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ARTICLE

Revitalizing urban landscapes: the economic impacts of building rehabilitation on property values in Hong Kong

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Abstract

This paper examines the external and internal property value effects of building rehabilitation projects in Hong Kong, a city renowned for its successful urban renewal model. Using housing transaction data and a Hedonic difference-in-difference model, the study uncovers a significant positive impact of building rehabilitations on the property values of nearby residences within a 300-m radius of the renovated buildings. Additionally, through a heterogeneity analysis, the research highlights variations in property value externalities according to the age of the buildings and the size of the flats. The findings reveal an 8.4% increase in property value for rehabilitated buildings, a result that is robustly validated through comprehensive testing. These results emphasize the cost-effectiveness of building rehabilitation as a tool for urban renewal and underscore the importance of prioritizing this approach to mitigate urban decay.

Keywords Urban renewal · Internal effects · Property value externalities · Building rehabilitation · Hong Kong

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1 Introduction

The market value of real estate is widely understood as the capitalization of its multifaceted attributes, including both inherent characteristics and the broader environmental context (Galster et al., 2004). The built environment, in particular, functions as a public good, demanding continuous maintenance and adaptation to meet shifting social needs and changing circumstances (Yau et al., 2015). Cities, especially those with historic infrastructure, often struggle with the consequences of aging buildings and urban decay. These challenges are compounded by the varying rates of obsolescence across properties constructed in different eras. This paper investigates two key research questions: what are the internal effects of building rehabilitation on the property values of rehabilitated buildings? and what are the external effects of building rehabilitation on the property values of neighboring properties?

Addressing these dual impacts is crucial for advancing both academic research and policy discussions. While much of the existing literature has focused on property value changes associated with redevelopment projects, relatively little attention has been given to building rehabilitation, which is a less disruptive but potentially equally impactful alternative (Chareyron et al., 2022; Tang & Wong, 2020). This gap is particularly noteworthy in places like Hong Kong, where large-scale redevelopment efforts have led to social conflicts and displacement (Chau et al., 2021; Lai et al., 2018). In contrast, building rehabilitation represents a more sustainable urban renewal strategy that could foster both environmental and social harmony.

Hong Kong provides an ideal case study for this research due to two significant factors. First, the city faces substantial challenges related to building obsolescence: over half of its private housing stock is over 30 years old and in need of repair (Rating and Valuation Department, 2019). Second, Hong Kong's high-density, vertical urban environment presents unique dynamics that differ from those observed in larger, lower-density cities often featured in prior studies (Koster & van Ommeren, 2019). Despite interventions like the Mandatory Building Inspection Scheme (MBIS) and associated fiscal subsidies, the economic justification for public investment in private building rehabilitation remains contentious (Chan, 2019; Chan & Choi, 2015; Yau et al., 2015). Empirical analysis of rehabilitation's economic impacts is essential to informing these debates and evaluating the necessity of such government policies.

This study examines the effects of 135 building rehabilitation projects in Hong Kong, employing a difference-in-differences (DID) framework. By analyzing both internal (improvements to rehabilitated buildings) and external (spillover effects on surrounding property values) impacts, the research makes several key contributions. First, it expands the literature on housing externalities by focusing on rehabilitation, complementing previous studies that have primarily concentrated on redevelopment. Second, the study provides practical insights into the policy rationale for fiscal subsidies in urban rehabilitation. In doing so, it bridges an important gap between academic research and urban planning practice, particularly in cities grappling with similar issues of building deterioration and urban renewal.

The paper is structured as follows: Sect. 2 reviews relevant literature on building rehabilitation and urban renewal; Sect. 3 presents the context of urban renewal efforts in Hong Kong; Sect. 4 details the research methodology and data used; Sects. 5 and 6 report the results and their implications for property value changes, both internal and external to rehabilitated buildings; and Sect. 7 concludes with policy recommendations and suggestions for future research.

2 Literature review

Urban renewal has become a pivotal strategy for revitalizing aging urban spaces, focusing on restoring deteriorated buildings and rejuvenating outdated communities. Two primary approaches—redevelopment and rehabilitation—dominate this field. Redevelopment typically involves the demolition and replacement of existing structures, while rehabilitation emphasizes the preservation and enhancement of existing buildings, often with a focus on maintaining historical and cultural value (Chen et al., 2020; Li et al., 2020; Savini, 2011; Verdini, 2015; Zhang et al., 2016). Unlike redevelopment, which can be disruptive and costly, rehabilitation offers a more cost-effective alternative by preserving the urban fabric and reducing environmental and economic impacts (Chan, 2014).

