Getting High and Low Prices: Marijuana Dispensaries and Home Values

Justin Tyndall

jtyndall@hawaii.edu
University of Hawai'i at Manoa

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Abstract

Laws concerning marijuana have recently undergone liberalization in many North American markets. The changing legal environment has enabled the establishment of retail marijuana dispensaries. Local externalities generated by dispensaries may impact home values, particularly by influencing demand for the surrounding neighbourhood. Recent empirical evidence has found a positive effect of dispensaries on home values. I use unique data on 84 dispensaries and 62,000 repeat home transactions from Vancouver, Canada to estimate the effect of dispensaries on home prices. Historical Google Street View images are used to construct a longitudinal record of dispensary activity. I find no evidence that dispensaries increase local home values in Vancouver and some evidence of a negative price effect for homes located within 100 meters of a dispensary.

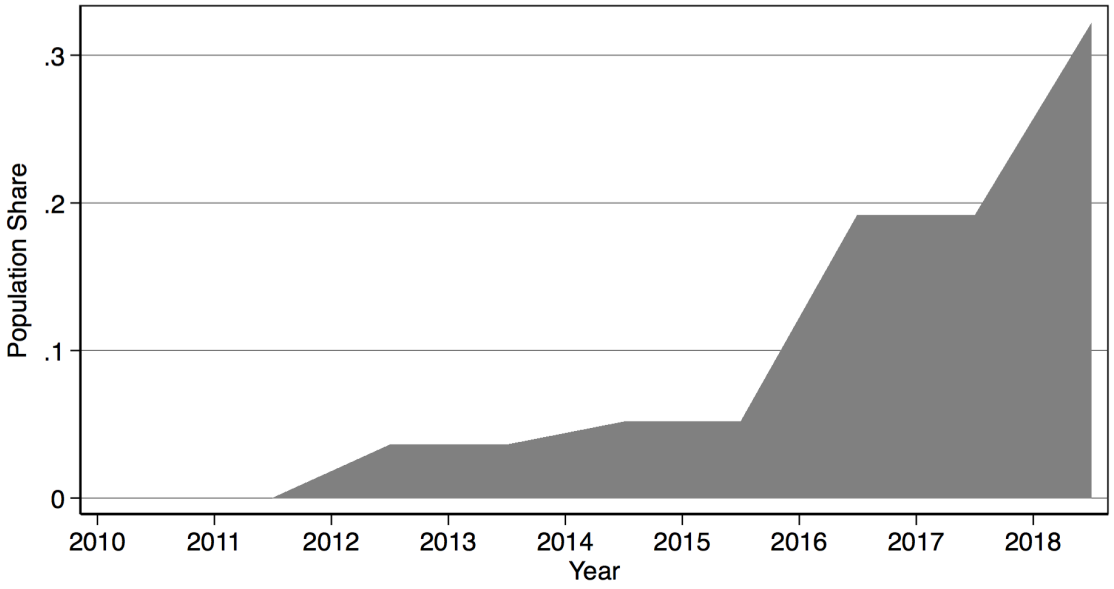
JEL: R21, R30, R31, R38

Housing, Marijuana, Local Amenity, Real Estate

Introduction

In 2011, no US state or Canadian province had sanctioned the sale of recreational marijuana. By the end of 2018, all Canadians and 25% of Americans lived in a jurisdiction where the sale of recreational marijuana was legal (Figure 1). The retail sale of recreational marijuana is commonly conducted through store fronts known as dispensaries. Marijuana dispensaries constitute a possible source of neighbourhood amenity (or disamenity) that has heretofore been largely unstudied. This study will estimate the effect of marijuana dispensaries on local home values in Vancouver, Canada. Understanding the neighbourhood effects of marijuana dispensaries will be vital to forming policy to regulate this new industry.

Figure 1: Share of Canadian and US Residents Living in a Jurisdiction Where Recreational Marijuana is Legal



In 2011, recreational marijuana was illegal in all 50 US states, the District of Columbia and Canada. At the end of 2018, 32% of Canadian and American residents lived in a jurisdiction where recreational marijuana was legal. US population data are from the US Census. Canadian population data are from Statistics Canada.

The first state to legalize recreational marijuana in the US was Colorado. Three notable studies have been conducted to investigate the home price effects of dispensaries in Colorado. Conklin et al. (2016) examined retail establishments that converted from medical marijuana providers to recreational marijuana providers, contemporaneous with

the state's legalization of recreational marijuana. The study compared homes near dispensaries to those located farther away, using controlled regressions. The central finding of Conklin et al. (2016) was that single-family homes within 0.1 miles of a recreational dispensary experienced an 8% increase in value. The effect was interpreted as causal. The authors hypothesised that the price increase could be the result of the increased local housing demand of dispensary employees and customers. However, Conklin et al. (2016) remained agnostic regarding the true underlying causal mechanisms. Burkhardt and Flyr (2018) also examined the Denver market and followed a similar methodology to Conklin et al. (2016), but estimated the average effect of a local dispensary generally, rather than estimating the effect of conversions from medical providers to recreational dispensaries. The study found that a home within a half-mile of a dispensary sold at an 8% premium, confirming the positive effect identified in Conklin et al. (2016).

The home price effect of legalized recreational marijuana in Colorado was also studied in Cheng et al. (2018). The study compared average home values at the municipal level, contrasting municipalities that allowed dispensaries with those that did not. Results indicated that allowing the operation of dispensaries generated a 6% increase in home values within a municipality, relative to municipalities that did not allow recreational dispensaries. The authors found larger positive effects among lower priced homes.

To the author's knowledge, the above studies represent the totality of empirical research estimating the effect of dispensaries on home values. Given that the estimates of Conklin et al. (2016) and Burkhardt and Flyr (2018) are surprising in their magnitude, and potentially the direction of the effect, it is worth effort to build additional evidence from other environments. As noted in the past studies, the effect of dispensaries on home prices may vary depending on the city studied and the details surrounding the legal status of marijuana. The current study focuses exclusively on Vancouver. Given differences in the details of the Vancouver and Denver markets, results may not be directly comparable. However, results from Vancouver provide additional evidence towards understanding the general effect of dispensaries on real estate markets.

Notwithstanding the above studies, it is plausible that dispensaries are a source of negative local externalities. A general discussion of dispensaries and their potential to act as a locally undesirable land use (LULU) in Denver is undertaken in Boggess et al. (2014). If dispensaries are undesirable they may be directed towards disadvantaged neighbourhoods, and once established, they may further reduce neighbourhood housing demand and property values. Boggess et al. (2014) demonstrated that local poverty and crime rates are higher in neighbourhoods that host medical marijuana dispensaries.

However, controlled regressions suggested that the correlation is spurious and can be explained by the general tendency of commercial firms to be located in neighbourhoods with higher poverty and crime. Morrison et al. (2014) conducted a spatial examination of dispensaries in California and found that they were more likely to locate in areas with below average local incomes and diminished political power.

In addition to Boggess et al. (2014), other studies have attempted to establish a relationship between dispensaries and crime rates. Kepple and Freisthler (2012) analyzed the spatial relationship between crime and medical marijuana dispensaries in Sacramento, California. The study found that dispensaries were not predictive of local crime rates. In an evaluation of the effect of medical marijuana legalization on crime rates across California, Morris et al. (2014) found no evidence that legalization increased crime. A study of sudden dispensary closures in Los Angeles actually found the closures to be correlated with increases in local crime (Chang and Jacobson, 2017). The authors suggest this is due to a vacancy effect, where the reduction in people around the commercial storefront provide an attractive location to commit crimes. While dispensaries do not appear to raise crime, the perception of the drug industry as a source of illicit behaviour may generate an aversion among some residents to living adjacent to a dispensary.

The use of marijuana and other drugs are generally stigmatized by society (Room, 2005). A study in Toronto, Canada concluded that marijuana use is commonly associated with deviant behaviour (Hathaway, 2004). Satterlund et al. (2015) found that even medical marijuana users in California experienced strong feelings of societal stigmatization. The stigmatization of marijuana could reduce housing demand around dispensaries, as residents resist locating close to an activity they consider to have negative social connotations.

