Retail Marijuana Deregulation and Housing Prices*

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February 12, 2020

Abstract

Despite federal law, twelve American states and Washington D.C. have legalized recreational marijuana since 2012. Using a national housing data set from the online real estate listing database Zillow.com, we identify the cross and inter-state effects of marijuana legalization on house prices in different points of the price distribution function. We find positive effects upwards of ten percent in the top half of the price distribution following successful legalization ballot initiatives, and between five and fifteen percent across the distribution after the state enacts the ballot initiative and the first legal sales take place. A spatial difference-in-differences model reveals that within Colorado and Washington, prices in neighborhoods with new dispensary openings nearby experience a seven percent price appreciation. Considered together, this research suggests that there are second order benefits associated with marijuana legalization that policy makers and voters should be aware of when deciding the drug's legal status.

Keywords: Marijuana legalization, housing

*For their indispensable advice, our thanks to Greg Burge, Daniel Hicks, Tyler Ransom, Pallab Ghosh, Myongjin Kim, Qihong Liu, Chunbei Wang, and seminar participants at the Applied Microeconomics Lunch Seminar (University of Oklahoma) and the Missouri Valley Economic Association's (MVEA) 56th Annual Conference.

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1 Introduction

Twelve states and Washington D.C. have passed initiatives legalizing the use of marijuana for recreational purposes since 2012. Additionally, 33 states and D.C. have passed medical marijuana laws since 1996. This rapid and radical change puts the states at odds with the federal government, which still classifies marijuana as a Schedule 1 narcotic on par with cocaine, heroin, and lysergic acid diethylamide (LSD).[1]

The disconnect between the public and the federal government reflects the evolution of the perceived benefits of marijuana. Large majorities of American adults believe that marijuana has medical benefits (Keyhani et al. (2018)), and adolescents have low risk perceptions of the drug (Roditis and Halpern-Felsher (2015)) even though medical professionals are unsure of its efficacy (Kondrad and Reid (2013); Carlini et al. (2017); Fitzcharles et al. (2014); Braun et al. (2018)). Despite the public's beliefs, most states have been reluctant to legalize marijuana for recreational use. Concerns about the potential effect on crime rates and the difficulty in policing impaired driving have been cited as reasons to slow-walk the path to full recreational legalization. This research contributes to the discussion, providing evidence that recreational marijuana legalization (RML) has large positive spillover effects on the local housing market.

The speculation and ambiguity of marijuana's medical benefits extends to legalization's effect on the local economy. An emerging literature studies the impact of medical marijuana legalization on labor market outcomes. Sabia and Nguyen (2018) find no effect on adult wages, employment or hours worked and a small decrease in wages among young men with access to marijuana dispensaries. Nicholas and Maclean (2019) focus on older adults, finding an increase in the labor supply of those over the age of 51 with the largest effect coming for adults with health conditions which qualify them for legal medical marijuana use. If there are positive labor supply effects, then it is possible that the housing market could be impacted directly through in-migration as individuals from non-legalization states seek to enjoy the

[1] From the Drug Enforcement Agency (DEA), https://www.dea.gov/drug-scheduling

perceived benefits. Research suggests that immigration inflows increased single family home prices in Switzerland (Degen and Fischer (2017)), but decreased in the United Kingdom as wealthy native homeowners leave the newly immigrant-populated neighborhoods (Sá (2015)). Legalization also provides a new source of tax revenue. Some RML states have used this tax revenue specifically for school funding, which is a mechanism through which home prices might increase. There is a long literature on school resources and student outcomes (Card and Krueger (1998); Jackson et al. (2016); Martorell et al. (2016)) and school capital investment's impact on the value of nearby homes (Cellini et al. (2010); Neilson and Zimmerman (2014)).

Legalization could increase crime rates, as the drug's effect can make users act more erratically, and easy access to marijuana creates a low-risk trafficking network across state lines. It is well established that crime and the perception of crime negatively impact home prices (Pope (2008); Buonanno et al. (2013)), so legalization might put downward pressure on the housing markets of states with successful ballot measures. Counter to the crime narrative however, early research suggests that there is no effect. Morris et al. (2014) find no evidence of an increase in crime rates following medical marijuana legalization (MML) and may have even decreased incidences of violent crime. Similarly, Huber et al. (2016) find a decrease in property crime in MML states but that marijuana decriminalization has no effect. If the null or negative crime effect generalizes to the RML case, then this could be an avenue through which housing prices increase, although that question is beyond the scope of this paper.

Other research has studied the impact of marijuana legalization on residential home prices. Cheng et al. (2018) find a 6% price increase in the Colorado housing market following the passage of RML using a difference-in-difference strategy. On the other hand, Thomas (2018) estimate a 1.7% decrease in home prices near existing and potential marijuana dispensary locations in Washington state. This paper improves on the existing research by combining the cross and within-state approaches with rich national level housing data from the online real estate database Zillow.com, as well as marijuana dispensary location data from Colorado and Washington.

First we estimate the cross-state impact using the Zillow housing data. The Zillow data is at the individual property transaction level. The treatment group consists of home transactions in states which have legalized the recreational use of marijuana and the control group consists of home transactions in states which have have not legalized it. We find consistent positive effects in the RML case of around 8% across a number of specifications which include time and location fixed effects ranging from the county level to the ZIP code level. The estimates are most pronounced when we consider the date that the sale of recreational marijuana is made legal, suggesting that housing demand responds primarily once the drug is being sold, not when the law is victorious at the ballot.

We then extend the cross-state analysis by estimating an unconditional quantile regression (UQR) as in Firpo et al. (2009) with city level fixed effects. Using city level fixed effects controls for unobserved local property taxes which have long been recognized to influence the housing market (Oates (1969); Anderson (1986)). Doing so provides additional insight into the forces driving our treatment effect. Due to the large heterogeneity in housing markets across the country, the UQR estimates are more robust against extreme value observations than our fixed effects models and provide a more complete understanding of central tendency and dispersion measures. The results of the UQR show positive effects in the top of the distribution following the success of the ballot measure legalizing recreational marijuana, but no effect in the lower half. The greatest impact occurs once it becomes legal to sell marijuana, with large positive effects across the price distribution, especially in the middle three deciles. Heterogeneous responses to a policy shock have not been well-researched in the housing literature, making the findings here one of our major contributions.

The discrepancy between the quick response at the top of the home transaction price distribution immediately after the vote and the slower effect which is more evenly distributed once sales are legal open could suggest a number of mechanisms. Access to liquidity is one possibility, as the wealthiest households can more rapidly move capital to RML states if they believe there to be some positive spillovers from legalization. It could also be that the wealthy more quickly shift their marijuana demand function than the rest of the population, which would effect the timing of response to legalization. There also likely exists a lag in the effect for the entire population, as heterogeneity in housing demand reflects different preferences across the price distribution for local amenities such as schooling, which only receive additional funding upon states generating new tax revenue from marijuana sales.

Finally, we estimate a spatial model within Colorado and Washington using the Zillow housing data and dispensary location information from the Marijuana Enforcement Division of the Colorado Department of Revenue and the Washington State Department of Health. Our identification strategy follows that of Dronyk-Trosper (2017), who use the staggered construction of municipal buildings such as fire stations to estimate their impact on home prices. In our application, homes which are within two miles of a dispensary at time t and have a second dispensary open within a half mile of the home at time $t+1$ increase in value by over 6%. The price appreciates the closer to the new dispensary a home is, suggesting that the dispensary itself is a neighborhood amenity which has some positive value among home buyers.

This paper contributes to the existing literature by providing robust evidence that marijuana legalization has beneficial spillover effects at both the state and local levels. Taken together, our three sets of results show that states which pass RML ballot measures benefit relative to other states and that marijuana dispensaries provide a boost to the home values in the immediate vicinity. Marijuana's liberalization provides a novel source of tax revenue which states have used to fund capital expenditures, especially in education and it acts as an amenity via the dispensaries that distribute it. The creation of a new legal market has direct implications for the local economy, as it establishes new dispensary jobs and reduces arrest rates. All of these factors have well-established impacts on housing markets. Indeed our results show that the spillover effects of marijuana legalization on the housing market are both statistically and economically significant, suggesting that states which have yet to legalize marijuana should consider a wider range of outcomes if and when citizens vote on the issue.

The paper proceeds as follows. Section 2 discusses the history of medical and recreational marijuana legalization in the United States, as well as potential mechanisms through which legalization could impact the housing market. Section 3 details three data sources used for estimation and presents summary statistics. Section 4 describes the empirical strategy and section 5 presents the impact of marijuana legalization on housing markets. Finally, section 6 concludes.

2 Background

2.1 Medical and Recreational Marijuana Legalization

Beginning in 1937, the federal government prohibited the use of marijuana for recreational consumption and sale with The Marijuana Tax Act of 1937 (Pub. L. No. 75-238, 50 Stat. 551). The law went into effect on October 1, 1937 and two days later a Mexican-American man named Moses Baca was arrested by Denver police for marijuana possession, the first such arrest in the country.[2] In 1968 Richard Nixon won the U.S. presidency on a platform of law and order,[3] quickly establishing drug abuse as "public enemy number one in the United States." The Controlled Substance Act (Pub. L. 91-513, 84 Stat. 1236) of 1970 created tiers of illegal drugs indicating the severity of negative health effects and the level of addictiveness. Marijuana is included in the Schedule 1 tier, indicating that its severity is at the highest

[2] For a brief history of the first marijuana arrests, see: https://www.leafly.com/news/politics/drug-war-prisoners-1-2-true-story-moses-sam-two-denver-drifters-became-cannabis-pioneers

[3] Nixon explicitly used drug control as a means of targeting his political enemies, as revealed by his domestic policy advisor John Ehrlichman in 1994. Ehrlichman stated in an interview that "[t]he Nixon campaign in 1968, and the Nixon White House after that, had two enemies: the antiwar left and black people. You understand what I'm saying? We knew we couldn't make it illegal to be either against the war [in Vietnam] or black, but by getting the public to associate the hippies with marijuana and blacks with heroin, and then criminalizing both heavily, we could disrupt those communities. We could arrest their leaders, raid their homes, break up their meetings, and vilify them night after night on the evening news. Did we know we were lying about the drugs? Of course we did." From: https://harpers.org/archive/2016/04/legalize-it-all/

possible level alongside addictive narcotics such as heroin. In 1973 the federal government established the Drug Enforcement Agency, which was the primary entity responsible for policing drug use in the country.

Some states introduced marijuana decriminalization proposals in response to the federal government's aggressive stance on marijuana, but that effort ultimately fell out of favor and the intensity of the War on Drugs escalated in the 1980s and early 90s (Pacula et al. (2003)). In 1996 California became the first state to legalize recreational marijuana, marking the beginning of the end of punitive escalation that began with the Marijuana Tax Act in 1937 and was amplified through the 70s, 80s, and 90s. Once California passed the Compassionate Use Act in 1996, the floodgates were opened and in the ensuing years states across the country legalized marijuana for medicinal purposes. Table 2 shows this progress. As of February 2020, 33 states and Washington DC have or are in the process of legalizing medical marijuana consumption.

Despite the progress in MML over the last 20 years, it has been a much slower path to full recreational marijuana legalization. Colorado and Washington were the first two states to approve RML on the ballot in 2012, 16 years after California passed its MML law and after 18 other states had done the same. In the years since, Colorado and Washington have been joined by Alaska, California, Maine, Massachusetts, Michigan, Nevada, Oregon, Vermont, and Washington D.C. Some states have had significant lags between their legalization measures passing a vote and the practical implementation of the law. Massachusetts, for example, voted in favor of RML in November 2016 but it was not until November 2018 that dispensaries selling marijuana opened. It is widely expected that this march of progress will continue in the 2020 election cycle and beyond. This paper contributes another data point to the debate over marijuana legalization, demonstrating that those early adopter states have experienced significant appreciations in home values since legalization has been implemented.

