2-2020

# What is the value of built heritage? Assessing spillover effects of conserving historic sites in Singapore

Shin Bin Tan
*Massachusetts Institute of Technology*

Edward S. W. TI
*Singapore Management University*, edwardti@smu.edu.sg

# What is the value of built heritage conservation? Assessing spillover effects of conserving historic sites in Singapore

Shin Bin Tan[ab*], Edward S.W. Ti[c]

a Department of Urban Studies and Planning, Massachusetts Institute of Technology, United States
b Lee Kuan Yew School of Public Policy, National University of Singapore, Singapore
c Singapore Management University, Singapore

Published in Land Use Policy, 91, 104393. DOI: 10.1016/j.landusepol.2019.104393

**Abstract**

Quantifying the economic benefits of built heritage facilitates the formulation and assessment of conservation policies and programs. There is however a lack of empirical research about the economic value of built heritage in Asian cities. This lack is problematic, given the rapid pace of demolition and redevelopment of historic landscapes in Asian cities. This study seeks to reduce the current gap in built heritage research by examining whether real estate premiums are generated by the designation of buildings as 'conserved' in Singapore, a city-state in South East Asia. Using 20 years of housing transaction data, and controlling for building, neighborhood and year fixed effects, we found that conservation designation had a positive impact on average sale prices per square meter of built area that was largest at residential locations between 800 m to 1.6 km from the conserved site. Findings also suggest that lower-cost public housing resale units gained a substantially smaller premium compared to private housing units. While our findings suggest an economic justification for building conservation programs in Asian cities, they also raise questions about such programs potential impact on neighborhood gentrification, and the need for appropriate taxation policies to ensure horizontal equity between property owners.

**Keywords:** Conservation, Built heritage, Real estate value, Singapore

## 1. Introduction

Built heritage, a term which refers to buildings, monuments and structures of architectural and historical value, is an important resource because it contributes to cultural identity and a sense of belonging by physically linking residents to their past (Tweed and Sutherland, 2007; Stipe, 2003). Architecture and cultural landscapes of the past also have intrinsic value as art (Stipe, 2003). Scholars also hypothesize that in the current age of rapid communication and technological transformations, and in the face of ensuing homogeneity, urban residents and officials value the difference and uniqueness offered by historic buildings and landmarks (Stipe, 2003).

Conservation of built landscapes typically entail preserving buildings' facades and sometimes interiors, and can be either carried out on individual properties, or throughout an entire district (Kovacs et al., 2008). Achieving meaningful conservation however cannot be wholly left up to the whims of individual property owners, as they may not all desire to preserve, given the costs required to maintain older building stock and the opportunity costs of forgoing redevelopment. Advocates of the preservation of built heritage thus call for government policies and laws, such as the designation of heritage conservation districts, to encourage and enforce conservation (Kovacs et al., 2008).

While qualitative, non-economic benefits to preserving buildings are fundamentally important, estimations of the quantifiable economic benefits of built heritage arguably capture much of the cultural importance of heritage value (Throsby, 2012) and form a cornerstone of policy decisions around conservation (Mason, 2008). Without a clear value assessment of built heritage, demolition or poor management of historic landscapes becomes more likely (Wright and Eppink, 2016). Thus, empirical research that quantifies the potential economic value of built heritage has been critical in facilitating better assessments of conservation-related policies.

Assessments of the value of conserving individual properties and larger districts have been conducted in the United States, Canada, the United Kingdom, and other countries in Europe. By and large, studies have found that heritage designations positively impact sale prices of designated buildings as well as nearby buildings (Ahlfeldt et al., 2012; Lazrak et al., 2014; Coulson and Leichenko, 2001; Clark and Herrin,

[*] Corresponding author at: Department of Urban Studies and Planning, Massachusetts Institute of Technology, 77 Massachusetts Ave, Cambridge, MA 02139, United States. E-mail address: shinbin@mit.edu (S.B. Tan).

1997; Rypkema, 2012), though there are also notable exceptions (Noonan and Krupka, 2011; Asabere and Huffman, 1994). Reasons for why heritage designation might increase real estate value include increased prestige of owning a rare asset, belief that the conserved property will be immune to compulsory acquisition by the State (Chan, 2005) and increased certainty that the neighborhood would maintain its' aesthetic and resident mix 'character' (Evans, 2004; Rypkema, 2012).

Most research to date has been carried out in Western countries, with little to no research completed within an Asian context. A 2016 meta-analysis of studies on the economic valuation of heritage sites identified 48 studies, of which only seven studies were based in Asian locales (Wright and Eppink, 2016). Given that the socio-cultural and economic meanings attributed to built heritage conservation differ from place to place (Rypkema, 2012), and because the actual practice of heritage conservation also differ markedly between European and Asian regions (Winter, 2014), assessing the economic value of heritage within Asian cities cannot be a simple extrapolation from existing studies.

The relative paucity of Asia-focused research is especially concerning in light of the rapid demolition of historic sites and neighborhoods in recent decades because of the growing pressures of urban development and modernization in Asian cities (Branigan, 2009; Henderson, 2012). Even in jurisdictions like Taiwan, which has a well-established government-led conservation program in place, property-owners have been resistant to further efforts at conservation due to fear of economic losses from redevelopment and the costs of maintaining older buildings (Go and Lai, 2019).

This paper seeks to reduce the current geographical gap in built heritage research, by contributing an empirically-grounded evaluation of the impact of conservation within a high-density Asian city-state Singapore. Singapore is a land-scarce 'developmental state' under tremendous development pressure. Its planners and policy-makers are thus familiar with having to balance conservation with development. Despite strong redevelopment pressures, conservation efforts in Singapore has received substantial support and attention (Lee, 1996) and the city's conservation program has been lauded as successful (Yeoh and Huang, 1996; Lee, 1996; Kong, 2017). Singapore thus provides a useful case-study and benchmark for other high-density, land-scarce Asian cities.

Our primary research question is: Do locations close to designated conservation sites see an increase in market value, measured by residential sale transaction prices, after such sites are officially designed as conserved, compared to areas further away?

While this paper's primary purpose is to provide a better appreciation of the spill-over economic effects of conservation, we are mindful of the potential downside that might be generated by conservation policies: gentrification, a phenomenon that has in recent years been viewed as negative and problematic (Arkaraprasertkul, 2018). Should heritage designation lead to rising property prices, it might precipitate displacement of poorer residents and formation of privileged enclaves around conserved sites (Steinberg, 1996; Donaldson et al., 2013). In our analysis of the changes in housing prices around conserved sites, we thus draw attention to the non-economic implications on residential demographic changes and neighborhood identity shifts that might arise from conservation.

## 2. Overview of Singapore's conservation policies

### 2.1. History

In the earlier years of Singapore's independence from British colonial rule, policy-makers and planners paid relatively less attention to built heritage conservation in Singapore, given their prioritization of economic growth, job creation, redevelopment and infrastructure modernization (Henderson, 2011; Kong and Yeoh, 1994). Conservation efforts in the 1970s and 1980s were thus largely concentrated around retaining significant individual monuments such as markets and places of worship, as well as smaller scale projects to rehabilitate shophouses. While the Urban Redevelopment Authority (URA), Singapore's de facto national land planning agency, had initiated exploratory studies of the conservation and rehabilitation of larger areas like Chinatown as early as 1976 (Kong and Yeoh, 1994) it was only until the late 1980s when policy-makers exhibited greater commitment to implementing larger scale conservation initiatives, in part driven by a pragmatic awareness that the "Oriental mystique and charm which are best symbolized in old buildings, traditional activities and roadside activities" could be a valuable attractor of tourist dollars (Chang, 1997).

In 1986, the URA published a Conservation Master Plan, which included the conservation of over 100 ha of land. URA's district conservation efforts were given additional impetus and support in 1989, when a new Planning Act was passed, which provided for the appointment of a conservation authority, the designation of conservation areas, the enforcement of conservation requirements and the formulation of conservation guidelines. The 1989 amendment to the Planning Act created the necessary legislative framework to allow URA to officially designate 10 neighborhoods as 'conservation areas', and through such designation control all works within those conservation areas in order to preserve, enhance, or restore their character or appearance; this extended to the trades, crafts, customs and other traditional activities carried in these areas. The 10 neighborhoods originally selected for conservation were Kreta Ayer, Bukit Pasoh, Telok Ayer, Tanjong Pagar, Little India, Kampong Glam, Boat Quay, Emerald Hill, Cairnhill and Clarke Quay.

In 1991, another 10 areas - Joo Chiat, Geylang, Jalan Besar, Blair Plain, River Valley, Beach Road, Bukit Pasoh Extension, Desker Road, Petain Road/Tyrwhitt Road and Race Course Road/Owen Road, were gazetted for conservation (Kong and Yeoh, 1994; Yuen, 2005).

Fig. 1 shows part of a conserved area, Emerald Hill, while Fig. 2 provides an example of a conserved bungalow within the White House Park/Nassim Road conservation area.

### 2.2. Conservation in Singapore today: policies and rationale

Today, a building or area can be designated as having 'conservation' status if deemed to possess 'special architectural, historic, traditional or aesthetic interests', according to section 9 of the Planning Act (Cap 232). Section 11 of the Planning Act empowers authorities to issue conservation guidelines that legally bind the owner of the property to maintain the conserved building within certain parameters. Depending on the specific development and location, the stipulated parameters could specify allowable building use, height and profile, as well as specific requirements for facade, roof, colors, and internal finishes

**Fig. 1.** Emerald Hill, a neighborhood with Straits Chinese style of 'Chinese Baroque' terrace houses, conserved in 1989.

**Fig. 2.** Eden Hall Bungalow at Nassim Road, a colonial bungalow that serves as the British High Commissioner's official residence in Singapore, was conserved in 1991.

(URA, 2019). Part IV of the Act further provides that sanctions for breaching conservation guidelines include monetary penalties and even imprisonment for egregious breaches.

A 1993 publication by URA and the Preservation Monument Board (PMB), an agency tasked with the specific responsibility of safeguarding monuments as historical landmarks, articulated the different values that would render a building of 'national historical or cultural significance' worthy of conservation. One value is 'aesthetic value', which depends on the design, style, construction and age of architectural work, and could be assessed on criteria such as form, scale, colour, texture and material. Another value is 'historic value', which is a characteristic of a place that has influenced, or has been influenced by, a historic figure, event, phase or activity. Third, a building worthy of conservation is one with 'social value', and which has become a focus for spiritual, political or national cultural sentiment for the nation as a whole or for each racial group. Finally, the building, structure, monument or area could possess 'technological value', which is assessed based on the rarity and quality of technology that was available at the time of construction and on the degree to which it reflects a certain period (URA and PMB, 1993).

URA plays a large role in selecting sites and buildings for conservation, as government planners "search[ed] and finely hone[d] the historic morphology of buildings and streets to identify and recover heritage inscribed in not just individual buildings and structures but also streets or entire areas" (Yuen, 2005).

Owners can also volunteer their properties for conservation, and are incentivized by an assortment of waivers of development-related charge (Yuen, 2005). In determining whether a property should be conserved, URA would conduct a thorough conservation study, which involves evaluating a building's architectural merit and rarity, historical significance, contribution to the environment, identity and economic impact. Other government agencies, the Conservation Advisory Panel, as well as relevant property owners would also be consulted. A recommendation report would then prepared, and the Ministry of National Development would decide on whether or not to conserve the property, based on the considerations outlined above (Mulchand, 2012).

### 2.3. Hypothesized impact of conservation policies on real estate value

If so designated, the conserved building or area would then be reflected as such in the Singapore's Master Plan, a publicly accessible statutory land use plan that serves as a blueprint for development over the next 10 to 15 years. Conserved properties are subject to conservation guidelines intended to protect a conserved building's facade and prevent further intensification of the site without prior permission. These guidelines could potentially decrease the market value of conserved properties because of higher maintenance costs associated with adhering to conservation guidelines, as well as the prohibition of significant redevelopment of the property.

However, even while the officially stated conservation policy principles emphasize aesthetic, historical and social value, actual conservation decisions have demonstrated a keen consideration of broader economic effects. For instance, researchers have observed the demolishment of buildings of historical and/or architectural significance when these buildings conflict with more 'pragmatic' uses, such as the improvement of road infrastructure (Kong and Yeoh, 1994). This suggests that conservation decisions are also made with a certain expectation that conservation designation would not overly constrain or reduce economic value of the area. Local scholars have also noted that potential conservation sites, such as early Housing Development Board estates, hawker centers, wet markets and schools, which were arguably meritous of conservation because of their function as 'repositories of collective memory' were instead demolished, given their location within districts that were under development pressure (Henderson, 2011).

Furthermore, conservation in Singapore includes a "strong element of change towards what is perceived to be an improved environment" (Kong and Yeoh, 1994), as the URA's plans for conservation of historic districts also include providing pedestrian walkways, plazas, landscaping, control of signage and the introduction of 'new activities', which have largely been seen as positive and beneficial by the public (Kong and Yeoh, 1994). The designation of conservation status in Singapore, as is often the case elsewhere (Rypkema, 2012), is thus likely to be accompanied by improvement works that enhance the attractiveness of the area.

As a significant policy impetus for conservation hinges on building up Singapore's tourism, it is also reasonable to assume that the choice of areas to conserve considers perceived commercial attractiveness, or at least the potential attractiveness, of these areas. Buildings that were selected to survive were thus likely to be ones expected to generate financial returns (Henderson, 2011). Furthermore, historic conserved districts have also been pitched and marketed as attractions for locals and tourists alike. Notably, a 1994 study found that 84% of local respondents surveyed felt that conserved districts had become too commercialized (Kong and Yeoh, 1994).

For these reasons, one may argue that even before the official designation of conservation status, heritage areas are likely to have commercial appeal, and therefore higher real estate value. Post conservation, the real estate value of conserved districts are also likely to benefit both from government funded physical improvements to the district, as well as the increased consumer traffic directed there by government marketing efforts.

For the purposes of this study, the 'treatment' of conservation designation thus necessarily includes associated infrastructural or marketing programs and does not attempt to uncouple the impact of conservation designation from the larger marketing and infrastructure improvement changes that may accompany the designation.

## 3. Method

### 3.1. Overview of study data

The project utilizes over 20 years of residential transaction data (1997 to 2nd quarter 2017, 1.05 million transactions), which includes the date of sale, sale price, size of unit in square meters, year the development was built, and street address. Each transaction was in turn geocoded using onemap.sg's API.

In Singapore, the housing market consists of two distinct segments: public housing and private housing. Public housing refers to developments built by the Singapore government and typically sold with 99-year leases to citizens and residents. While the government sets the initial sale prices of new units, owners of these units can subsequently sell their units on the secondary market, with prices negotiated between seller and potential buyers. Currently, over 80% of housing stock in Singapore can be considered 'public housing'. This study focuses on resale transactions only, rather than 'first sale' transactions, since the former more transparently reflects 'market value' whereas the pricing mechanism behind the latter is policy-driven and opaque. Public housing resale transaction information was downloaded from data.gov.sg, which is the Singapore government's data repository of publicly-available datasets from government agencies.

The rest of Singapore's housing market consists of a variety of developments, ranging from high-rised towers to sprawling bungalows, developed, bought and sold by private entities. Resale transactions were downloaded from REALIS, an online repository of real estate data, including records of the caveats lodged at the Singapore Land Registry since 1995 for residential, commercial and industrial properties. Lodging of caveats is usually done voluntarily by purchasers through their lawyers to protect their interest in the property. Buyers may thus choose not to lodge a caveat for privacy reasons. Nevertheless, caveated transaction records cover a sizeable proportion of the market, accounting for an estimated 80 to 90% of all sub-sale and resale transactions (data.gov.sg).

Information on the 233 buildings and areas have been designated as 'conserved' throughout Singapore's history of conservation, from 1989 to 2015 (see Fig. 3 which illustrates the locations and years of official designation of conservation). Data on these were also downloaded from data.gov.sg, and cleaned to remove duplicate entries.

### 3.2. *Defining units of analysis*

One of the oft-cited challenges of empirical research on the value of heritage designation is the 'omitted variable' bias. Historic designation is likely to be correlated with unobserved characteristics of the property and its surrounding neighborhood. For instance, as discussed in Section 2.3, neighborhoods in premium locations, or which are deemed commercially attractive, may more likely see designations. As these unobserved characteristics, which some label 'omitted variables', may directly affect the neighborhood's sale prices, any analysis that does not account for them is likely to produce biased results (Noonan, 2007; Coulson and Lahr, 2005). To address this challenge of accounting for 'omitted variables', we adopted a 'fixed effects' analysis, where dummy variables were included for every postal code within our dataset. In Singapore, a unique postal code is assigned for each building, so each postal code effectively represents a building. As these building 'fixed effects' dummy variables effectively capture the effect of building-specific, time-invariant characteristics on housing sale prices, including them in the analysis facilitates the estimation of heritage designation's effect on housing value without the above-mentioned unobserved confounders (Angrist and Pischke, 2008). While the standard approach in real estate analysis is a repeated sale procedure based on repeated unit-level transactions, this approach poses some challenges because of the relatively limited number of repeated unit transactions in Singapore. Other scholars have thus adopted an alternative approach, similar to ours, of analyzing repeated sales within the same housing development project (Baltagi and Li, 2015).

Additionally, we included year effects, where a dummy variable is included for each year of the dataset, to capture any aggregate time trends.

Specifying fixed effects for buildings however resulted in a significant loss of data, since only buildings with multiple years of repeated transactions were included in this analysis. Restricting our analysis to repeat sales excluded transactions from many buildings. To illustrate, the original dataset included transactions from 8408 unique postal codes located within 400 m of the conserved sites, of which 5102 belonged to single-unit, low-rised 'landed housing', 2578 to multi-unit private apartments or condominiums, and 728 to public housing blocks. 46% ($n = 3826$) of these postal codes however did not have repeated transactions across different years and thus could not be included in the building fixed effects analysis. Of these, 3430 were landed housing, which translates to a loss of 67% of the original 5102 landed housing buildings in the dataset. In contrast, about 15% ($n = 383$) of the high-rise, multi-unit private apartments and 2% ($n = 13$) public housing blocks had to be dropped. Relying on a building fixed effects model thus significantly reduces the number of locations analyzed and skews the sample towards housing types with more repeat sales, which might affect the representativeness of the analysis.

Thus, in addition to specifying building-level fixed effects, we conducted a parallel analysis where housing transactions were aggregated by 200 m by 200 m grid-cells, and compared both analyses. In choosing the grid size, we sought a balance between having small enough grid cells so that locational characteristics such as access to different amenities would be roughly similar throughout the cell, and having large enough grid cells to ensure a good number of sale transactions within each cell over the study period.