The economic theory underlying real estate prices suggests that property values are shaped by a combination of intrinsic factors—such as size, quality, and design—and external influences, including neighborhood conditions and nearby amenities (Galster et al., 2004; Rosen, 1974). From a hedonic pricing perspective, building rehabilitation impacts property values through two main channels: internal effects, which enhance the value of the rehabilitated property itself, and external effects, which involve the spillover impacts on neighboring properties (Koschinsky, 2009; Tobler, 1970). While rehabilitation is gaining attention globally, research on its effects, particularly its external spillover impacts, remains limited compared to studies on redevelopment (Guo et al., 2018; Lai & Tang, 2016).

2.1 Internal effects of building rehabilitation

Research into building rehabilitation increasingly focuses on its internal benefits, defined as the direct impacts rehabilitation has on the properties undergoing renovation. These benefits arise from improvements in structural integrity, energy efficiency, and overall marketability. Shipley et al. (2006) found that rehabilitation enhances safety, comfort, and aesthetics while costing 10–12% less than new construction. Structural upgrades also increase the longevity of buildings, improve their market appeal, and lower long-term maintenance costs (Adams & Hastings, 2001; Horman et al., 2006).

From an environmental standpoint, incorporating energy-efficient features in rehabilitated buildings yields substantial operational cost savings (Abu-Hijleh et al., 2017; Manfredi & Masi, 2018). For instance, thermal insulation installations in Italy reduced energy consumption by 40% (Berg & Fuglseth, 2018), demonstrating the significant environmental and financial benefits of rehabilitating older buildings, particularly in densely populated urban environments where energy performance is often suboptimal (Chan, 2019).

Furthermore, rehabilitation can yield positive economic outcomes. Shipley et al. (2006) demonstrated that renovating existing buildings in Ontario was 10–12% cheaper than new construction. A study on multi-family buildings in Spain revealed that rehabilitation was considerably less expensive than demolition and new construction (Alba-Rodríguez et al., 2017). Additionally, rehabilitation can enhance rental income, reduce vacancy rates, and extend a building's lifespan (Horman et al., 2006). Amenyah and Fletcher (2013) found that rental rates for rehabilitated buildings were strongly correlated with improved access to amenities. Adams and Hastings (2001) showed that sustainable renovation increased both capital value and investment returns. For example, Singapore's Main Upgrading Program (MUP) demonstrated significant value appreciation, as rehabilitated properties sold for substantially higher prices (Ho et al., 2009; Lum et al., 2004).

However, while studies from North America and Europe highlight the internal benefits of building rehabilitation, these findings offer limited applicability to dense, high-rise urban areas like Hong Kong. Existing research on building rehabilitation in Hong Kong often focuses on government-led initiatives, such as the Mandatory Building Inspection Scheme (MBIS), with fewer empirical investigations into the economic benefits of rehabilitation in such high-density contexts (Chan, 2019; Hui et al., 2008). This underscores the need for further research to evaluate the economic value of rehabilitation in densely populated cities facing unique building lifecycle and renewal challenges.

2.2 Property value spillovers and neighborhood dynamics

External property value impacts, also referred to as spillover effects, occur when the rehabilitation of one building leads to changes in the property values of neighboring buildings (Ding & Knaap, 2002; Rosen, 1974). The magnitude of these impacts often depends on various contextual factors, such as the scale of intervention, spatial proximity, and pre-existing urban conditions.

Tobler's first law of geography (1970) and hedonic pricing models suggest that properties situated near rehabilitated buildings are likely to experience value changes due to visual improvements, reduction in blight, and enhanced neighborhood aesthetics. Research on redevelopment projects, which typically involve alterations to building façades, streetscapes, and neighborhood amenities, indicates significant positive spillovers on surrounding property prices (Fischer & Amekudzi, 2011; van Duijn et al., 2016). Redevelopment, due to its more transformative nature, often generates larger external effects. For example, brownfield redevelopments and infill housing have been shown to be positively linked with property value increases (De Sousa et al., 2009; Ding & Knaap, 2002). However, mixed or even negative externalities have been reported in situations where redevelopment projects disrupt existing communities or fail to align with local housing markets (Chau & Wong, 2014; Mesthrige & Poon, 2015; Woo et al., 2016).