2.2 The Housing Market Connection

Marijuana legalization comes with a number of trade-offs that make its connection to the housing market ambiguous. The expected direction of legalization's effect depends on a number of forces pushing in opposite directions. Increased public capital expenditures and in-migration would increase demand for housing in the short run and, assuming housing supply is fixed in the short run, raise prices. On the other hand, out-migration, negative health impacts, and increases in crime rates could deflate home values.

To establish the direction of the effect on home prices following marijuana legalization, Figures 1, 2, and 3 shows the trend in the national housing market since 2000, divided by when each state adopted RML. There are three cohorts of states. Figure 1 includes Colorado and Washington, the first two states to legalize recreational marijuana in 2012. Figure 2 includes Oregon, which legalized in 2014, and Figure 3 includes California, Massachusetts, and Nevada, all of which legalized recreational marijuana in 2016. The four other states and Washington D.C. which have legalized recreational marijuana are not included because they are outside the sample for reasons discussed in Section 3.1. Solid lines are treatment states across the three figures, and dotted lines reflect states which did not legalize recreational marijuana. To verify that this divergence is a feature of marijuana legalization and not a few wealthy states outpacing the national trend, we divide non-RML states into three groups based on average house price per square foot levels. The six treatment states would all fall into the High average price per square foot grouping with the exception of Nevada, which would be classified in the Middle group if it were not a treatment state. By by comparing the trend in those states to other wealthy and middle income states, we can get a better idea of the impact legalization has had on the housing market.

Figures 1, 2, and 3 demonstrate that all three control groups show similar housing market trends since 2000. The RML states meanwhile consistently diverge from the control trends upon their respective cohorts' legalization dates. Across the three graphs, the price trend was similar across RML and non-RML states until 2012. Colorado and Washington display a clear divergence in their housing markets following legalization at the end of 2012. A similar divergence can be seen in Figure 2 when Oregon voted in favor of RML in 2014. At the end of the time trend, the 2016 legalization cohort also see distinct jumps in the housing markets relative to the non-RML states.

The housing markets of RML states have recovered faster and stronger than those of non-RML states. The effect in Figures 1, 2, and 3 are all despite the period spanning the Great Recession. Volatility in the housing market can be seen clearly in each figure; the market begins accelerating in 2002, peaks in 2006, and reaches its nadir in 2011. The difference in recovery between RML and non-RML states can be seen most dramatically in the first cohort of Colorado and Washington. This could reflect slack in housing as the market over-corrected during the recession, but there can be no doubt that those two states recovered at a faster rate than their economic peers. It appears that the implementation of RML raised house prices despite the burden of the housing market recovery.

2.3 Mechanisms

Having established that states which enacted RML laws received a positive boost during the recovery period following the Great Recession, we now turn our attention to the mechanisms through which this change occurred. We consider two possible avenues, which we will broadly refer to as the the "economic development" effect and the "amenity" effect. The economic development effect reflects the idea that the public views marijuana as a scarce (due to its illegal nature in much of the country) economic good that creates positive demand effects not just for marijuana itself, but also for residency and tourism in the states which offer legal marijuana services. A positive economic development effect would reflect positive marijuana demand and potential inflows from other states. A negative effect would suggest that the positive inflow is outweighed by out-migration, as residents of a state which legalized marijuana move to avoid the perceived negative effects.

By legalizing the use of marijuana, Colorado and other RML states could become an attractive option for residents of other states who value the ability to consume marijuana without fear of legal repercussions. This consumption cost of marijuana factors into an individual's residency decision. For consumers who chooses to migrate to a state with legal recreational marijuana, the cost of moving is less than the consumption cost. People who use marijuana for medicinal purposes could fall into this category, as easy access to legal marijuana decreases the cost of obtaining and consuming what for them is equivalent to a prescription drug. The in-migration of these individuals that results from passing legalization measures will possibly affect local housing markets.

The effect of inter-country migration on housing markets is ambiguous in the existing literature (Degen and Fischer (2017); Sá (2015)). However, there is substantial evidence that the number of people migrating within the United States is shrinking and local labor markets conditions and home equity have explain much of the decision to migrate (Henley (1998); Foote (2016); Zabel (2012); Koar et al. (2019)). Despite this downturn in internal migration, young educated households frequently move to areas with high quality business environments (Chen and Rosenthal (2008)). Recreational marijuana legalization liberalizes the criminal code, but it also creates a new industry in the states that enact it. Business creation increases employment opportunities and growth (Baptista and Preto (2011); Andersson and Noseleit (2011)), which in turn puts upward pressure on housing markets (Liu et al. (2016); Reichert (1990)). The combination of new job creation and demand for marijuana from non-locals could boost the housing markets of states that enact RML. These associated benefits (and potential costs) could be capitalized into housing values (Cheng et al. (2018)).

The economic development effect considers long-run changes to the community which legalization induces. Marijuana sales are an entirely new source of tax revenue. The illegal marijuana market prior to legalization is necessarily un-taxed. In the debate over legalization, supporters often advocate for the sales tax applied to recreational marijuana sales to be tied to local projects, such as infrastructure improvements or education funding. For example the disposition of Colorado marijuana tax revenue is first distributed to the Public School

Capital Construction Assistance Fund, and any revenue over $40 million is transferred to the Public School Fund.[4]

There is a long literature on school resources and student outcomes (Card and Krueger (1998), Jackson et al. (2016)). The physical condition of school capital and government investment as a vehicle for student achievement is also of interest in the existing literature (Martorell et al. (2016)). There is further evidence that school capital investment increases the value of local homes. Cellini et al. (2010) use a regression discontinuity design method, using local referenda on bond issuances for capital expenditures to identify the causal effect of referenda passage on the local housing market. Their results suggest a sizable and immediate positive impact on local home values. Neilson and Zimmerman (2014) exploit the staggered implementation of a school construction project in New Haven, Connecticut, finding that home prices increase in the local neighborhood by approximately 10%. We contribute to this literature by examining whether the passage of recreational marijuana legalization laws – and therefore new sources of tax revenue – affect local home prices.

We estimate the effect of marijuana legalization at different points of the process (i.e. at the time of the vote to legalize, when the law goes into effect, and when the first dispensaries open), which provides insight into the magnitude of the economic development effect. Since the two-way fixed effects and UQR models define treatment as all homes in a state, the coefficients should reflect the broad treatment inside each state. Homes without nearby dispensaries therefore are likely not experiencing the positive shock through an amenity effect, but through secondary mechanisms such as increased school funding and capital investment. We estimate the UQR model to capture the sensitivity of the price distribution to the economic development effect. The hedonic price function frequently estimated in the housing literature can be highly non-linear. For this reason, the UQR model is our preferred model specification and the primary contribution of this research's estimates of RML on the economic development effect in housing.

[4] https://www.colorado.gov/pacific/revenue/disposition-marijuana-tax-revenue

The amenity effect will be captured in our Spatial Difference-in-Differences model (see Section 4). By restricting our sample to just homes near dispensaries in Colorado and Washington, we recover the dispensaries' effect on the nearby housing market. This approach is in line with previous research, as prices exhibit localized variation based on a number of amenity factors, including public school quality (Bogart (2000); Cheshire and Sheppard (2004)), public transit options (Bajic (1983); Dewees (1976)), water quality (Epp and Al-Ani (1979); Young and Teti (1984); Leggett and Bockstael (2000)), rail lines (Bowes and Ihlanfeldt (2001); Gibbons and Machin (2005); McMillen and McDonald (2004)), and crime (Hellman and Naroff (1979)). Home prices vary significantly as households are heterogeneous in their amenity preferences and income (Gibbons and Machin (2008)). If dispensaries are an amenity – either positive or negative – then we should be able to recover an effect with the Spatial Difference-in-Differences model. Recovering the amenity effect of dispensaries using a novel estimation method is the second major contribution of this research.

3 Data

This research relies on three primary sources of data. First is a national housing data set from the online real estate database company Zillow (Zillow (2017)). The second is a hand-compiled data set identifying each states' laws regarding the liberalization of marijuana use. Finally, we have yearly data on the construction of marijuana dispensaries in Colorado and Washington.

3.1 Housing Data

Zillow is a popular tool used by the public to search for properties available for sale in the United States. The company provides a centralized source of property transactions through its Zillow Transaction and Assessment Dataset (ZTRAX).[5] This dataset compiles multiple

[5]Data provided by Zillow through the Zillow Transaction and Assessment Dataset (ZTRAX). More information on accessing the data can be found at http://www.zillow.com/ztrax. The results and opinions are

listing services (MLS) from all fifty states, Washington D.C., and other U.S. territories to provide a comprehensive resource for real estate transactions.

The information includes not only details of a given housing market transaction, such as the sales price and date, but also information about the house itself. The ZTRAX repository provides access to a large number of home characteristics, such as the number of rooms, square foot area of the property, and any structures on it. Table 1 shows the summary statistics for all homes in our sample, as well as annual state-level economic variables, such as GDP. The differences among both the home characteristic and local economic variables suggest that local fixed effects will be an important factor in our model specifications.

We consider all homes in each state, conditional on the data being representative of a state's housing market. This is not the case for every state, as some do not have MLS public reporting requirements across all counties. For example, North Dakota has only one county which consistently reports transactions to the state's MLS, so we exclude it from our sample. Additionally, since this research is interested in the spillover effect of marijuana legalization of the housing market, we only consider homes which Zillow documents as residential properties. The richness of the data means that some states report business, government, and other non-residential properties. We exclude these observations.

The data is also filtered for observations that are likely non-market transactions. All included observations are categorized as a deed transfer, which signifies the exchange of a property's title from one party to another. Despite this, there are observations where a non-market transfer occurs between, for example, family members in the case of inheritance. These types of observations are often indicated as such, but in order to further exclude cases where reporting standards differ, we also filter for transactions which have a listed sales price below $10,000 and above $10,000,000. Doing so substantially reduces the sample size, but it is unlikely that homes below that price are actual market transactions given the price distribution. Additionally, states that have fewer than 100,000 transaction across the sample

those of the authors and do not reflect the position of Zillow Group.

period are excluded in order to reinforce that a state's housing market sample is properly represented. We provide a more comprehensive examination of our data cleaning process for the Zillow data in Appendix A.

3.2 Marijuana Laws

In addition to the housing and dispensary data, we used the legalization dates as determined by each state to identify our treatment conditions. As mentioned in the introduction, there are three possible legal states that marijuana can be classified as: legal to use recreationally, legal to use medicinally, and illegal. We used successful laws and ballot measures to indicate the relative legality of marijuana in each state. The information in this data is presented in Table 2. The second column reflects the date that a given state votes for and passes recreational legalization. The third column is the "effective date" for recreational legalization when either the result of a popular vote is approved or a law goes into effect. This is the date when it is no longer illegal to possess or grow marijuana for recreational purposes.

It is not until the date in Column (4) that there is a way to legally purchase recreational marijuana. An important distinction to note is the difference between the "Dispensary Date" and "First Dispensary" columns. In some cases, the ballot question outlines a specific date on which dispensaries are allowed to open. This is not always the case, however, as some states leave the decision when to open dispensaries up to local municipalities. This distinction is why Dispensary Date and First Dispensary are considered two separate treatments. Some states, such as California and Colorado, specify the Dispensary Date in their ballot questions, and as a result have dispensaries open on that date. In that case, the Dispensary Date and First Dispensary column dates are identical. Other states such as Massachusetts and Maine have large time gaps between the two dates due to local governing bodies having discretion over dispensary permit approvals. The preferred treatment and what is presented in our primary models is the Dispensary Date. We provide separate estimates for both variables, and consider the First Dispensary treatment as a robustness check.