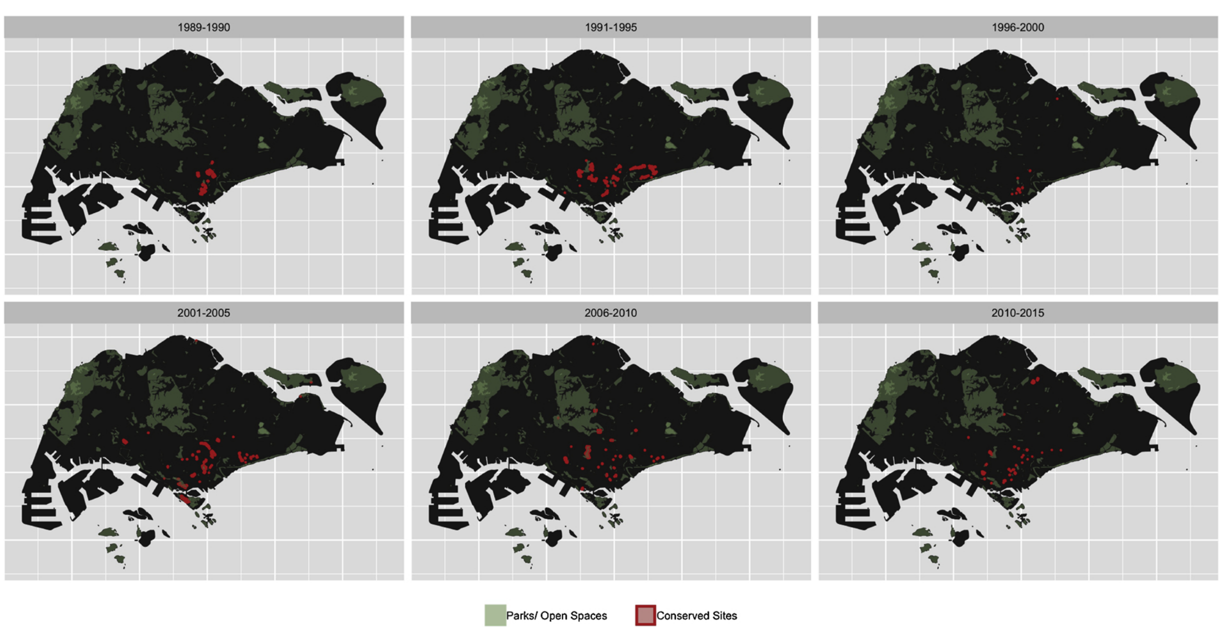


**Fig. 3.** Map showing locations of conserved developments over time.

Grid cells' average sale prices were then analyzed in models that included dummy variables for each of these grid-cells, to ascertain changes in prices pre and post historic designation. This more aggregated approach facilitates retention of transaction data from more locations. For instance, using the grid-level approach for the analysis of housing transactions within 400 m of conserved sites retains 6289 postal codes, which is substantially more than the building-level approach

### 3.3. Defining outcomes and treatment

For the building fixed effects (FE) model, the outcome variable of interest is the average residential sale price per square meter of total built area (Singapore Dollar per square meter) of all transactions within a building that occurred within a year. For reference, one Singapore Dollar roughly equates to 0.72 US Dollars in 2019. For instance, if there were 20 transactions within the same apartment block in 2016, the 'outcome' for that particular building would be the average dollar per square meter of those 20 units. For the grid cell FE model, the outcome of interest is similarly defined, but with an areal-based aggregation of transactions.

As this study's focus is on the 'spillover' effects of conservation, transactions that occurred within the conserved site boundaries were excluded from all analyses. For the grid-cell analysis, sale transactions of developments that were built after the dates of conservation gazette were excluded from the analysis, to avoid skewing the average cell sale prices with new 'post-treatment' developments. Effectively, this means that the resultant model estimates of treatment effect are of changes in real estate value of existing building stock that was already built within each cell before sites were gazetted for conservation.

In order to examine whether the impact of conservation on housing prices decays with distance from the conserved site, we first defined 10 'proximity zones', which are discrete spatial rings fanning out in 400 m increments from each conserved site (see Fig. 4). Different tiers of treatment was then specified in subsequent model estimations as the number of officially conserved sites that a building had within each zone of proximity.

A housing sale transaction would be coded as having received 'treatment' of having one conserved site within 400 m (Zone 1) if the transaction happened at a date after the official gazette date of said conserved site. If a housing sale transaction occurred within 400 m of two conserved sites, and after the gazette dates of both sites, it would be coded as having received two units of 'treatment'. Conversely, if a housing sale transaction in the same sale location occurred prior to the two official gazette dates, it would be coded as having received no treatment at all.

In order to identify the number of officially gazetted conservation sites that each building is proximate to in any given year, we first calculated the Euclidean distances between each building and all 233 conserved sites, and then classified each building according to which 'proximity zones' it fell into. As many of the conserved sites were located fairly close to each other, they had overlapping 'proximity zones'. This thus meant that a single building could belong to multiple zones.

If a building was within more than one 'proximity zones' at any given time, we assumed that the closest zone took precedence, in terms of impact. For instance, if a building falls within Zone 1 of a conserved site, and within Zone 2 (400–800 m) of another conserved site, it would be assumed to have received treatment of Zone 1 only.

The underlying assumption here is that the impact of closer conserved sites would likely outweigh any impact of conserved sites further away. Thus, when modelling the treatment effect of being within Zone 2 proximity of a conserved site, this particular grid cell would be excluded from the analysis, since the changes in sale prices within this building is likely to be more significantly affected by being in Zone 1

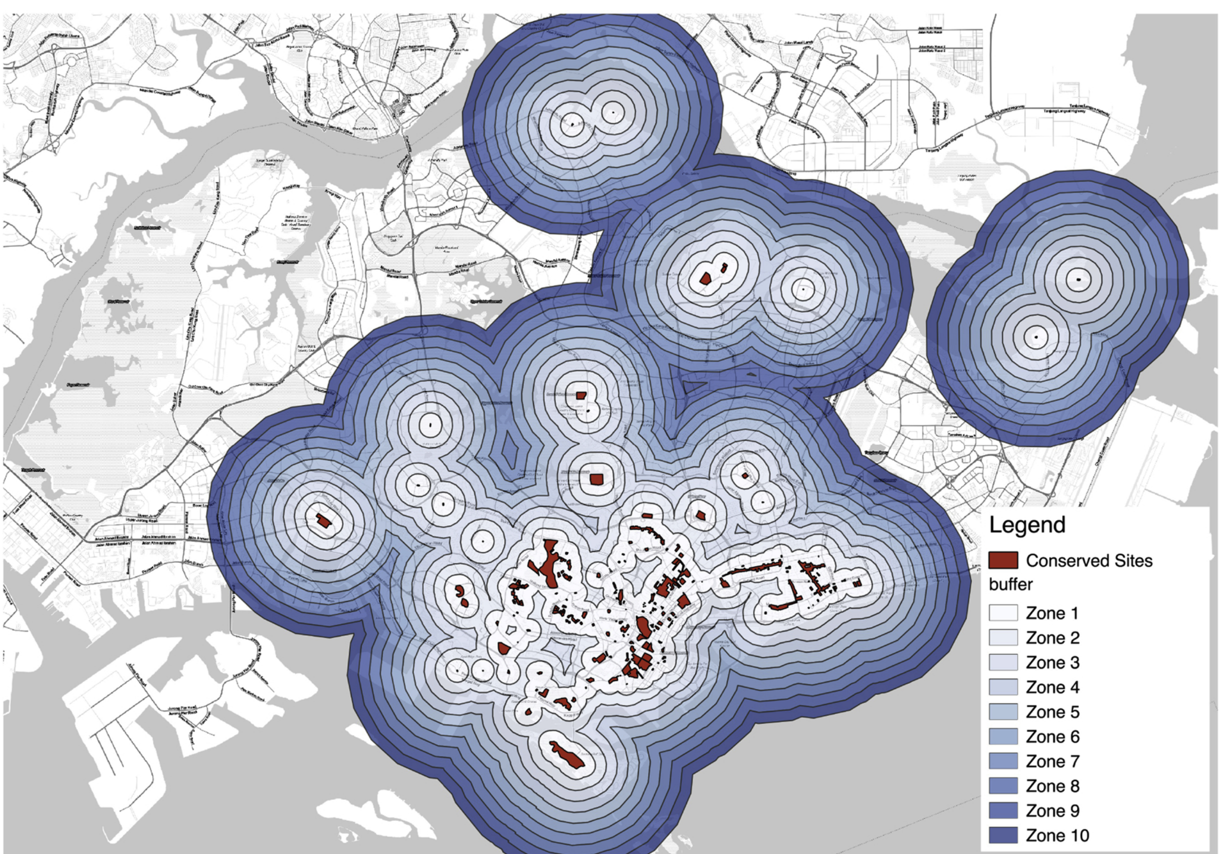


**Fig. 4.** Map showing the 10 treatment proximity zones.

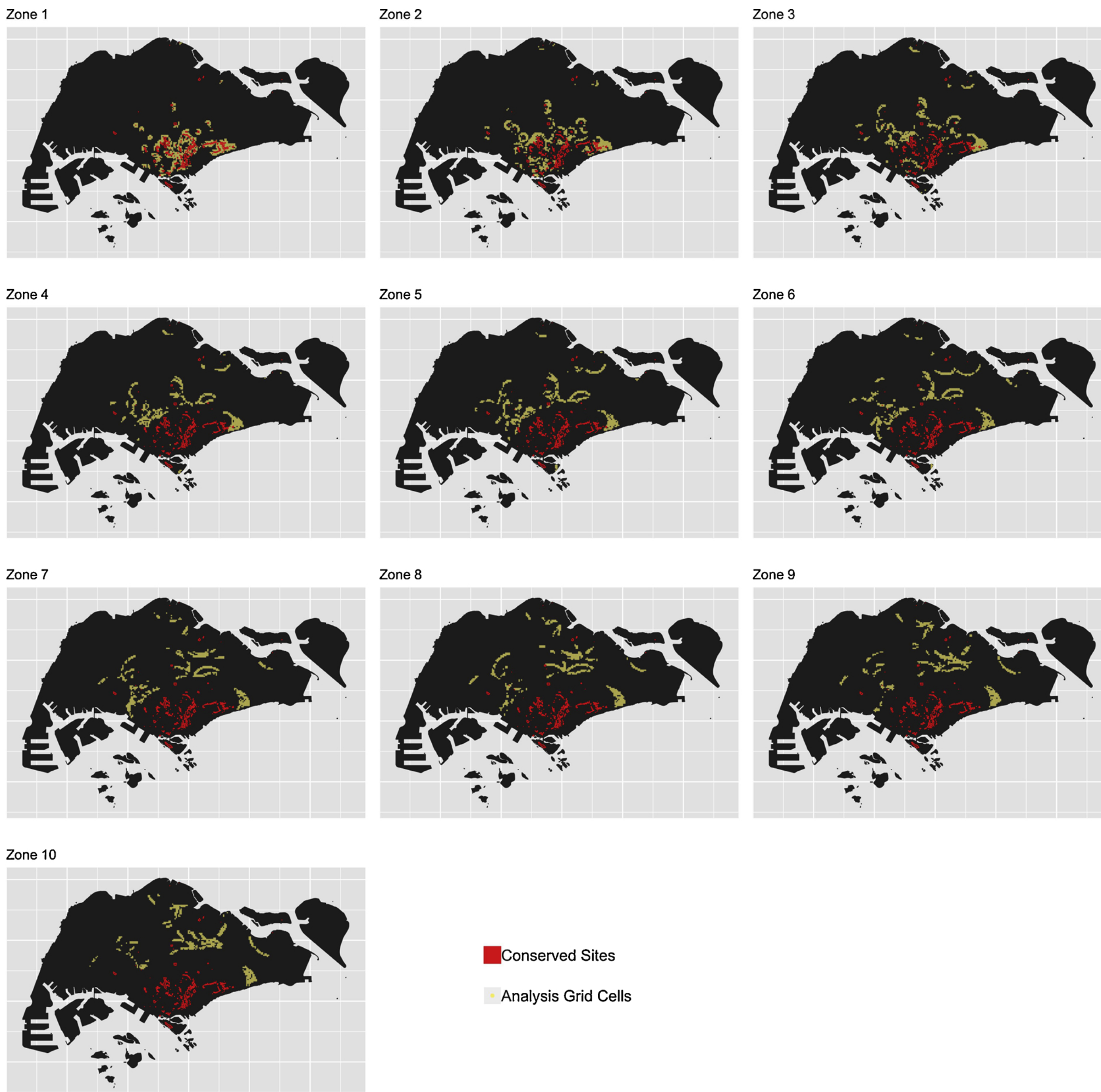


**Fig. 5.** Map showing building locations analyzed under each proximity zone.

than Zone 2. However, if the Zone 1 conserved site was officially gazetted for conservation later than the Zone 2 site, then for the years prior to conservation of the Zone 1 site, the building is assumed to receive treatment of Zone 2.

Assignment of treatment to grid cells follows the same logic as buildings, using the centroid of each grid cell as a spatial reference for calculating proximity to conserved sites. Appendix A illustrates this approach in more detail.

Fig. 5 shows the location of buildings that were included in each of the 10 proximity zones. Tables 1 and 2 summarize the characteristics of housing sale transactions in these zones, for the building FE analysis and grid cell FE analysis respectively.

For both sets of analyses, characteristics of the housing sale transactions that took place within each defined 'proximity zone' were roughly similar to each other, except that public housing sales took up a substantially smaller proportion of transactions within Zone 1 and 4 compared to the other zones.

Comparing the analytic sample of transactions included in the building FE model to that of the grid FE model, it is evident that the former includes a larger percentage of public housing buildings than the

**Table 1**
Summary of the characteristics of resale transactions included in the postal code analysis, for each treatment zone. Transactions are generally similar across zones except for a lower percentage of public housing units in some zones.

| | No. sales | No. postal codes | Avg. unit size ($m^2$) | Avg. unit price ($/$m^2$) | Avg. building year built | % Public housing buildings |
|---|---|---|---|---|---|---|
| Zone 1 | 181,749 | 4582 | 114 | 10,564 | 1993 | 15.95 |
| Zone 2 | 112,372 | 3915 | 115 | 7392 | 1991 | 22.09 |
| Zone 3 | 78,637 | 3206 | 116 | 5581 | 1992 | 22.33 |
| Zone 4 | 69,080 | 2900 | 122 | 5534 | 1994 | 17.48 |
| Zone 5 | 95,118 | 2587 | 112 | 4970 | 1993 | 33.51 |
| Zone 6 | 104,982 | 3158 | 110 | 5313 | 1994 | 28.78 |
| Zone 7 | 100,173 | 3004 | 106 | 4610 | 1993 | 30.33 |
| Zone 8 | 115,985 | 3412 | 103 | 3637 | 1992 | 37.31 |
| Zone 9 | 120,830 | 2857 | 102 | 3775 | 1992 | 43.44 |
| Zone 10 | 115,788 | 3139 | 106 | 4060 | 1994 | 40.52 |

**Table 2**
Summary of the characteristics of resale transactions included in the grid cell analysis, for each treatment zone. Transactions are generally similar across zones except for a lower percentage of public housing units in some zones.

| | No. sales | Number of postal codes | Avg. size ($m^2$) | Avg. price per $m^2$ | Avg. building year built | % Public housing buildings | Number of cells |
|---|---|---|---|---|---|---|---|
| Zone 1 | 77,094 | 6289 | 132 | 6272 | 1984 | 9.25 | 734 |
| Zone 2 | 74,300 | 7258 | 126 | 4744 | 1984 | 9.93 | 688 |
| Zone 3 | 64,107 | 6328 | 129 | 4500 | 1986 | 9.85 | 590 |
| Zone 4 | 57,645 | 6425 | 137 | 4623 | 1989 | 7.46 | 548 |
| Zone 5 | 77,547 | 5518 | 121 | 4120 | 1988 | 14.41 | 609 |
| Zone 6 | 84,913 | 6213 | 118 | 4389 | 1991 | 12.68 | 588 |
| Zone 7 | 86,925 | 6360 | 114 | 3954 | 1992 | 13.18 | 592 |
| Zone 8 | 108,770 | 7115 | 109 | 3443 | 1994 | 16.60 | 613 |
| Zone 9 | 110,871 | 5783 | 108 | 3357 | 1994 | 20.92 | 582 |
| Zone 10 | 99,598 | 5710 | 110 | 3276 | 1993 | 21.94 | 550 |

latter. This difference can be attributed to the fact that there are relatively fewer repeated landed private housing sales, as discussed in earlier paragraphs. Additionally, because newer developments built post-gazette were excluded from the grid cell FE analysis, the housing stock analyzed in the grid cell FE analysis is on average older than that included in the building FE analysis.

### 3.4. Model specifications

To model the relationship between the outcome and treatment, we fitted a series of linear two-way fixed effects models. The basic model is as follows:

$$\text{Price}_{\text{it}} = \beta\text{Treatment}_{\text{it}} + \alpha_i + \text{Year}_t + \epsilon_{\text{it}} \quad (1)$$

where $i$ is the spatial unit of analysis. Either a building or a 200 × 200 m cell; $Price_{it}$ is the average sale price per square meters of transactions within analysis unit $i$ in time period $t$; $Treatment_{it}$ is the continuous variable: Total number of conserved sites in 'zone' of proximity for spatial unit $i$ in time period $t$; $\alpha_i$ is the unobserved, time-invariant building characteristics (e.g. age of building; architectural style) AND/OR locational characteristics (e.g. proximity to 'value-enhancing' features, such as parks, waterbodies, the Central Business District etc.); $Year_t$ is the year fixed effects, to control for potential year-specific confounders; $\epsilon_{it}$ is the residuals for each spatial unit, per time period.

To estimate the treatment effect, the outcome variable was regressed on the treatment variables, while accounting for spatial unit and year fixed effects, using the 'plm' package version 2.0.1, in R. Standard errors were further clustered at spatial unit-level to account for possible serial correlation. This regression model was fitted 10 times, with each run's analytic sample being defined as units located within each of the 10 'proximity zones' (see Fig. 5).