The estimation of the effect of marijuana dispensaries on local home values has direct relevance to regulatory and zoning policy. If dispensaries carry strong local negative externalities, their presence may reduce the welfare of surrounding residents. However, dispensaries may represent a positive local amenity for some individuals. Dispensaries provide a convenience for individuals who wish to purchase marijuana and provide employment for local workers. Dispensaries may also contribute to government tax revenue, which could be invested in welfare improving public works (Hollenbeck and Uetake, 2018). The net impact of dispensaries on home values is therefore ambiguous and an empirical question.

The methodological approach undertaken in this paper is similar to other studies examining home value effects of local amenities (or disamenities), for example Currie et al.

(2015), Davis (2011) or Harding et al. (2009). An analogous project was undertaken in Brooks et al. (2018), where the authors estimated the local home value impacts of strip clubs in the Seattle area. The paper made use of longitudinal data on strip clubs to estimate price effects on surrounding homes but found no evidence that strip clubs affect local home values.

This study benefits from comprehensive data on home transactions in Vancouver, spanning 2005 to 2015. The rich and spatially disaggregated data set allows for the differing characteristics of houses and neighbourhoods to be tightly controlled for. Given a large data set, I am able to focus on repeat home sales, an approach which is unique to the related literature. The use of a repeat sales method can eliminate the influence of time varying heterogeneity in the characteristics of homes being transacted (Case and Shiller, 1990; Shiller, 1991). Data on marijuana dispensaries can be difficult to obtain given the reticence of dispensary owners to disclose operations due to questionable legality. A lack of disclosure of operations has made the marijuana industry difficult to study. I implement a unique data collection approach by identifying dispensary activity through a combination of municipally supplied data and Google Street View images. I identify the presence of dispensaries by observing store fronts over time. The novel methodology will be subjected to numerous robustness checks.

The current paper empirically estimates the effect of marijuana dispensaries on the transaction price of homes in Vancouver. The findings provide evidence from the study period that home buyers in Vancouver generally do not consider dispensaries to be a local amenity. I provide results from 10 alternative regression specifications and housing submarkets. Overall, I conclude that marijuana dispensaries have essentially zero effect on home prices. A potential exception is for homes very close (within 100 meters) of a dispensary. For homes within 100 meters of a dispensary I estimate that dispensaries cause a small reduction in home price. The statistical significance of this result is dependent on the estimation approach used. Results are in significant contrast to the large, positive price effects reported by prior studies. I provide discussion regarding the probable source of conflict between my findings and the findings of the Denver studies. In particular, the Vancouver study period spans a time when dispensaries were largely considered as an illegal land use, which may have contributed to an aversion among home buyers to live near a dispensary. Additionally, legal uncertainty caused dispensaries to face a risk of forced closure, which may have impacted the decisions of dispensary owners regarding investment and location. While the particular conditions are specific to Vancouver, the ambiguity of legal status caused by different levels of government removing restrictions at

different times has some commonality with the process of legalization in US jurisdictions. The specifics of the Vancouver study environment will be discussed and are relevant to the interpretation of results.

The legalization and retail sale of recreational marijuana is likely to have broad societal impacts. I limit my analysis to the home price effects of dispensaries and leave to future work the task of estimating broader societal impacts.

The Vancouver Marijuana Market

Marijuana is consumed by a small share of the Canadian population. 12.2% of Canadians over the age of 15 report using cannabis at least once per year.[1] Given consumption habits, only a small minority of Canadians would directly value the ability to purchase marijuana locally. A 2017 poll of Canadians found that only 23% of respondents would support a privately owned marijuana dispensary "within proximity" of their home.[2] According to polling, there is little evidence to support the hypothesis that Canadian residents consider dispensaries as a local amenity.

During the period of study, marijuana dispensaries in Vancouver operated with ambiguous legality. While medically prescribed marijuana had been legal throughout Canada since 2001, dispensaries operating in Vancouver typically did not meet the federal regulations surrounding medical marijuana sales and evolved to embrace a liberal definition of what constituted a valid medical need. For example, many dispensaries began employing on-site health care workers to issue marijuana prescriptions in exchange for a membership fee. A local news investigation in 2014 attempted to procure membership cards from local dispensaries and concluded that, "recreational marijuana may as well be legal in the city of Vancouver."[3] In response to the rapid growth of recreational marijuana establishments, operating under the moniker of medical marijuana, the City of Vancouver passed a by-law in June of 2015, effectively regulating retail marijuana establishments. The by-law provided tacit approval at the municipal level for the operation of some retail marijuana establishments. Additionally, the Vancouver Police Department put forward an official policy in which it generally declined to close dispensaries or prosecute dispensary operators, despite an acknowledgement that the operation of dispensaries violated federal law.[4]

[1]Statistics Canada, Cannabis Stats Hub, 2012. Reported use in the province of British Columbia, which contains Vancouver, is 14.4%.

[2]Navigator, *Cannabis in Canada*, 2017.

[3]Vancouver Sun. *Medical marijuana: Easy to get, easy to buy*, 09/02/2014.

[4]Vancouver Police Department, Report to the Vancouver Police Board, Service and Policy Complaint

Preceding a federal election on October 19, 2015, the Liberal Party of Canada included in it's official platform a commitment to "design a new system of strict marijuana sales and distribution" (Liberal Party of Canada, 2015). The Liberal Party was subsequently elected with a majority of the seats in the national parliament. The Liberal victory initiated a public expectation that the sale of recreational marijuana would become legal. After a series of legislative delays the final date for national legalization was set for October 17, 2018. A general history of marijuana and its prohibition in Canada can be found in Kenny and Nolin (2003).

The bulk of legislation to legalize marijuana in Vancouver came into effect after the period of study, which extends to the end of 2015. However, legislation was developed in response to the existing recreational marijuana market that had been operating with impunity in Vancouver and other Canadian cities. Legal uncertainty regarding the operation of dispensaries in Vancouver during the study period is important for a number of reasons. First, obtaining firm level data for marijuana dispensaries is difficult because business licences were not issued for marijuana dispensaries prior to the municipal by-law change in 2014, and after 2014 only a subset of active dispensaries obtained licences. Therefore, publicly available business licence data does not reflect dispensary activity, necessitating data collection from nontraditional sources. The issue is not unique to Vancouver, but represents a general barrier to the study of illicit markets. Second, living adjacent to an illegal land use may represent a disamenity for residents, above and beyond any distaste for living next to a dispensary *per se*. As marijuana sales become legal in Canada the home price effect of living adjacent to a dispensary may change as the social stigma associated with marijuana use and sales may evolve. The possible relationship between legalization, changing attitudes towards marijuana and home price effects will be generally outside the scope of this study. Results should therefore be interpreted as specific to the legal and social context of Vancouver during the study period. Proving the generalizability of results to other cities will need to rely on the future study of other markets.

Data

Empirical analysis is enabled by three novel data sources: (1) a 2015 list of dispensaries collected by the City of Vancouver, (2) approximated opening and closing dates of dispensaries collected through historical Google Street View (GSV) images and (3)

#2015-112 regarding enforcement against marihuana dispensaries. 09/01/15.

a comprehensive database of Vancouver home transactions compiled by a provincial agency, the British Columbia Assessment Authority (BCAA).

In response to public concern over the growing proliferation of marijuana dispensaries and a lack of information on their operation, the City of Vancouver commissioned a census of all dispensaries operating in the city in April of 2015. The data was meant for internal use, but a freedom of information request initiated by a local newspaper compelled the city to release the list of dispensaries.[5] I obtained the original list through contact with the newspaper. The data set contains the street address and name of 84 dispensaries. The list was considered by the city to be a comprehensive list of all dispensaries in operation.