We use a similar logic for cases of medical marijuana legalization. This process is significantly more complicated, however, as the regulations enacted by each state vary widely. A state may vote via a ballot measure or through the state legislature to legalize the use of marijuana for medicinal purposes, but the process following that approval has many additional steps. Similar to the recreational case, the law becomes effective as soon as it is passed, but the possession of marijuana is not necessarily legal due to the method through which the state distributes licenses. California, which was one of the first states to enact medical marijuana legalization, distributed medical license cards similar to a driver's license for those eligible for marijuana possession. Additionally, there are complications with prescriptions that vary by state which add a layer of complexity to identifying the timing of our effective date. It is also not always clear whether dispensaries that can sell medical marijuana to users with a valid prescription have opened, or if there is some other distribution mechanism that the state has adopted. As a result, we use a similar logic to the recreational case and consider the effective medical marijuana legalization date to be the date that a ballot measure is ratified or a state legislative measure is signed by the governor.

3.3 Dispensary Data

For our spatial analysis we use data from the Marijuana Enforcement Division of the Colorado Department of Revenue and the Washington State Liquor and Cannabis Board, which detail every dispensary location in the two states since their legalization of recreational marijuana. These data include the spatial coordinates of a given dispensary and the year it opened. Our estimation focuses on the opening of new dispensaries, so the data begins in 2014 when the first strictly recreational dispensaries opened in Colorado and Washington. It is worth noting however that there existed dispensaries in both states prior to recreational legalization due to the previous passage of medical legalization. Those dispensaries are taken as given and exist at the start of the data. The spatial identification strategy depends on the opening of new dispensaries, so whether a dispensary was an already-existing medical dispensary should have no bearing on the validity of the estimation. We combine the dispensary data with the Zillow housing data to estimate the effect of new dispensaries opening on the housing market in the immediate vicinity. This represents the within-state amenity effect of legalization.

4 Empirical Strategy

Our empirical strategy involves three primary specifications. First is a linear model, which we test with varying fixed effect levels to establish a baseline relationship between marijuana legalization (both MML and RML) and home prices. We estimate the following:

$$\begin{aligned} \log(\text{Price}_{ijst}) = \alpha_1 &\text{Recreational Vote}_{st} + \alpha_2 \text{Recreational Possession}_{st} \\ &+ \alpha_3 \text{Dispensary Date}_{st} + \alpha_4 \text{Medical}_{st} + \beta X'_{ijst} + \delta_j + \rho_q + \epsilon_{ijst} \end{aligned} \tag{1}$$

Since the Zillow housing data is at the transaction level, our primary dependent variable Price_{ist} is the price of home i in county/city/ZIP j and state s at time t. In this simple model the variables of interest are $\text{Recreational Vote}_{st}$, $\text{Recreational Possession}_{st}$, $\text{Dispensary Date}_{st}$, and Medical_{st}, which are all binary variables indicating whether state s has adopted RML (for Recreational Vote, Recreational Possession, and Dispensary Dates) or MML (for Medical) at time t. $\text{Recreational Vote}_{st} = 1$ if the state has approved RML during a statewide ballot vote or by a legislative statute before the transaction date, $\text{Recreational Possession}_{st} = 1$ if the RML law has gone into effect and it is legal to possess marijuana, $\text{Dispensary Date}_{st} = 1$ if dispensaries can apply for permits to sell recreational marijuana, and $\text{Medical}_{st} = 1$ if MML has been approved by state voters or legislators. In addition to these indicators, X'_{ijst} is a vector of housing characteristics and local economic measures including the number of bedrooms, bathrooms, the age of the home, state GDP, state population, and state land area. Finally we include location and time fixed effects, δ_j and ρ_q, respectively. We use year-quarter fixed effects for ρ_q, but the legalization dummies are defined by the exact date of RML voting, possession, and dispensary openings. This makes our models traditional hedonic estimations, not a Difference-in-Differences strategy.

The second model employed is an unconditional quantile regression (UQR), as specified by Firpo et al. (2009) (FFL). Table 1 demonstrates the large amount of variation across the data, especially with regard to our outcome variable of choice, home price. The observed prices and house characteristics exhibit significant heterogeneity, which makes a UQR an attractive estimation strategy. As we demonstrated in Figures 1, 2, and 3, response to the housing recovery varied widely between RML states and non-RML states. Extending this idea to the distribution of prices, a UQR model accounts for systematic differences across states that may influence their decision to pass legalization measures. The UQR model is evaluated on the distribution of independent variables marginally. Because of this, the model does not depend on the covariates conditioned on as in a traditional conditional model.

The UQR model evaluates the impact of RML and MML on house prices across the price distribution using a recentered influence function (RIF) (Hampel et al. (2005)). Although the RIF can be applied to any distributional statistic, FFL use it to estimate quantiles along the distribution. The marginal effect of any quantile on the home price can be represented by:

$$\begin{aligned} E[\text{RIF}(\text{Price}_{ijst}; q_\tau)|\text{RML}, \text{MML}, X, \delta, \rho] &= \alpha_1 \text{Recreational Vote}_{st} \\ &+ \alpha_2 \text{Recreational Possession}_{st} + \alpha_3 \text{Dispensary Date}_{st} \\ &+ \alpha_4 \text{Medical}_{st} + +\beta X'_{ijst} + \delta_j + \rho_q + \epsilon_{ijst} \end{aligned} \tag{2}$$

Model 2 is the same equation as in Model 1, with the only difference being the estimation of the RIF. q_τ in the RIF reflects each quantile being estimated. In our case we will derive estimates for each decile along the price distribution (i.e. $q_\tau = (0.1, 0.2, ..., 0.9)$). By estimating each decile, the RIF allows us to interpret the effect of RML across the distribution which may provide additional insight into the mechanisms behind legalization's impact on the housing market.

Like the fixed effects Model 1, the UQR estimates the difference in home prices along the distribution across states. It could be the case that there are differences within states that legalized marijuana use as well. To test this we use data from the Marijuana Enforcement Division of the Colorado Department of Revenue, the state agency in Colorado tasked with regulating the sale of marijuana, and the Washington State Liquor and Cannabis Board. The agencies' data provide the location of marijuana dispensaries opened in the states between 2014-2018. By combining this data with the Zillow housing data, we are able to estimate the effect of a dispensary opening on neighborhood home values.

A clear source of endogeneity in a standard difference-in-differences (DiD) approach is that the location of a dispensary is not random; a firm chooses what it believes to be the most profitable location for its dispensary and finds suitable properties to rent or purchase. The firm may rent property in a business district or near transit, which could bias the housing market in the immediate area upward. On the other hand if these are new or inexperienced businesses that have capital constraints, they might locate where property is relatively inexpensive. This would have the opposite effect, as homes in less dense areas are generally on the lower tail of the price distribution.

To account for the endogeneity concern, we use a DiD approach developed in Dronyk-Trosper (2017). The authors use the local government's construction of public service facilities, such as fire departments and police stations, to identify changes in the local housing market. Control homes are those which maintain their distance from the closest facility throughout the sample period. Treatment homes are those which – at period t_0 – have the same distance as the control group but at some future period t_s, where $s > 0$, a new facility is constructed that reduces the distance to the nearest option. We modify this approach by substituting the public facilities for marijuana dispensaries. The spatial DiD model is represented by:

$$\log(\text{Price}_i) = \beta_1 \text{Treatment}_i + \beta_2 \text{State}_i + \beta_3 (\text{Treatment}_i \times \text{State}_i) + \gamma X_i + \epsilon_i \tag{3}$$

with Treatment_i is an indicator variable which reflects whether a home is in our treatment group – whether a new dispensary has opened closer to home i since period t_0. State_i is a dummy for whether a home sale occurred before or after the construction of a new closer dispensary, and X_i is a vector of home characteristic controls. β_3 is our variable of interest, which represents the change in home values for treated units following the opening of a new dispensary. Figure 4 demonstrates the buffer zones around marijuana dispensaries in the Denver metropolitan area and the homes that fall within the buffer zone. For the purpose of Model 3, only a subset of the homes that appear in Figure 4 will be included in our treatment group.

5 Results

5.1 Housing Prices Following Statewide Marijuana Legalization

Tables 3 and 4 estimate the effect of recreational marijuana legalization on housing prices using a simple linear model and a fixed effects model, respectively. In these tables and in the rest of the main specifications, the dependent variable is the logged value of home prices. Each column in the two tables includes a single treatment variable with the exception of Column (5), which includes three treatment variables. The treatment variable indicating the date recreational marijuana possession is legalized is excluded in Column (5) because, as indicated in Table 2, the gap between the vote and possession dates are typically no longer than a month. If this gap is longer than a month, then the possession date is typically very close to the first legal sales date. We estimate the coefficient for possession separately in Column (2) of Tables 3 and 4, and as expected its point estimate falls between the vote and sales points estimates.

In Table 3, as in the rest of the tables that follow, each estimation includes variables which control for house characteristics and state economic indicators. Table 3 includes city-level clustered standard errors to account for potential correlations of error terms, but does not include any fixed effects indicators. In this simple linear model the estimated coefficients of interest are large and significant, with each point estimate reflecting greater than a eighteen percent appreciation in home prices for the RML variables of interest. Table

4 includes city and year-quarter fixed effects for the same five estimations as Table 3. This table represents the primary linear cross-state results. Similar to the previous table, we find large and positive estimates for the three RML treatment indicators, again exceeding ten percent when considered individually. A noteworthy difference between the fixed effects and OLS models is the magnitude of the coefficients. Including fixed effects greatly reduced the estimated effect, which is to be expected considering the data is a national sample which features large amounts of heterogeneity in housing and economic characteristics.

The model is designed to identify the effect of RML specifically, but we include the medical coefficient in order to address the potential endogeneity issue of states voting in favor of recreational legalization. Policy treatment represents a selection issue as voters choose whether to vote in favor of marijuana legalization. As seen in Table 2, however, there are a large number of states which have legalized medical marijuana but only ten which have legalized recreational marijuana. Due to the limitations of the Zillow housing data discussed in Section 3.1, the only states which are in the RML treatment group are California, Colorado, Massachusetts, Nevada, Oregon, and Washington. RML treatment states make up less than a quarter of the MML states as a result. Every state that has enacted RML has enacted MML, but the inverse is not true. By including the medical treatment in our primary model specification, we cannot guarantee the consistency of the medical coefficient but we should recover the marginal effect for the two RML treatment variables.

Column (5) of Table 4 demonstrates that once we include city and year-quarter fixed effects into our primary linear model, both Recreational Vote and Dispensaries Date's coefficients retain large, positive, and significant point estimates. The larger effect happens at the Dispensary Date, when the first dispensary *could* open. This estimate reflects an eleven percent appreciation in home prices. As explained in Section 3.2, this is not necessarily the date that the first dispensary opens since each municipality in a given treatment state has different permitting rules for new businesses. As a robustness check, we use the opening date of the first dispensary in a state as the dispensary treatment and find qualitatively similar results. The estimated coefficient for the Recreational Vote treatment meanwhile reflects 5.4 percent price appreciation. Taken together, the two linear models support the hypothesis that RML induces large positive effects in the housing market.