The base model was then expanded to test whether the designation of conservation had a lagged effect or an anticipation effect. A lagged effect seems quite likely, since the impact of conservation may be distributed over time, given that conservation announcements are sometimes accompanied by continued publicity, promotion and upgrading works over the next year or more, as described in the 'Overview of Conservation' section of this paper. Similarly, a small anticipatory effect may be possible, as conservation decisions are sometimes preceded by public consultation efforts or publicity announcements that provide a signal that conservation may occur. However, anticipatory effects more than one year ahead of official conservation seem unlikely, and may be a sign of spurious confounding that was not accounted for. Treatment lags and leads of 1, 2 and 3 years were thus incorporated into our Models (2) and (3), which are specified as follows:

$$\begin{aligned}\text{Price}_{\text{it}} = {} & \beta_0\text{Treatment}_{\text{it}} + \beta_1\text{Treatment}_{\text{it}-1} + \beta_2\text{Treatment}_{\text{it}-2} \\ & + \beta_3\text{Treatment}_{\text{it}-3} + \alpha_i + \text{Year}_t + \epsilon_{\text{it}} \quad (2)\end{aligned}$$

$$\begin{aligned}\text{Price}_{\text{it}} = {} & \beta_0\text{Treatment}_{\text{it}} + \beta_1\text{Treatment}_{\text{it}+1} + \beta_2\text{Treatment}_{\text{it}+2} \\ & + \beta_3\text{Treatment}_{\text{it}+3} + \alpha_i + \text{Year}_t + \epsilon_{\text{it}} \quad (3)\end{aligned}$$

The above models are based on assumptions that there were no unobserved, time-variant locational characteristics that could have confounded findings. However, between 1997 and 2017, there were 89 new Mass Rapid Transit (MRT) subway stations opened for operation, which represent a not-insubstantial change in locational characteristics islandwide. Given that proximity to subway stations is usually associated with higher real estate values (Murakami, 2018), we thus included an additional unit-level time-varying variable 'distance to MRT', with unit measurement of kilometres, into the analysis.

Another time-variant locational characteristics specific to the grid cell analysis that could confound our findings is the mix of public-private housing transactions in each cell. Given that private housing is more expensive than public housing (which is largely 'no-frills' in nature), in Singapore, an increase in ratio of private housing to public housing sale transactions within a grid cell location over time would raise the average price per square meter within that grid cell, even if neither the average price per square meter of public housing or private housing increased. To account for this potential confounder, we included an additional grid cell-level time-varying variable 'Percentage of transactions that are of public housing', into the analysis. However, as public housing units are never mixed with private housing units within the same building in Singapore, this variable was omitted from the building level fixed effects model.

The models include a three-year treatment lag variable, as it had the most substantial, significant effects across several proximity zones based on Models (2) and (3) results.

$$\begin{aligned}\text{Price}_{\text{it}} = {} & \beta_0\text{Treatment}_{\text{it}} + \beta_1\text{DistanceMRT}_{\text{it}} + \beta_2\text{Percent. Public.} \\ & \text{Housing}_{\text{it}} \\ & + \beta_3\text{Treatment}_{\text{it}-3} + \alpha_i + \text{Year}_t + \epsilon_{\text{it}} \quad (4)\end{aligned}$$

Finally, the above models adopt an assumption that the conservation of sites imposes a constant treatment effect on housing types, which may not be a realistic assumption given that the treatment may have differentiated impact on public housing units compared to private housing units. Given that the composition of public private housing sales differ between the various 'proximity zones' zones, there is thus a need to interrogate this assumption. To do so, we split the housing transaction data into 'public' and 'private' housing sales, to test the treatment effect of conservation on these two types of housing transactions separately, as follows:

$$\begin{aligned}\text{Price(Public)}_{\text{it}} = {} & \beta_0\text{Treatment}_{\text{it}} + \beta_1\text{DistanceMRT}_{\text{it}} \\ & + \beta_3\text{Treatment}_{\text{it}-3} + \alpha_i + \text{Year}_t + \epsilon_{\text{it}} \quad (5)\end{aligned}$$

$$\begin{aligned}\text{Price(Private)}_{\text{it}} = {} & \beta_0\text{Treatment}_{\text{it}} + \beta_1\text{DistanceMRT}_{\text{it}} \\ & + \beta_3\text{Treatment}_{\text{it}-3} + \alpha_i + \text{Year}_t + \epsilon_{\text{it}} \quad (6)\end{aligned}$$

Additionally, for the grid cell FE model, we further isolated the landed housing transactions, and repeated the above model analysis on this subset of transactions, to examine if the treatment effect of conservation on landed housing properties differed from the effect on other housing types. However, as there were relatively few repeated sales of landed housing, we were unable to fit a similar building level FE model with only landed housing transactions, due to the low sample size.

To test for whether there might be diminishing returns to the number of designated properties, we included a squared primary treatment variable to the above model specifications. As the coefficient associated with this quadratic term was non-significant across the models for most treatment zones, the analyses reported in Section 4 excludes this quadratic term. Appendix B summarizes the analyses with

**Table 3**
Results from building FE baseline model, which show positive treatment effects on residential resale prices from each additional conservation designation up to 2.4 km, and between 3.6 to 4 km.

| | Treatment effect (*p*) |
|---|---|
| Within 400 m | 102.6 (0.00) |
| 400–800 m | 166.5 (0.00) |
| 800 m–1.2 km | 496.6 (0.00) |
| 1.2–1.6 km | 467.7 (0.00) |
| 1.6–2 km | 211.2 (0.00) |
| 2–2.4 km | 102.1 (0.00) |
| 2.4–2.8 km | −43.1 (0.08) |
| 2.8–3.2 km | −80.9 (0.00) |
| 3.2–3.6 km | −68.3 (0.00) |
| 3.6–4 km | 95.9 (0.00) |

**Table 4**
Results from grid FE baseline model, which show positive treatment effects on residential resale prices from each additional conservation designation up to 2 km, and between 3.6 to 4 km.

| | Treatment effect (*p*) |
|---|---|
| Within 400 m | 26.8 (0.62) |
| 400–800 m | 131.9 (0.06) |
| 800 m–1.2 km | 515.1 (0.00) |
| 1.2–1.6 km | 579.9 (0.00) |
| 1.6–2 km | 279.9 (0.01) |
| 2–2.4 km | −79.4 (0.24) |
| 2.4–2.8 km | −128 (0.03) |
| 2.8–3.2 km | −257.6 (0.00) |
| 3.2–3.6 km | −184.1 (0.00) |
| 3.6–4 km | 242.5 (0.00) |

the quadratic treatment variable.

## 4. Results

The following paragraphs present results from the described model specifications 1 to 6, for both building FE and grid cell FE results. For each model specification, results for all 10 treatment zones are summarized in a table that reports the fitted coefficients and p-values of the primary treatment variable as well as any additional model variables. To aid visual interpretation, plots of the each model specification's estimated variable coefficients over zones, and associated 95% confidence intervals are also included.

### 4.1. Model 1: Base model

Results from the building FE Model 1 suggest a significant sale premium following the designation of a site as conserved up to 2.4 km from the conserved site (Table 3, Fig. 6). This positive effect started small at the Zone 1 (within 400 m) of the conserved sites at SG$103, increased to SG$166 for Zone 2 and peaked at close to SG$500 in Zone 3 and Zone 4, before tapering and decreasing to insignificance in Zone 7, and relatively small negatives at Zones 8 and 9. Unexpectedly though, a smaller positive impact of SG$ 96 resurfaced at Zone 10 (3.6–4 km).

Results from the grid cell FE analysis were similar to the building-level analysis in terms of relative magnitude of each zone of treatment, with some differences(Table 4, Fig. 7). Like the building-level analysis, the premium effect from conservation were largest in Zone 3 and 4, at over SG$500, before petering off after 2 km, dipping into negative at Zones 7, 8 and 9, and resurfacing again at Zone 10. One difference between the building FE and grid FE analyses was that the estimated coefficient of conservation designation within Zone 1 was statistically significant only in the former.

### 4.2. Models 2 and 3: Leads and lags

Results from the building FE model with lagged (Table 6, Fig. 9) and lead effects (Table 5, Fig. 8) were largely consistent with results from the base model, in that a significant sale premium was observed from the designation of one site up to 2.4 km. In both the lead and lag effects models, the largest premiums were observed in Zone 4 (1.2 to 1.6 km), of SG$ 245 and 273 respectively.

We found the one and two year leads to be either insignificant or relatively smaller, at a maximum of SG$74.5, compared to the main treatment, across all treatment zones. For the three-year treatment lead, we observed a negative effect (SG$ −175) for locations within Zone 1 that negates much of the estimated positive main treatment effect (SG$218). One tentative explanation might be that the market values of

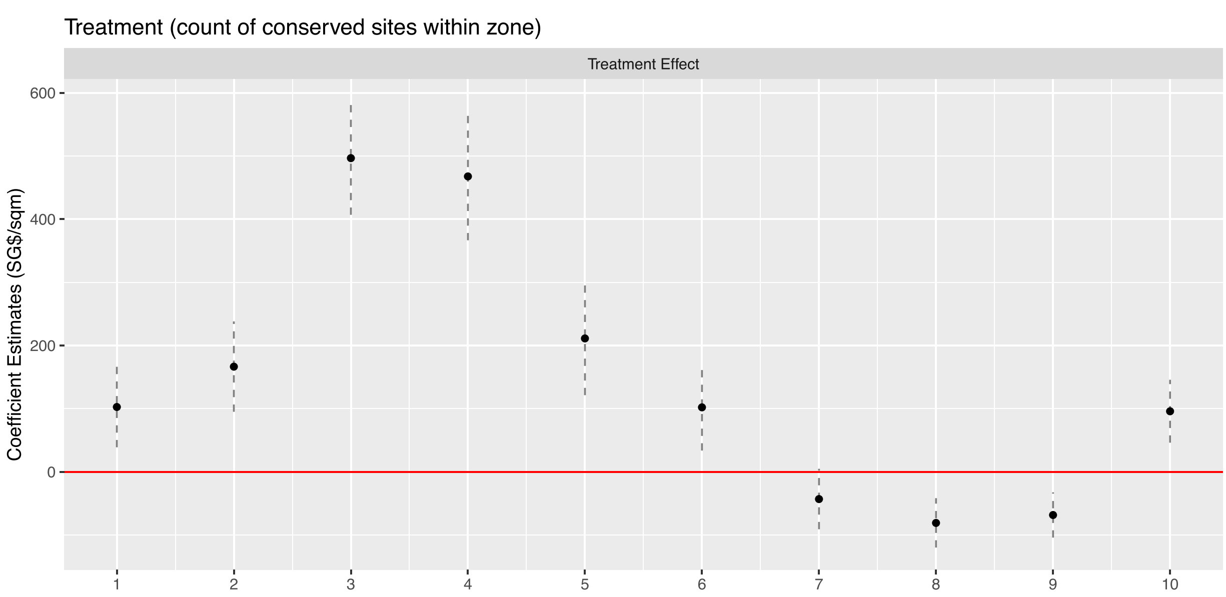


**Fig. 6.** Building FE model: plot of treatment coefficients across 10 proximity zones, showing largest positive treatment effects on residential resale prices in Zones 3 and 4.

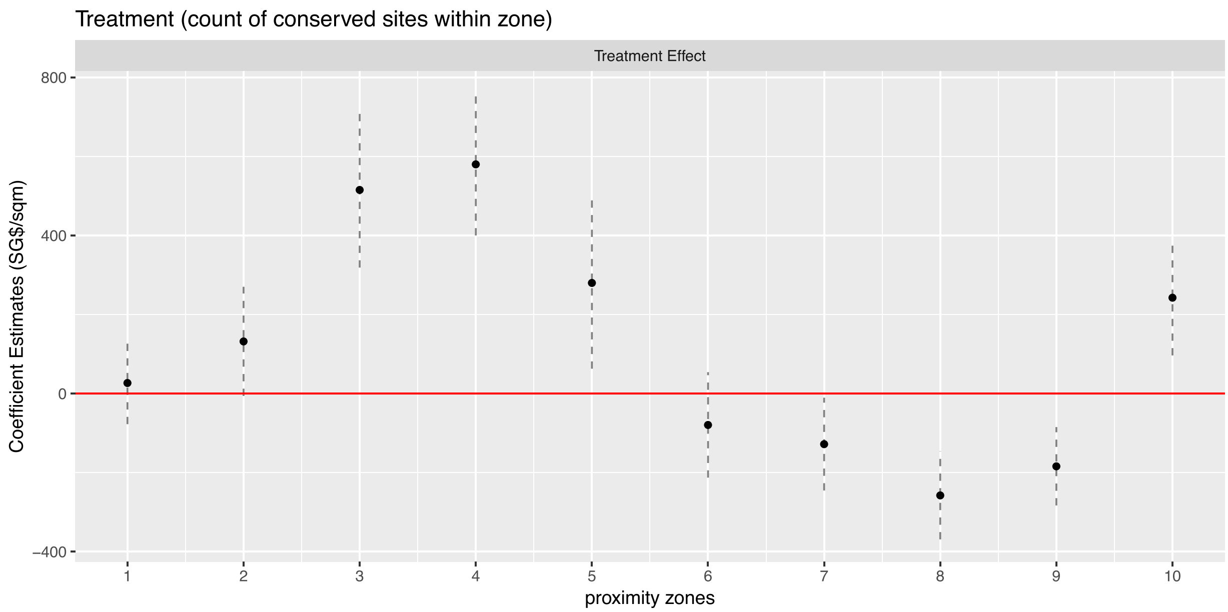


**Fig. 7.** Grid FE model: plot of treatment coefficients across 10 proximity zones, showing largest positive treatment effects on residential resale prices in Zones 3 and 4.

**Table 5**
Results from building FE model with leads, which show sizeable positive main treatment effects from each additional conservation designation up to 2.4 km, and mostly small lead effects except for a negative 3 year lead effect within 400 m.

| | Treatment effect (*p*) | Lead 1 (*p*) | Lead 2 (*p*) | Lead 3 (*p*) |
|---|---|---|---|---|
| Within 400 m | 218 (0.00) | −34.8 (0.22) | −6.7 (0.80) | −174.8 (0.00) |
| 400–800 m | 94.3 (0.04) | 42.6 (0.18) | 37.7 (0.22) | −43.8 (0.08) |
| 800 m–1.2 km | 162.3 (0.00) | 58.8 (0.17) | 59.3 (0.10) | −19.5 (0.60) |
| 1.2–1.6 km | 244.6 (0.00) | 89.9 (0.05) | 10.8 (0.80) | 112.8 (0.01) |
| 1.6–2 km | 104.3 (0.00) | −56.4 (0.03) | −3.3 (0.91) | 2.6 (0.91) |
| 2–2.4 km | 92.1 (0.00) | −26.2 (0.26) | 37.7 (0.10) | −0.7 (0.98) |
| 2.4–2.8 km | −9.7 (0.72) | 74.5 (0.00) | −66 (0.01) | 102.5 (0.00) |
| 2.8–3.2 km | −31.1 (0.06) | 3.5 (0.76) | 13.8 (0.12) | 80.7 (0.00) |
| 3.2–3.6 km | −18.9 (0.20) | −8.8 (0.45) | −9.9 (0.38) | 77.8 (0.00) |
| 3.6–4 km | −60.9 (0.02) | 18.1 (0.28) | 10.4 (0.59) | 6.7 (0.71) |

**Table 6**
Results from building FE model with lags, which show sizeable positive main treatment effects from each additional conservation designation from 400 m to 2.4 km, and sizeable positive 3 year lag effects across several proximity zones.

| | Treatment effect (*p*) | Lag 1 (*p*) | Lag 2 (*p*) | Lag 3 (*p*) |
|---|---|---|---|---|
| Within 400 m | −25.3 (0.53) | −21.1 (0.54) | −1.8 (0.96) | 85.5 (0.08) |
| 400–800 m | 123.2 (0.00) | −76.1 (0.01) | 68.9 (0.04) | 17.5 (0.67) |
| 800 m–1.2 km | 209.9 (0.00) | 2.6 (0.94) | 94.6 (0.00) | 189.5 (0.00) |
| 1.2–1.6 km | 272.7 (0.00) | 29 (0.43) | 232.2 (0.00) | 235.9 (0.00) |
| 1.6–2 km | 78.9 (0.04) | −16 (0.62) | 38.7 (0.15) | 169.4 (0.00) |
| 2–2.4 km | 107.3 (0.00) | 44.1 (0.06) | −52.7 (0.06) | 150.5 (0.00) |
| 2.4–2.8 km | 77.3 (0.00) | −40.7 (0.03) | 0.4 (0.98) | 27.2 (0.33) |
| 2.8–3.2 km | 34.7 (0.01) | −2.6 (0.82) | 1.8 (0.87) | −37.8 (0.03) |
| 3.2–3.6 km | 8 (0.58) | 5.4 (0.63) | 44.1 (0.00) | 13.6 (0.45) |
| 3.6–4 km | −53.1 (0.01) | −22.8 (0.15) | 89.5 (0.00) | 70.7 (0.05) |

residential buildings closest to the conserved site were negatively affected by the combined effect of firstly an increased uncertainty over whether the site would actually be conserved in the years leading up to official confirmation, and secondly the negative impact of being close to an old, possibly dilapidated development in need of restoration.

The one year lag was also small or insignificant across all treatment zones. For the two-year lag, a sizeable positive effect of SG$ 232 was observed only for the Zone 4 treatment, while for the three-year lag, sizeable positive effects ranging from $150 to $236 were observed for multiple zones, including Zones 3, 4, 5, 6.

Similar to the building FE model, the grid cell FE model found sizeable conservation premiums up to 2 km. Also similar to the building FE model was the finding of a sizeable negative three-year treatment lead effect for locations within Zone 1 was observed (Table 7, Fig. 10).