The opening and closing dates of the 84 dispensaries are not indicated in the city data set. I approximate opening and closing dates by making use of historical GSV images. By viewing the dispensary store front on multiple dates, I compile longitudinal images of the store fronts. GSV images include the month and year that the photo was taken. I infer the opening dates by examining images taken before April, 2015 and recording the latest date where the dispensary is not visible and the earliest date where the dispensary is visible. Figure 2 provides one example of inferring an opening date from GSV images. In Figure 2, the June, 2012 image shows no dispensary at the address, while the April, 2014 image shows the presence of the dispensary. I assume the dispensary opened at the midpoint of the relevant images. For the dispensary in Figure 2, the opening date is assumed to be May 15$^{\text{th}}$, 2013.

The growth in dispensaries through time is graphed in Figure 3. The earliest image in which I observe a dispensary was taken in April, 2009. In cases where the dispensary has closed, I approximate the closing date using an analogous method. I have no record of dispensaries that both opened and closed prior to April, 2015. Such instances may affect a small fraction of control observations and may be a source of bias in estimation. Adjacency to an unobserved dispensary would mean a control housing transaction was actually treated. Unobserved dispensaries would cause estimates to be biased towards zero and therefore do not explain the negative results I report.

For images that capture the change in store use from non-dispensary to dispensary, the average gap between photographs is 23 months. The method introduces a significant source of measurement error to the timing of dispensary openings. However, the method provides a substantial advantage over reliance on business licence data, which fails to capture the presence of most dispensaries and may suffer from inconsistencies in reporting.

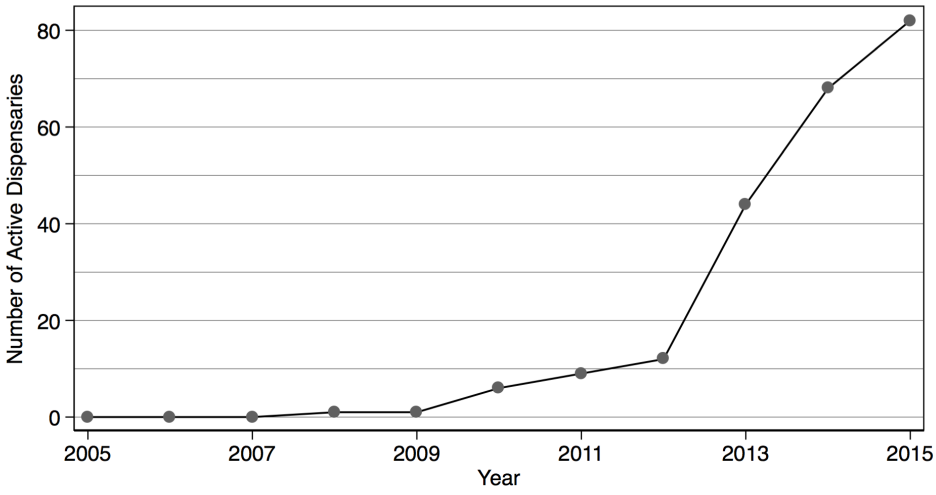
[5]The Georgia Straight, *Map: The definitive guide to Vancouver's medicinal marijuana dispensaries*, 05/04/15

Figure 2: Google Street View Methodology

June, 2012 April, 2014

Historical Google Street View data are used to approximate opening dates of dispensaries. The above images demonstrate that this particular dispensary opened between June, 2012 and April, 2014.

Figure 3: Number of Dispensaries in Vancouver



Vancouver experienced a large increase in the number of marijuana dispensaries operating in the city, particularly between 2012 and 2015.

I subject the GSV methodology to robustness checks in the Results section and find that results are robust to several alternative assumptions regarding opening dates.

Two of 84 dispensaries cannot be found in GSV images because they are located inside

shopping malls. I drop these two observations from the data set. Additionally, I drop any property transaction that occurred within 300 meters of the location of these two dispensaries, as I cannot discern the treatment status of these transactions.

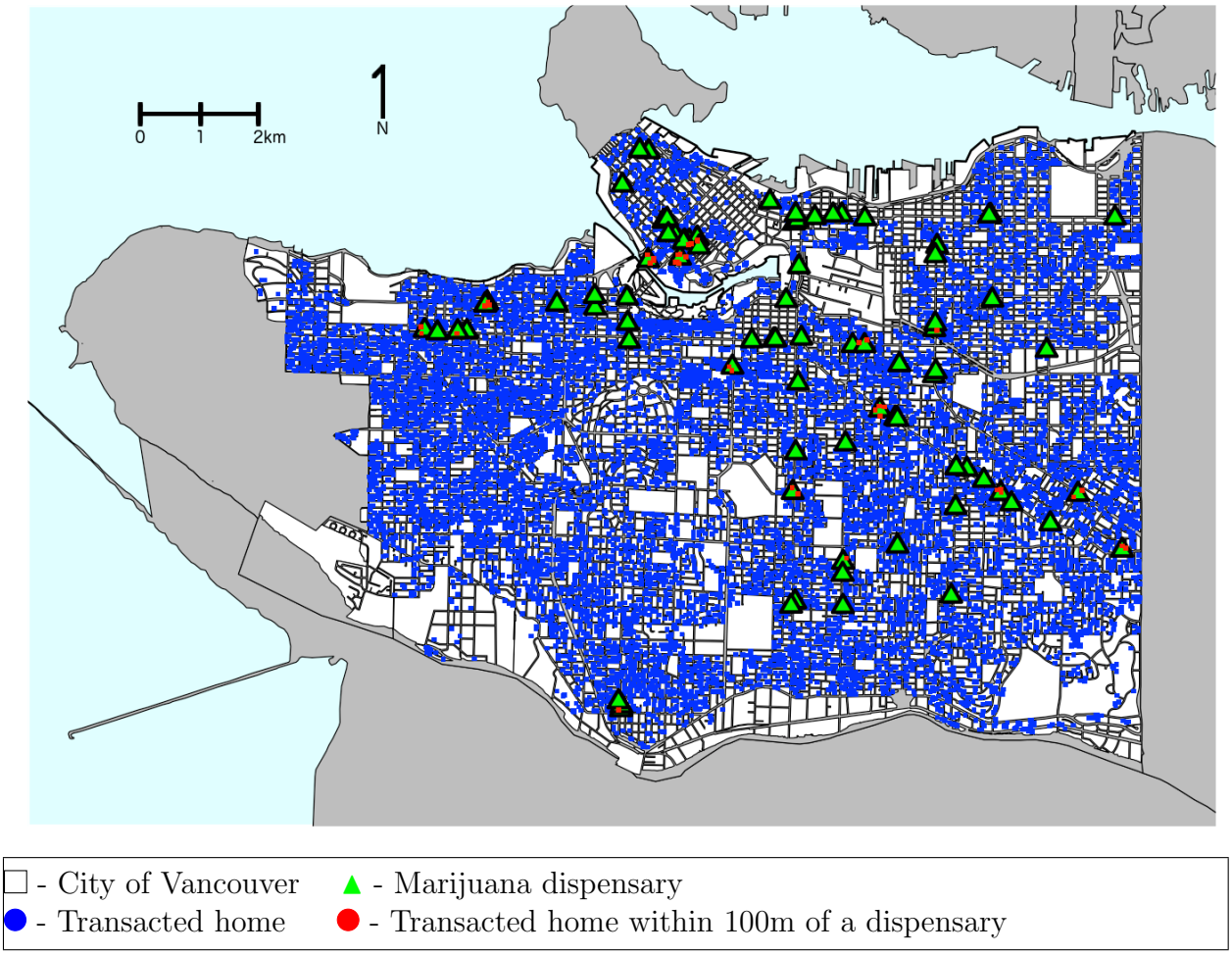
Proprietary access to data from BCAA provides the universe of housing transactions for Vancouver between January, 2005 and December, 2015. I construct a dataset of repeat home sales for the city of Vancouver. Homes that sold more than once during the period of study are retained for analysis. I limit analysis to homes that sold multiple times to enable regression fixed effects at the individual property level, removing the potentially biasing effect of changes in the composition of sold homes.