In contrast to redevelopment, rehabilitation projects generally have a subtler and less visible impact, leading to weaker external effects. Most studies on rehabilitation emphasize its social outcomes, such as improvements in community ties and demographic shifts (Chan & Yung, 2004; Uysal, 2012), with fewer focusing on economic spillover effects. Exceptions include Yau et al. (2008) and Koster and van Ommeren (2019), who used hedonic pricing models to identify positive spillovers for properties near rehabilitated buildings. Yau et al. (2008) found evidence of positive externalities in Hong Kong, although their methodology may oversimplify the complexities of price determination. In the Netherlands, Koster and van Ommeren (2019) confirmed that investments in the rehabilitation of public housing led to price increases and faster property sales, thus indirectly demonstrating the external value of rehabilitation.

While existing literature explores the external effects of redevelopment and rehabilitation in some detail, the spillover effects of rehabilitation, especially in high-density urban areas like Hong Kong, remain underexplored. This study aims to fill this gap by empirically assessing the spatial spillover effects of rehabilitation and contributing to a deeper understanding of its broader economic impacts.

3 Urban renewal in Hong Kong

In Hong Kong, the process of urbanization has consistently encountered challenges stemming from limited land resources and escalating population density, leading to significant conflicts between human settlement and available land. Over the past decades of rapid economic growth and urbanization since World War II, the central regions of Hong Kong have grappled with issues of urban decay and structural dysfunction in buildings. Until 1990, the revitalization of old towns in Hong Kong primarily relied on market-driven approaches, resulting in unsatisfactory outcomes. To address these challenges and enhance the efficiency of old town revitalization and renewal, the Urban Renewal Authority of Hong Kong (URAHK) was established in 2001, signaling increased government intervention. By December 2019, URAHK had announced over 70 redevelopment projects and 460 rehabilitation projects, leading to the revitalization of more than 4200 buildings and 140,000 housing units. This wealth of experience and data offers valuable insights for studying the economic impacts of urban renewal during the transformation of old towns.

Presently, Hong Kong employs two comprehensive modes of urban renewal—redevelopment and rehabilitation, coupled with heritage preservation and revitalization—to combat the urban decay resulting from aging buildings. While redevelopment is a highly effective form of urban renewal in terms of rezoning and comprehensive development, it typically involves a protracted process of 6–10 years, from land acquisition and demolition to reconstruction and completion. This extended and intricate redevelopment timeline limits its efficacy in slowing down the aging of old districts. As an alternative to exclusive reliance on redevelopment, Hong Kong has embraced rehabilitation as a less time-consuming and environmentally friendly approach to renewal, focusing on improving the physical condition of aging structures.

The Mandatory Building Inspection Scheme (MBIS) is a long-term holistic practice in Hong Kong designed to address building deterioration, covering both residential buildings and other types of buildings. It mandates inspections to enhance the safety and overall condition of buildings, applying to structures over three stories high and 30 years old or above (Chan, 2019). The inspection encompasses key building elements such as external features, structural integrity, fire safety measures, and drainage systems, ensuring the safety of the housing environment. Ultimately, this approach enhances the efficiency of public resource utilization and fully unlocks the development potential of lands in old districts.

Housing rehabilitation can yield several positive external effects for neighboring communities. It improves the overall environmental landscape of surrounding areas and attracts more investment to nearby properties. For instance, renovating dilapidated buildings eliminates safety hazards, restores building facades, and extends the lifespan of structures, resulting in increased property values for both the rehabilitated buildings and the surrounding properties. Figure 1 provides an illustrative example of a residential building before and after rehabilitation.