Again similar to the building FE model, we found mostly small or insignificant one and two year lag effects across the proximity zones, but substantial and significant positive three year lag effects, which ranged from $468 per square meter to $291 (Table 8, Fig. 11) within Zones 3 to 5. Collectively, both the building FE and grid cell FE models suggest that, in addition to the boost in residential property prices during the year of conservation gazette, a sizeable boost to prices occurred three years after gazette which might be due to the completion

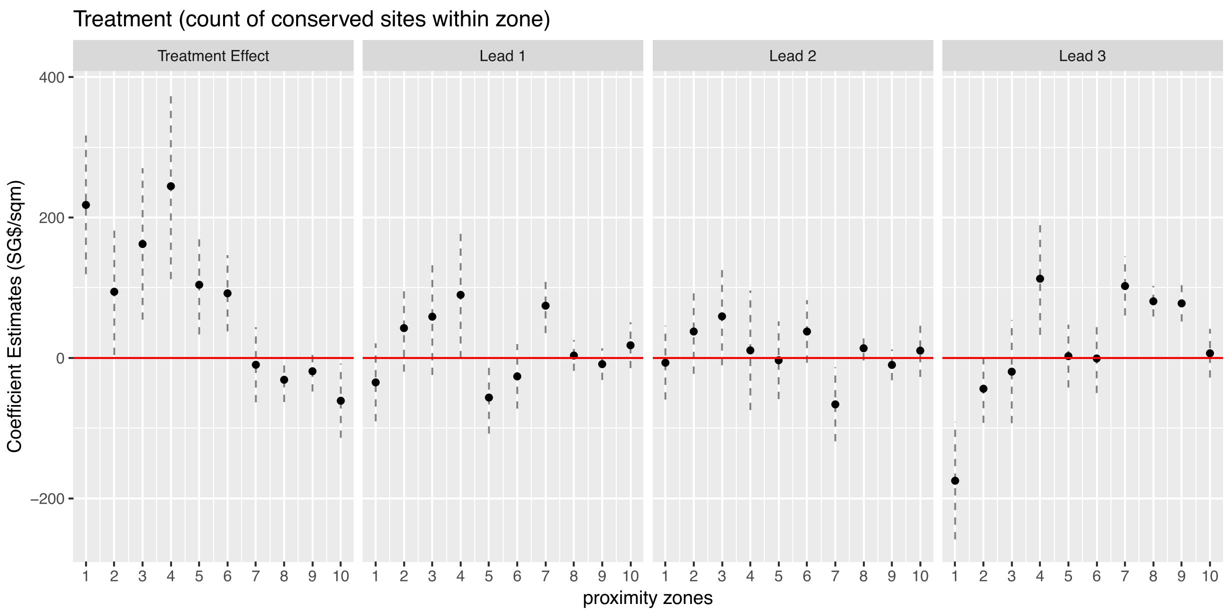


**Fig. 8.** Building FE model: plot of treatment and treatment lead effects coefficients across 10 proximity zones, showing largest positive treatment effects in Zone 4, and mostly insignificant or small lead effects.

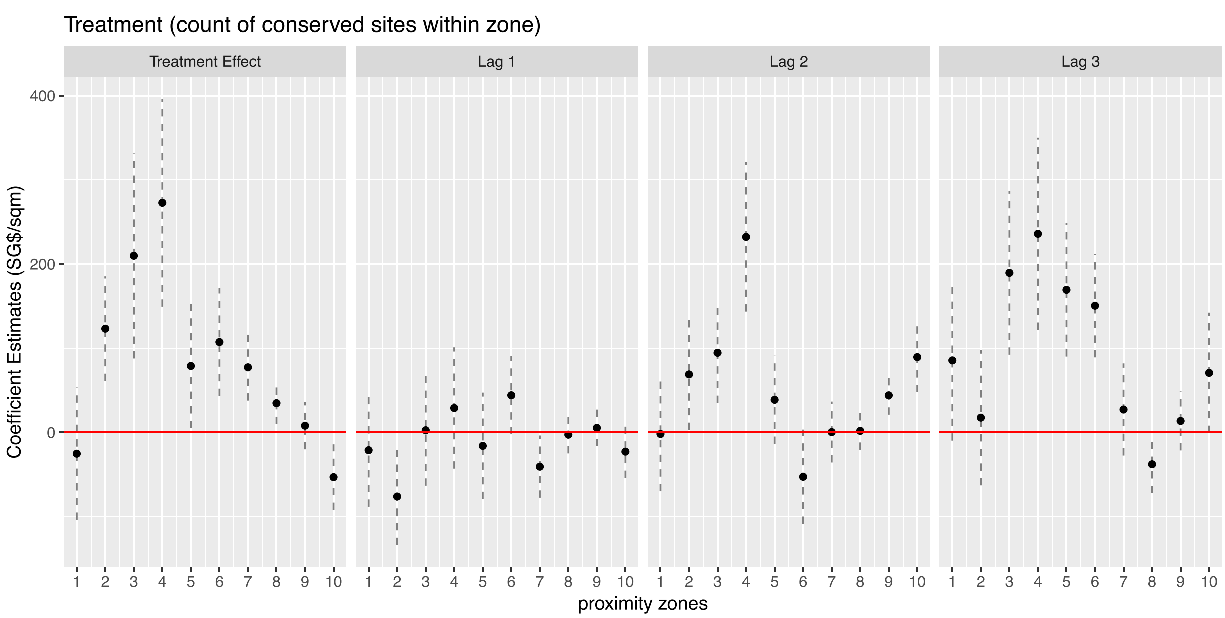


**Fig. 9.** Building FE model: plot of treatment and treatment lag effects coefficients across 10 proximity zones, showing largest positive treatment effects in Zone 4, and sizeable 3 year lag effects.

**Table 7**
Results from grid FE model with leads, which show sizeable positive main treatment effects from each additional conservation designation between 800 m to 2 km, and comparatively small lead effects except for a negative 3 year lead effect within 400 m.

| | Treatment effect (*p*) | Lead 1 (*p*) | Lead 2 (*p*) | Lead 3 (*p*) |
|---|---|---|---|---|
| Within 400 m | 107.5 (0.21) | 49 (0.33) | 81 (0.10) | −220.2 (0.00) |
| 400–800 m | 54 (0.40) | 125.2 (0.01) | 92.7 (0.04) | −103.8 (0.03) |
| 800 m–1.2 km | 317.2 (0.00) | 187.3 (0.01) | 48.9 (0.37) | −64.4 (0.36) |
| 1.2–1.6 km | 599 (0.00) | 5.5 (0.93) | 13.2 (0.86) | 49.9 (0.46) |
| 1.6–2 km | 197.4 (0.02) | −45.1 (0.47) | 79.4 (0.23) | 40.3 (0.59) |
| 2–2.4 km | −98.1 (0.17) | 26.8 (0.57) | −27 (0.54) | 59.2 (0.33) |
| 2.4–2.8 km | −286.1 (0.00) | 162.9 (0.00) | −47.8 (0.34) | 167.7 (0.00) |
| 2.8–3.2 km | −64.1 (0.18) | −12 (0.73) | 5.4 (0.88) | 3.5 (0.92) |
| 3.2–3.6 km | −51.6 (0.16) | −41.6 (0.10) | −19.2 (0.48) | 71.7 (0.01) |
| 3.6–4 km | 16 (0.75) | 44.6 (0.19) | 127 (0.00) | 65.6 (0.11) |

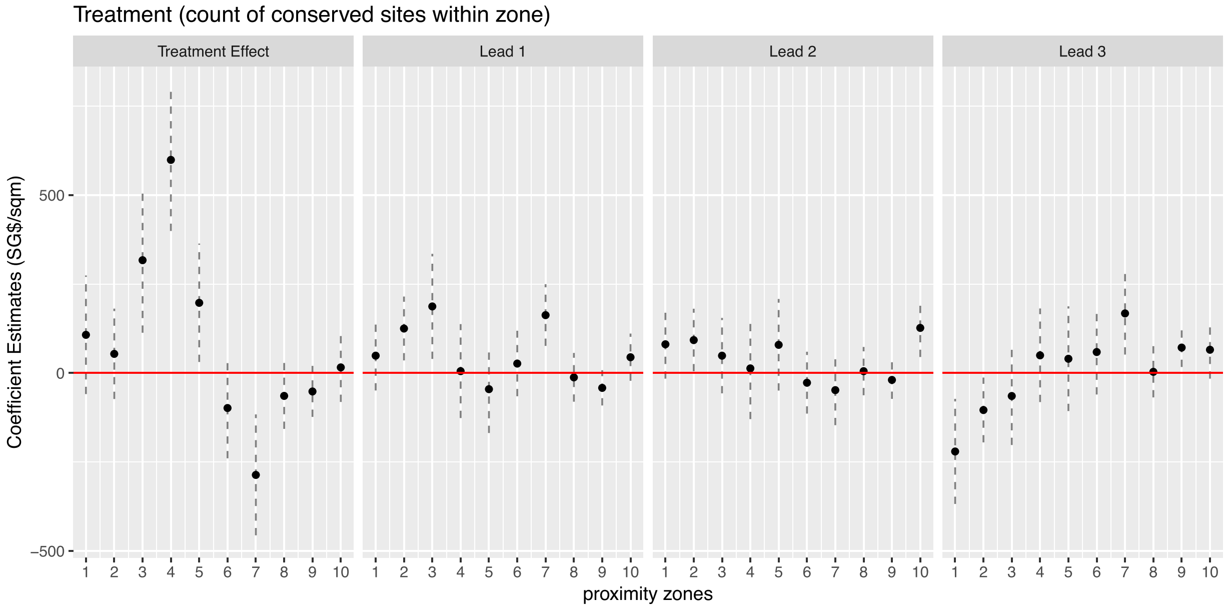


**Fig. 10.** Grid FE model: plot of treatment and treatment lead effects coefficients across 10 proximity zones, showing largest positive treatment effects in Zone 4 and comparatively small lead effects.

**Table 8**
Results from grid FE model with lag variables, which show sizeable positive main treatment effects from 400 m to 1.6 km,and sizeable positive and negative 3 year lag effects across several proximity zones.

| | Treatment effect (*p*) | Lag 1 (*p*) | Lag 2 (*p*) | Lag 3 (*p*) |
|---|---|---|---|---|
| Within 400 m | −42.2 (0.52) | −9.5 (0.87) | 85.4 (0.17) | 12.8 (0.88) |
| 400–800 m | 198.1 (0.01) | −24.5 (0.64) | 84.5 (0.08) | −111.3 (0.11) |
| 800 m–1.2 km | 282 (0.01) | −20.9 (0.81) | 62.9 (0.43) | 380 (0.00) |
| 1.2–1.6 km | 348.4 (0.00) | 66 (0.42) | 66.9 (0.37) | 468.2 (0.00) |
| 1.6–2 km | 103.9 (0.23) | 20 (0.76) | 24.9 (0.71) | 291.8 (0.01) |
| 2–2.4 km | 18.7 (0.78) | −30.9 (0.57) | −114.8 (0.05) | 67.7 (0.41) |
| 2.4–2.8 km | 90.8 (0.13) | −69.2 (0.13) | −180.6 (0.00) | −203.7 (0.02) |
| 2.8–3.2 km | −3.7 (0.93) | −202.5 (0.00) | −87.6 (0.06) | −140.6 (0.02) |
| 3.2–3.6 km | −48.2 (0.19) | −45.3 (0.15) | −26.7 (0.36) | −170.6 (0.00) |
| 3.6–4 km | 119.4 (0.03) | 35.1 (0.43) | 209.5 (0.00) | 204.6 (0.01) |

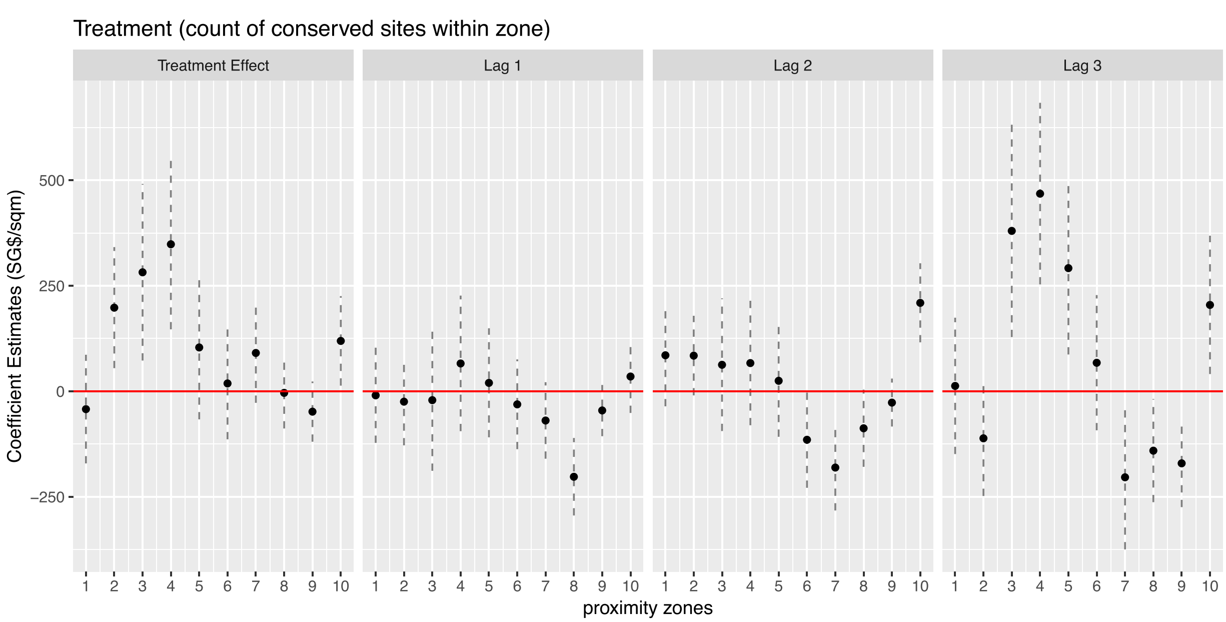


**Fig. 11.** Grid FE model: plot of treatment and treatment lag effects coefficients across 10 proximity zones, showing largest positive treatment effects in Zone 4, and sizeable 3 year lag effects.

**Table 9**
Results from building FE model with 3 year lag and distance to MRT variables, which show sizeable positive main treatment effects of conservation from 400,m to 2.4 km; and 3 year lagged effect from 800 m to 2.4 km; as well as lower residential sale prices when further from subway stations.

| | Treatment effect (*p*) | 3 year lag (*p*) | KM to MRT (*p*) |
|---|---|---|---|
| Within 400 m | −42.9 (0.21) | 74.7 (0.13) | 150.3 (0.02) |
| 400–800 m | 100.8 (0.00) | 36.5 (0.34) | −176.2 (0.00) |
| 800 m–1.2 km | 216.9 (0.00) | 241.6 (0.00) | −264.3 (0.00) |
| 1.2–1.6 km | 361.8 (0.00) | 388.5 (0.00) | 17.4 (0.66) |
| 1.6–2 km | 81.3 (0.02) | 172.6 (0.00) | −94.7 (0.01) |
| 2–2.4 km | 117.5 (0.00) | 130.7 (0.00) | −43.8 (0.18) |
| 2.4–2.8 km | 52.2 (0.00) | 14.5 (0.64) | −4.2 (0.80) |
| 2.8–3.2 km | 36.1 (0.01) | −37.4 (0.05) | 37.6 (0.00) |
| 3.2–3.6 km | 25.6 (0.08) | 43 (0.04) | 8.5 (0.25) |
| 3.6–4 km | −41.4 (0.07) | 120.8 (0.00) | 8.4 (0.14) |

of additional upgrading or restoration works post-gazette.

One difference between the lag model results from building level FE analysis and the grid cell FE analysis was that only the latter suggested unexpectedly large negative lagged treatment effects within Zones 7, 8 and 9. This divergent finding may be due to unaccounted for, within-cell confounding variables specific to these zones, that had otherwise been accounted for by the inclusion of individual building fixed effects. For instance, there might be a differences in the relative composition of housing units within each grid cell sold before and after conservation gazette.

Subsequent models reported in the main paper include only the three year lag variable, as the most substantial and significant effects across proximity zones was observed there. We also tested models with two year lag and three year lead variables, which did not change the observed main treatment effects substantially. Results from those models can be made available upon request.

### *4.3. Model 4: Subway opening and percent public housing transactions*

The building FE model results (Table 9, Fig. 12) suggest that controlling for changes in 'distance to MRT' did not substantially change the key treatment effect discussed above. As before, there was still a substantial, significant treatment effect of conservation at locations within 2.4 km of a conserved site. The estimated premium was largest within Zone 3 and 4, at $217 and $362 respectively during the year of gazette, and $242 and $389 three years after gazette. The combined premium of conserving one site during gazette and three years tapered in Zone 5 and subsequent zones.

Intuitively, one would expect that reduced distances to MRT stations, due to the opening of new stations, would result in a residential sales premium. This intuition held true for buildings within Zones 2, 3 and 5 of the conserved sites. For these buildings, having a one kilometer reduction in distance to MRT was associated with a $95 to $264 premium in average sales per square meter.

The grid cell FE model's results (Table 10, Fig. 13) were generally aligned with the building FE model's. Including additional variables 'distance to MRT' and 'Percentage of transactions that were of public housing' did not substantially change the key result findings discussed above. As before, there was still a substantially significant treatment effect of conservation within 2km of conserved sites. The main treatment effect was largest across Zones 2, 3 and 4, ranging from $235 to $402 during year of gazette. There was also a large and significant three-year treatment lagged effect of $384, $535 and $307 within Zones 3, 4 and 5 respectively.

As expected, as the percentage of transactions that were of public housing increased, the average sale price dipped across all 10 proximity zones. For a ten percentage point increase in public housing transactions, the average sales per square meter dropped a maximum of $331. As discussed previously, we included this public-private housing transaction mix variable to control for possible confounders in terms of housing transaction composition. However, changes in public-private housing transaction mix did not account for the negative treatment lag effect for Zones 7 to 9 observed in Model 3, which suggests that other unobserved aspects of within-cell housing transaction mix might be driving the effect.

Consistent with the building FE model, results from the grid cell FE model suggests that reducing the distance to an MRT station generates a sizeable sales premium, but only for certain locations (Zones 2, 3, 5,6,7) While it is beyond the scope of this paper to interrogate this particular finding, we hypothesize that this finding arises because proximity to MRT stations might be valued differently across different locations, where certain neighborhoods value access to public transport more highly than others.