BCAA flags observations that they consider to be unrepresentative of the broader market, for example, transactions between members of a family or condominiums sold before construction. I drop all observations that BCAA deems as unrepresentative. The data also flags instances of significant home renovations. The renovation flags allow for the impact of major home renovations on sale price to be controlled for in analysis. My final set of housing transactions contains 62,498 sales from 27,091 unique properties. 20,147 of the properties sold twice during the 2005-2015 period, 5,753 sold three times and the remainder sold more than three times. The most transacted property in the data set sold eight times over the study period. The average transaction price in the final data set is \$908,370, the median is \$603,570 and the standard deviation is \$917,258. 60.3% of observed transactions are condominiums, 2.2% are duplexes and the remainder are detached, single-family homes. I report all prices in 2018 Canadian dollars.

The dispensary observations and home transaction observations have precise street addresses. I successfully geocode all street addresses using an online geocoding service. Figure 4 displays the location of the 82 dispensaries and 27,091 unique properties retained for analysis. Dispensaries are located across a large swath of Vancouver. A particularly large cluster of dispensaries are located on the dense peninsula in the north of the city, which contains Vancouver's central business district. Dispensaries are largely absent from the neighbourhoods in the south-west of Vancouver, this area contains a disproportionate share of high-value, single-family homes. Home transaction data covers all populated areas of the city.

To identify transactions that occurred near a dispensary, the distance between every transacted property and every dispensary is calculated. The distance to the nearest operating dispensary is retained for every home sale observation. The incorporation of estimated opening dates means that the closest dispensary is only drawn from the subset of

Figure 4: Location of Marijuana Dispensaries and Home Transactions



The map shows the location of the 82 marijuana dispensaries and 27,091 unique properties used in analysis.

dispensaries that were open at the time the home transacted. 1.11% of observed transactions were within 200 meters of an active dispensary, 0.70% were within 150 meters and 0.37% were within 100 meters. Many dispensaries do not have any adjacent repeat sales transactions. 18 of the 82 dispensaries had at least one repeat sale property within 100 meters. Figure 4 indicates the location of repeat sales transactions that were within 100 meters of a dispensary.

Local controls will be included at the census tract and dissemination block level. Spatial data on census tracts and dissemination blocks are obtained from Statistics Canada. Every housing transaction is assigned to a tract and block through spatial mapping software. The size of the median census tract in Vancouver is 0.962km^2 while the

median block is 0.013km^2. The average population of a tract is 5,582 people, while the average population of a block is 191 people. In almost all cases, a block corresponds to an actual city block. The locational detail of the data allows for granular spatial controls.

Estimation Methodology

This study aims to estimate the causal effect of marijuana dispensaries on local home values. A bivariate regression of home value on a measure of proximity to a marijuana dispensary would suffer from two primary sources of bias. First, the characteristics of homes that transact near a marijuana dispensary may be systematically different from those in other areas. Such spurious correlation interferes with a causal interpretation of regression results. Second, the economic trajectories of neighbourhoods that received dispensaries may differ from those that did not. For example, the owners of dispensaries may try to locate close to prospective customers. Using survey data from California, Morrison et al. (2014) found that dispensaries were more likely to locate in areas of higher demand for marijuana. To the extent that the locational preferences of dispensaries are correlated with local economic trends, the endogenous location of a dispensary may be spuriously correlated with local home price changes. The proposed methodology is designed to correct for these two sources of bias and estimate the causal effect of a dispensary on local home prices. The first issue is dealt with through property level fixed effects, the second issue through controls for spatial time trends.

Homes that sold close to dispensaries had a lower average transaction price than homes that sold elsewhere in Vancouver. Ignoring the longitudinal variation in dispensary activity, I first compare homes that were transacted close to a location that ever contained a dispensary to homes that were never close to a dispensary. Homes that transacted within 200 meters of a dispensary location sold at an average price of $580,000, while homes in other locations sold for an average price of $917,000, 58% higher. Clearly, this discrepancy can not be attributed to a causal effect of dispensaries. Housing close to dispensaries appear to have characteristics that are substantially inferior to housing in other areas of Vancouver. The preference of dispensaries to locate in low price areas is consistent with past research from Denver (Conklin et al., 2016; Boggess et al., 2014). This study will look exclusively at homes that sold multiple times during the study period, enabling the introduction of fixed effects at the individual property level. Through this repeat sales method I am able to control for any inherent differences between properties. The use of property level fixed effects also controls for any time invariant differences in neighbourhood

amenities, as property level fixed effects are nested within any possible neighbourhood level controls. Estimation is therefore based on the relative price changes of individual homes through time. As dispensaries have been shown to be systematically correlated with spatial differences in housing quality, this method will be important to establishing the causal effect of dispensaries on home prices.

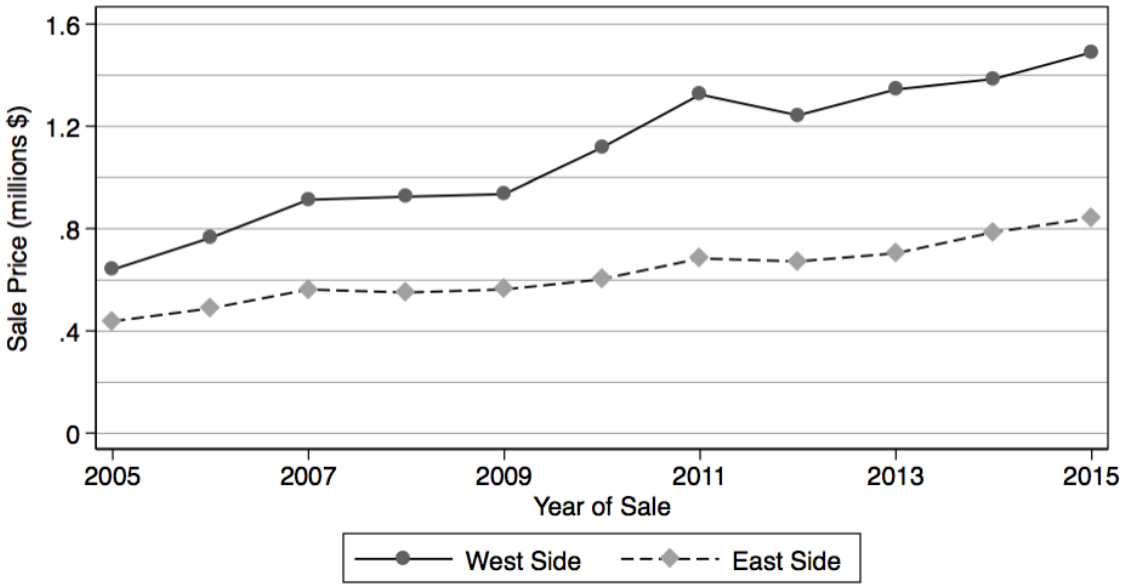
Data on home renovations allows for major home alterations to be controlled for directly. Minor renovations are unobserved and therefore are not controlled for. Billings (2015) found that endogenous renovations typically introduce only a small amount of bias in repeat sale estimations. The main results of this paper are almost identical when major renovations are not controlled for, suggesting this source of variation is not driving results.

In addition to being located in areas of below average home prices, I find that dispensaries locate in areas of below average price appreciation. Figure 5 illustrates a clear source of heterogenous home price appreciation in Vancouver. Figure 5 contrasts home appreciation on the east and west sides of Vancouver. Between 2005 and 2015 the average sale price on the east side of Vancouver increased by 92%, while the average sale price on the west side increased by 133%, in real terms. Figure 4 demonstrates that dispensaries were far more common in the low price appreciation, east side of Vancouver. While controlling for this broad trend would be simple, similar disparities in growth may exist within smaller geographies, complicating identification.

$$\text{Log Price}_{it} = \beta_0 + \beta_1(D_i \times Y_t) + \psi H_i + \phi M_t + \varepsilon_{it} \tag{1}$$

Equation 1 provides a regression framework to test for differential price appreciation trends close to dispensaries. i indexes a property and t indexes the specific year and month of the housing sale. D is a dummy variable that takes a value of one if the transaction occurred close to a dispensary site. Y captures the year of sale. Therefore, $(D_i \times Y_t)$ captures the differential price appreciation trend between homes adjacent to and not adjacent to dispensary sites. H is a property fixed effect and M is a month fixed effect. The data spans 132 months, therefore M contains 132 fixed effects. The nearness to a dispensary site necessary for D_i to take a value of one will be altered in different specifications. β_1 is the parameter of interest, reported in Table 1. I find that homes within 200 meters of a dispensary location had averaged, annual price appreciation that was 1.6% less than houses located elsewhere. The estimated effect is highly statistically significant. While some of this effect could be related to the home price impact of dispensary activity,

Figure 5: Average Home Prices in Vancouver



I delineate the east and west sides of Vancouver by Main Street (specifically -123.10 degrees latitude). The average west side home is consistently more expensive. Price appreciation is higher for west side homes. Data only includes homes that sold multiple times between 2005 and 2015. All prices are in inflation adjusted 2018 dollars.

the majority of the effect is likely spurious correlation driven by the locational decisions of dispensary operators. Differential growth trends highlight the importance of controlling for locational time trends in the main regression analysis.