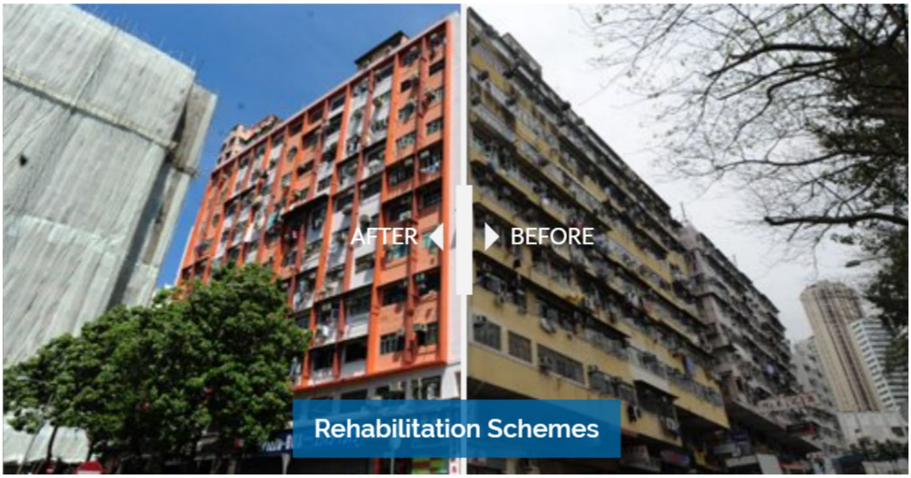

Fig. 1 An example of building rehabilitation. *Source*: HKURA, https://www.ura.org.hk/en/rehabilitation

4 Estimation strategy

4.1 Study area

Since 2001, the Urban Renewal Authority of Hong Kong (URAHK) has been designated as the statutory body responsible for promoting the renewal and revitalization of the old city of Hong Kong. Over the past two decades, URAHK has undertaken more than 460 building rehabilitation projects in Hong Kong, significantly extending the lifespan of these buildings. This study focuses on 135 rehabilitation projects of residential compounds (buildings) located on Hong Kong Island, completed before 2018.[1] These 135 building restoration projects[2] encompassed 7,114 residential units, with the majority completed between 2010 and 2016. The average age of the buildings at the time of the repair works was 42 years. Figure 2 illustrates the geographical distribution of the 135 rehabilitation projects on Hong Kong Island and other residential buildings that have not undergone rehabilitation. The red stars represent the rehabilitation projects, while the gray dots indicate private residential buildings within an 800-m radius of the nearest rehabilitation project.

[1] Our study sample only includes rehabilitation projects on Hong Kong Island and excludes rehabilitation projects for public housing buildings and commercial/office buildings. The average number of residential units in these rehabilitation projects is 53.

[2] Most of the rehabilitation projects include similar types of renovation items, primarily focused on the common parts of the buildings as required under the MBIS and the Mandatory Window Inspection Scheme. The primary renovations cover priority inspection and repair works, followed by additional items such as improvements to fire safety, water drainage, sanitary services, barrier-free access, security systems, and the use of environmentally friendly materials. Additionally, some projects include repairs for private projecting structures, with subsidies available for owner-occupiers. More details can be found via the website of Building Rehabilitation Platform (https://brplatform.org.hk).

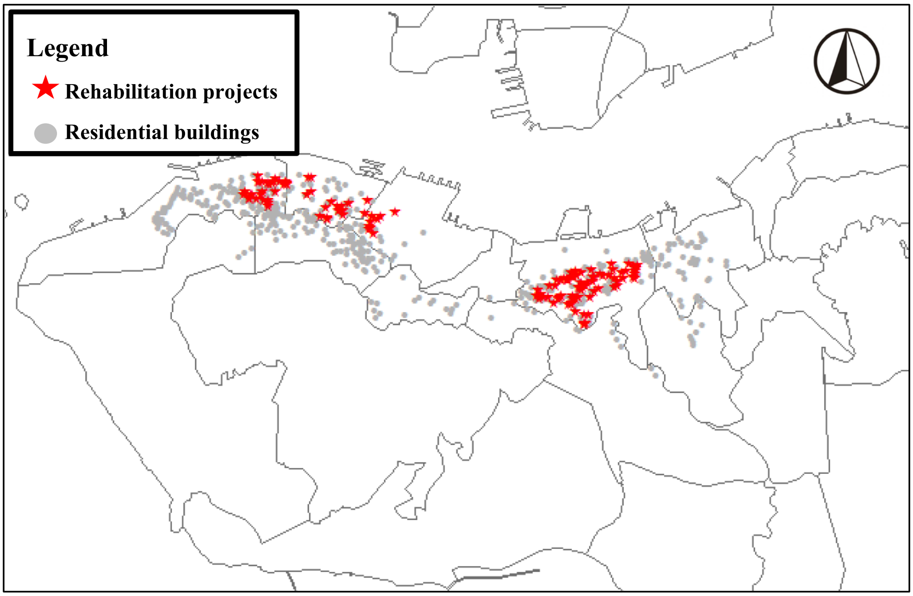

Fig. 2 Geographical distribution of rehabilitation projects on Hong Kong Island

4.2 Methodology

In our study, we define internal effects as the value changes directly attributable to a building's own rehabilitation (e.g., improved structural integrity, upgraded facilities, and enhanced visual appeal), whereas external effects refer to the spillover benefits (or costs) experienced by neighboring properties due to proximity to the rehabilitated building. Adopting the methodology outlined by Currie et al. (2015), Zheng et al., (2020a, 2020b), and Nian (2023), we employ the Hedonic DID approach to assess the impact of housing rehabilitation on the prices of adjacent buildings. The model specification is as follows:

$$\ln\left(\text{price}_{i,j,t}\right) = \beta_0 + \beta_1 \text{Treat}_j^r \times \text{Post}_t + \gamma X_{i,t} + \eta_j + \lambda_t + \varepsilon_{i,j,t} \quad (1)$$

where i,j, and t represent transaction record, residential building, and transaction time, respectively; $\ln\left(\text{price}_{i,j,t}\right)$ is the logarithm of a housing flat (Hong Kong dollars per square meter), the variable of primary interest is $\text{DBR}_{j,t}^{\text{radius}} = \text{Treat}_j^{\text{radius}} \times \text{Post}_t$, Treat_j^r is a dummy variable, which equals one if the transacted housing flat in building j is located within a r meter radius of the nearest rehabilitation buildings; otherwise, zero[3]; Post_t is an indicator

[3] Since the critical value (r) is quite different in different cities or regions, this paper will use further sensitivity analysis in the follow-up benchmark regression to determine the effective impact radius of the treatment effect of the old city renovation project. In addition, considering the high density of buildings in the urban area of Hong Kong, we set the maximum influence radius to 300 m.

variable for whether the housing transaction took place after the rehabilitation project within a given radius was completed.[4] $\mathrm{DBR}^r_{j,t} = \mathrm{Treat}^r_j \times \mathrm{Post}_t$ equals one in the years after the first and nearest rehabilitation building project was completed within r meters of a residential building, otherwise zero. The standard DID estimator β_1 is the parameter of primary interest, which measures the spillover effects of building rehabilitation on the prices of neighboring properties. $X_{i,t}$ is a vector of Hedonic control variables in logarithmic form and their quadratic term, including floor level, gross floor area, and building age. η_j and λ_t are building and year-fixed effects, which control for time-invariant unobserved comments of buildings and capture the overall market trend of housing prices.

Similarly, we use the following Hedonic DID model to identify the internal effects of building rehabilitation projects.

$$\ln\left(\mathrm{price}_{i,j,t}\right) = \delta_0 + \delta_1 \mathrm{Treat}_j \times \mathrm{Post}_t + \gamma X_{i,t} + \eta_j + \lambda_t + \varepsilon_{i,j,t} \tag{2}$$

where Treat_j is a binary treatment variable indicating whether the transacted flat i in building j experiences building rehabilitation during the sample period; Post_t is a binary indicator for whether the transaction took place after the rehabilitation of building j. $\mathrm{DID}_{j,t} = \mathrm{Treat}_j \times \mathrm{Post}_t$ is the variable of primary interest, which takes on the value one if housing flat i experienced building rehabilitation and transacted after the completion of building rehabilitation. The coefficient δ_1 on $\mathrm{DID}_{j,t}$ captures the treatment effects (internalities) of building rehabilitation on the values of renewed buildings. The rest of the variables have the same definitions as Eq. (1).

The classic DID model assumes that the externality effects of rehabilitation remain constant in the year after the rehabilitation. We employ an event study approach to explore the dynamic impact of building rehabilitation and verify the parallel trend assumption of our DID framework.

$$\ln\left(\mathrm{price}_{i,j,t}\right) = \sum_{k=-4}^{4} \delta_k (\mathrm{Treat}_j \times \mathrm{Year}_{j,k}) + \gamma X_{i,t} + \eta_j + \lambda_t + \varepsilon_{i,j,t} \tag{3}$$

where $\mathrm{Year}_{j,k}$ is a binary variable indicating the years before or after the completion of the nearest rehabilitation building within an r-meter radius for the external dynamic model, or the completion of building j's rehabilitation for the internal dynamic effect model. The coefficient δ_k denotes the dynamic effects of building rehabilitation on the prices of neighboring properties (or renewed buildings) over time. The rest of the variables have the same definitions as Eq. (1).