As an additional robustness check, we also tested whether

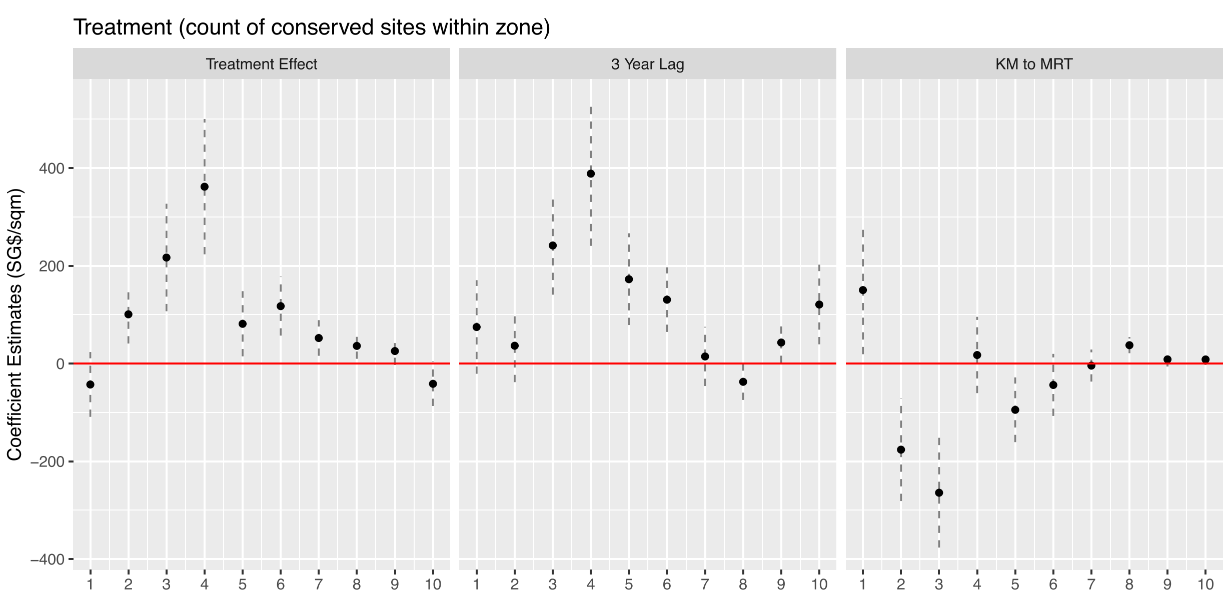


**Fig. 12.** Building FE: plot of treatment, 3 year lag and subway proximity coefficients across 10 proximity zones, which show largest positive main and lagged treatment effects in Zone 4.

**Table 10**
Results from grid FE model with 3 year lag, housing type and distance to MRT, which show sizeable positive main treatment effects of conservation from 400 m to 2.4 km; and 3 year lagged effect from 800 m to 2.4 km. Results suggest lower residential sale prices when proportionally more transactions were of public housing units, and when located further from subway stations.

| | Treatment effect (*p*) | 3 year lag (*p*) | + 10% Public housing (*p*) | KM to MRT (*p*) |
|---|---|---|---|---|
| Within 400 m | − 5.7 (0.92) | 58.1 (0.44) | − 331.1 (0.00) | − 99.2 (0.31) |
| 400–800 m | 235.2 (0.00) | − 82.2 (0.21) | − 271.2 (0.00) | − 556.7 (0.00) |
| 800 m–1.2 km | 291.7 (0.00) | 384.5 (0.00) | − 272.6 (0.00) | − 362.3 (0.00) |
| 1.2–1.6 km | 402.3 (0.00) | 535.4 (0.00) | − 189.4 (0.00) | − 0.2 (1.00) |
| 1.6–2 km | 130.2 (0.15) | 306.7 (0.02) | − 170.3 (0.00) | − 153.4 (0.01) |
| 2–2.4 km | − 22.7 (0.73) | − 43.1 (0.63) | − 143.1 (0.00) | − 332.1 (0.00) |
| 2.4–2.8 km | − 5.6 (0.92) | − 336.2 (0.00) | − 138.7 (0.00) | − 120.4 (0.04) |
| 2.8–3.2 km | − 151.8 (0.00) | − 263.9 (0.00) | − 70.9 (0.04) | 84 (0.01) |
| 3.2–3.6 km | − 81.3 (0.03) | − 202.9 (0.00) | − 46.7 (0.01) | 33.3 (0.13) |
| 3.6–4 km | 194.1 (0.00) | 353.3 (0.00) | − 64 (0.01) | 15.3 (0.48) |

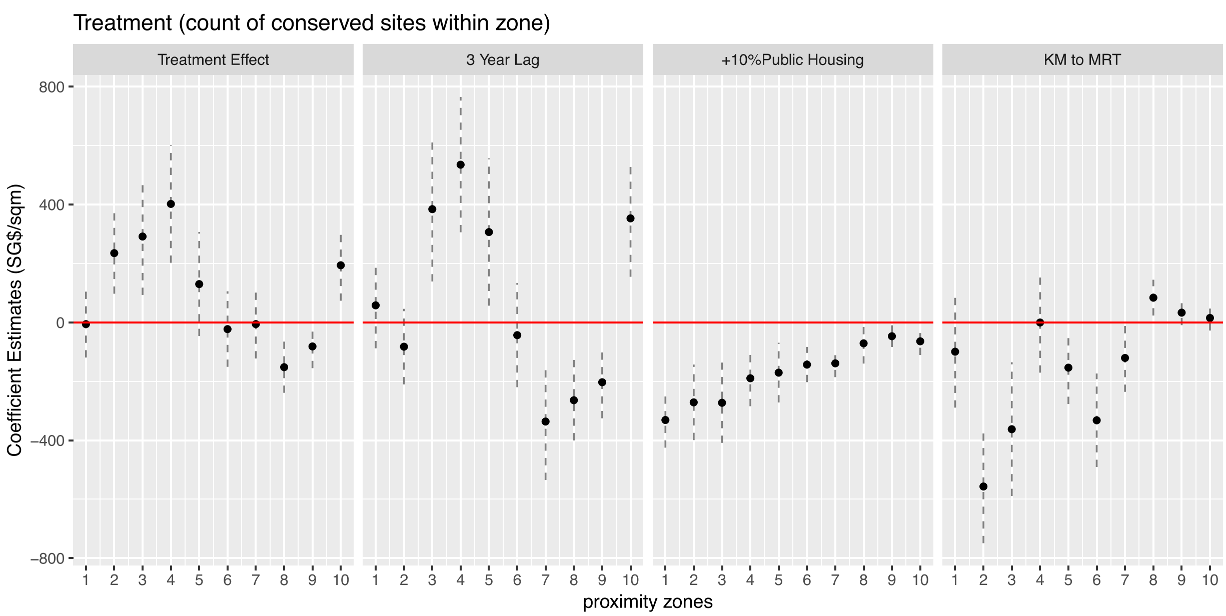


**Fig. 13.** Grid FE: plot of treatment, 3 year lag, proportion public housing, and subway proximity coefficients across 10 proximity zones, which show largest positive main and lagged treatment effects in Zone 4; negative effects from having proportionally more public housing transactions, as well as being further from the subway stations.

**Table 11**
Results from private housing only, building FE model, which show sizeable, positive main treatment effects and lagged effects of conservation from 800 m to 2.4 km, but negative main and lagged effects between 2.8 to 3.2 km.

| | Treatment effect (*p*) | 3 year lag (*p*) | Distance to MRT (km) (*p*) |
|---|---|---|---|
| Within 400 m | − 10.9 (0.79) | 146.3 (0.02) | 287.2 (0.00) |
| 400–800 m | 173.9 (0.03) | 12 (0.88) | − 40.1 (0.61) |
| 800 m–1.2 km | 476.2 (0.00) | 377.5 (0.00) | − 208.4 (0.01) |
| 1.2–1.6 km | 679.2 (0.00) | 408 (0.00) | 205.6 (0.02) |
| 1.6–2 km | 231.6 (0.01) | 482.1 (0.00) | − 222.9 (0.01) |
| 2–2.4 km | 278.4 (0.00) | 336.4 (0.00) | − 275 (0.01) |
| 2.4–2.8 km | 9 (0.90) | − 6.3 (0.95) | − 39.8 (0.29) |
| 2.8–3.2 km | − 249 (0.01) | − 305.4 (0.01) | 37.2 (0.28) |
| 3.2–3.6 km | − 20.6 (0.73) | 153 (0.09) | 19.1 (0.48) |
| 3.6–4 km | 104.7 (0.13) | 394.1 (0.00) | − 12 (0.45) |

controlling for the proportion of landed housing sales within a grid cell might affect the above estimates. Doing so yielded very similar point estimates as before (see Appendix C).

### *4.4. Models 5 and 6: Public vs private housing markets*

One clear result from comparing the building FE models of the different housing types is that the sales premium generated by conservation was higher for private housing units (Table 11, Fig. 14) compared to public housing (Table 12, Fig. 15). For instance, the premium for private housing located in areas within Zone 3 of a newly conserved site was $476 per square meter during the year of gazette, compared to $83 per square meter for public housing.

Treatment and lagged treatment effects were also significant within more treatment zones for private housing than public housing. For instance, there were positive, significant effects when treatment is defined by Zone 2, 4 and 5, and a negative effect for Zone 8 only for private housing but not for public housing. For Zone 10, there was a significant, positive 3 year lagged effect for the private housing transactions, but a negative treatment and lagged effect on public housing.

The grid cell FE models yielded findings that were very similar to the building FE models. First, sales premium from conservation gazettes were higher for private housing units (Table 13, Fig. 16) than public housing (Table 14, Fig. 17). The premium for private housing located in areas within Zone 3 of a newly conserved site was $594 per square meter during the year of gazette, compared to $63 per square meter for public housing. Significant positive effects were also observed for Zone 2, 4 and 5 treatments, and a negative effect for Zone 8 treatment, but only for private housing. As with the building FE model, we found differentiated effects of Zone 10 treatment: there was a significant, positive treatment and 3 year lagged effect for the private housing transactions, but a negative treatment and lagged effect on public

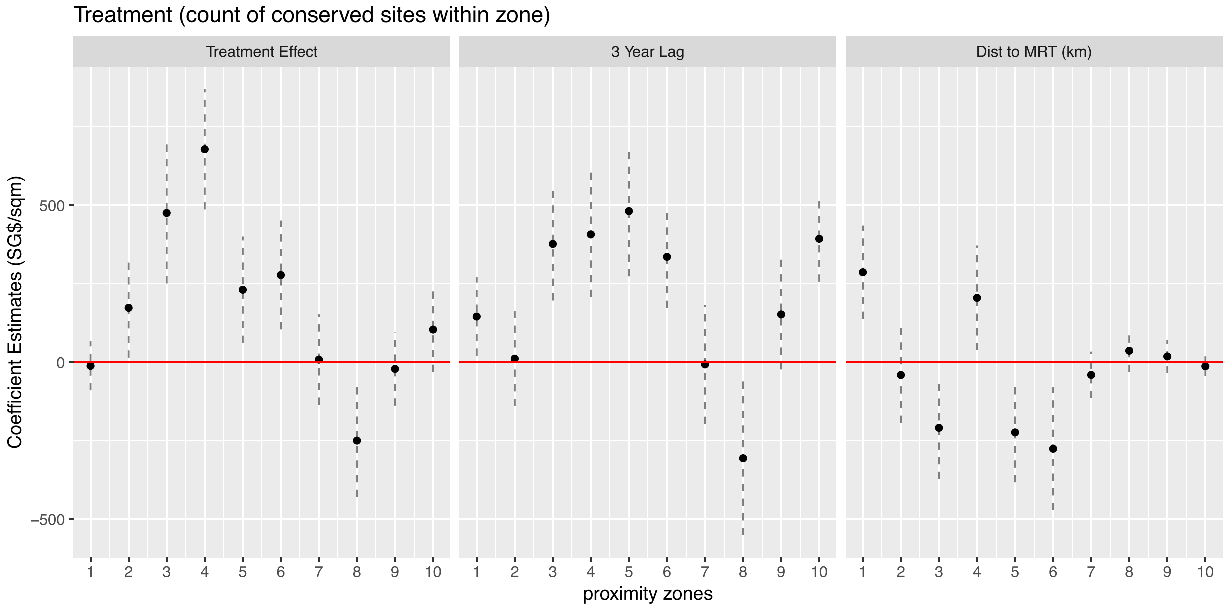


**Fig. 14.** Building FE for private housing only: plot of treatment, 3 year lag and subway proximity coefficients across 10 proximity zones, which show largest positive main treatment effects in Zone 4, and largest lagged effect in Zone 5.

**Table 12**
Results from public housing only, building FE model, which show smaller positive main treatment effects and lagged effects of conservation compared to the private housing model.

| | Treatment effect (*p*) | 3 year lag (*p*) | Distance to MRT (km) (*p*) |
|---|---|---|---|
| Within 400 m | 28.8 (0.05) | 85.6 (0.00) | 9.9 (0.72) |
| 400–800 m | 1.7 (0.87) | 113.7 (0.00) | 44.1 (0.05) |
| 800 m–1.2 km | 83 (0.00) | 47.5 (0.12) | −81.1 (0.02) |
| 1.2–1.6 km | 26.7 (0.21) | −68.9 (0.00) | −226.7 (0.00) |
| 1.6–2 km | 20.1 (0.22) | 16.6 (0.32) | −18.7 (0.20) |
| 2–2.4 km | 4.2 (0.80) | 106.5 (0.00) | 41.2 (0.00) |
| 2.4–2.8 km | 24.3 (0.09) | 56.3 (0.01) | 28.7 (0.02) |
| 2.8–3.2 km | 57.8 (0.00) | 22 (0.05) | 34.1 (0.00) |
| 3.2–3.6 km | 58.3 (0.00) | 44.8 (0.00) | 13.4 (0.05) |
| 3.6–4 km | −87.4 (0.00) | −62.4 (0.00) | 20.4 (0.00) |

housing.

Additionally, we isolated the private landed housing transactions, and repeated the grid-cell model analysis on this subset of transactions, to examine if the treatment effect of conservation on landed housing properties differed from the effect on other housing types. Compared to the private housing model, the landed housing model produced higher point estimates of the main treatment and 3 year lag effects. For example, the estimated main treatment effect on landed housing within Zone 3 of a newly conserved site was $852.7. These findings suggest that the premium from conservation designations may be largest for landed properties, compared to non-landed private housing and public housing. Details of this analysis can be found in Appendix C.

Collectively, both building FE and grid cell FE Models 5 and 6 suggest the negative effect of having a gazetted site located around Zone 7 to 9 observed in earlier models might be specific only to the

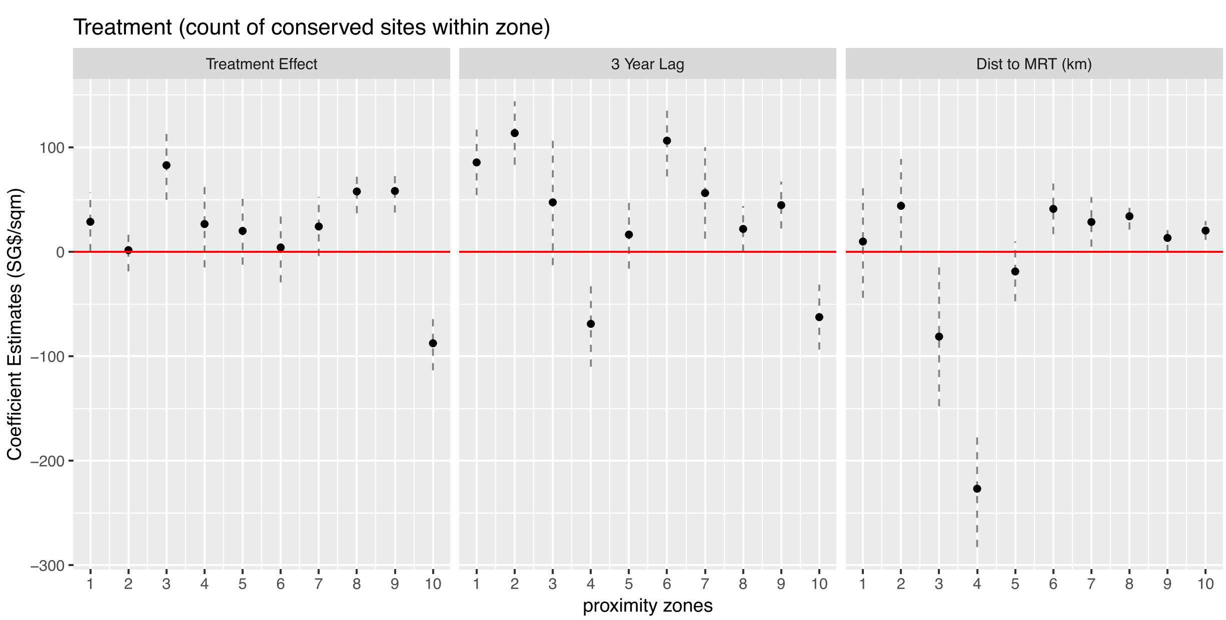


**Fig. 15.** Building FE for public housing only: plot of treatment, 3 year lag and subway proximity coefficients across 10 proximity zones, which show much smaller positive main treatment and lagged effects compared to the private housing only model.

**Table 13**
Results from private housing only, grid FE model, which show sizeable, positive main treatment effects and lagged effects of conservation between 400 m to 2 km, and 3.6 to 4 km, but negative main and lagged effects between 2.8 to 3.2 km.

| | Treatment effect (*p*) | 3 year lag (*p*) | Distance to MRT (km) (*p*) |
|---|---|---|---|
| Within 400 m | −62.2 (0.40) | 51.8 (0.60) | 225.5 (0.02) |
| 400–800 m | 269.5 (0.01) | −39.5 (0.62) | −91 (0.36) |
| 800 m–1.2 km | 594.6 (0.00) | 327.6 (0.01) | 44.7 (0.67) |
| 1.2–1.6 km | 567.4 (0.00) | 204.7 (0.12) | 94.4 (0.33) |
| 1.6–2 km | 267.5 (0.02) | 539.1 (0.00) | −55.6 (0.48) |
| 2–2.4 km | −134.7 (0.27) | 21.9 (0.88) | −392.9 (0.00) |
| 2.4–2.8 km | −82.3 (0.50) | −399.8 (0.04) | −27.5 (0.79) |
| 2.8–3.2 km | −277 (0.02) | −311.7 (0.10) | 213.7 (0.00) |
| 3.2–3.6 km | −83.3 (0.34) | −259.2 (0.06) | 8 (0.89) |
| 3.6–4 km | 446.8 (0.00) | 537.8 (0.00) | 45.8 (0.35) |

**Table 14**
Results from the public housing only, grid FE model, which show smaller positive main treatment effects and lagged effects of conservation compared to the private housing model.

| | Treatment effect (*p*) | 3 year lag (*p*) | Distance to MRT (km) (*p*) |
|---|---|---|---|
| Within 400 m | 29.9 (0.14) | 97.8 (0.00) | −11.1 (0.79) |
| 400–800 m | −1.4 (0.93) | 107.7 (0.00) | 15.6 (0.74) |
| 800 m–1.2 km | 63.3 (0.00) | 101.5 (0.02) | −61 (0.33) |
| 1.2–1.6 km | 28.8 (0.35) | −28.8 (0.34) | −175.7 (0.00) |
| 1.6–2 km | 10.8 (0.67) | −14.4 (0.60) | −5 (0.82) |
| 2–2.4 km | 7.9 (0.74) | 45.7 (0.10) | 46.9 (0.01) |
| 2.4–2.8 km | 46.4 (0.05) | 42 (0.17) | 26 (0.15) |
| 2.8–3.2 km | 66.2 (0.00) | 25 (0.12) | 40.3 (0.00) |
| 3.2–3.6 km | 44.1 (0.03) | 45.1 (0.01) | 25.6 (0.03) |
| 3.6–4 km | −87.6 (0.00) | −55.6 (0.05) | 26.4 (0.00) |

private housing market.