To further test the state-level effect of marijuana legalization on housing prices, we estimate an unconditional quantile regression (UQR) as specified by Firpo et al. (2009). A UQR has three principle advantages over a traditional linear model despite the fact that it simply recovers the marginal effect of the treatment indicators. First, it is less sensitive to extreme values in the dependent variable. This is unlikely to be an issue in the data used for this paper as the number of observations is substantial, but it is nonetheless a strength of the model. Second, a UQR model accounts for differences across states that could affect the likelihood of a given state passing a marijuana legalization bill, which is a significant concern. Finally it marginalizes the treatment effect across the price distribution, which provides a more complete understanding of the impact of RML on the housing market.

With those advantages in mind, Figures 5 and 6 plot the UQR coefficients for each decile along the distribution. For a more precise view of the estimated coefficients, Tables 9 and 10 in Appendix B display the point estimates. Again we have estimated two model specifications, one with the Dispensary Date treatment and one with First Dispensary due to the close time proximity of those two variables. A pattern emerges in both cases: there appears to be some significant effect in the Medical Vote or Recreational Vote treatments and a significant, positive, and increasing effect across the Dispensary Date/First Dispensary distributions. The Recreational Vote treatment show some significant appreciation in the top four deciles, but as in the linear models the Medical coefficients should be interpreted conservatively.

The positive effect in the upper deciles for the two Vote treatments range between a three and twelve percent increase in home price. The concentration, especially in $Q_\tau = .80, .90$ could point to the level of liquidity available to those purchasing the most expensive properties. For example, if those wealthy buyers have greater access to credit than buyers lower in the distribution, then their demand for marijuana and in turn housing in RML or MML states could shift immediately upon the success of a ballot measure. This interpretation would be consistent with the economic development hypothesis presented in Section 2.3; demand for housing is responsive to employment gains, which itself is a natural byproduct of new business creation, and potential in-migration. The results support the those from the linear fixed effects model estimated in Table 4, with the top two deciles dominating the average effect,

The Dispensary Date and First Dispensary treatments differ from the two Vote treatments in that they have large, positive, and significant effects across the price per square foot distribution. These values range from approximately seven percent to nineteen percent, with the point estimates increasing in magnitude until beginning to decrease at the 7th decile. It should be noted that the values in the 8th and 9th deciles have very large confidence intervals and so the point estimates may be overstating the effect. Regardless of the estimated confidence intervals, we can say with some certainty that the two dispensary treatment dates reflect a shift in housing demand in RML and MML states. This large effect again supports the hypothesis that the economic development effect drives the change in the housing market. Once recreational marijuana becomes available to buy easily at a dispensary and tax revenue is generated, there is significant home price appreciation.

5.2 Spatial Model

To further test whether it is open dispensaries that are driving the increased demand for housing, we estimate the results from a spatial model which identifies the effect of new dispensaries on the value of nearby homes. The model, which is described in Section 4 and follows the empirical strategy developed in Dronyk-Trosper (2017), estimates the within-state effect, as opposed to the cross-state effect of the linear and UQR models presented in the previous section. The various treated groups in this model represent homes which have already been "exposed" to a dispensary by having a dispensary open within a two-mile radius of the property. They are then considered treated when a second dispensary opens geographically closer at a later date. Figure 4 demonstrates this idea graphically.

In order for this empirical strategy to be valid, homes in the treatment groups must not differ from each other in price and house characteristics. Table 5 presents the mean and standard deviation values for the four groups. The group "Inside 0.5 Miles" includes all homes sold which were within a half mile of a dispensary at any point in the sample period of 2014-2018 in Colorado and Washington; "Between 0.5 and 1 Mile" includes homes sold which were between a half and one mile of a dispensary at any point in the sample period; "Between 1 and 2 Miles" contains homes sold which were between one and two miles of a dispensary at any point in the sample period; and the "Outside 2 Miles" group includes homes which are outside a two-mile radius of any dispensary.

Table 6 presents the results for the spatial difference-in-differences models. Like the linear and UQR estimates in the previous section, each of the models have the logged value of price as the dependent variable. Column (1) is a simple fixed effects model, where the point estimates for 1/2 Mile Zone, 1 Mile Zone, and 2 Mile Zone reflect the premium for homes within a two mile radius of a dispensary in Colorado and Washington during our sample period. This model in this column has no causal mechanism and simply estimates the mean difference between homes near (i.e. within two miles) of a dispensary and those outside that bound. Homes within 0.5 miles have a slight premium of 4.5 percent, but homes between 0.5 miles and one mile and homes between one and two miles have a slight discount.

The primary spatial model specifications appear in Columns (2) and (3) of Table 6. Both columns follow the identification strategy in Dronyk-Trosper (2017), and so can be interpreted as the causal effect of a marijuana dispensary opening on the local housing market. Column (2) uses homes within two miles of a dispensary as the control group. The two treatment variables – 1/2 Mile Zone and 1 Mile Zone – are indicators for homes which previously were within two miles of a dispensary and were subsequently sold after a new dispensary opens. The sold homes are newly situated within a half mile or between a half mile and a mile of a dispensary, respectively. The coefficients for 1/2 Mile Zone and 1 Mile Zone represent the premium for these homes. Both treatment zones experience an appreciation in price after the construction of a new dispensary. The 1 Mile Zone homes increase in value by slightly under one percent and the 1/2 Mile Zone homes increase by slightly over seven percent. Column (3) is the same specification, except now the only treated homes are those within a half mile of a new dispensary. The homes in 1 Mile Zone that were previously considered part of our treatment group in Column (2) are now included in the control group. Again the estimated coefficient for the half mile group is significant and positive with an eight percent appreciation. In order to guarantee that the results are not being driven by one of the two state's effect dominating the other, we separate the sample into tables for Colorado and Washington as a robustness check. Tables 11 and 12 appear in the Appendix. The results are similar between the two states and between the individual state estimates and the combined estimates, suggesting that this effect is not due to one state's influence.

Dronyk-Trosper (2017) find that the effect of municipal government service buildings, such as police stations and firehouses, increases the value of homes at a decreasing rate. Those homes closest to the government buildings actually decrease in value, likely as a response to the increased traffic and noise associated with those services. Our results imply the opposite; when a dispensary opens nearby, homes closest to it appreciate in price the most. This is consistent with our interpretation that new dispensaries act as amenities in the local housing market. Since the spatial model is restricted to Washington and Colorado – the first two states to legalize recreational marijuana – we cannot guarantee that these results generalize to each subsequent state that legalizes. However, together with the cross-state models presented in the previous section, it is clear that recreational marijuana legalization has large positive effects on the housing market of states that legalize and municipalities which allow dispensaries to open in their communities.

5.3 Robustness Checks

There are two primary robustness check categories we employ. First, we use the home price per square foot as the dependent variable rather than home price. Geographic heterogeneity in our sample suggests that simply using house price as the dependent variable could bias the results since treatment homes are in high-price states. By using house price per square foot as the dependent variable, we can ensure that this potential source of bias is accounted for. Second, we include the First Dispensary treatment in place of the Dispensary Date variable for the reasons outline in Section 3.2. If the primary mechanism in our cross-state models is the economic development effect, then it is possible that the impact is only felt once the first dispensaries open and a large volume of marijuana sales take place, thereby generating tax revenue.

Table 7 uses the log value of house price per square foot as the dependent variable in the two linear cross-state models. In this table, Dispensary Date is still the right-hand side treatment variable of choice. As in the price per square foot results, the OLS model in the first five columns shows large positive results for all four treatment variables, including the Medical Vote treatment. Again, these results should be interpreted carefully as the Medical Vote treatment is likely absorbing a large amount of the effect due to the lack of time fixed effects. That being said, the point estimates are very similar to those presented in Table 3. The same can be said for the fixed effects results in columns (6) through (10). The Recreational Vote variable is still significant and positive, as is the Dispensary Date. The point estimates are large and positive, as in the original specification.

Next, we check our results using First Dispensary as our treatment variable of interest rather than Dispensary Date. For some states these dates are the same, so we would expect the results to be very similar. Table 8 presents the estimates, and indeed that is what we find. The results are consistent with the Dispensary Date results. Once again, there are positive effects for each of the two RML variables, Recreational Vote and First Dispensary, just as in our primary results. The magnitude of the First Dispensary estimates are similar to those for

Dispensary Date presented in Table 4. Table 8 also presents the original model specification with various levels of controls. Excluding house characteristic and local economic variables do no affect the magnitude or significance of the estimated models.

6 Conclusion

Uncertainty regarding the costs and benefits of marijuana legalization, along with marijuana's status on the federal level as a Schedule 1 drug, have made the public reluctant to support policies which liberalize its use and distribution. To help fill this information gap, this research demonstrates that there is a large positive spillover effect on the housing market following legalization. We further support these findings with a spatial approach which shows that within states that legalize recreational marijuana use, homes experience a positive valuation shock when a dispensary opens nearby. The results are robust to a number of of specifications, including a different (but temporally similar) date for the actual sale of marijuana at dispensaries. Taken together, the inter and intra-state results suggest that preferences for public services – derived from a new source of tax revenue – and dispensaries as a commercial amenity create largely positive effects following the legalization of recreational marijuana.

The impact of legalization on the housing market is supported by two models. First, a fixed effects model demonstrates a five percent appreciation in home prices following the passage of RML and an eleven percent appreciation once sales of marijuana products begin. Extending this logic to an unconditional quantile regression approach, we find positive effects across the home price distribution following the date that dispensaries are allowed to open. Differences across the price distribution can likely be thought of as heterogeneous preferences among different levels of wealth. The promise of future funding to schools and other public infrastructure as a result of legalization supports a long literature showing a positive relationship between home prices and local economic development.

To approximate the effect of dispensaries we estimate a spatial model in Colorado and Washington. The results again show price appreciations for homes as the distance to the nearest dispensary decreases. This demonstrates that is it not simply the benefits of increased tax revenue, but also the existence of the dispensaries themselves, that is driving the price increases. The dispensaries act as commercial amenities that the public puts a premium on being nearby.

Without the benefit of foresight, our research is not able to determine whether the positive effect will persist. For example if immigration inflows are the primary cause of our results, then we would expect that states would experience diminishing returns to legalization. The first cohort of states which legalized recreational marijuana would draw those that valued legalization most, and each successive state should not expect a similar inflow. Additionally, more research on marijuana legalization is required to fill in the remaining knowledge gaps. We do not estimate some of the other second-order effects, such as the impact on policing and the outcomes for minority communities that were previously convicted for marijuana possession at a disproportionate rate. Future research would be well served to approach these questions, as it will better inform the public and policy makers with respect to the reclassification of recreational drugs.