Table 1: Price Appreciation Differences Between Treatment and Control Homes

	(1)	(2)	(3)
Treatment Radius:	**100 meters**	**150 meters**	**200 meters**
Differential price appreciation	-.012**	-.013**	-.016**
among treated homes (β_1)	(.001)	(.001)	(.001)
Month Fixed Effects?	Y	Y	Y
Property Fixed Effects?	Y	Y	Y
N	62,498	62,498	62,498
Average price of treated home ($)	517,047	596,481	579,899

Significance levels: $*$: 5% $**$: 1%. Robust standard errors in parenthesis.

This study's methodology will control for local economic trends by including time-location fixed effects and location time trends in regressions. The spatially

disaggregated data allows for the local spatial unit to be defined with arbitrary precision. I use census tract by year fixed effects as well as dissemination block specific linear time trends. The inclusion of census tract by year fixed effects absorb potentially nonlinear differences in home price appreciation occurring across tracts. After the inclusion of census tract by year fixed effects, the possibility remains that the location of a dispensary is endogenous to differences in home price appreciation *within* tracts. Indeed, Table 1 demonstrates that price appreciation trends among properties within 100 meters of a dispensary site are higher than that of properties within 200 meters of a site. While dispensaries locate in low price appreciation tracts, within those tracts, they locate in the higher appreciation areas. The use of dissemination blocks allows for economic trends to be controlled for at a very fine level of geography. 3,522 blocks had at least one case of a repeated home sale. I allow for the possibility that economic trends differ between blocks by introducing a linear control for block level time trends.

In addition to the above controls, I control for trends that may be specific to a particular street, but cut across blocks and tracts. I use the street address of all transacted homes from the BCAA data and introduce linear controls for street specific time trends. Transacted properties are found on 636 unique streets. A key result of the study is that controlling for differential locational trends with sufficient granularity is vital to identifying the effect of dispensaries on transaction prices.

The main regression specification is shown in Equation 2. i indexes a property and t indexes the year and month of the housing sale. D is a dummy variable that takes a value of one if the transaction occurred close to an active dispensary at the time of sale. R is a dummy variable that takes a value of one if the home undertook significant renovations before the sale occurred. H is a property fixed effect. M is a month fixed effect. Z is a tract by year fixed effect. Y captures the year the transaction took place. B takes a unique value for each dissemination block and S takes a unique value for each street. Therefore $(B_i \times Y_t)$ and $(S_i \times Y_t)$ control for linear time trends at the block and street level respectively. β_1 is the estimated effect of a proximal dispensary on the transaction price.

$$\text{Log Price}_{it} = \beta_0 + \beta_1 D_{it} + \beta_2 R_{it} + \psi H_i + \phi M_t + \chi Z_{it} + \gamma(B_i \times Y_t) + \lambda(S_i \times Y_t) + \varepsilon_{it} \qquad (2)$$

Results

I present results by gradually increasing the number of controls in the specification, with the final specification corresponding to Equation 2. Table 2, column 1 estimates the relationship between logged home price and a dummy variable for being near a dispensary, controlling only for month fixed effects and whether the unit underwent a renovation prior to sale. Including a unique fixed effect for each month covered by the data will be important to isolating the causal effect, particularly given Vancouver as a whole experienced rapid home price appreciation over the period of study. The result of column 1 suggests that the typical house close to a dispensary sold at a significant discount relative to other homes. Being within 100 meters of a dispensary at the time of sale is correlated with a 37.6% reduction in home price relative to homes that did not have a dispensary within 100 meters, after controlling for month of sale and renovations. This effect is primarily driven by omitted variables. The characteristics of homes close to dispensaries are substantially inferior to those of average Vancouver homes, as noted above. The presence of a recent renovation is found to substantially increase home sale price across all specifications, as expected.

The ability to introduce property level fixed effects allows regressions to absorb all time invariant characteristics of homes. Table 2, column 2 introduces property level fixed effects. The estimated effect of dispensaries declines dramatically relative to column 1. With a bandwidth of 100 meters, the estimated effect of a local dispensary is a 7.6% reduction in home price. Table 2, column 3 adds census tract by year fixed effects. Under this specification, the estimated effect of a dispensary is slightly positive, consistent with the prior research (Burkhardt and Flyr, 2018; Conklin et al., 2016). However, this specification does not account for the possibility that dispensary location is endogenous to differential price trends within tracts. The relatively large size of census tracts and the tendency of dispensaries to locate on commercial corridors may lead to bias in estimation of the causal effect of dispensaries on home values.

Columns 4 and 5 add controls for dissemination block level time trends. Column 5 additionally controls for street level time trends. Column 5 is the preferred specification as it controls for local appreciation trends at the most granular level, in addition to fully controlling for housing characteristics. With a treatment bandwidth of 100 meters, I estimate that a local marijuana dispensary reduces a home's value by an average of 3.7%. For the median valued home within the treatment radius ($490,481), the effect amounts to a reduction in home value of $18,266.

Table 2: Effect of Dispensary Proximity on Log Home Values

	(1)	(2)	(3)	(4)	(5)
	Treatment Radius: 100 meters				
Adjacent to dispensary (dummy)	-.472**	-.079**	.018	-.034**	-.038**
	(.025)	(.009)	(.011)	(.013)	(.013)
Renovation (dummy)	1.118**	.597**	.498**	.453**	.455**
	(.069)	(.028)	(.031)	(.029)	(.029)
	(treatment observations = 232)				
	Treatment Radius: 150 meters				
Adjacent to dispensary (dummy)	-.428**	-.089**	.023*	.006	.002
	(.025)	(.009)	(.011)	(.013)	(.014)
Renovation (dummy)	1.110**	.596**	.498**	.453**	.455**
	(.069)	(.028)	(.031)	(.029)	(.029)
	(treatment observations = 439)				
	Treatment Radius: 200 meters				
Adjacent to dispensary (dummy)	-.454**	-.097**	.013	.010	.007
	(.020)	(.007)	(.009)	(.010)	(.010)
Renovation (dummy)	1.095**	.593**	.498**	.453**	.455**
	(.069)	(.028)	(.031)	(.029)	(.029)
	(treatment observations = 695)				
Month Fixed Effects?	Y	Y	Y	Y	Y
Property Fixed Effects?	N	Y	Y	Y	Y
Census Tract x Year Fixed Effects?	N	N	Y	Y	Y
Dissemination Block Time Trends?	N	N	N	Y	Y
Street Time Trends?	N	N	N	N	Y
N	62,498	62,498	62,498	62,498	62,498