The differentiated estimated effect of conservation on public and private housing makes intuitive sense. Since public housing units tend to be significantly cheaper compared to private housing units, they would also thus likely appreciate less in absolute terms compared to their private housing counterparts. Another interpretation may be that the residents in private housing developments who are wealthier may prioritize proximity to built heritage more than less well-off residents in public housing estates, and thus be willing to pay a larger premium to be located closer to a heritage development.

### *4.5. Estimated gains in resale housing values for two conserved sites*

We calculated the aggregated gains in resale housing values from two conserved sites, using the estimated main treatment and three-year lagged treatment coefficients from Models 5 and 6 that were statistically significant. We estimated the spill-over effects of the 2005 conservation of Beaulieu House building located in Singapore's northern region, and that of Rochester Park, a site located closer to city center that was gazetted for conservation in 2010 (see Fig. 18) based on actual transactions within each treatment zone during the respective year of gazette, as well as three years after.

The two sites are located in neighborhoods with different housing type mixes—most of the resale transactions around the Beaulieu House were of public housing while the housing sale mix around Rochester Park was more evenly split between public and private (see Tables 15 and 16, which summarizes the characteristics of transactions and estimated net gain in resale value from each conservation gazette)

Overall the housing sales of locations around the Beaulieu site gained an estimated 1.7 million dollars during the year of gazette, and an additional $6.6 million three years after. Locations around the Rochester Park site saw a bump of $11.8 million the year of gazette, and an additional $10.4 million three years after.

While it would be useful to compare these estimated premiums to incurred costs of conservation, there are currently no comprehensive estimates available about the average cost of conservation in Singapore, which can range widely depending on the project's age, size, condition and intended functional use. Nevertheless, some estimates of the costs of upkeep or restoration of specific sites are available. A 2016 interview with the Beaulieu building's owner highlighted a $30,000 yearly cost associated with maintaining the property (Woo, 2016). For Rochester Park, an estimated $10 million was spent on restoring three of the 11 bungalows within the site (Zaccheus, 2015; JTC, 2019).

Another benchmark might be the estimated real estate value attributable to the opening of new MRT stations, which is generally

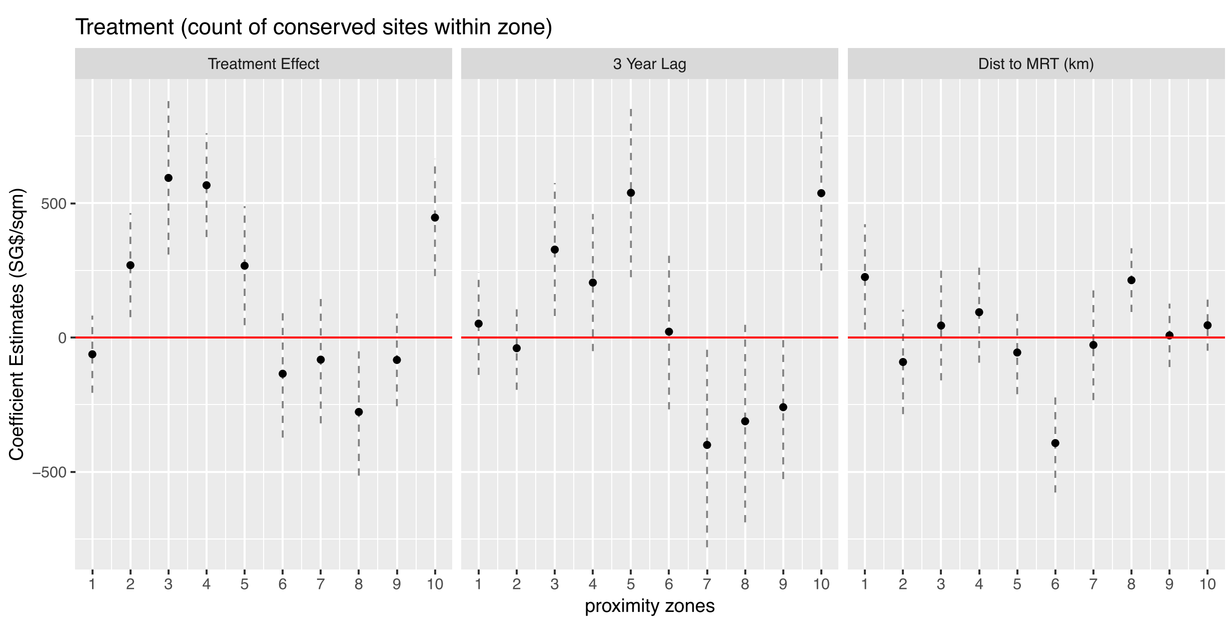


**Fig. 16.** Grid FE for private housing only: plot of treatment, 3 year lag and subway proximity coefficients across 10 proximity zones, which show largest positive main treatment effects in Zone 3, and largest lagged effect in Zone 5.

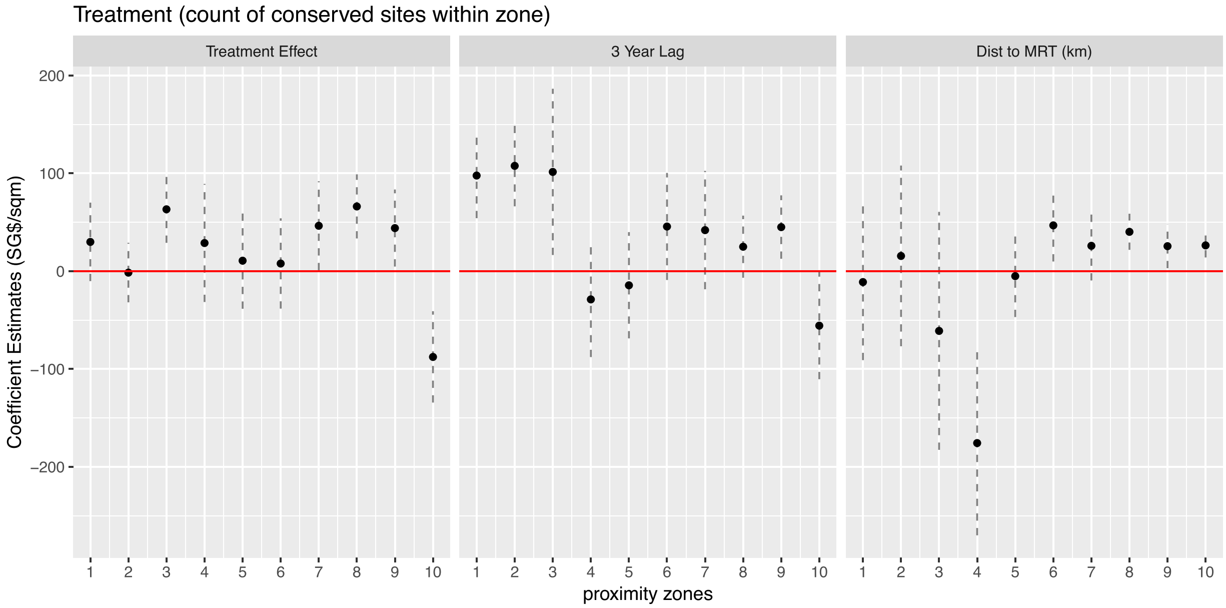


**Fig. 17.** Grid FE for public housing only: plot of treatment, 3 year lag and subway proximity coefficients across 10 proximity zones, which show much smaller positive main treatment and lagged effects compared to the private housing only model.


**Fig. 18.** Locations of two case study sites and surrounding buildings at each treatment zones.

acknowledged to be an important driver of property prices in Singapore. A recent study estimated to be around $380 million for 27 stations on the Circle Line opened between 2009 to 2011 (Diao et al., 2017).

Against these benchmarks, the estimated impact of the conservation of Beaulieu House and Rochester Park on residential housing prices is sizeable. Furthermore, these estimates are arguably conservative as they were calculated based on transactions in buildings that were not located closer to other conserved sites than to the main analysis sites of interest. These estimates also did not include estimations of any

**Table 15**
Estimated economic value from conserving two sites (main treatment effect), which add up to $13.5 million.

| | Private housing | | | | Public housing | | | |
|---|---|---|---|---|---|---|---|---|
| Zones | Count | Total area ($m^2$) | Treatment effect (per $m^2$) | Total effect (million SGD) | Count | Total area ($m^2$) | Treatment effect (per $m^2$) | Total effect (million SGD) |
| Site: Beaulieu House | | | | | | | | |
| Zone 2 | 30 | 6613 | 173.9 | 1.15 | – | – | – | – |
| Zone 5 | 1 | 395 | 231.6 | 0.091 | 16 | 1587 | – | – |
| Zone 6 | 8 | 1036 | 278.4 | 0.288 | 167 | 16,657 | – | – |
| Zone 7 | 118 | 15,434 | – | – | 483 | 47,729 | – | – |
| Zone 8 | 42 | 8247 | −249 | −2.054 | 443 | 43,562 | 57.8 | 2.518 |
| Zone 9 | 10 | 1515 | – | – | 427 | 34,794 | 58.3 | 2.028 |
| Zone 10 | 21 | 2738 | – | – | 324 | 26,767 | −87.4 | −2.339 |
| Total | 230 | 35,978 | n.a. | −0.525 | 1860 | 171096 | n.a. | 2.207 |
| Site: Rochester Park | | | | | | | | |
| Zone 2 | 4 | 811 | 173.9 | 0.141 | 99 | 7553 | – | – |
| Zone 3 | 35 | 8311 | 476.2 | 3.958 | 26 | 1867 | 83 | 0.155 |
| Zone 4 | 51 | 8628 | 679.2 | 5.86 | – | – | – | – |
| Zone 6 | 39 | 6023 | 278.4 | 1.677 | 108 | 8713 | – | – |
| Zone 7 | 91 | 11,091 | – | – | 119 | 9621 | – | – |
| Zone 5 | – | – | – | – | 56 | 4404 | – | – |
| Zone 8 | – | – | – | – | 6 | 442 | 57.8 | 0.026 |
| Total | 220 | 34,864 | n.a. | 11.636 | 414 | 32,600 | n.a. | 0.181 |

**Table 16**
Estimated economic value from conserving two sites (three year treatment lag), which add up to $17.2 million.

| | Private housing | | | | Public housing | | | |
|---|---|---|---|---|---|---|---|---|
| Zones | Count | Total area ($m^2$) | Treatment effect (per $m^2$) | Total effect (Mil SGD) | Count | Total area ($m^2$) | Treatment effect (per $m^2$) | Total effect (Mil SGD) |
| Site: Beaulieu House | | | | | | | | |
| Zone 5 | 11 | 1410 | 482.1 | 0.68 | 35 | 3704 | – | – |
| Zone 6 | 9 | 1156 | 336.4 | 0.389 | 182 | 18,553 | 106.5 | 1.976 |
| Zone 7 | 94 | 12,509 | – | – | 394 | 40,013 | 56.3 | 2.253 |
| Zone 8 | 34 | 6636 | −305.4 | −2.027 | 280 | 26,928 | 22 | 0.592 |
| Zone 9 | 13 | 1841 | – | – | 308 | 25,839 | 44.8 | 1.158 |
| Zone 10 | 85 | 11,173 | 394.1 | 4.403 | 473 | 43,012 | −62.4 | −2.684 |
| Total | 246 | 34,725 | n.a. | 3.445 | 1672 | 158,049 | n.a. | 3.295 |
| Site: Rochester Park | | | | | | | | |
| Zone 2 | 3 | 803 | – | – | 44 | 3339 | 113.7 | 0.38 |
| Zone 3 | 11 | 2603 | 377.5 | 0.983 | 16 | 1115 | – | – |
| Zone 4 | 28 | 7110 | 408 | 2.901 | – | – | – | – |
| Zone 5 | 9 | 4099 | 482.1 | 1.976 | 25 | 2279 | – | – |
| Zone 6 | 39 | 9585 | 336.4 | 3.224 | 53 | 4616 | 106.5 | 0.492 |
| Zone 7 | 53 | 14,704 | – | – | 63 | 5323 | 56.3 | 0.3 |
| Zone 8 | 65 | 9244 | −305.4 | −2.823 | 4 | 283 | 22 | 0.006 |
| Zone 9 | 24 | 7187 | – | – | – | – | – | – |
| Zone 10 | 22 | 7887 | 394.1 | 3.108 | 11 | 1246 | −62.4 | −0.078 |
| Total | 254 | 63,222 | n.a. | 9.369 | 216 | 18201 | n.a. | 1.1 |

additional real estate value that might have been generated through new developments built after the date of gazette.

## 5. Discussion and conclusions

This paper presents empirical analysis, using year and spatial unit fixed effects, where the spatial unit is defined both at a building-level and small-areal, neighborhood-level level, to quantify the spillover effects of designating an area or building as a 'conserved site'. Across all models, we found a consistently positive effect of conservation designation on average sale price per square meter of built area, for locations within closer proximity to the conserved sites. Across all models, we found that this positive impact to be most consistently largest for residential locations between Zone 3 and 4 (800 m to 1.6 km) from the conserved site. For both the building and grid cell models, this positive effect dissipated as the distance from conserved sites increased. Findings also suggest that public housing units gain a substantially smaller premium compared to private housing units.

There was however an unexpected effects observed across both building and grid cell models. For the private housing, we observed negative effects (−$249 in building FE model, −$277 in grid cell FE model) associated with conservation when the gazetted sites were located 2.8 to 3.2 km away (Zone 8), but also a sizeable positive lagged effect ($394 in building FE model, $538 in grid cell FE model) when the gazetted sites were 3.6 to 4 km (Zone 10). In contrast, we found negative effects of conservation on public housing (around −$87 in both models) when the gazetted sites were 3.6 to 4 km away (Zone 10). One speculative interpretation of these findings is that the potential impact of conservation on housing resale prices is complex and location specific. Buildings that are located in treatment zones closer to conserved sites tend to also be located in areas closer to the city center where many conservation sites are currently located, whereas those in treatment zones further away tend to be in more suburban areas (see Fig. 5). Residents choosing to live in Zone 1, 2, 3 and 4 neighborhoods may have differing views on whether having a conserved site nearby as an amenity or disamenity, compared to residents living in more suburban Zones.

One key difference between the building FE and grid cell FE model results is that the former generally produced lower point estimates of the treatment effects of conservation. We attribute this difference to the exclusion of private housing developments, particularly landed houses, that did not have repeated sales from the building FE model, but which were included in the grid cell model. Given our findings that more expensive private housing developments, particularly landed housing developments, enjoyed higher premiums from conservation compared to public housing units, it is reasonable that the grid cell models estimated larger treatment effects. This difference suggests that quantification of conservation's economic benefits using estimates from the building FE models, as was done in the two case studies above, can be interpreted as a lower-bound estimate, especially if the conserved site is in an area with many landed housing units.

This study's findings are consistent with observations in other jurisdictions that conservation of buildings enhances real estate values. These findings provide economic justification for building conservation programmes in the Asian region. Our estimates of the $30 million increase in residential resale value generated by the conservation of Beaulieu House and Rochester Park serve as a useful illustration of the market value gains of heritage conservation. Arguably, with appropriate taxation policies, these enhanced real estate values could translate into additional government revenue that could in turn finance additional conservation projects.

However, our study also raises questions about what would be an appropriate taxation policy around conservation decisions. In Singapore, when a land parcel's value is enhanced through a change in its zoning, a tax is imposed. Some have thus argued that a betterment levy should be imposed on buildings gazetted for conservation if that gazette creates an increase in the property's economic value, as this would ensure consistency within Singapore's overall planning framework (Ti, 2019). However, levying a higher tax on properties that are not directly gazetted but which might have benefited from positive spillover effects of the conservation gazette would prove harder to defend as there are a myriad of circumstances where land value is indirectly affected. Attempting to include every type of regulation that could affect land values would be administratively unworkable. Policy-makers considering levying a tax on conserved buildings should thus carefully consider how this can be done without unfairly penalising the owners of the gazetted building vis-a-vis their neighbours who are likely to enjoy some windfall benefits from the gazette, and ensuring ‘horizontal equity’ (Phang, 1996).

Another policy response would be to consider the knock-on effects on neighborhoods surrounding newly conserved sites, in terms of demographic and urban identity shifts precipitated by changing residential prices. Much empirical research has been done on the impact of historical designations, and have reached varied conclusions. For example, in a recent analysis of New York City, researchers found significant sociodemographic shifts in designated neighborhoods following historic preservation designations (McCabe and Ellen, 2016). On the other hand, a 2019 study by Kinahan found little evidence of neighborhood change that is typically associated with gentrification in neighborhoods that federal historic rehabilitation tax credits were utilised (Kinahan, 2019). Similarly, Coulson and Leichenko found no evidence of demographic shifts in Fort Worth, Texas (Coulson and Leichenko, 2004). One explanation for the inconsistent findings is that the strength of housing markets and potential for redevelopment affects how neighborhoods respond. Historical designation in more hotly contested housing markets like New York's may be more prone to generate gentrification and demographic change than weaker housing markets (McCabe, 2019). While this study does not specifically examine demographic shifts in neighborhoods surrounding conserved sites, our observation that higher housing prices in an area followed historic designation in Singapore, a city-state with limited land resources, healthy economy, high population density and thus a correspondingly high demand for housing (Deng et al., 2018), provides some support for this hypothesis. Policy-makers in cities with strong housing markets who are concerned with the potential downsides of gentrification and residential socioeconomic segregation should thus monitor changes in neighborhood mix post-conservation, and if necessary consider ways to maintain sufficient affordable housing stock around conserved sites. For instance, maintaining some public housing stock close to conserved sites could be an appropriate strategy for Singapore, as our analysis suggests that public housing units are much less price-sensitive to conservation gazettes.

