77	77	77	77	77	77	77	77
R^2	0.390	0.566	0.479	0.578	0.211	0.399	0.220	0.408

Note: Coefficients are obtained from panel OLS regressions with MSA fixed effects. The dependent variable is the house price volatility, measured as a 5-year backward moving window standard deviation of: (i) house price real growth rates (columns I-IV), and (ii) deviation of real house prices from their HP-filtered values (columns V-VIII). The regulatory restriction index is taken from Gyourko et al. (2008) — it measures zoning regulations or project approval practices that constrain new residential real estate development.
Economic significance measures the response of house price volatility to 25-75 interquartile increases in regulatory restrictions index and property tax rates.
Robust standard errors are in brackets. *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent levels, respectively.

Figure 1. Graphical Illustration: Demand Shock and House Prices

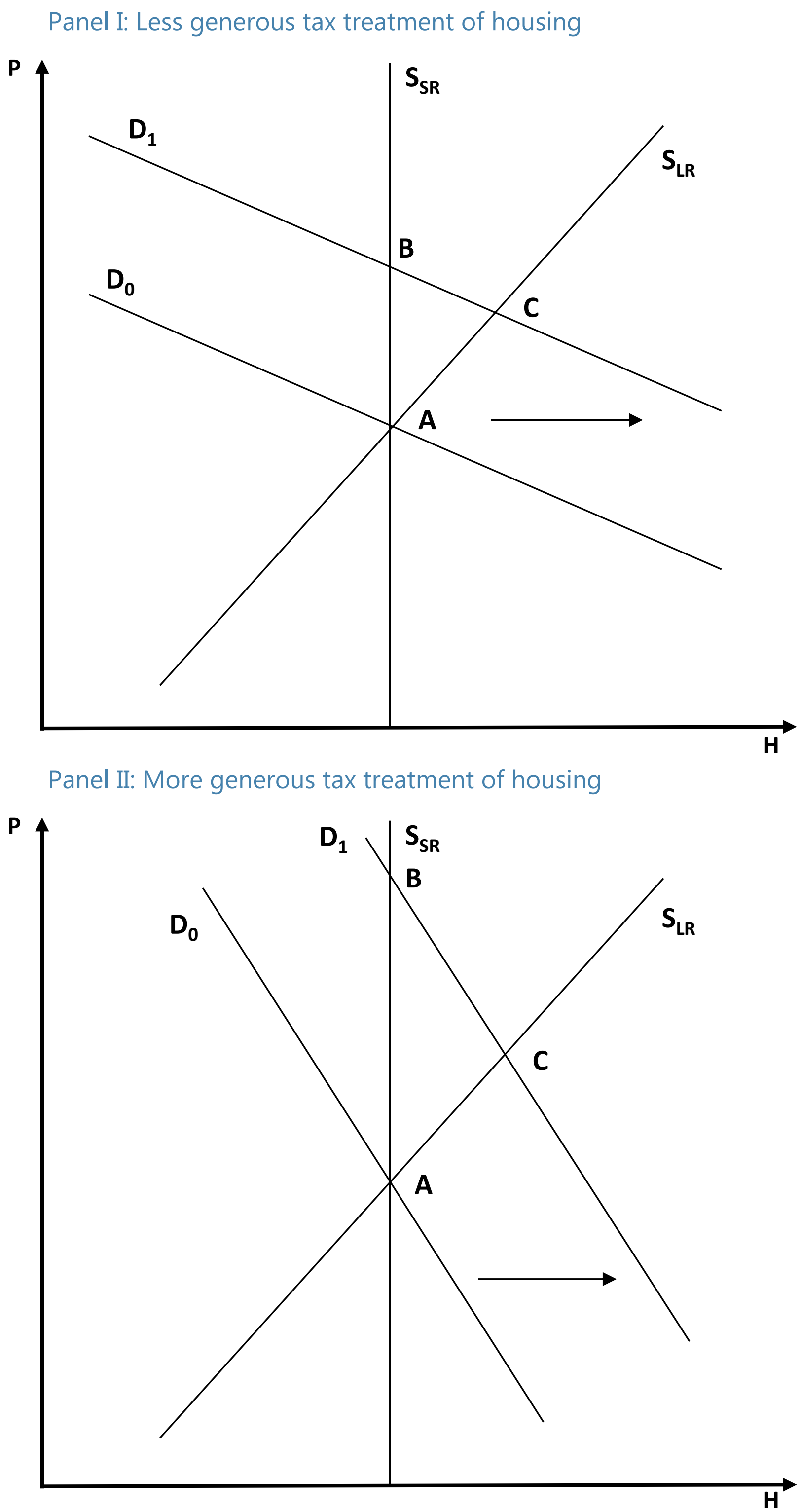


Figure 2. The Impact of Exogenous Demand Shock on House Prices

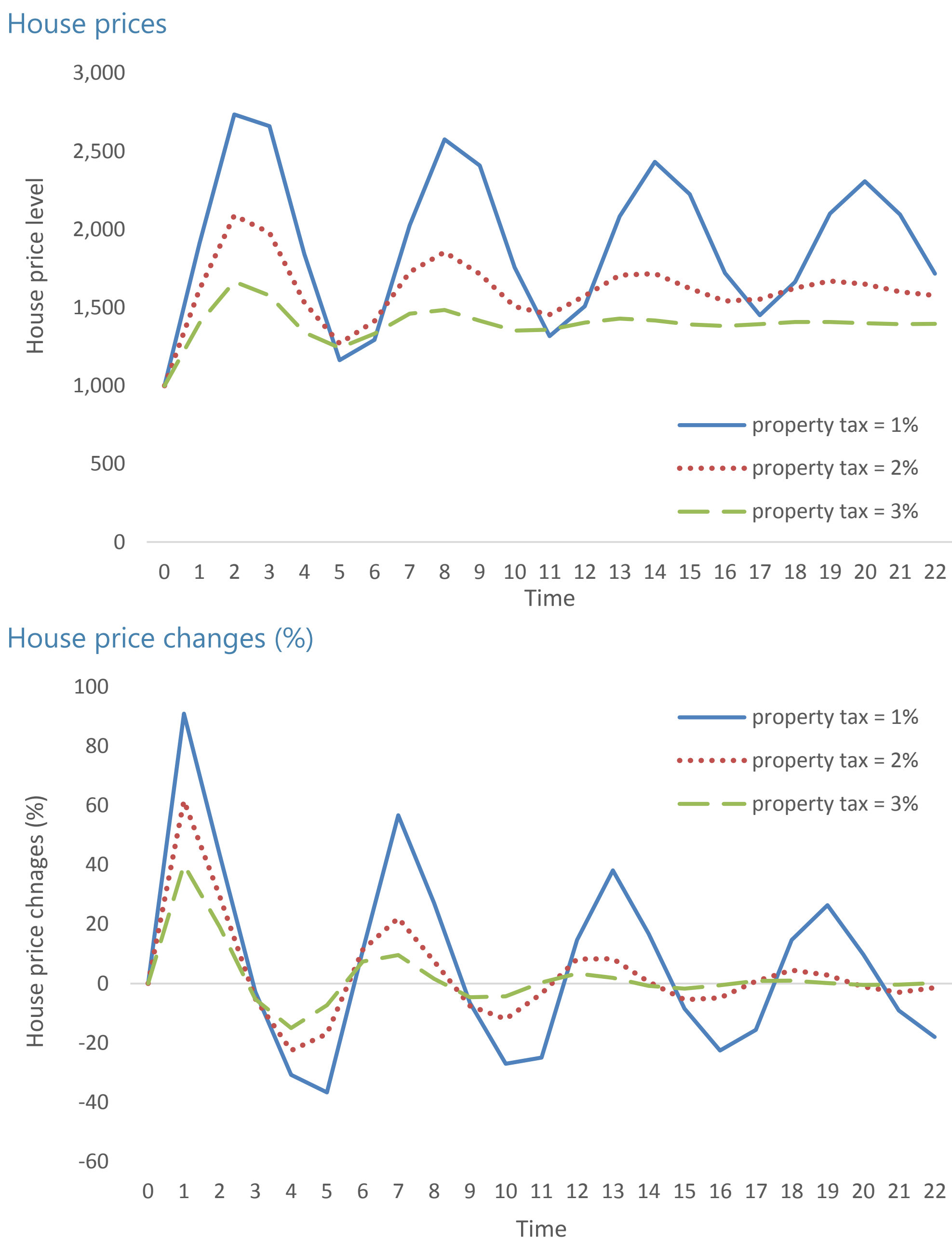
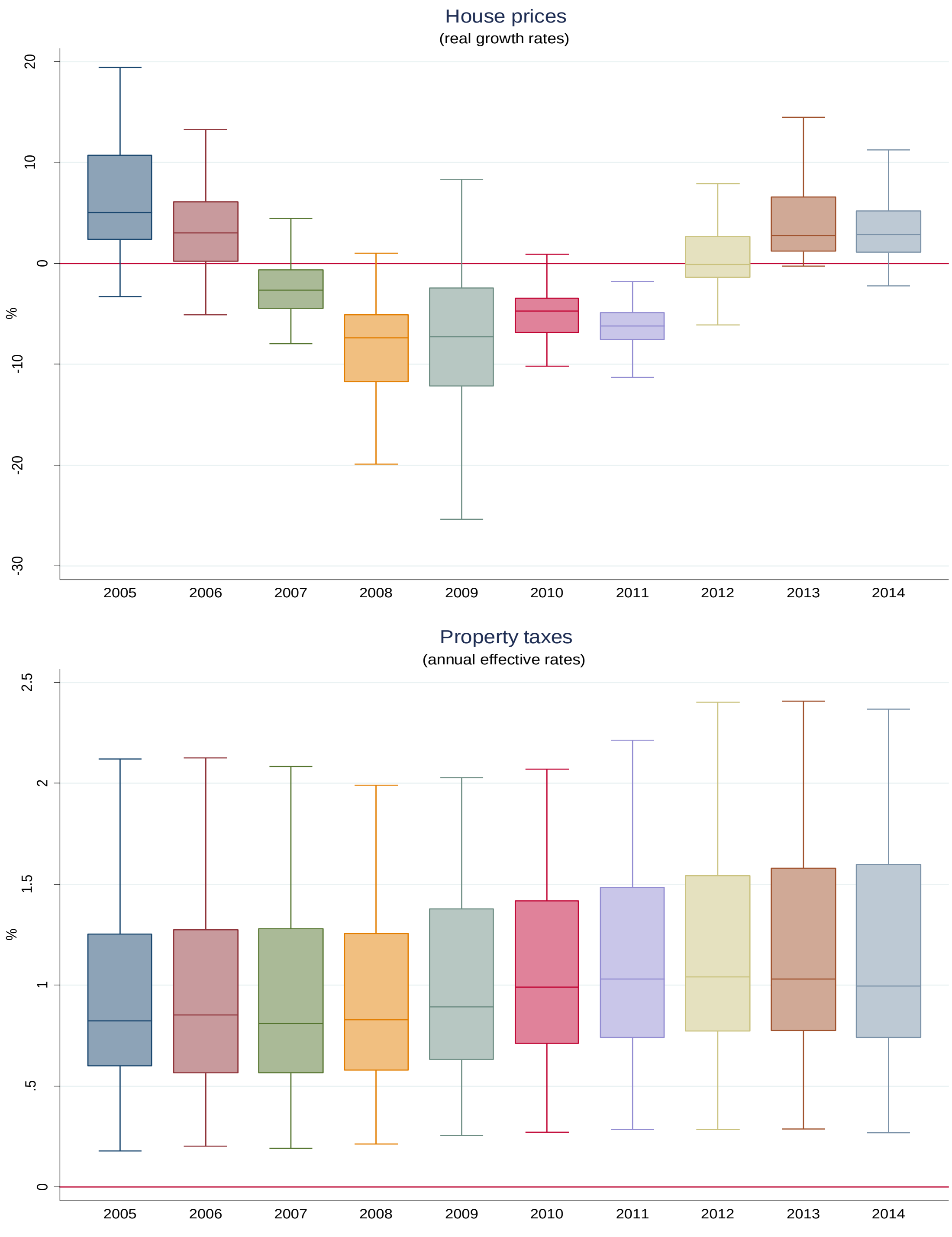
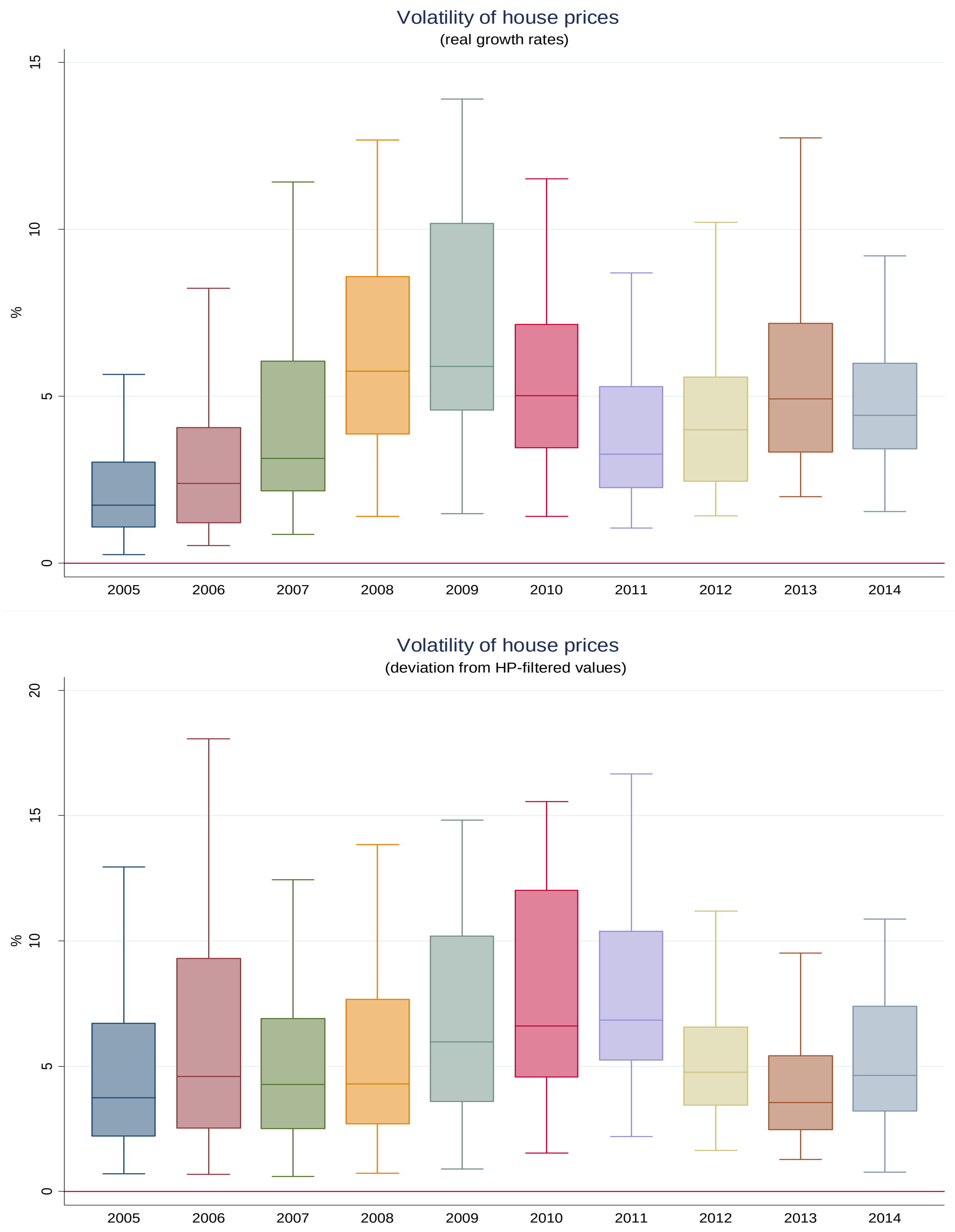