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Tables

Table 1: Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Transaction Prices ($)					
House Price	330,342	364,989	10,838	9,999,181	38,145,054
log(House Price)	12.35	0.86	9.29	16.12	38,145,054
Price per Sq. Foot	180	179	1.24	23,088	38,145,054
log(Price per Sq. Foot)	4.90	0.80	0.21	10.05	38,145,054
Property Characteristics					
Bedrooms	3.1	0.9	1.0	7.0	38,145,054
Bathrooms	2.1	0.8	0.25	7.0	38,145,054
Sq. Feet	1,948	1,065	420	10,228	38,145,054
log(Sq. Feet)	7.6	0.4	6.0	9.2	38,145,054
Year Built	1976	29	0.00	2018	38,145,054
State Characteristics					
GDP (Millions $)	787,941	706,135	36,281	2,968,117	38,145,054
Population	15,535,151	12,272,350	567,136	39,557,045	38,145,054
Land (Acres)	77,264	50,066	61	261,797	38,145,054
Density	2.83	6.04	0.19	114.41	38,145,054
log(GDP)	13.18	0.92	10.50	14.90	38,145,054
log(Population)	16.21	0.89	13.25	17.49	38,145,054
log(Land)	10.96	0.96	4.12	12.48	38,145,054
Treatment Indicators					
Recreational Vote	0.07	0.25	0	1	38,145,054
Recreational Possession	0.06	0.25	0	1	38,145,054
Dispensary Date	0.04	0.20	0	1	38,145,054
First Dispensary	0.04	0.20	0	1	38,145,054
Medical	0.45	0.50	0	1	38,145,054

Housing variables are at the individual property transaction level ist, where i is a single property in state s. t reflects the date of transaction. The Price and Price per Sq. Foot variables represent unique transaction prices and are deflated using the 2018 Consumer Price Survey. The home characteristics Bedrooms, Bathrooms, Sq. Feet, and Year Built are unique to a given property but not necessarily unique to the dataset if a given property was sold more than once during the sample period. State characteristic variables are yearly at the state level s. GDP is the gross domestic product in a given year, Population is the state's total population, Land is the total land area of state s in acres, and Density is Population divided by Land which represents how concentrated a state's population is geographically. Treatment indicators are those indicators described in Section 3.2.

Table 2: Marijuana Legalization Laws

State	Vote	Possession	Dispensary Date	First Dispensary	Medical
Alaska	Nov 4, 2014	Feb 24, 2015	Feb 24, 2015	Oct 31, 2016	Mar 4, 1999
Arizona					Nov 2, 2010
Arkansas					Nov 9, 2016
California	Nov 8, 2016	Nov 9, 2016	Jan 1, 2018	Jan 1, 2018	Nov 6, 1996
Colorado	Nov 6, 2012	Dec 6, 2012	Jan 1, 2014	Jan 1, 2014	Jun 1, 2001
Connecticut					May 31, 2012
Delaware					Jul 1, 2011
Florida					Jan 3, 2017
Hawaii					Jun 14, 2000
Illinois	Jun 25, 2019	Jan 1, 2020	Jan 1, 2020	Jan 1, 2020	Jan 1, 2014
Louisiana					1978
Maine	Nov 8, 2016	Jan 30, 2017	May 2, 2018	Spring 2020 (Expected)	Dec 22, 1999
Maryland					Jun 1, 2014
Massachusetts	Nov 8, 2016	Dec 15, 2016	Jul 1, 2018	Nov 20, 2018	Jan 1, 2013
Michigan	Nov 6, 2018	Dec 6, 2018	Dec 1, 2019	Dec. 1, 2019	Dec 4, 2008
Minnesota					May 30, 2014
Missouri					Dec 6, 2018
Montana					Nov 2, 2004
Nevada	Nov 8, 2016	Jan 1, 2017	Jan 1, 2017	Jul 1, 2017	Oct 1, 2001
New Hampshire					Jul 23, 2013
New Jersey					Jul 1, 2010
New Mexico					Jul 1, 2007
New York					Jul 5, 2014
North Dakota					Apr 18, 2017
Ohio					Sep 8, 2016
Oklahoma					Jul 26, 2018
Oregon	Nov 4, 2014	Jul 1, 2015	Oct 1, 2015	Oct 1, 2015	Dec 3, 1998
Pennsylvania					May 17, 2016
Rhode Island					Jan 3, 2006
Utah					Dec 1, 2018
Vermont	Jan 22, 2018	Jul 1, 2018			Jul 1, 2004
Washington	Nov 6, 2012	Dec 6, 2012	Jul 8, 2014	Jul 8, 2014	Nov 3, 1998
Washington DC	Nov 4, 2014	Feb 26, 2015			Jun 20, 2010
West Virginia					Jul 1, 2018
Total	12	12	10	10	34

Note: Vermont and Washington D.C. have passed laws allowing for the possession and cultivation of recreational marijuana, but have yet to allow for sales at retail locations as of this writing in February 2020. The data was derived from legislative and ballot acts, which are compiled nationally at the Marijuana Policy Project – https://www.mpp.org/

Table 3: Effect of Marijuana Legalization on House Price per Sq. Foot (OLS)

	log (House Price)				
	(1)	(2)	(3)	(4)	(5)
Medical	0.414***				0.409***
	(0.035)				(0.034)
Recreational Vote		0.180***			0.110***
		(0.029)			(0.020))
Recreational Possession			0.186***		
			(0.029)		
Dispensary Date				0.152***	-0.024
				(0.035)	(0.029)
R-squared	0.322	0.281	0.281	0.280	0.323
F-stat	847	699.8	700	697.9	696.1
Observations			38,145,054		

Note: (i) The Possession dummy is excluded in the main column (5) since the time gap between Recreational Vote and Possession or Possession and the Dispensary Date are typically quite small. (ii) Both house characteristics – which includes bedrooms, bathrooms, the year built – and state characteristics such as state per capita GDP and density are controlled for in each model. (iii) City level clustered standard errors in parenthesis to take into account potential correlation in the error terms. (iv) As a robustness check we use house price per square foot as the dependent variable, which can be seen in Table 7 in Appendix B.

$***: p < 0.01$

$**: p < 0.05$

$*: p < 0.1$

Table 4: Effect of Marijuana Legalization on Home Price (Fixed Effects)

	log (Price)				
	(1)	(2)	(3)	(4)	(5)
Medical	0.039**				0.061***
	(0.019)				(0.020)
Recreational Vote		0.106***			0.054***
		(0.014)			(0.013)
Recreational Possession			0.107***		
			(0.014)		
Dispensary Date				0.138***	0.111***
				(0.015)	(0.010)
City FE	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	Yes	Yes	Yes	Yes	Yes
R-squared	0.610	0.610	0.610	0.610	0.611
F-stat	1174	1194	1194	1207	1013
Observations			38,144,444		

Note: All models include city and year-quarter fixed effects. Beside our typical house characteristic controls (number of bedrooms, bathrooms, age), we also include local economic indicators at the state level. These include per capita GDP and population density. City level clustered standard errors are in parentheses to account for potential correlation in the error terms. As a robustness check we use house price per square foot as the dependent variable, which can be seen in Table 7 in Appendix B.

$*** : p < 0.01$

$** : p < 0.05$

$* : p < 0.1$.

Table 5: Summary Statistics by Spatial Difference-in-Difference Treatment

	Inside 0.5 Miles		**Between 0.5 and 1 Mile**		**Between 1 and 2 Miles**		**Outside 2 Miles**	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
House Price ($)	413,997	373,542	364,451	338,805	378,964	355,227	368,097	296,083
Price per Sq. Foot ($)	255	193	214	149	198	132	186	128
Sq. Feet	1,711	873	1,723	846	1,941	963	2,046	964
Bedrooms	2.9	0.9	3.0	0.9	3.1	0.9	3.1	0.9
Bathrooms	2.0	0.9	2.1	0.8	2.3	0.8	2.4	0.9
Age of House at Sale (Years)	41.5	31.3	43.3	28.9	33.3	24.7	27.1	22.8
Observations	382,937		134,337		150,123		218,436	

The sample for the spatial difference-in-differences (SDD) model includes all home transactions in Colorado and Washington from 2014-2018. Each grouping represents the distance a home is from a dispensary, so for example homes in the first group are less than a half mile away from the nearest dispensary.

Table 6: Spatial Difference-in-Differences

	log (Price)		
	(1)	(2)	(3)
1/2 Mile Zone	0.045***	0.072***	0.082***
	(0.002)	(0.002)	(0.002)
1 Mile Zone	-0.028***	0.009***	
	(0.002)	(0.002)	
2 Mile Zone	-0.034***		
	(0.002)		
Control Group	Outside 2 Miles	Within 2 Miles	Within 1 Mile
Observations	885,833	650,437	565,923
R-squared	0.406	0.425	0.431
F-stat	38,060	33,363	32,681

The sample includes transactions in the period between 2014 and 2018 in Colorado and Washington. Logged county level data such as county number of employees, wage, and the county employment ratio (county employees/state total employees), as well as home characteristics including the number of bedrooms, the square value of bedrooms, the age of the home, the number of bathrooms, and the square footage of the home, are used in the regression to control for differences across the states. Column 1 is an OLS model where treatment homes are homes that fall within 2 miles or closer of a dispensary and control homes are home that are not within 2 miles of a dispensary. Column 2 is the spatial difference in difference model where the control group becomes all homes that fall within 2 miles of a dispensary and the treatment group are homes that start off within 2 miles of a location and move within .5 or 1 mile of a dispensary. Column 3 is the same but now control are home starting off 1 mile and moving within .5 miles of a dispensary. Robust standard errors in parenthesis.

$***: p < 0.01$
$**: p < 0.05$
$*: p < 0.1$

Figures

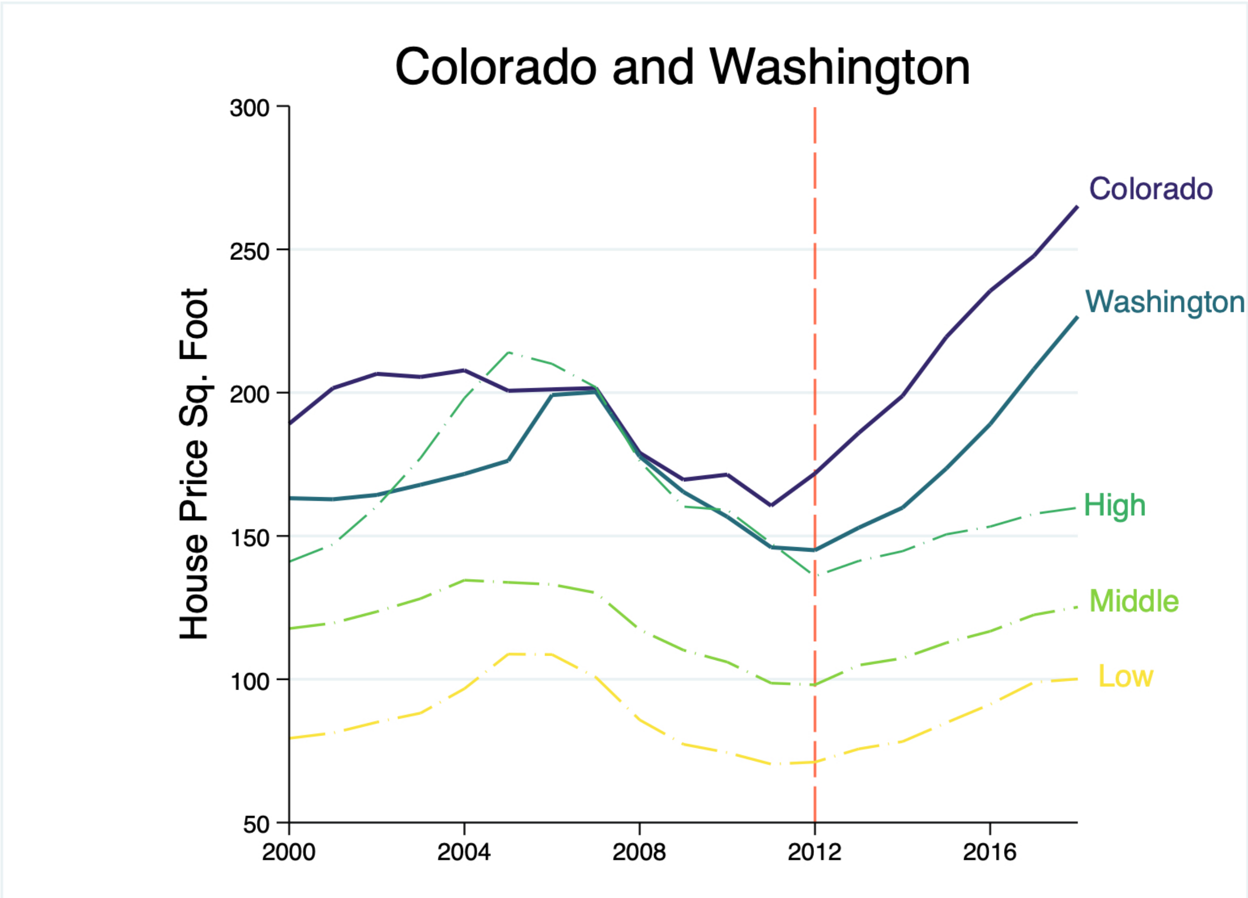

Figure 1: Trend of Average House Price Per Sq. Foot (CO, WA)

Note: (i) Control states are divided into three groups – high, middle, and low – based on their average home price per square foot. The low group is composed of Alabama, Florida, New Hampshire, Rhode Island, South Carolina, Tennessee, Texas, and West Virginia. The middle group consists of Georgia, Iowa, Kentucky, Mississippi, Montana, Nebraska, North Carolina, and Pennsylvania. The high group is made of Connecticut, Washington D.C., Delaware, Illinois, Minnesota, New Jersey, Virginia, and Wisconsin. (ii) The vertical line reflects the recreational marijuana legalization date for Colorado and Washington, 2012.