4.3 Data and variables

Housing transaction records spanning from 2001 to 2018 were gathered from the Hong Kong Economic Property Research Centre. Each record contains comprehensive details about the transacted housing flats, encompassing information such as transaction price,

[4] It should be noted that we did not exclude transaction records occurring during the rehabilitation period for the following reasons: (a) we lack detailed data on the exact start dates of each rehabilitation project; (b) anticipation effects may influence property values once rehabilitation work begins, as externalities can start to manifest early in the construction phase; and (c) we adopt an event study approach to capture the dynamic effects of rehabilitation over time, helping to account for any changes occurring during and after the rehabilitation period.

Table 1 Summary statistics of key variables

Variable	Observation	Mean	Std. Dev	Min	Max
	Panel A: Spillover effect model				
ln(HP)	39,965	8.603	0.622	6.909	11.02
ln(age)	39,965	2.782	0.784	0.693	4.094
ln(gfa)	39,965	6.465	0.451	5.298	8.006
ln(floor)	39,965	1.070	0.305	0.693	2.079
	Panel B: Internality model				
ln(HP)	42,590	8.584	0.626	6.909	11.02
ln(age)	42,590	2.813	0.775	0.693	4.094
ln(gfa)	42,590	6.445	0.447	5.050	8.006
ln(floor)	42,590	1.064	0.303	0.693	2.079

This table reports descriptive measures for the key covariates in both the spillover effect model (Panel A) and the internality model (Panel B), including the natural logarithms of housing prices (ln(HP)), building age (ln(age)), gross floor area (ln(gfa)), and floor level (ln(floor))

building name, address, gross floor area, floor level, and transaction date, among others. The dataset encompasses over 4000 residential compounds on Hong Kong Island. Latitude and longitude coordinates for the transaction samples were acquired through Google Maps and utilized to compute the Euclidean distance for each rehabilitation project and housing transaction.

Prior to the empirical test, the records were filtered to exclude transactions related to affordable housing, Home Ownership Schemes, and other public housing programs. To ensure uniformity within the same administrative division and housing submarket, transactions located within 800 m of the nearest rehabilitation project were retained. Additionally, transactions with a gross floor area exceeding 3000 square feet or a unit price lower than HK$1000 per square foot were excluded to mitigate the influence of large-scale luxury residential units and abnormal transaction records on the regression results. Subsequently, 39,965 records for the spillover effect model and 42,590 records for the internality model were obtained. The summary statistics of the key variables are presented in Table 1.

5 Results of the property value externalities

5.1 Benchmark result

The benchmark results for property value externalities are presented in Table 2. Columns 1 through 5 of Table 2 incrementally extend the spillover radius for the treatment group (i.e., 50 m, 100 m, 200 m, 300 m, and 400 m). The coefficients of the primary explanatory variable are significantly positive at the 1% significance level in the first four columns and become statistically insignificant with a smaller magnitude in the last column when the radius of influence is extended to 400 m. These findings suggest that completed building rehabilitation projects on Hong Kong Island exert substantial positive externalities on

Table 2 Benchmark results of property value externalities

Radius	(1) ≤ 50m	(2) ≤ 100m	(3) ≤ 200m	(4) ≤ 300m	(5) ≤ 400m
$DRP^{r}_{i,j,t}$	0.069***	0.081***	0.062***	0.032***	0.005
	(0.010)	(0.007)	(0.005)	(0.005)	(0.005)
lnage	0.242***	0.233***	0.238***	0.245***	0.245***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
$(\text{lnage})^2$	−0.227***	−0.226***	−0.228***	−0.229***	−0.229***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
lngfa	−1.394***	−1.410***	−1.395***	−1.390***	−1.384***
	(0.120)	(0.120)	(0.120)	(0.120)	(0.120)
$(\text{lngfa})^2$	0.103***	0.104***	0.103***	0.103***	0.102***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
lnfloor	−0.272***	−0.269***	−0.268***	−0.270***	−0.272***
	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
$(\text{lnfloor})^2$	0.218***	0.217***	0.216***	0.217***	0.218***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
constant	14.530***	14.589***	14.539***	14.516***	14.500***
	(0.392)	(0.393)	(0.393)	(0.393)	(0.393)
Control group	(50m, 800m)	(100m, 800m)	(200m, 800m)	(300m, 800m)	(400m, 800m)
Building fix effects	√	√	√	√	√
Year fixed effects	√	√	√	√	√
Month fixed effects	√	√	√	√	√
Observations	39,965	39,965	39,965	39,965	39,965
Adj. R^2	0.88	0.88	0.88	0.88	0.88

Standard errors clustered at the residential level are presented in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively

housing prices in the surrounding communities. Consistent with Tobler's (1970) first law of geography, this positive effect diminishes as the distance between the transaction unit and the restoration project increases. Residential units closer to the building rehabilitation sites experience greater benefits, which can be attributed to several localized improvements, including enhancing the urban landscape, mitigating safety risks, and addressing aesthetic issues stemming from aging buildings.