This study focuses primarily on residential housing sale transactions, and thus might not capture the full spillover effects of conservation. Additional analysis on the impact of conservation gazettes on the value of non-residential properties and on residential rents would help provide a fuller picture. Furthermore, while this study finds empirical evidence that conservation generates positive real estate value, the exact mechanisms behind this value creation remain opaque. While explaining why conservation produces such residential real estate premiums is currently beyond the scope of our study, we see value in future research within the Asian context on this precise question. Additionally, while a close examination of the link between conservation policies, gentrification and neighborhood change goes beyond the main thrust of this paper, we believe that more qualitative and quantitative research here is much needed, especially in a rapidly urbanizing Asian context where the challenges of balancing economic growth, spatial equity and cultural heritage are thrown into sharp relief.

**Declaration of Interest**

No potential conflict of interest and no financial disclosures were reported by the authors of this paper.

**Funding**

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Acknowledgements**

The authors are grateful to the Editor and two anonymous reviewers for their useful advice and comments.

## Appendix A. Illustration of treatment assignment

Fig. A.1 illustrates how treatment is defined for a hypothetical grid cell. Prior to 2003, the cell is considered to be ‘not treated’ at all, since there were no officially conserved sites in its vicinity. In 2003 and 2004, it is then considered to receive a ‘Zone 2’ treatment by one site that was gazetted in 2003. From 2005 onwards, the cell is then considered to receive a Zone 1 treatment, because of the site gazetted in 2005.

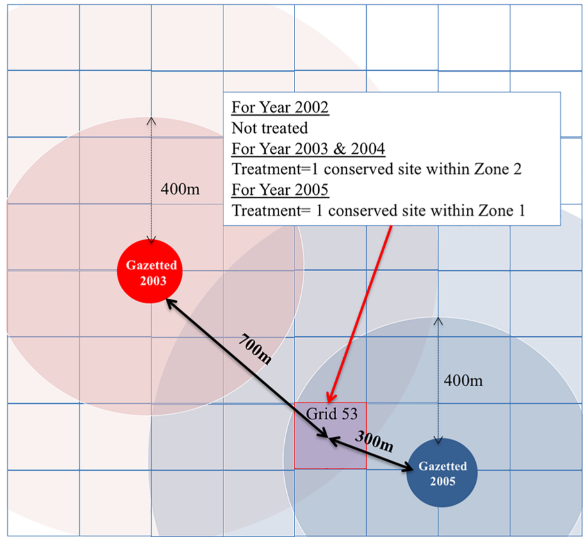


**Fig. A.1.** Illustration of how treatment status was identified for a cell.

## Appendix B. Models that include a quadratic term for treatment, to model non-linear returns

We fitted the basic building FE and grid cell FE models with a squared treatment term, as follows:

$$\text{Price}_{\text{it}} = \beta_1 \text{Treatment}_{\text{it}} + \beta_2 \text{Treatment}_{\text{it}}^2 + \alpha_i + \text{Year}_t + \epsilon_{\text{it}} \tag{B.1}$$

For both the building-level FE model and the grid-cell FE model, the coefficient for the squared treatment variable was largely non-significant or substantively small, across the proximity zones (Tables B.1 and B.2, Figs. B.1 and B.2).

Table B.3 summarizes the analysis which includes three-year treatment lag and controls for distance to subways for the building FE analysis, while Table B.4 reports findings from the grid cell FE analysis. For both, the coefficients for the estimated squared treatment variable were largely non-significant or small across proximity zones (Figs. B.3 and B.4).

**Table B.1**
Building fixed effects baseline model.

| | Treatment effect (*p*) | Treatment squared (*p*) |
|---|---|---|
| Within 400 m | −165.5 (0.01) | 33 (0.00) |
| 400–800 m | 383.2 (0.00) | −26.4 (0.00) |
| 800 m–1.2 km | 578.9 (0.00) | −11.5 (0.09) |
| 1.2–1.6 km | 285.5 (0.00) | 59.8 (0.00) |
| 1.6–2 km | 251.1 (0.00) | −11.2 (0.21) |
| 2–2.4 km | 94.6 (0.02) | 2.6 (0.83) |
| 2.4–2.8 km | −105.1 (0.00) | 22.3 (0.06) |
| 2.8–3.2 km | −169.1 (0.00) | 29.8 (0.00) |
| 3.2–3.6 km | −126.3 (0.00) | 23.3 (0.01) |
| 3.6–4 km | −182.4 (0.00) | 170.2 (0.00) |

**Table B.2**
Grid fixed effects baseline model, treatment with quadratic term.

| | Treatment effect (*p*) | Treatment squared (*p*) |
|---|---|---|
| Within 400 m | −151.9 (0.10) | 24.2 (0.03) |
| 400–800 m | 555.1 (0.00) | −64.8 (0.00) |
| 800 m–1.2 km | 940.1 (0.00) | −55.7 (0.00) |
| 1.2–1.6 km | 459.8 (0.00) | 32.7 (0.08) |
| 1.6–2 km | 230.6 (0.07) | 12.5 (0.50) |
| 2–2.4 km | −44 (0.59) | −10.7 (0.51) |
| 2.4–2.8 km | −128.8 (0.12) | 0.3 (0.99) |
| 2.8–3.2 km | −276.8 (0.00) | 6 (0.66) |
| 3.2–3.6 km | −208 (0.01) | 8.5 (0.56) |
| 3.6–4 km | 133.8 (0.25) | 65 (0.43) |

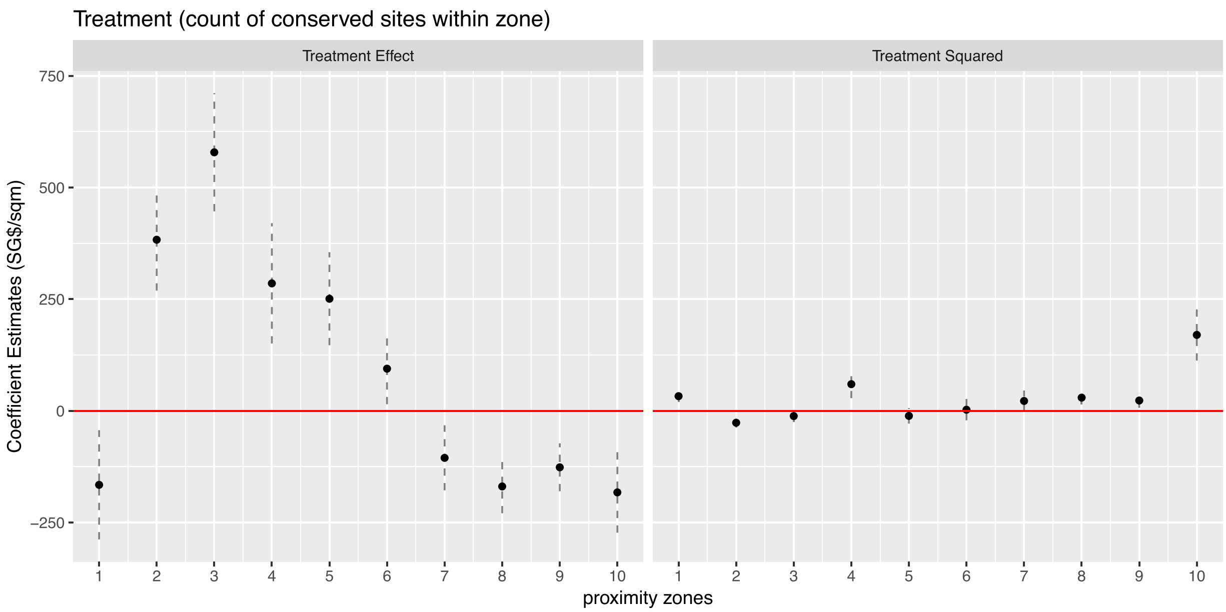


**Fig. B.1.** Building FE model: plot of treatment & treatment squared coefficients for each zone.

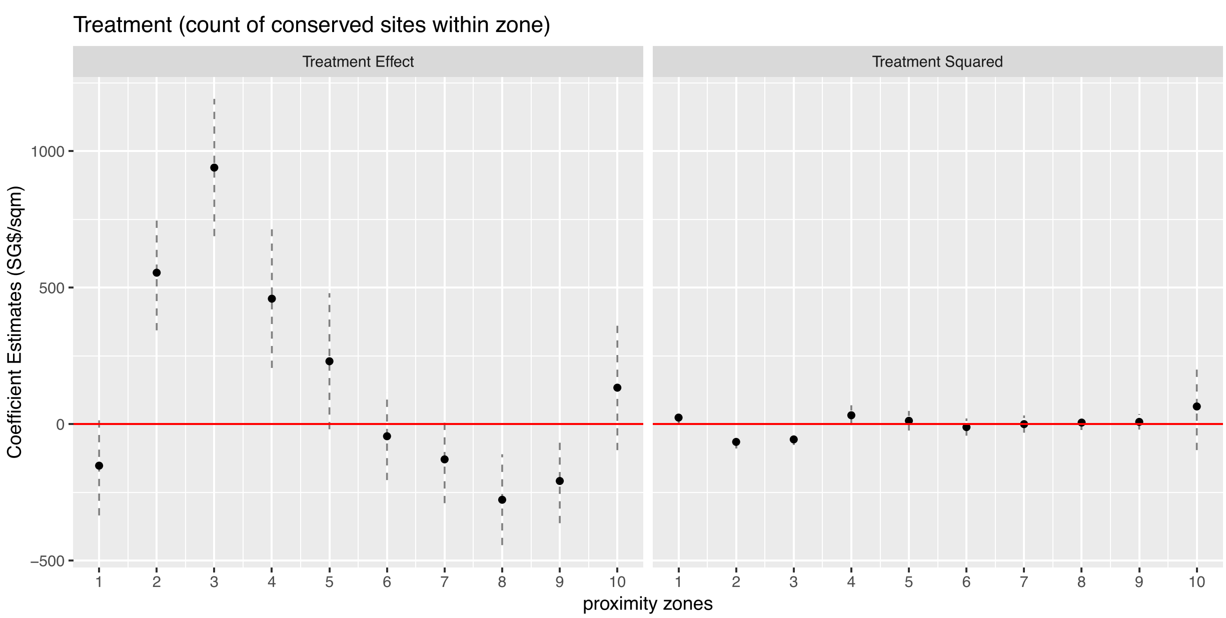


**Fig. B.2.** Grid FE model: plot of treatment & treatment squared coefficients for each zone.

**Table B.3**
Building fixed effects model with 3 year lag and MRT distance, treatment with quadratic term.

| | Treatment effect (*p*) | 3 year lag (*p*) | KM to MRT (*p*) | Treatment squared (*p*) |
|---|---|---|---|---|
| Within 400 m | −320.4 (0.00) | 60.9 (0.22) | 130.1 (0.05) | 33.4 (0.00) |
| 400–800 m | 224.5 (0.00) | 67.3 (0.09) | −161.9 (0.00) | −17.8 (0.01) |
| 800 m–1.2 km | 241.2 (0.00) | 247.9 (0.00) | −260.5 (0.00) | −4.1 (0.70) |
| 1.2–1.6 km | 151.8 (0.18) | 370.8 (0.00) | 0.3 (0.99) | 116.3 (0.06) |
| 1.6–2 km | 169.8 (0.00) | 191.3 (0.00) | −85 (0.01) | −39.1 (0.01) |
| 2–2.4 km | 132.9 (0.00) | 134.3 (0.00) | −42.6 (0.19) | −6.1 (0.64) |
| 2.4–2.8 km | −44.1 (0.29) | −25.4 (0.42) | −11.2 (0.50) | 41.6 (0.05) |
| 2.8–3.2 km | −27.1 (0.24) | −63 (0.00) | 32.5 (0.00) | 24.7 (0.00) |
| 3.2–3.6 km | 3.4 (0.89) | 37.6 (0.09) | 7.2 (0.33) | 9.8 (0.27) |
| 3.6–4 km | −385.6 (0.00) | 82.3 (0.02) | 6.2 (0.29) | 220.9 (0.00) |

**Table B.4**
Grid fixed effects model with 3 year lag, housing type and MRT distance, treatment with quadratic term.

| | Treatment effect (*p*) | 3 year lag (*p*) | +10% Public housing (*p*) | KM to MRT (*p*) | Treatment squared (*p*) |
|---|---|---|---|---|---|
| Within 400 m | −28 (0.79) | 50.5 (0.52) | −330.8 (0.00) | −102.1 (0.29) | 3.9 (0.80) |
| 400–800 m | 662.8 (0.00) | 44.1 (0.53) | −268.7 (0.00) | −498.6 (0.00) | −79.8 (0.00) |
| 800 m–1.2 km | 718.6 (0.00) | 583.8 (0.00) | −265.7 (0.00) | −280.3 (0.02) | −74 (0.00) |
| 1.2–1.6 km | 291.5 (0.03) | 516 (0.00) | −190.3 (0.00) | −12.1 (0.89) | 44.3 (0.15) |
| 1.6–2 km | 138.9 (0.25) | 308.9 (0.01) | −170.3 (0.00) | −152.5 (0.01) | −2.9 (0.94) |
| 2–2.4 km | 61.5 (0.50) | −15.1 (0.87) | −143.2 (0.00) | −324.1 (0.00) | −34.8 (0.14) |
| 2.4–2.8 km | −8.2 (0.92) | −337.2 (0.00) | −138.7 (0.00) | −120.6 (0.04) | 1.1 (0.96) |
| 2.8–3.2 km | −161.5 (0.04) | −267.8 (0.00) | −70.9 (0.04) | 83.3 (0.01) | 3.7 (0.86) |
| 3.2–3.6 km | −114.8 (0.11) | −213.2 (0.00) | −46.6 (0.01) | 31.2 (0.16) | 13.3 (0.46) |
| 3.6–4 km | 175.3 (0.19) | 349.6 (0.00) | −64.1 (0.01) | 15.2 (0.49) | 11.8 (0.89) |

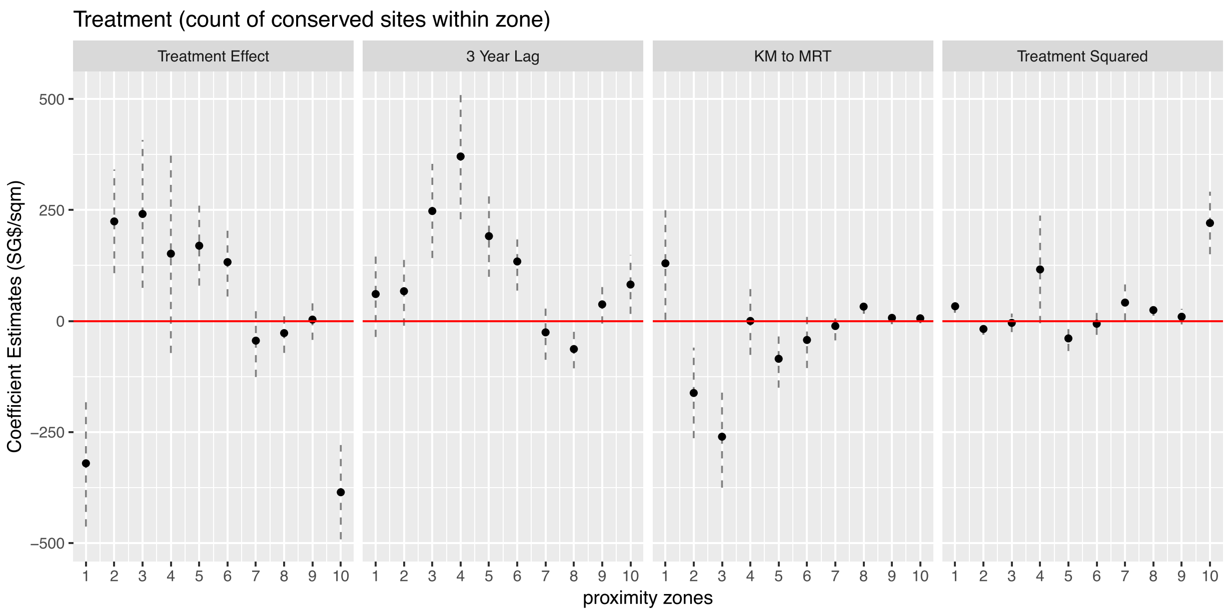


**Fig. B.3.** Building FE model: plot of treatment & treatment squared, 3 year lag and MRT distance coefficients, for each zone.

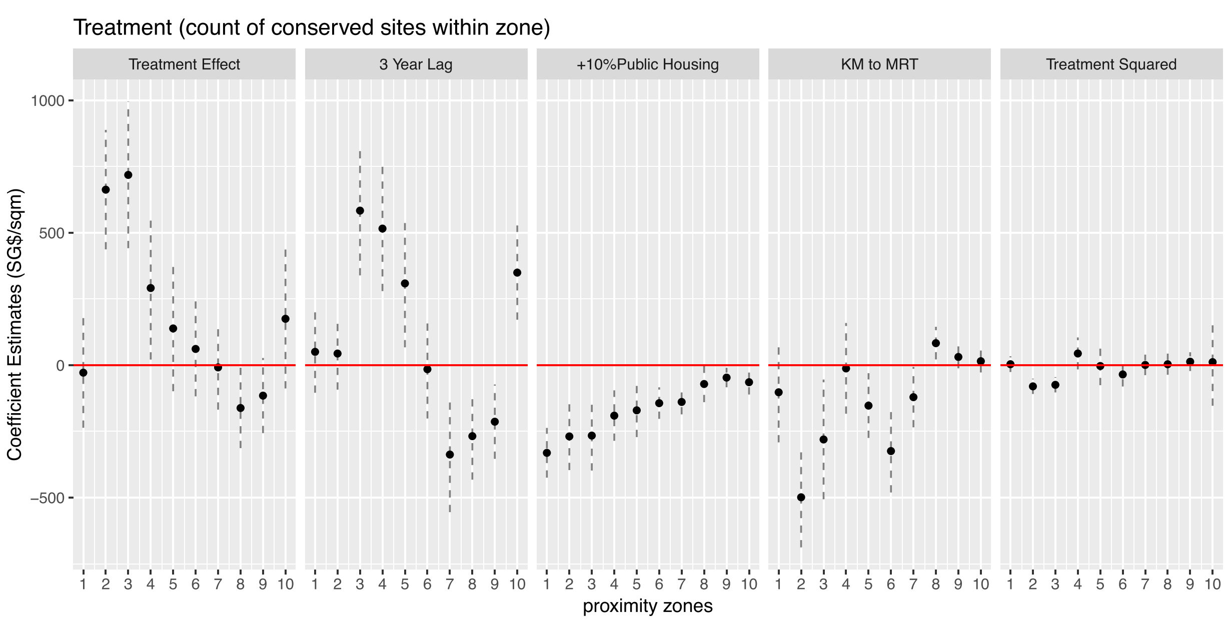


**Fig. B.4.** Grid FE model: plot of treatment & treatment squared, 3 year lag, housing mix and MRT distance coefficients for each zone.