Figure 3. House Prices and Property Tax Rates



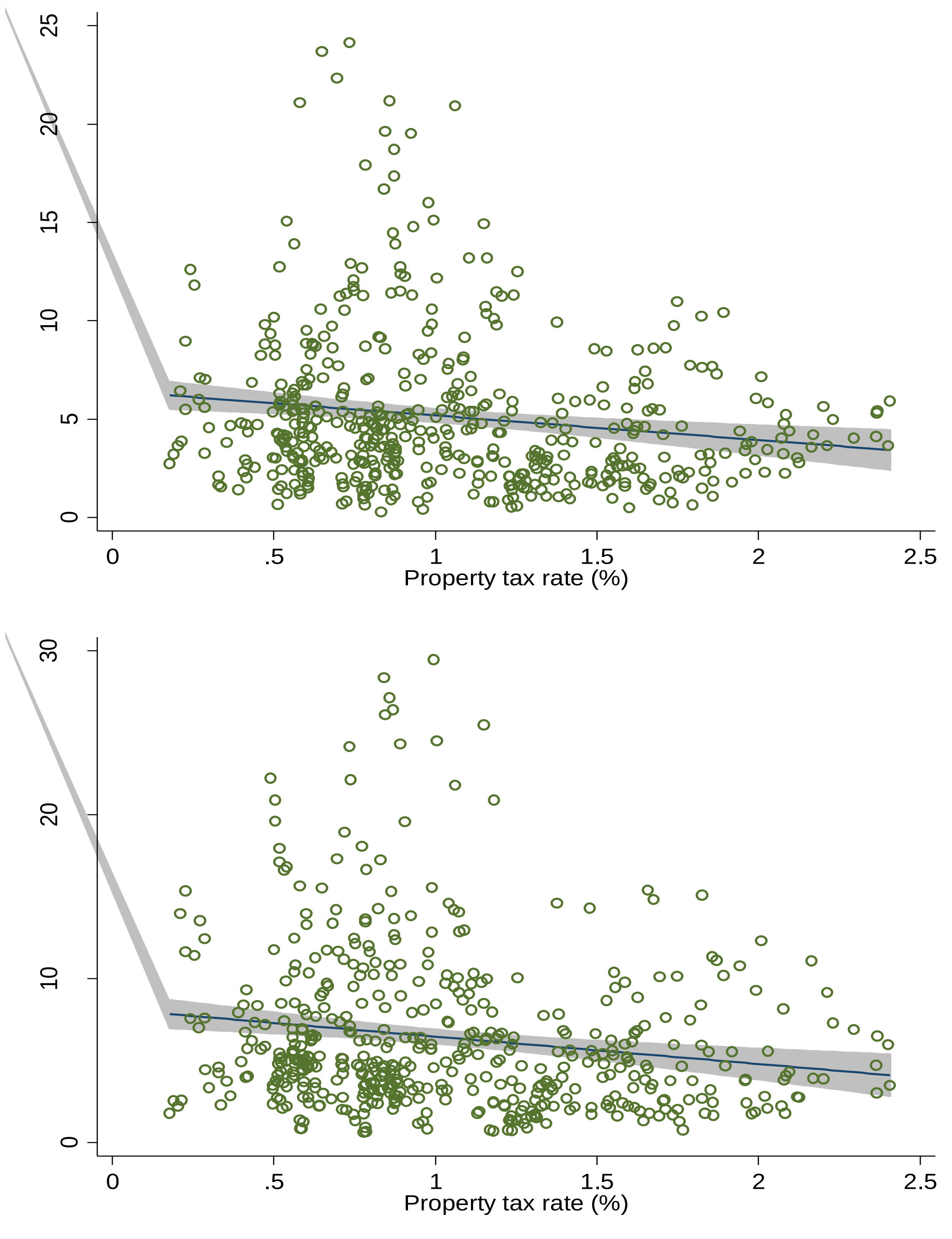
Note: Reported are variation ranges of variables across 51 U.S. states. Real house prices are estimated using state GDP deflators. The whiskers of the plot denote the minimum and maximum values of variables for each year. The edges of the box denote 25th and 75th percentiles of the distribution across states. The line splitting the box denotes the state median.