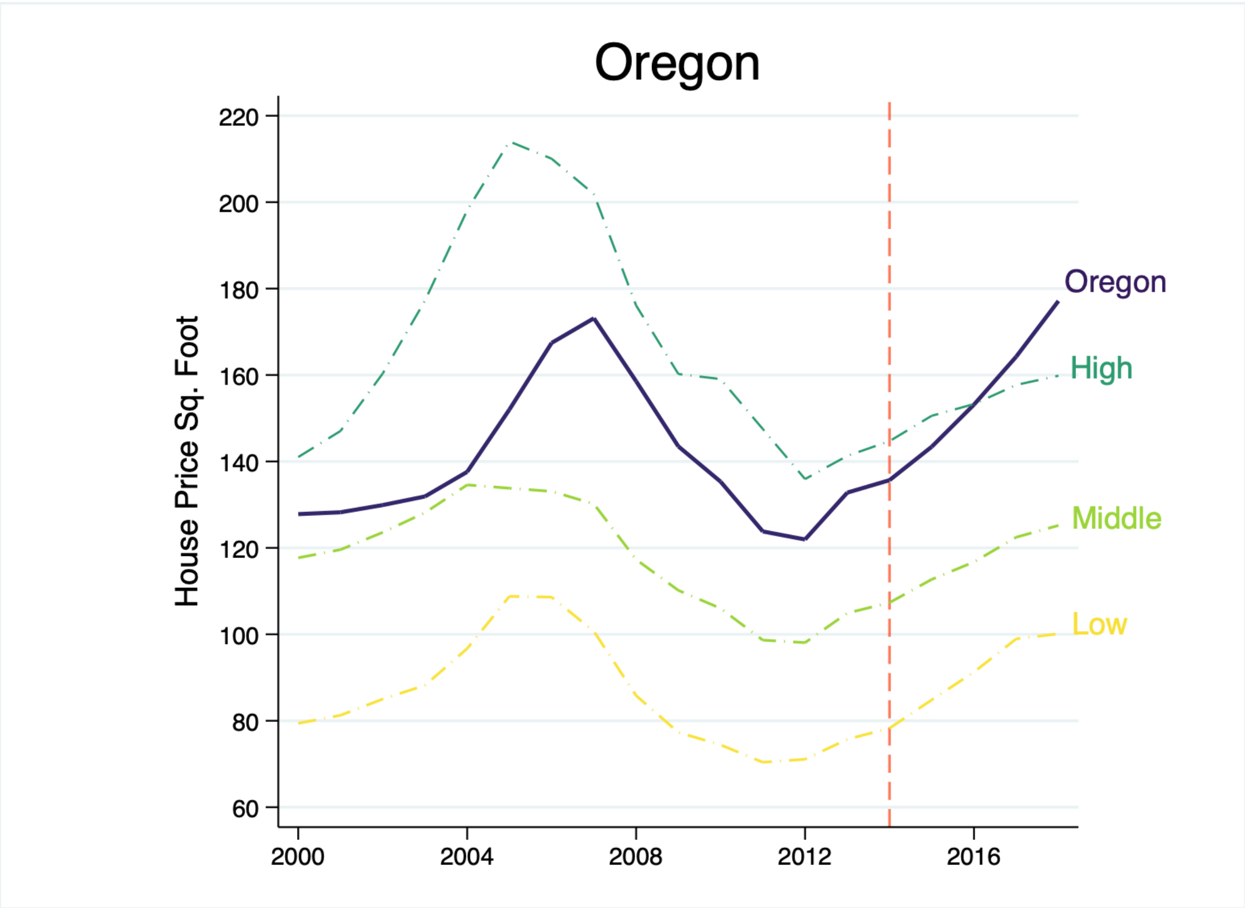

Figure 2: Trend of Average House Price Per Sq. Foot (OR)

Note: The control grouping is the same as in Figure 1. The vertical line reflecting the RML treatment date is 2014 for Oregon.

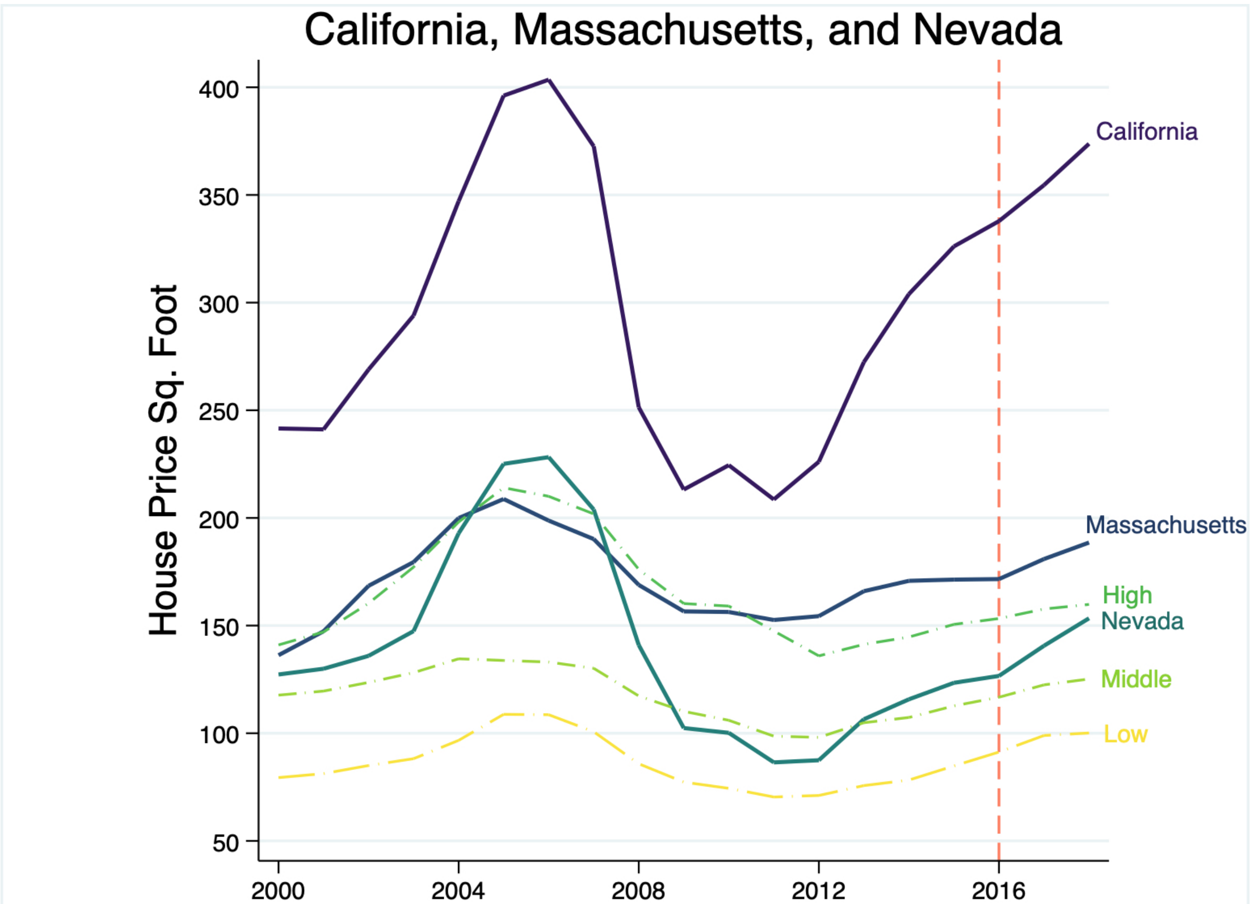

Figure 3: Trend of Average House Price Per Sq. Foot (CA, MA, NV)

Note: The control grouping is the same as in Figures 1 and 2. The vertical line reflecting the RML treatment date is 2016 for California, Massachusetts, and Nevada.

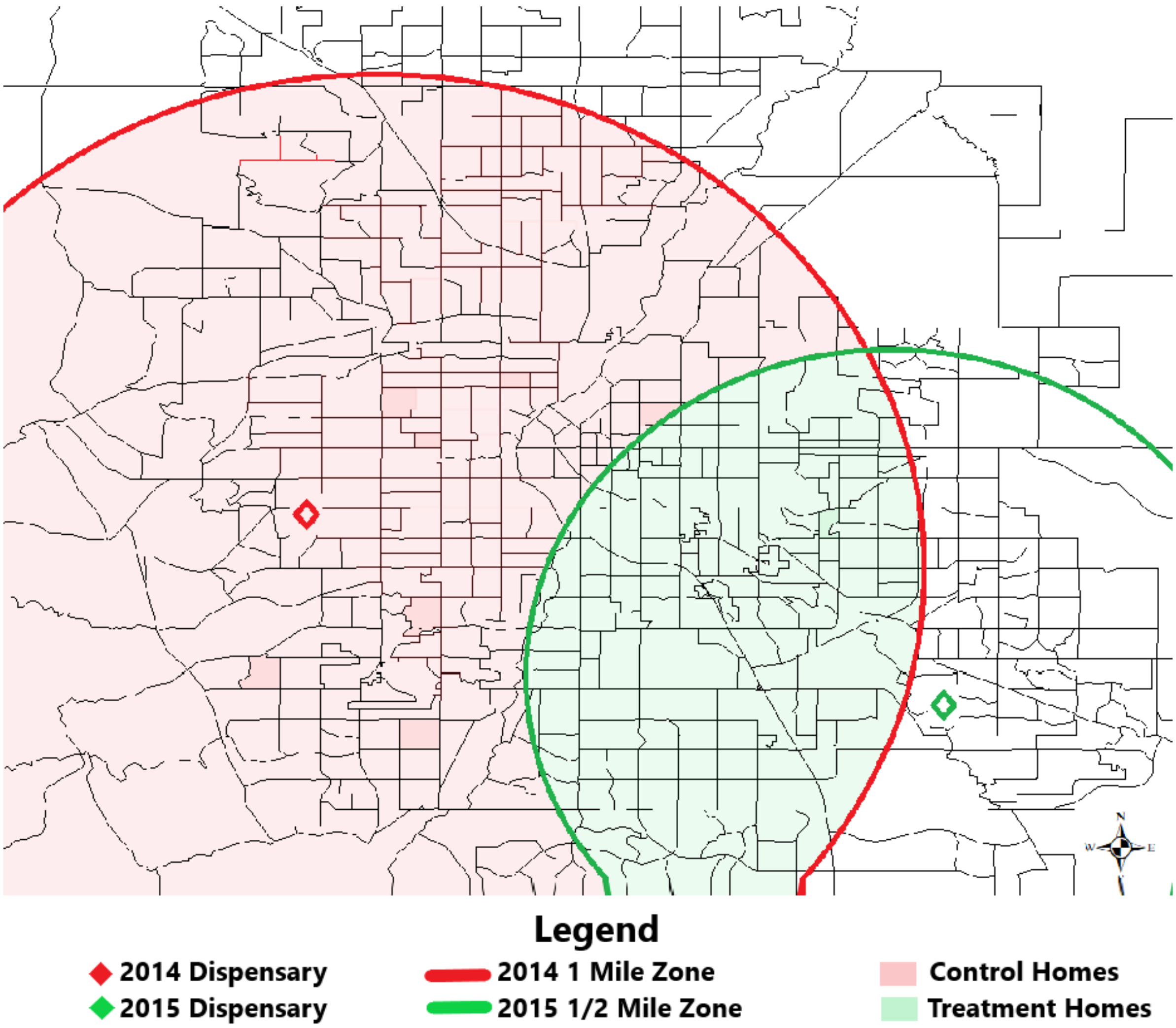

Figure 4: Illustration of Spatial Difference in Difference Model in Denver, Colorado