Our findings align with the broader empirical literature that identifies a spatial decline in property value externalities due to distance. For example, Zheng et al., (2020a, 2020b), using a similar database for Hong Kong, demonstrate that housing redevelopment projects produce significant spillover effects ranging from 6.34 to 7.35%. Although the magnitude of impact for rehabilitation in our results is lower—yielding an average price increase of 3.2%[5] within a 300-m radius—the presence of positive externalities remains evident. This

[5] The continuous DID strategy assumes that average treatment effects increase linearly with the number of rehabilitation projects happening around treated properties. However, considering agglomeration economies, the positive externalities on prices might be significantly larger when treated properties are surrounded by a cluster of rehabilitation projects. The magnitude of these positive externalities might be underestimated in this case. It is important to note that this limitation, while acknowledging the potential underestimation of positive externalities, does not compromise the robustness of our main results.

Table 3 Spatio-temporal Autoregression

Radius	(1) $\leq$ 50m	(2) $\leq$ 100m	(3) $\leq$ 200m	(4) $\leq$ 300m	(5) $\leq$ 400m
$DRP^{r}_{i,j,t}$	0.068***	0.077***	0.061***	0.034***	0.009
	(0.022)	(0.014)	(0.012)	(0.012)	(0.012)
$\ln(price^{S-T}_{i,j,t})$	0.341***	0.335***	0.338***	0.343***	0.343***
	(0.029)	(0.028)	(0.028)	(0.029)	(0.029)
Control group	(50m, 800m)	(100m, 800m)	(200m, 800m)	(300m, 800m)	(400m, 800m)
Control variables	√	√	√	√	√
Building Fix effects	√	√	√	√	√
Year fixed effects	√	√	√	√	√
Month fixed effects	√	√	√	√	√
Observations	39,758	39,758	39,758	39,758	39,758
Adj. R^2	0.88	0.88	0.88	0.88	0.88

All regressions include a full set of control variables, as shown in Table 2. Standard errors clustered at the residential building level are presented in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively

distinction aligns with studies such as Kurvinen and Vihola (2016), Galster et al. (2006), and Ellen et al. (2001), which highlight that redevelopment projects generally produce more substantial property value impacts compared to rehabilitation efforts due to their transformative nature.

Several scholars attribute the lower spillover effects of rehabilitation projects to their focus on incremental improvements rather than large-scale structural transformations (Koster & van Ommeren, 2019). For example, rehabilitation primarily addresses superficial changes (e.g., façade improvements, minor energy efficiencies, and safety upgrades) without fundamentally altering urban infrastructure or land use intensity. In contrast, redevelopment involves demolishing outdated structures and replacing them with entirely new buildings, which tend to generate broader economic and visual changes for nearby properties (Greenaway-McGrevy et al., 2018).

The nuanced understanding of how rehabilitation projects influence property values can be further enhanced through interview-based evidence. Interviews with local residents, property agents, and urban planners can provide qualitative insights into how physical upgrades—such as façade restorations or safety improvements—positively influence perceptions of building quality, livability, and safety. Prior studies (Helms, 2012; Lee & Chan, 2008) emphasize that improvements perceived as directly enhancing the quality of life are particularly influential for nearby residents and property owners, despite having a more limited physical footprint than redevelopment projects.

Qualitative evidence can also help clarify why the radius of impact diminishes beyond 300 m. As rehabilitation often addresses localized issues (e.g., removing safety hazards or improving appearances), its visible and tangible benefits are most pronounced for nearby properties. This finding parallels the work of Yau et al. (2008), who demonstrated that refurbishment increases property values primarily within the immediate vicinity of rehabilitated buildings.