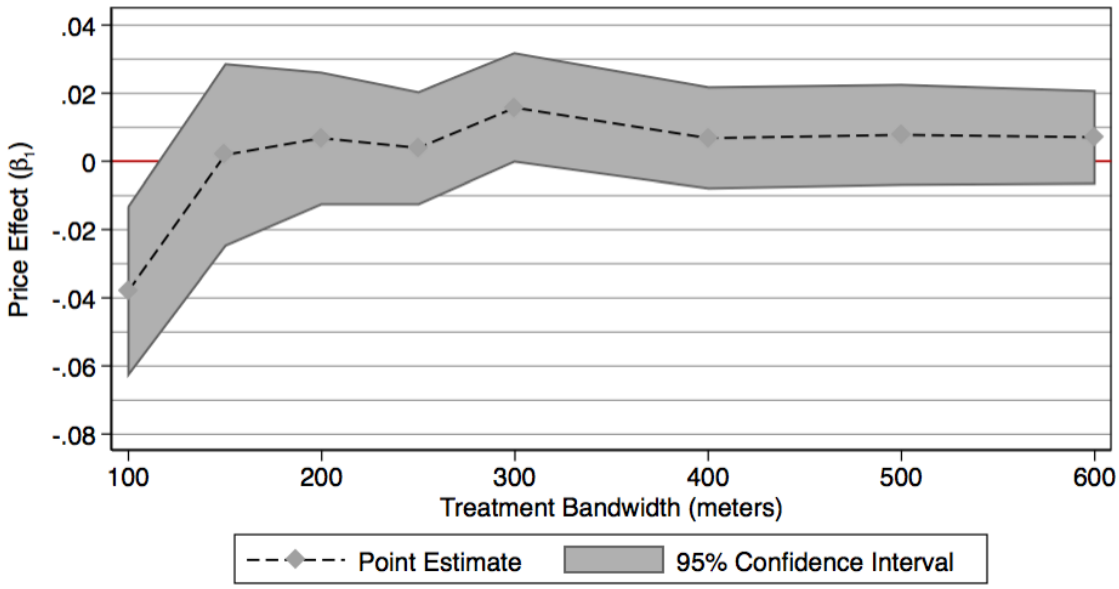
Significance levels: $*$: 5% $**$: 1%. Robust standard errors in parenthesis. Dependent variable is log of home sale price. The table shows the results of 15 separate regressions.

The regression described by Equation 2 contains 32,658 control variables. This represents the most tightly controlled version of the regression for which I report results. The inclusion of a full set of block by year fixed effects rather than the linear block time trends is possible and would further control for differences in growth by capturing nonlinearities in block level growth. In practice, such a regression provides limited inference. Annual fixed effects at geographies smaller than the treatment radius absorb the effect of dispensaries that I aim to estimate, eliminating the variation needed for causal estimation. When I include block by year fixed effects in the model the effect of a local dispensary is estimated to be zero, consistent with the fixed effects controlling away the meaningful variation.

Consistent with Tobler's first law of geography (Tobler, 1970), the effect of

dispensaries on home values is expected to decline with distance. Table 2 repeats analysis for a treatment bandwidth of 150 meters and 200 meters. While a significant and negative effect is found at 100 meters, the effect is indistinguishable from zero for the 150 and 200 meter bandwidths when a full set of controls are included. The confidence intervals are relatively small, suggesting that the price effect is close to zero. Figure 6 displays how the main result (β_1, Equation 2) changes with the changing treatment bandwidth. As noted above, when the bandwidth is set to 100 meters, the estimated effect on property value is a reduction of 3.7% ($\beta_1 = -.038$). As the treatment bandwidth is gradually increased in Figure 6, the effect quickly falls to zero and remains indistinguishable from zero as the bandwidth is expanded to an arbitrarily large size. These results suggest that dispensaries have a negative influence on the value of adjacent homes but the negative effect disappears rapidly through space. The robustness of this finding to alternative model specifications and housing submarkets will be tested below.

Figure 6: Estimated Home Price Effect as Function of Treatment Bandwidth



Each point estimate corresponds to a separate regression result (β_1). Regressions include month fixed effects, property fixed effects, census tract by year fixed effects, dissemination block time trends and street time trends; as per Equation 2 and Table 2, column 5.

An alternative specification to test the effect of local dispensaries would be to include multiple treatment bandwidths in a single regression, as shown in Equation 3. The Equation includes a dummy variable for being within 100 meters of a dispensary, a dummy

variable for being between 100 and 150 meters of a dispensary and a dummy variable for being between 150 and 200 meters of a dispensary. The equation also includes the same set of fixed effects and time trend control variables as the main (Equation 2) specification. Table 3 presents results from this alternative regression equation (column 5), as well as specifications with fewer control variables (columns 1-4). Results are consistent with the estimates relating to Equation 2. I find a significantly negative price effect for homes within 100 meters of a dispensary, with insignificant price effects for larger distances (column 5).

$$\text{Log Price}_{it} = \beta_0 + \alpha_1 D_{it}^{<100\text{m}} + \alpha_2 D_{it}^{100-150\text{m}} + \alpha_3 D_{it}^{150-200\text{m}} + \beta_2 R_{it} + \psi H_i + \phi M_t + \chi Z_{it} + \gamma(B_i \times Y_t) + \lambda(S_i \times Y_t) + \varepsilon_{it} \quad (3)$$

Table 3: Effect of Dispensary Proximity on Log Home Values, Alternative Specification

	(1)	(2)	(3)	(4)	(5)
<100m from dispensary (dummy)	-.490**	-.084**	.021	-.026	-.033*
	(.025)	(.009)	(.012)	(.014)	(.014)
100-150m from a dispensary (dummy)	-.384**	-.094**	.021	.023	.014
	(.044)	(.015)	(.016)	(.018)	(.019)
150-200m from a dispensary (dummy)	-.484**	-.114**	-.002	.006	.002
	(.030)	(.010)	(.010)	(.011)	(.012)
Renovation (dummy)	1.112**	.618**	.509**	.460**	.461**
	(.066)	(.023)	(.025)	(.027)	(.027)
Month Fixed Effects?	Y	Y	Y	Y	Y
Property Fixed Effects?	N	Y	Y	Y	Y
Census Tract x Year Fixed Effects?	N	N	Y	Y	Y
Dissemination Block Time Trends?	N	N	N	Y	Y
Street Time Trends?	N	N	N	N	Y
N	62,498	62,498	62,498	62,498	62,498

Significance levels: * : 5% ** : 1%. Robust standard errors in parenthesis. Dependent variable is log of home sale price. The table shows the results of 5 separate regressions.

As shown in Figure 4, some areas of Vancouver have no dispensaries. These neighbourhoods are potentially unique from neighbourhoods that did have dispensaries and may therefore provide relatively poor comparison observations. This concern should be mostly allayed by the extensive use of location specific control variables. As an alternative specification, Table 4 reruns the analysis, but limits the transactions to those that were within 500 meters of a site that contained a dispensary at some point, reducing the sample size from 62,498 to 6,168. A limitation of this approach is that it ignores potentially

meaningful variation from the majority of the property transaction data. The benefit of the approach is that it may avoid bias introduced by observations that are far from dispensaries and experience price variation that is driven by omitted variables. Running Equation 2 on the reduced sample estimates a price effect of -1.2% for the 100 meter bandwidth, though the estimate is statistically insignificant (Table 4, column 5). The estimate derived from the full sample (Table 2, column 5) is well within the 95% confidence interval of the reduced sample estimate, suggesting they are not contradictory. However, the reduced sample estimate provides some evidence that the effect of a local dispensary may be closer to zero than is suggested by the methodology used in Table 2. Taken together, the estimates suggest the price effect of a dispensary is close to zero and potentially negative.

Table 4: Effect of Dispensary Proximity on Log Home Values, Homes Within 500 meters of a Dispensary Site

	(1)	(2)	(3)	(4)	(5)
	Treatment Radius: 100 meters				
Adjacent to dispensary (dummy)	-.072**	-.004	.016	-.014	-.012
	(.027)	(.009)	(.011)	(.019)	(.017)
	(treatment observations = 232)				
	Treatment Radius: 150 meters				
Adjacent to dispensary (dummy)	-.020	-.0004	.024*	.002	-.001
	(.027)	(.009)	(.010)	(.015)	(.016)
	(treatment observations = 439)				
	Treatment Radius: 200 meters				
Adjacent to dispensary (dummy)	-.046*	-.012	.014	-.002	-.008
	(.023)	(.008)	(.009)	(.011)	(.012)
	(treatment observations = 695)				
Renovation dummy?	Y	Y	Y	Y	Y
Month Fixed Effects?	Y	Y	Y	Y	Y
Property Fixed Effects?	N	Y	Y	Y	Y
Census Tract x Year Fixed Effects?	N	N	Y	Y	Y
Dissemination Block Time Trends?	N	N	N	Y	Y
Street Time Trends?	N	N	N	N	Y
N	6,168	6,168	6,168	6,168	6,168

Significance levels: $*$: 5% $**$: 1%. Robust standard errors in parenthesis. Dependent variable is log of home sale price. The table shows the results of 15 separate regressions.