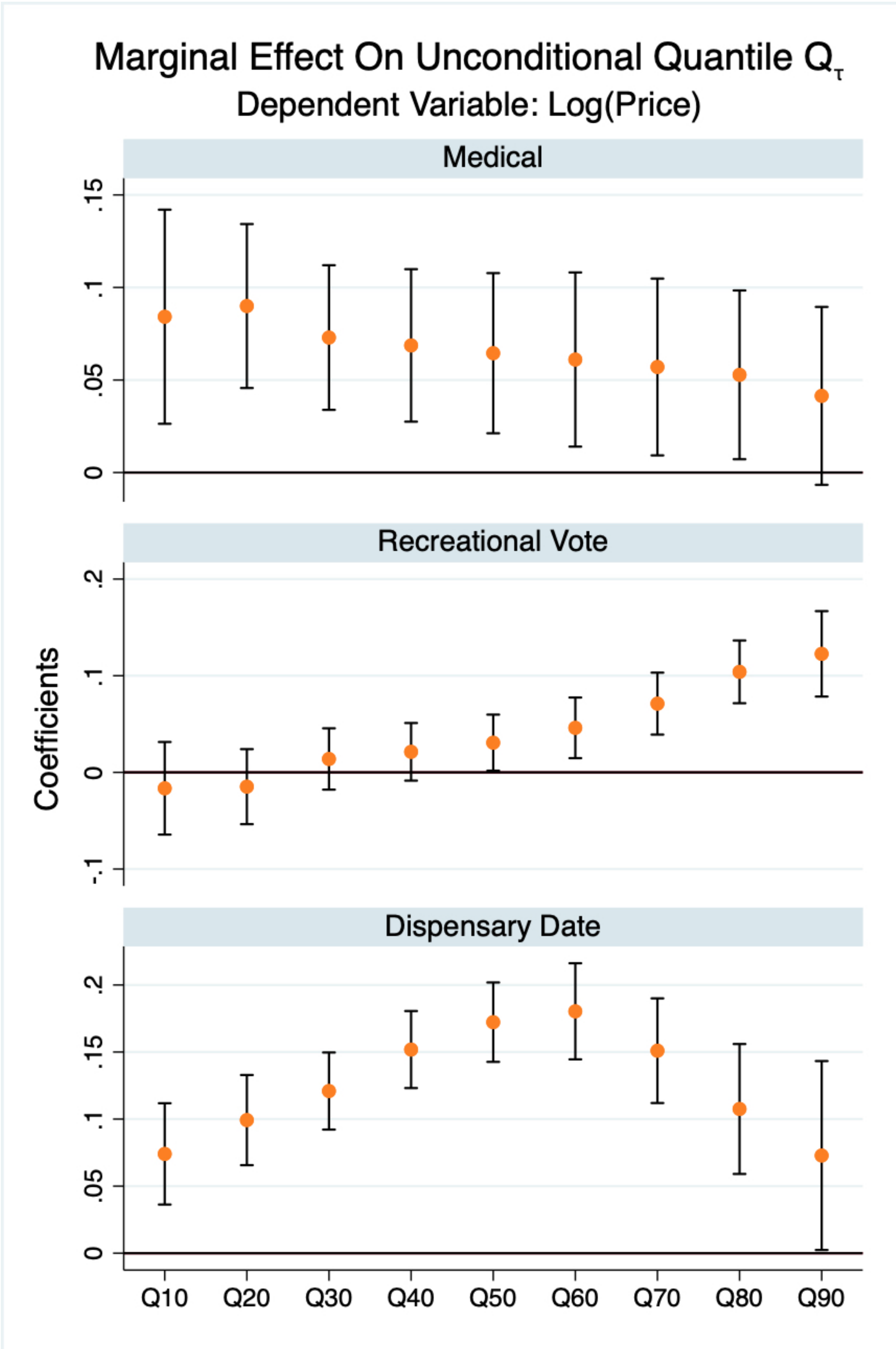
Marginal Effect On Unconditional Quantile Q_τ
Dependent Variable: Log(Price)
Medical
Recreational Vote
Dispensary Date
Coefficients
0
.05
.1
.15
-.1
.2
Q10
Q20
Q30
Q40
Q50
Q60
Q70
Q80
Q90

Figure 5

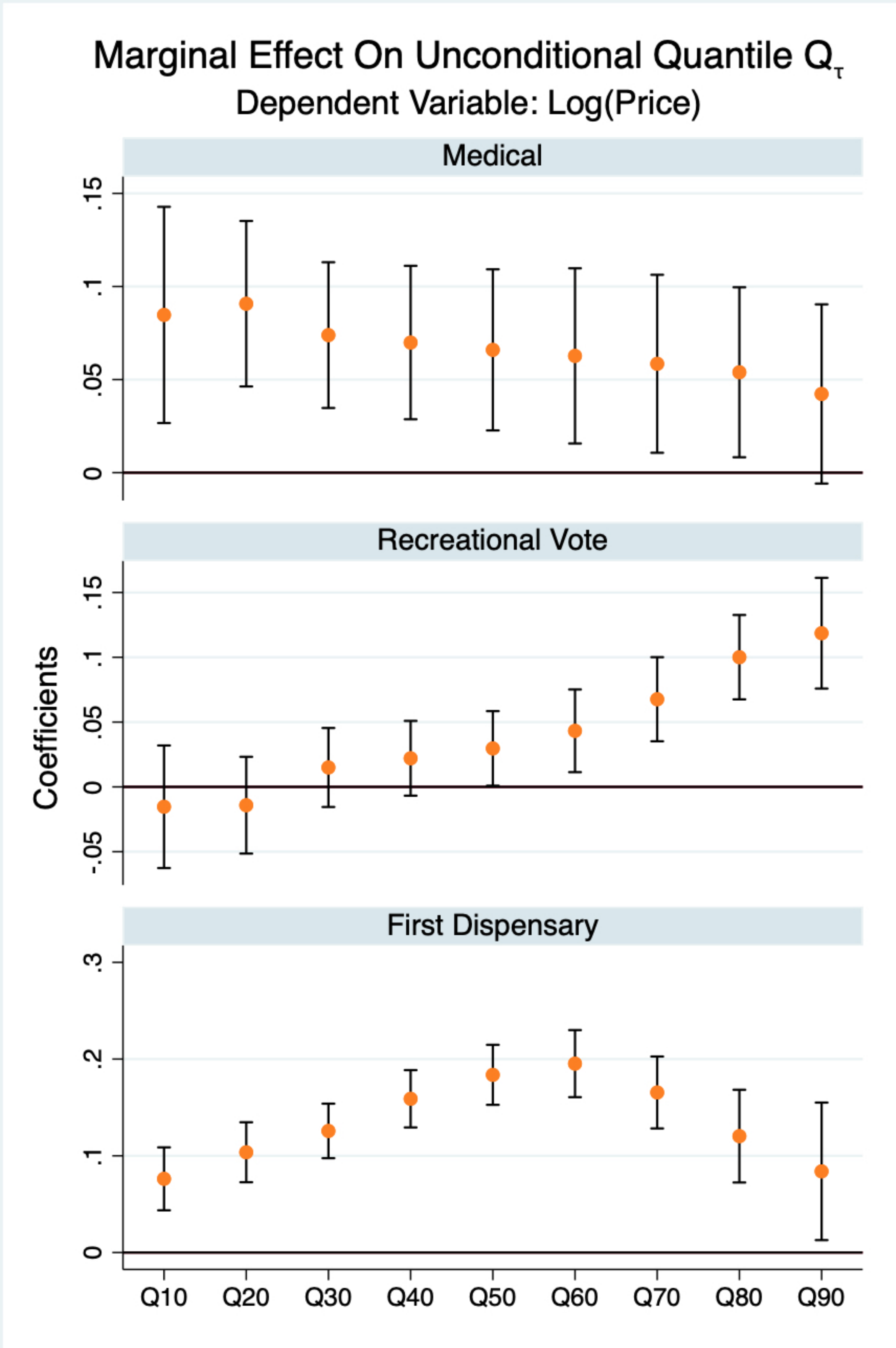
Marginal Effect On Unconditional Quantile Qτ
Dependent Variable: Log(Price)
Medical
Recreational Vote
First Dispensary
Coefficients
0
.05
.1
.15
-.05
.2
.3
Q10
Q20
Q30
Q40
Q50
Q60
Q70
Q80
Q90

Figure 6

Appendix A: Data Cleaning Description

Zillow Housing Data

Considering the size and scope of the Zillow ZTRAX repository, it is necessary to document the data cleaning process used for this research. However, in order to create a dataset that is both national and representative, some adjustments were made to the import process. In general, the effort follows Zillow's own script which creates a hedonic dataset.[6] The end product results in a dataframe in which each row is a home transaction and each column reflects home and transaction characteristics. The files are initially imported state-by-state and then appended together to make a master file.

The process goes as follows. First, three tables are imported from the Assessment repository: Main, Building, and BuildingAreas. These three tables combine to provide house characteristics, as well as information about the type of property exchanged in a given transaction. For example, the variable "PropertyLandUseStndCode" in the Building table details whether a property is a single-family residence, used in industry, is a farm, et cetera. We erred on the side of inclusivity when filtering for these variables during import, as reporting standards across counties and states vary widely. The properties included are described as follows in Zillow's documentation:

1. Residential General
2. Single-Family Residences
3. Rural Residences
4. Mobile Home
5. Townhouse
6. Cluster Home
7. Condominium
8. Cooperative
9. Row House
10. Planned Unit Development

[6] The original file is publicly available on the firm's ZTRAX GitHub repository: `https://github.com/zillow-research/ztrax/blob/master/ExampleRcode_UsingZTRAXtoCreateHedonicDataset.R`

11. Residential Common Area
12. Seasonal, Cabin, Vacation Residence
13. Bungalow
14. Zero Lot Line
15. Manufactured, Modular, Prefabricated Homes
16. Patio Home
17. Garden Home
18. Landominium
19. Inferred Single-Family Residential

Also, following the logic described by Zillow, we filter the "BuildingAreaStndCode" from the BuildingAreas table in order to get as accurate a measure of total square footage as possible. Again, different counties have different reporting standards as to what is included in their square footage calculations, so to ensure consistency we have included only those options which enumerate the buildings on the property, not the land itself. These two filters – for "PropertyLandUseStndCode" and "BuildingAreaStndCode" – are the only two at this point in the process. Once this is complete, the three assessment tables are merged to create a single assessment file with all the necessary housing characteristic variables to be used in analysis.