Figure 4. Volatility of House Prices



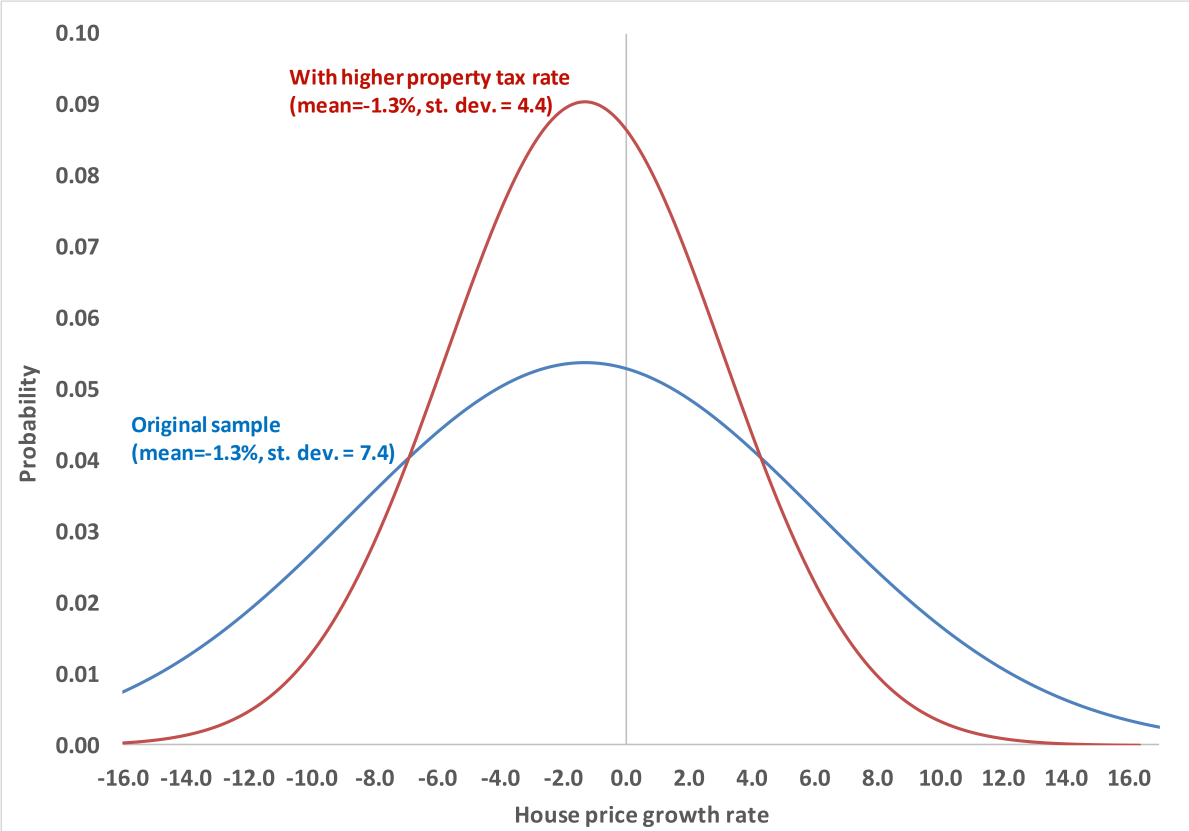
Note: Reported are volatilities measures using 5-year backward moving window.

Figure 5. House Price Volatility and Property Tax



Note: The sample covers 51 U.S. states for the period 2005-14.

Figure 6. The Impact of Property Taxes on House Price Volatility



Note: The exercise assumes that house price growth rates have normal distribution. The blue line represents the distribution of house price growth rates using the mean and standard deviation from the sample. The red line represents the distribution of house price growth rates assuming 0.48 percent higher property tax rates, which would translate into lower volatility/standard deviation. The latter is calculated as 7.4-0.48*3, where 3 is the average economic significance of the property tax rate impact across all regressions.