The effect of treatment may be heterogeneous between condominiums and single family homes. Within the full sample of repeat sales observations, roughly 60% of transactions are condominiums while 40% are single family homes or duplexes. However, among repeat sales observations that were within 100 meters of an active dispensary 94% were condominiums. This should be considered in the interpretation of main results as

much of the meaningful variation among treated observations applies to condominiums specifically. Table 5 reruns the main analysis (Equation 2) separately for the two housing types. The estimated effect on the sample of condominiums is generally consistent with the aggregate estimates, though falls short of statistical significance. Among the smaller sample of single family homes, estimates have much larger standard errors. At the 100 meter bandwidth I find a very large negative price effect on single family homes (-12%), but the effect cannot be identified with any confidence given large standard errors generated by few (14) treatment observations. Table 5 demonstrates that the statistical significance of the negative price effect in the Table 2 specification is largely due to a small number of single family home observations. The treated single family home observations are "outliers" in that they are unique from the large majority of treated observations. However, it is not clear that they should be ignored if the desired estimate is the average price effect on all homes. Once again, results provide no evidence of a positive price effect, and some marginal, statistically insignificant evidence of a negative effect for homes within 100 meters of a dispensary.

Throughout the above analysis I have relied on a sample of repeat sales. A repeat sales method has the clear benefit of removing bias that may arise from the characteristics of transacted homes changing over time. However, the characteristics of properties that sell multiple times are possibly unique from the full set of Vancouver homes, rendering the estimates unrepresentative of the broader market. I am able to match transacted homes to a set of housing characteristics using BCAA data. Of the 27,091 homes that sold multiple times, 23,670 can be matched to property characteristic data. There are 42,525 additional homes in the data set that sold exactly one time during the period of study and can be matched to characteristic data. Table 6 compares average home characteristics between properties that sold multiple times during the period of study to those that sold only once. The average sale price among homes selling multiple times was 4% less than the average home that sold only once. In terms of housing characteristics such as square footage, number of bedrooms and number of bathrooms, the properties that sold multiple times do not have substantially different characteristics than those that sold once (Table 6). Condominiums were somewhat more common in the repeat sales transactions than in the single transaction homes.

Table 7 shows hedonic regression results. I regress the log of transaction price on a set of available housing characteristics, as listed in Table 7, as well as the same fixed effects and time trends that are included in the main model specification, omitting property fixed effects but adding block and street fixed effects. In column 1 I use all available home

Table 5: Effect of Dispensary Proximity on Log Home Values, Estimating Single Family Home and Condominium Effects Separately

	(1) **Single Family Homes**	(2) **Condominiums**
	Treatment Radius: 100 meters	
Adjacent to dispensary (dummy)	-.131	-.014
	(.094)	(.012)
Treatment observations	14	218
	Treatment Radius: 150 meters	
Adjacent to dispensary (dummy)	.059	.001
	(.074)	(.012)
Treatment observations	38	401
	Treatment Radius: 200 meters	
Adjacent to dispensary (dummy)	.013	.006
	(.053)	(.009)
Treatment observations	71	624
Renovation dummy?	Y	Y
Month Fixed Effects?	Y	Y
Property Fixed Effects?	Y	Y
Census Tract x Year Fixed Effects?	Y	Y
Dissemination Block Time Trends?	Y	Y
Street Time Trends?	Y	Y
N	24,802	37,696

Significance levels: $*$: 5% $**$: 1%. Robust standard errors in parenthesis. Dependent variable is log of home sale price. The table shows the results of 6 separate regressions. Duplexes are considered single family homes in this analysis.

transactions, including homes that sold only once. In column 2 I limit the sample to properties that sold multiple times so the sample is more consistent with the primary analysis. Both samples yield similar results. I find a highly significant and negative price effect on homes located within 100 meters of a dispensary and estimate effects that are indistinguishable from zero at the 150 and 200 meter bandwidths. On the full sample of observed transactions the hedonic analysis estimates that homes within 100 meters of a dispensary sold at a 4.9% discount, which is similar to the 3.7% estimate generated by the repeat sales methodology in Table 2.

I use GSV images as a novel method to generate a longitudinal record of dispensary activity. A limitation of this approach is the introduction of measurement error due to the significant lag between images. For the above analysis I assumed that dispensaries opened at the midpoint between the final image without a dispensary and the first image with a

Table 6: Characteristics of Repeat Sales Homes and Homes That Sold Only Once

Characteristic	Repeat Sale Homes	Single Transaction Homes
Log of sale price ($)	13.46	13.53
Square footage	1,547	1,581
Bedrooms	2.71	2.83
Full bathrooms	1.80	1.72
Condominium (dummy)	.57	.52
Observations	54,279	42,525

The table presents average home characteristics for transacted homes in Vancouver between 2005 and 2015. The sample is limited to transactions for which housing characteristic data is available from BCAA.

dispensary. If it is assumed that the timing of the actual opening occurred with a uniform distribution between the two images, then the midpoint approach will successfully minimize the average measurement error. To ensure that results are not driven by the midpoint assumption, I repeat the main (Equation 2) regression but alter the assumed opening date (Table 8). I first assume that each dispensary opened on the earliest possible date that is consistent with the images. Under this alternative assumption, I estimate that properties within 100 meters of a dispensary sold at a 2.4% discount relative to other properties (column 1). I then assume that dispensaries opened at the latest possible date that is consistent with the images (column 2), in which case I estimate that dispensaries lead to a price discount of 3.6%. Both estimates are statistically significant at the 1% level. The estimates are generally consistent with this paper's main estimate (-3.7%). It is reasonable that they would be estimated closer to zero as the inferior assumptions likely capture less of the meaningful variation in dispensary location, creating attenuation bias.

As an additional robustness check for the validity of the GSV assumptions I rerun the analysis on a reduced sample that contains only observations for which I have high quality data on opening dates. While the average gap between photos covering a dispensary opening is 23 months, Table 8, column 3 repeats the regression analysis while retaining only dispensaries that appeared between GSV photos that were 12 months or less apart. I adjust the sample of housing observations by dropping any observation that was within 300 meters of a site that contained a dispensary for which the gap between relevant photos was greater than 12 months. The reduced data set contains 60,358 home transaction observations and 30 dispensaries. Limiting the data to higher quality GSV images reduces the number of treated observations. In the main specification the treated observations

Table 7: Effect of Dispensary Proximity on Log Home Values, Hedonic Regressions

	(1) **Hedonic, Full Sample**	(2) **Hedonic, Limited Sample**
	Treatment Radius: 100 meters	
Adjacent to dispensary (dummy)	-.050**	-.048*
	(.015)	(.023)
	Treatment Radius: 150 meters	
Adjacent to dispensary (dummy)	.018	.025
	(.011)	(.017)
	Treatment Radius: 200 meters	
Adjacent to dispensary (dummy)	-.012	.013
	(.009)	(.012)
Renovation control?	Y	Y
Number of Bedrooms Fixed Effect?	Y	Y
Number of Full Bathrooms Fixed Effect?	Y	Y
Log of Square Footage	Y	Y
Condominium? (dummy)	Y	Y
Duplex? (dummy)	Y	Y
Month Fixed Effects?	Y	Y
Dissemination Block Fixed Effect?	Y	Y
Street Fixed Effect?	Y	Y
Census Tract x Year Fixed Effects?	Y	Y
Dissemination Block Time Trends?	Y	Y
Street Time Trends?	Y	Y
N	96,804	54,279