The second set of data comes from the Transaction repository. Included are the PropertyInfo and Main tables. All the information provided here reflects the transaction itself, not any characteristics of the home. This includes variables like the price of the transaction, the date of transfer, and the type of transfer. The only filtering that occurs in this step is in regard to the variable "DataClassStndCode," which details the type of transaction occurring. Since the subject of study are property transactions, only deed transfers and deed transfers with concurrent mortgages are included. This excludes other types of transactions, including foreclosures and inter-family transfers as in the case of inheritances. These two tables are appended together to make a single transaction file. Finally, the transaction and assessment files are combined to make a single master file for a given state. The states files are then appended together to make a national-level dataset which is then used for analysis.

The master file is filtered to exclude extreme observations, as well as define the period of study. To ensure that results are not being driven but incorrect or implausible observations, we drop transactions which had sales prices below \$10,000 and above \$10,000,000, similar to Cheng et al. (2018). On the lower end it is unlikely that transactions with prices below \$10,000 occurred on the market, and may have slipped through the "DataClassStndCode" filter. Prices above \$10,000,000 are extraordinary and in some cases are likely the result of data entry errors. Similarly, house characteristics are filtered to exclude observations that are in the top thousandth or top ten-thousandth percentile. Doing so, for example, eliminated an observation with over 1000 bedrooms. This process removed a large number of observations in states which do not require counties to report the home characteristics, leaving small states like Maine with just 11,000 transaction observations. To guarantee a representative sample, we then dropped states which did not have at least 100,000 observations. That is an arbitrary standard, but by doing so we can more confidently argue that each states' market is properly represented. Finally, prices were adjusted to reflect 2018 prices using the Federal Reserve's Consumer Price Index.

Appendix B: Additional Model Specifications

Table 7: Effect of Recreational Marijuana Legalization on House Price per Sq. Foot

	log (Price per Sq. Foot)									
	OLS					Fixed Effects				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Medical	0.466***				0.461***	0.046**				0.069***
	(0.035)				(0.035)	(0.020)				(0.021)
Recreational Vote		0.187***			0.088***		0.108***			0.055***
		(0.030)			(0.020)		(0.014)			(0.014)
Recreational Possession			0.193***					0.109***		
			(0.031)					(0.015)		
Dispensary Date				0.169***	0.001				0.141***	0.116***
				(0.037)	(0.030)				(0.015)	(0.011)
Bedrooms	-0.434***	-0.458***	-0.458***	-0.459***	-0.433***	-0.102***	-0.102***	-0.102***	-0.102***	-0.102***
	(0.035)	(0.036)	(0.036)	(0.036)	(0.036)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Bedrooms^2	0.044***	0.047***	0.047***	0.047***	0.044***	0.004*	0.004*	0.004*	0.004*	0.004*
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Bathrooms	0.188***	0.192***	0.192***	0.192***	0.187***	0.044***	0.044***	0.044***	0.045***	0.045***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)
Age	0.001**	0.001	0.001	0.001	0.001**	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age^2	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GDP Per Capita	0.356***	0.828***	0.826***	0.870***	0.314***	1.323***	1.273***	1.273***	1.302***	1.252***
	(0.053)	(0.062)	(0.062)	(0.061)	(0.059)	(0.109)	(0.114)	(0.114)	(0.113)	(0.111)
Density	0.004***	-0.004	-0.003	-0.004	0.005***	-0.003	-0.002	-0.002	-0.002	-0.001
	(0.001)	(0.003)	(0.003)	(0.003)	(0.001)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)
City FE	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Year-Quarter FE	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
City Clustered S.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.161	0.099	0.099	0.098	0.162	0.528	0.529	0.529	0.529	0.530
F-stat	98.63	73.48	73.65	72.09	88.95	129.3	156.7	157	161.8	134.9
Observations	38,145,054	38,145,054	38,145,054	38,145,054	38,145,054	38,144,444	38,144,444	38,144,444	38,144,444	38,144,444

Note: (i) The dependent variable is the log of house price per square foot while the first half columns are OLS results and the latter half are FE results. (ii) Possession dummy is excluded in our main columns (5) and (10) since the time gap between vote and possession, or sale and possession are too small to capture significantly valuable variations. (iii) City level clustered standard errors in parenthesis to take into account the correlations of error terms.

$***: p < 0.01$

$**: p < 0.05$

$*: p < 0.1$

Table 8: Effect of Recreational Marijuana Legalization on House Price (Robustness)

	log (Price)				
	(1)	(2)	(3)	(4)	(5)
Medical	0.094***	0.101***	0.095***	0.102***	0.062***
	(0.023)	(0.023)	(0.023)	(0.023)	(0.020)
Recreational Vote	0.168***	0.154***	0.161***	0.146***	0.052***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Dispensary Date	0.063***	0.074***			
	(0.013)	(0.013)			
First Dispensary			0.078***	0.091***	0.120***
			(0.011)	(0.011)	(0.011)
Bedrooms		0.023		0.023	0.035*
		(0.021)		(0.021)	(0.020)
Bedrooms^2		-0.005**		-0.005**	-0.007***
		(0.002)		(0.002)	(0.002)
Bathrooms		0.136***		0.136***	0.135***
		(0.007)		(0.007)	(0.007)
log(Sq. Feet)		0.654***		0.654***	0.645***
		(0.017)		(0.017)	(0.016)
Age		-0.002***		-0.002***	-0.002***
		(0.000)		(0.000)	(0.000)
Age^2		0.000*		0.000*	0.000**
		(0.000)		(0.000)	(0.000)
GDP Per Capita					1.282***
					(0.104)
Density					-0.001
					(0.002)
R-squared	0.427	0.601	0.428	0.601	0.611
F-stat	83.05	1116	77.29	1070	1017
Observations			38,144,444		

Note: (i) Various levels of controls are used to ensure that the models are not misspecified. (ii) City level clustered standard errors in parenthesis to take into account the correlations of error terms.
$***: p < 0.01$
$**: p < 0.05$
$*: p < 0.1$

Table 9: Heterogeneous Effect of Marijuana Legalization on House Price across Q_τ

	Log(Price per Sq. Foot)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Q10	Q20	Q30	Q40	Q50	Q60	Q70	Q80	Q90
Recreational Vote	-0.016	-0.015	0.014	0.021	0.031**	0.046***	0.071***	0.104***	0.123***
	(0.024)	(0.020)	(0.016)	(0.015)	(0.015)	(0.016)	(0.016)	(0.017)	(0.023)
Dispensary Date	0.074***	0.099***	0.121***	0.152***	0.172***	0.180***	0.151***	0.108***	0.073**
	(0.019)	(0.017)	(0.015)	(0.015)	(0.015)	(0.018)	(0.020)	(0.025)	(0.036)
Medical	0.084***	0.090***	0.073***	0.069***	0.064***	0.061**	0.057**	0.053**	0.041*
	(0.030)	(0.023)	(0.020)	(0.021)	(0.022)	(0.024)	(0.024)	(0.023)	(0.025)
R-squared	0.060	0.123	0.179	0.218	0.243	0.254	0.247	0.220	0.163
F-stat	24.99	50.24	88.05	138.1	162.9	163.9	136.8	101	49.36
Number of Cities					10,640				
Observations					38,145,054				

Note: (i) Possession dummy is excluded since the time gap between vote and possession, or sale and possession are quite small. (ii) House characteristics such as the number of bedrooms, bathrooms, year built and state characteristics such as state GDP, population, land area, and density are controlled in the regressions. (iii) City level clustered standard errors in parenthesis to take into account the correlations of error terms.

$*** : p < 0.01$

$** : p < 0.05$

$* : p < 0.1$

Table 10: Heterogeneous Effect of Marijuana Legalization on House Price across Q_τ

	Log(Price per Sq. Foot)								
	(1) Q10	(2) Q20	(3) Q30	(4) Q40	(5) Q50	(6) Q60	(7) Q70	(8) Q80	(9) Q90
Recreational Vote	-0.015	-0.014	0.015	0.022	0.030**	0.043***	0.068***	0.100***	0.119***
	(0.024)	(0.019)	(0.016)	(0.015)	(0.015)	(0.016)	(0.017)	(0.017)	(0.022)
First Dispensary	0.076***	0.104***	0.126***	0.159***	0.184***	0.195***	0.165***	0.120***	0.084**
	(0.017)	(0.016)	(0.014)	(0.015)	(0.016)	(0.018)	(0.019)	(0.024)	(0.036)
Medical	0.085***	0.091***	0.074***	0.070***	0.066***	0.063***	0.058**	0.054**	0.042*
	(0.030)	(0.023)	(0.020)	(0.021)	(0.022)	(0.024)	(0.024)	(0.023)	(0.025)
R-squared	0.060	0.123	0.179	0.218	0.243	0.254	0.247	0.220	0.164
F-stat	25.04	50.75	88.60	138.1	161.5	162.2	136.2	100.6	48.94
Number of Cities					10,640				
Observations					38,145,054				

Note: (i) First Dispensary is used in place of Dispensary Date for the purpose of a robustness check. (ii) The Possession dummy is excluded since the time gap between Recreational Vote and Recreational Possession, or First Dispensary and Recreational Possession are quite small. (iii) House characteristics such as the number of bedrooms, bathrooms, year built and state characteristics such as state per capita GDP, and density are controlled in the regressions. (iv) City level clustered standard errors in parenthesis to take into account the correlations of error terms.

$*** : p < 0.01$

$** : p < 0.05$

$* : p < 0.1$

Table 11: Spatial Difference-in-Differences: Colorado Subsample

	log (Price)		
	(1)	(2)	(3)
1/2 Mile Zone	0.059***	0.114***	0.123***
	(0.003)	(0.003)	(0.003)
1 Mile Zone	-0.036***	0.041***	
	(0.003)	(0.003)	
2 Mile Zone	-0.067***		
	(0.003)		
Control Group	Outside 2 Miles	Within 2 Miles	Within 1 Mile
Observations	447,501	256,699	218,605
R-squared	0.411	0.414	0.413
F-stat	18,278	11,298	10,470

The results in this table are from the same model specification as in the Spatial Difference-in-Differences Table 6, but limited to the observations in the Colorado subsample. House characteristics and county-level economic data are used as controls with robust standard errors.

$***: p < 0.01$
$**: p < 0.05$
$*: p < 0.1$

Table 12: Spatial Difference-in-Differences: Washington Subsample

	log (Price)		
	(1)	(2)	(3)
1/2 Mile Zone	0.061***	0.065***	0.061***
	(0.002)	(0.002)	(0.002)
1 Mile Zone	-0.015***	-0.006***	
	(0.003)	(0.002)	
2 Mile Zone	-0.013***		
	(0.003)		
Control Group	Outside 2 Miles	Within 2 Miles	Within 1 Mile
Observations	438,332	393,738	347,318
R-squared	0.491	0.510	0.519
F-stat	31537	32975	33053

The results in this table are from the same model specification as in the Spatial Difference-in-Differences Table 6, but limited to the observations in the Washington subsample. House characteristics and county-level economic data are used as controls with robust standard errors.
$*** : p < 0.01$
$** : p < 0.05$
$* : p < 0.1$