## Appendix C. Models that factor in landed housing transactions

Table C.1 and Fig. C.1 summarizes the grid cell FE analysis that includes a control variable for the proportion of landed housing sales within each grid cell. Adding this control variable did not change the point estimates of the main treatment and lag effects without this additional control.

Additionally, we also ran a 'landed housing transactions' only grid cell FE analysis, to test the effect of conservation designations on this particular subset of housing types. Table C.2 and Fig. C.2 summarizes key findings.

**Table C.1**
Grid fixed effects model with 3 year lag and housing types.

| | Treatment effect (*p*) | 3 year lag (*p*) | +10% Public housing (*p*) | +10% Landed housing (*p*) |
|---|---|---|---|---|
| Within 400 m | −8.3 (0.89) | 54.9 (0.46) | −313.6 (0.00) | 106.3 (0.01) |
| 400–800 m | 211.6 (0.00) | −57.3 (0.41) | −266 (0.00) | 27.2 (0.44) |
| 800 m–1.2 km | 291.2 (0.00) | 413.9 (0.00) | −230.8 (0.00) | 106.5 (0.00) |
| 1.2–1.6 km | 407.9 (0.00) | 532.4 (0.00) | −152.4 (0.00) | 95.8 (0.00) |
| 1.6–2 km | 120.9 (0.19) | 332.2 (0.01) | −153.4 (0.00) | 67.6 (0.02) |
| 2–2.4 km | −25.4 (0.71) | −24.9 (0.78) | −141.8 (0.00) | −13.5 (0.81) |
| 2.4–2.8 km | −9.4 (0.88) | −336.9 (0.00) | −135.7 (0.00) | −2.3 (0.97) |
| 2.8–3.2 km | −154.1 (0.00) | −258.8 (0.00) | −75.9 (0.03) | −36.7 (0.60) |
| 3.2–3.6 km | −83.6 (0.03) | −202.3 (0.00) | −42.9 (0.02) | 161.5 (0.01) |
| 3.6–4 km | 196.7 (0.00) | 361.7 (0.00) | −53.8 (0.01) | 67.6 (0.08) |

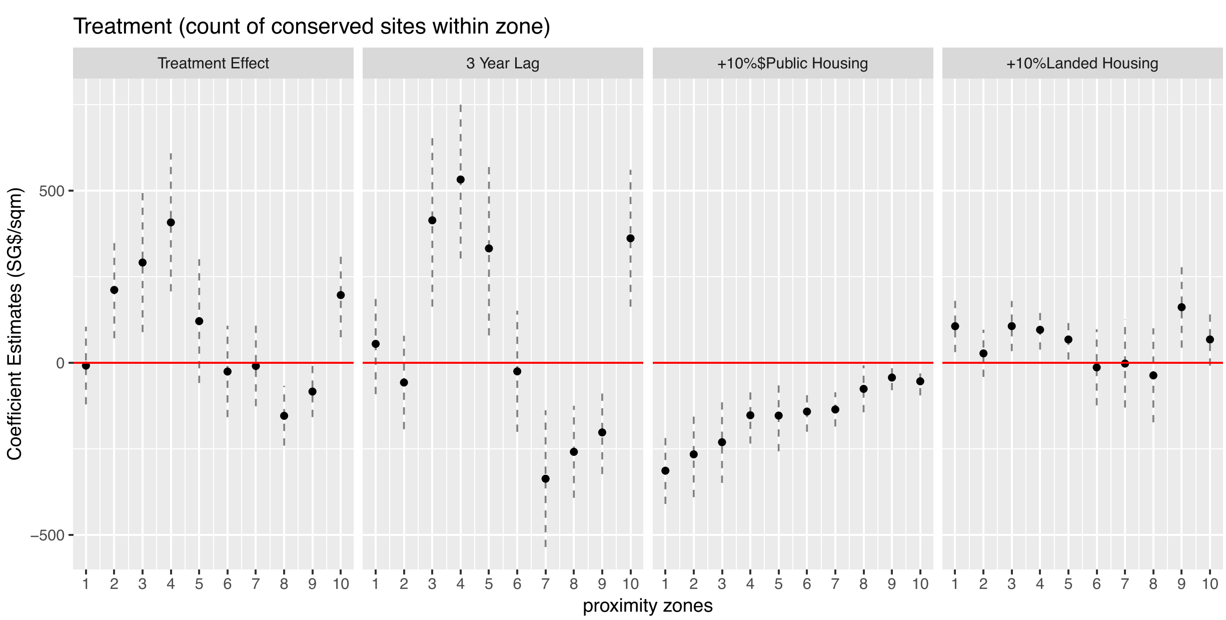


**Fig. C.1.** Grid FE model: plot of treatment & treatment squared, 3 year lag, percent public housing, percent landed housing, and MRT distance coefficients for each zone.

**Table C.2**
Grid fixed effects model: landed housing, with 3 year lag and MRT.

| | Treatment effect (*p*) | 3 year lag (*p*) | Distance to MRT (km) (*p*) |
|---|---|---|---|
| Within 400 m | 347.5 (0.04) | 591.9 (0.00) | 41.3 (0.78) |
| 400–800 m | 439.9 (0.00) | 406.5 (0.00) | −160.5 (0.23) |
| 800 m–1.2 km | 852.7 (0.00) | 707.8 (0.00) | 22.9 (0.86) |
| 1.2–1.6 km | 590.8 (0.00) | 479.5 (0.00) | 50.7 (0.63) |
| 1.6–2 km | 394.8 (0.02) | 712.8 (0.00) | 12.5 (0.90) |
| 2–2.4 km | −195.1 (0.11) | 573.6 (0.00) | −184.9 (0.01) |
| 2.4–2.8 km | 71.2 (0.71) | 675.5 (0.00) | −24.9 (0.77) |
| 2.8–3.2 km | −126.4 (0.36) | 701.2 (0.00) | −116.8 (0.15) |
| 3.2–3.6 km | 294.5 (0.12) | −252.4 (0.35) | −88.7 (0.45) |
| 3.6–4 km | 147.8 (0.12) | 304.3 (0.17) | −20.5 (0.84) |

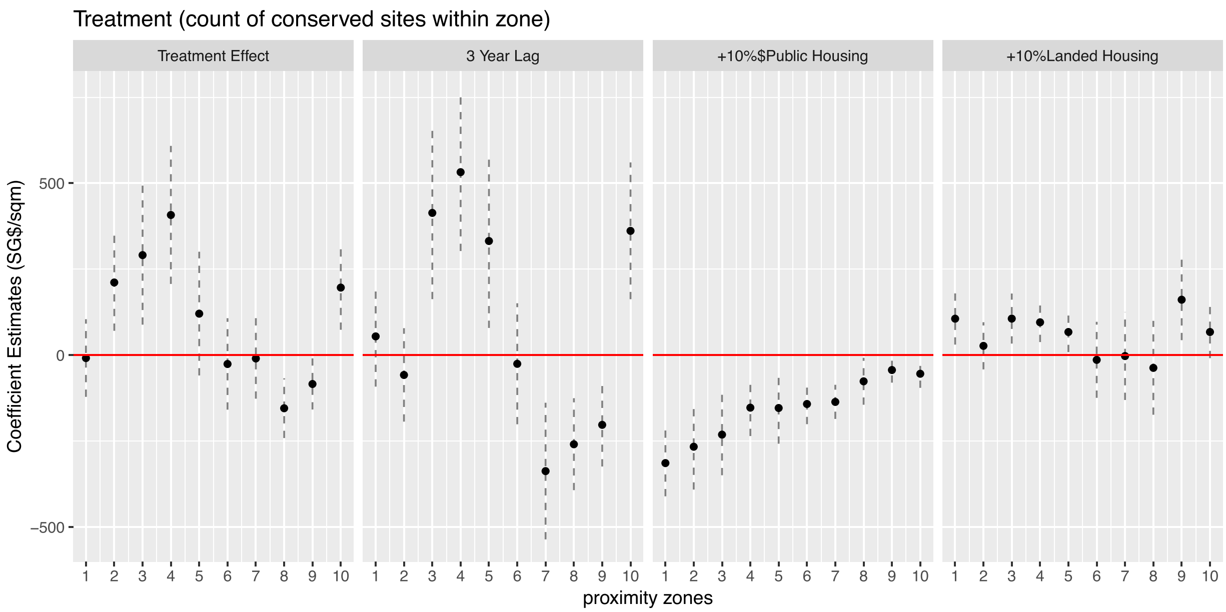


**Fig. C.2.** Grid FE model: plot of treatment & treatment squared, 3 year lag, percent public housing, percent landed housing, and MRT distance coefficients for each zone.

## References


Ahlfeldt, G.M., Holman, N., Wendland, N., 2012. An assessment of the effects of conservation areas on value.

Angrist, J.D., Pischke, J.S., 2008. Mostly Harmless Econometrics: An Empiricist's Companion. Princeton university press.

Arkaraprasertkul, N., 2018. Gentrification and its contentment: an anthropological perspective on housing, heritage and urban social change in Shanghai. Urban Stud. 55, 1561–1578.

Asabere, P.K., Huffman, F.E., 1994. Historic designation and residential market values. The Appraisal Journal; Chicago 62, 396. http://search.proquest.com/docview/199946971/abstract/D515498AC10448ADPQ/1.

Baltagi, B.H., Li, J., 2015. Cointegration of matched home purchases and rental price indexes? Evidence from Singapore. Reg. Sci. Urban Econ. 55, 80–88.

Branigan, T., 2009. China loses thousands of historic sites. The Guardian. http://www.theguardian.com/world/2009/dec/14/china-historic-sites-survey.

Chan, Y.L., 2005. Conservation and change—a Singapore case of urban conservation and development. Proceedings of the ICOMOS 15th General Assembly and Scientific Symposium, vol. 1 302.

Chang, T., 1997. Heritage as a tourism commodity: traversing the tourist-local divide. Singapore J. Trop. Geogr. 18, 46–68. https://doi.org/10.1111/1467-9493.00004.

Clark, D.E., Herrin, W.E., 1997. Historical preservation districts and home sale prices: evidence from the Sacramento housing market. Rev. Reg. Stud. 20.

Coulson, E., Leichenko, R., 2001. The internal and external impact of historical designation on property values. J. Real Estate Finance Econ. 23 (1), 113–124.

Coulson, N.E., Lahr, M.L., 2005. Gracing the land of Elvis and Beale Street: historic designation and property values in Memphis. Real Estate Econ. 33, 487–507. https://doi.org/10.1111/j.1540-6229.2005.00127.x.

Coulson, N.E., Leichenko, R.M., 2004. Historic preservation and neighbourhood change. Urban Stud. 41, 1587–1600. https://doi.org/10.1080/0042098042000227028.

data.gov.sg, Private Residential Property Transactions in the Whole of Singapore, Quarterly. https://data.gov.sg/dataset/private-residential-property-transactions-in-the-whole-of-singapore-quarterly.

Deng, Y., Gyourko, J., Li, T., 2018. Singapore's cooling measures and its housing market. J. Hous. Econ. 101573. https://doi.org/10.1016/j.jhe.2018.04.001.

Diao, M., Leonard, D., Sing, T.F., 2017. Spatial-difference-in-differences models for impact of new mass rapid transit line on private housing values. Reg. Sci. Urban Econ. 67, 64–77. https://doi.org/10.1016/j.regsciurbeco.2017.08.006.

Donaldson, R., Kotze, N., Visser, G., Park, J., Wally, N., Zen, J., Vieyra, O., 2013. An uneasy match: neoliberalism, gentrification and heritage conservation in Bo-Kaap, Cape Town, South Africa. Urban Forum 173–188 Springer.

Evans, A.W., 2004. Economics and Land Use Planning. Blackwell Pub. Ltd.

Go, V.K., Lai, L.W.C., 2019. Learning from Taiwan's post-colonial heritage conservation. Land Use Policy 84, 79–86. https://doi.org/10.1016/j.landusepol.2019.01.012.

Henderson, J., 2011. Understanding and using built heritage: Singapore's national monuments and conservation areas. Int. J. Herit. Stud. 17, 46–61. https://doi.org/10.1080/13527258.2011.524006.

Henderson, J.C., 2012. Conserving heritage in South East Asia: cases from Malaysia, Singapore and the Philippines. Tour. Recreat. Res. 37, 47–55. https://doi.org/10.1080/02508281.2012.11081687.

JTC, JTC Rochester Park. URL: https://www.jtc.gov.sg/industrial-land-and-space/Pages/rochester-park.aspx.

Kinahan, K.L., 2019. The neighborhood effects of federal historic tax credits in six legacy cities. Hous. Policy Debate 29, 166–180. https://doi.org/10.1080/10511482.2018.1452043.

Kong, L., 2017. Conserving urban heritage: remembering the past in a developmental city-state. In: 50 Years of Urban Planning in Singapore. World Scientific. pp. 237–256.

Kong, L., Yeoh, B.S.A., 1994. Urban conservation in Singapore: a survey of state policies and popular attitudes. Urban Stud. 31, 247–265. https://doi.org/10.1080/00420989420080231.

Kovacs, J.F., Shipley, R., Snyder, M., Stupart, C., 2008. Do heritage conservation districts work? The case of Kitchener's Upper Doon district. Can. J. Urban Res. 17, 125–141.

Lazrak, F., Nijkamp, P., Rietveld, P., Rouwendal, J., 2014. The market value of cultural heritage in urban areas: an application of spatial hedonic pricing. J. Geogr. Syst. 16, 89–114. https://doi.org/10.1007/s10109-013-0188-1.

Lee, S.L., 1996. Urban conservation policy and the preservation of historical and cultural heritage. Cities 13, 399–409. https://doi.org/10.1016/0264-2751(96)00027-3.

Mason, R., 2008. Be interested and beware: joining economic valuation and heritage conservation. Int. J. Herit. Stud. 14, 303–318. https://doi.org/10.1080/13527250802155810.

McCabe, B.J., 2019. Protecting neighborhoods or priming them for gentrification? Historic preservation, housing, and neighborhood change. Hous. Policy Debate 29, 181–183. https://doi.org/10.1080/10511482.2018.1506391.

McCabe, B.J., Ellen, I.G., 2016. Does preservation accelerate neighborhood change? Examining the impact of historic preservation in New York City. J. Am. Plann. Assoc. 82, 134–146. https://doi.org/10.1080/01944363.2015.1126195.

Mulchand, A., 2012. Skyline 2012 MayJun_a labour of love for conservation.pdf. Skyline 11–13.

Murakami, J., 2018. The government land sales programme and developers' willingness to pay for accessibility in Singapore, 1990–2015. Land Use Policy 75, 292–302. https://doi.org/10.1016/j.landusepol.2018.03.050.

Noonan, D.S., 2007. Finding an impact of preservation policies: price effects of historic landmarks on attached homes in Chicago, 1990–1999. Econ. Dev. Q. 21, 17–33. https://doi.org/10.1177/0891242406296326.

Noonan, D.S., Krupka, D.J., 2011. Making-or Picking-Winners: evidence of internal and external price effects in historic preservation policies: evidence of internal and external price effects. Real Estate Econ. 39, 379–407. https://doi.org/10.1111/j.1540-6229.2010.00293.x.

Phang, S.Y., 1996. Economic development and the distribution of land rents in Singapore: a Georgist implementation. Am. J. Econ. Sociol. 55, 489–501.

Rypkema, D., 2012. Heritage conservation and property values. In: Licciardi, G., Amirtahmasebi, R. (Eds.), The Economics of Uniqueness: Investing in Historic City Cores and Cultural Heritage Assets for Sustainable Development. The World Bank, pp. 107–141. https://doi.org/10.1596/978-0-8213-9650-6.

Steinberg, F., 1996. Conservation and rehabilitation of urban heritage in developing countries. Habitat Int. 20, 463–475.

Stipe, R.E., 2003. A Richer Heritage: Historic Preservation in the Twenty-First Century. Univ. of North Carolina Press.

Throsby, D., 2012. Heritage economics: a conceptual framework. In: Licciardi, G., Amirtahmasebi, R. (Eds.), The Economics of Uniqueness: Investing in Historic City Cores and Cultural Heritage Assets for Sustainable Development. The World Bank, pp. 45–72. https://doi.org/10.1596/978-0-8213-9650-6.

Ti, E.S.W., 2019. Compensating regulation of land: UK and Singapore compared. J. Prop. Plann. Environ. Law 11, 135–150. https://doi.org/10.1108/JPPEL-01-2019-0003.
Tweed, C., Sutherland, M., 2007. Built cultural heritage and sustainable urban development. Landscape Urban Plan. 83, 62–69.
URA, 2019. Conservation Guidelines. https://www.ura.gov.sg/Corporate/Guidelines/Conservation/Conservation-Guidelines.
URA, PMB, 1993. Objectives, Principles and Standards for Preservation and Conservation. URA.. https://books.google.com.sg/books?id=5BfrAAAACAAJ.
Winter, T., 2014. Beyond Eurocentrism? Heritage conservation and the politics of difference. Int. J. Herit. Stud. 20, 123–137. https://doi.org/10.1080/13527258.2012.736403.
Woo, A., 2016. The neo-classical beauty of Beaulieu House. The Straits Times. https://www.straitstimes.com/lifestyle/home-design/the-neo-classical-beauty-of-beaulieu-house.
Wright, W.C., Eppink, F.V., 2016. Drivers of heritage value: a meta-analysis of monetary valuation studies of cultural heritage. Ecol. Econ. 130, 277–284. https://doi.org/10.1016/j.ecolecon.2016.08.001.
Yeoh, B.S., Huang, S., 1996. The conservation-redevelopment dilemma in Singapore. Cities 13, 411–422. https://doi.org/10.1016/0264-2751(96)00028-5.
Yuen, B., 2005. Searching for place identity in Singapore. Habitat Int. 29, 197–214. https://doi.org/10.1016/j.habitatint.2003.07.002.
Zaccheus, M., 2015. Restored Alkaff mosque wins heritage design award. The Straits Times. https://www.straitstimes.com/singapore/restored-alkaff-mosque-wins-heritage-design-award.