Significance levels: $*$: 5% $**$: 1%. Robust standard errors in parenthesis. Dependent variable is log of home sale price. The table shows the results of six separate regressions. The limited sample only includes homes that sold multiple times.

numbered 232, 439 and 695 for the 100 meter, 150 meter, and 200 meter bandwidths respectively, while the number of treated observations in the reduced sample are 113, 224 and 389 for the respective bandwidths. Running Equation 2 on the restricted sample, I estimate that a home within 100 meters of a dispensary sold at an 4.1% discount. The result is very close to the main estimate from the full sample. This robustness check is suggestive that the measurement error introduced by the primary GSV methodology may be resulting in attenuation bias that pushes the main estimate towards zero, but this effect is small. Given the reduced number of treatment observations in this robustness check, the possibility that a few outlier properties are responsible for the change in the estimated effect is also plausible. Using the restricted sample, the estimated effect of a dispensary within 150 or 200 meters of a home is statistically indistinguishable from zero, congruent

Table 8: Robustness Test of GSV Methodology

	(1) **Early Opening**	(2) **Late Opening**	(3) **Restricted Sample**
	Treatment Radius: 100 meters		
Adjacent to dispensary (dummy)	-.024**	-.037**	-.042*
	(.008)	(.010)	(.021)
	Treatment Radius: 150 meters		
Adjacent to dispensary (dummy)	-.007	-.012	.017
	(.007)	(.008)	(.026)
	Treatment Radius: 200 meters		
Adjacent to dispensary (dummy)	-.002	-.009	.014
	(.006)	(.007)	(.016)
Renovation control?	Y	Y	Y
Month Fixed Effects?	Y	Y	Y
Property Fixed Effects?	Y	Y	Y
Census Tract x Year Fixed Effects?	Y	Y	Y
Dissemination Block Time Trends?	Y	Y	Y
Street Time Trends?	Y	Y	Y
N	62,498	62,498	60,358

Significance levels: $*$: 5% $**$: 1%. Robust standard errors in parenthesis. Dependent variable is log of home sale price. The table shows the results of nine separate regressions.

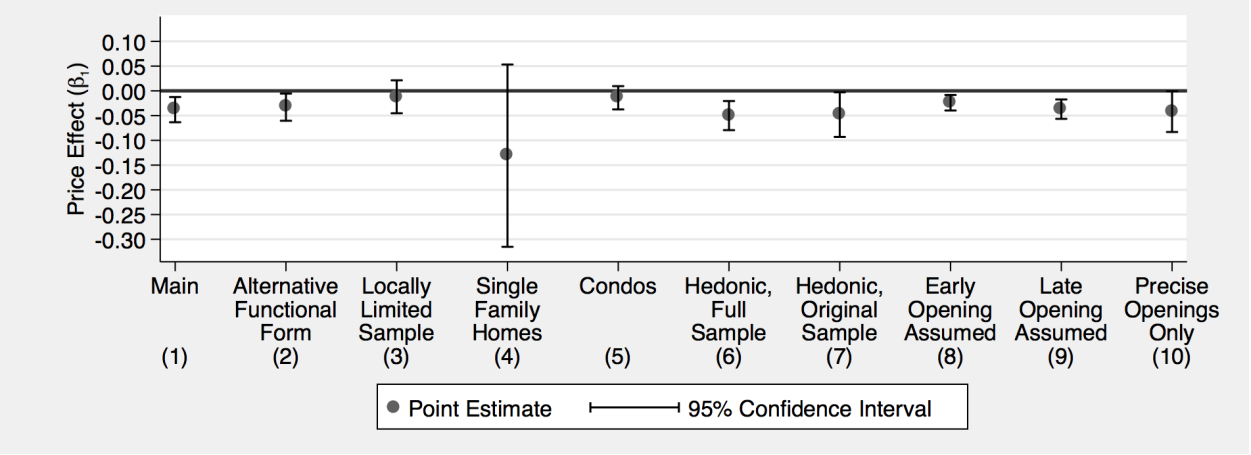
with the main estimates.

Figure 7 plots all of the alternative estimates and robustness checks for the 100 meter bandwidth in the same figure. Across the 10 estimates, it is notable that all of the point estimates take negative values. The estimate is not statistically significant across all approaches. Notably, when the sample of properties is limited to only those homes within 500 meters of a dispensary site the effect is statistically indistinguishable from zero. Similarly, when the main regression equation is estimated on the submarkets of condos or single family homes separately the effect is also statistically indistinguishable from zero. Taken together, results provide no evidence that dispensaries increase home values in Vancouver and some evidence they decrease the value of homes very close to dispensaries.

Conclusion

The arrival of marijuana dispensaries in urban environments raises many important policy questions. This paper explores the effect of dispensaries on residential home prices in Vancouver, Canada. The study has benefited from geographically precise information on

Figure 7: Comparing Alternative Estimates of Local Dispensary Price Effects



All estimates consider a home to be treated if it was within 100 meters of an active dispensary. Result 1 corresponds to Table 2, result 2 corresponds to Table 3, result 3 corresponds to Table 4, results 4 and 5 correspond to Table 5, results 6 and 7 correspond to Table 7, and results 8-10 correspond to Table 8.

dispensaries and home transactions. The unclear legality of retail marijuana sales has made reliable data on the location of dispensaries difficult to obtain. I rely on a combination of municipal data on dispensary locations and GSV images to construct a longitudinal record of dispensaries, generating approximate dispensary opening and closing dates. As marijuana legalization progresses it should be possible for future studies to obtain precise public data on dispensary activity.

Contrary to prior studies, I find no evidence that marijuana dispensaries increase local home values. For homes farther than 100 meters from a dispensary I find dispensaries have no effect on transaction prices. For homes within 100 meters of a dispensary, the main estimation strategy estimates a negative effect, with homes proximal to a dispensary selling at a 3.7% discount. Alternative estimation strategies and robustness checks generally find a negative price effect, though the significance of the result is marginal and the possibility the effect is zero remains plausible. The only comparable estimates in the literature come from Conklin et al. (2016) and Burkhardt and Flyr (2018) who both found dispensaries to increase prices of single-family homes in Denver by 8%. Numerous explanations could make sense of the difference in findings. First, Conklin et al. (2016) estimated the impact of a medical marijuana establishment converting to a recreational dispensary, while the current research focuses on the presence of dispensaries in general. However, Burkhardt and Flyr (2018) estimated the effect of dispensaries in general, similar to the current study. Second,

as demonstrated above, the inclusion of geographically specific time trends are important to results. Both Conklin et al. (2016) and Burkhardt and Flyr (2018) delineate the city of Denver into geographic neighbourhoods and control for local appreciation trends. Conklin et al. (2016) divides Denver into 283 neighbourhoods, while Burkhardt and Flyr (2018) use 177. The current study delineates Vancouver (a city of approximately the same population) into 3,391 blocks, each with independent time trends. In addition, I include controls for trends at the street level. I am also able to use property level fixed effects to eliminate possible bias due to changing composition of sales, which was not undertaken in Conklin et al. (2016) or Burkhardt and Flyr (2018). Finally, both of these prior studies were regarding the Denver market. The tastes of Denver home buyers may be different to those of Vancouverites, potentially leading them to react differently to the presence of a local dispensary. In particular, if the disamenity of a dispensary is derived from its illegality, this source of disamenity would be more salient in Vancouver, where the operation was generally illegal, than in Denver, where operation was legal from the perspective of the state. Understanding people's perceptions of illegality is difficult given overlapping federal, state/provincial and local regulations. The results presented in this study should be considered specific to the context of Vancouver during the period analysed and are not necessarily generalizable to other locations or times. Potential heterogeneity in effects across cities suggests the importance of studying dispensaries in other regions.

The consequences of marijuana legalization are relevant to public health, crime, social justice and public finance. This study has confined itself narrowly to estimating local home price effects. Future studies should attempt to establish the local real estate impacts of dispensaries by adding evidence from other jurisdictions. Work should also be undertaken to identify the underlying mechanisms that relate dispensaries to local housing demand.

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