Table 4 Robust check: number of rehabilitation projects within the specified radius

Radius	(1) ≤ 50 m	(2) ≤ 100 m	(3) ≤ 200 m	(4) ≤ 300 m
$NRP^{r}_{i,j,t}$	0.041***	0.028***	0.010***	0.007***
	(0.010)	(0.003)	(0.001)	(0.001)
Control variables	√	√	√	√
Building fix effects	√	√	√	√
Year fixed effects	√	√	√	√
Month fixed effects	√	√	√	√
Observations	39,965	39,965	39,965	39,965
Adj. R^2	0.88	0.88	0.88	0.88

All regressions include a full set of control variables, as shown in Table 2. Standard errors clustered at the residential building level are presented in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively

5.2 Robust check

5.2.1 Spatial and temporal autocorrelation

Previous studies suggest that housing transaction data may have spatial and temporal effects (see Pace et al., 2000; Liu, 2013; Zheng et al., 2020a, 2020b, for examples), which might result in biased estimates of coefficients. To address this concern, we employ the Spatio-Temporal Autoregressive Regression (STAR) model (Pace et al., 2000).[6] The STAR model captures the intricate interplay between spatial and temporal factors. We consider the transaction records of the past six months to incorporate the temporal dimension, establishing a spatio-temporal weight matrix. The results of STAR models in Table 3 are estimated using the exact specification of Table 2. The results demonstrate positive and significant coefficients on the spatio-temporally lagged housing prices (i.e. $\ln(\text{price}^{S-T}_{i,j,t})$ for all columns, indicating the existence of spatial autocorrelation in housing transactions. Meanwhile, the estimated coefficients of $DRP^{r}_{i,j,t}$ are only slightly different than the benchmark OLS results. Therefore, spatial and temporal effects are not the major concerns of our model (Table 4).

5.2.2 Alternative measurement of treatment

Another potential concern remains regarding the concentration of multiple rehabilitation projects in a small area, as illustrated in Fig. 1. The Hedonic-DID method's estimation of the treatment effect could be influenced by the clustering of several rehabilitation projects within the same confined space. To address this issue, we employ the count variable $NRP^{r}_{i,j,t}$ as an alternative measure of the treatment effect, representing the number of rehabilitation projects within a specified radius after the transaction date i. As indicated in Table 5, all estimates of $NRP^{r}_{i,j,t}$ at different radii are significantly positive at the 1% significance level, with the coefficient magnitude decreasing as the radius increases. For instance,

[6] To conserve space, we have omitted the complete details of the STAR model, which are fully described in Liu (2013).

Table 5 Robust check: mutually exclusive rings

	(1)	(2)	(3)	(4)	(5)
Ring (0–50 m)	0.068***				
	(0.021)				
Ring (50–100 m)		0.080***			
		(0.019)			
Ring (100–200 m)			0.035**		
			(0.017)		
Ring (200–300 m)				− 0.038*	
				(0.019)	
Ring (300–400 m)					− 0.032
					(0.025)
Control Variables	√	√	√	√	√
Building Fix effects	√	√	√	√	√
Year fixed effects	√	√	√	√	√
Month fixed effects	√	√	√	√	√
Observations	39,965	33,492	25,838	16,089	11,003
Adj. R^2	0.88	0.87	0.87	0.86	0.88

All regressions include a full set of control variables, as shown in Table 2. Standard errors clustered at the residential building level are presented in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively

in column (2), an additional rehabilitation project within a 100 m radius corresponds to a 2.8% increase in residential property price.

5.2.3 Mutually exclusive rings

Another concern is that using cumulative rings may be misleading since it might not overestimate the impact radius of the rehabilitated building. We use mutually exclusive rings to address this concern, specifically adopting mutually exclusive rings (0–50 m, 50–100 m, 100–200 m, 200–300 m, and 300–400 m) instead of cumulative rings in our benchmark regression. The results in Table 5 indicate that treated housing properties, where rehabilitation projects occurred in 0–50, 50–100, and 100–200 concentric rings, exhibit a significant positive price premium compared to control properties where rehabilitation projects happened outside the ring. Furthermore, the magnitude of this premium begins to decrease as the radius of the concentric rings becomes larger. Interestingly, there is a noticeable shift toward a potential price discount when compared with control groups for treated properties in the outer rings, specifically in the 200–300 and 300–400 m categories. This phenomenon might be attributed to the siphon effect. Rehabilitation projects may contribute to gentrification in the neighborhood, attracting a cluster of wealthier individuals. This, in turn, could lead to the reallocation of amenities across the neighborhood, influencing housing prices in a nuanced manner. The observed variation in price effects across different distance rings underscores the complexity of externalities resulting from rehabilitation projects. Nevertheless, the effect of the rehabilitation project on surrounding properties becomes insignificant when the distance exceeds 300 m.

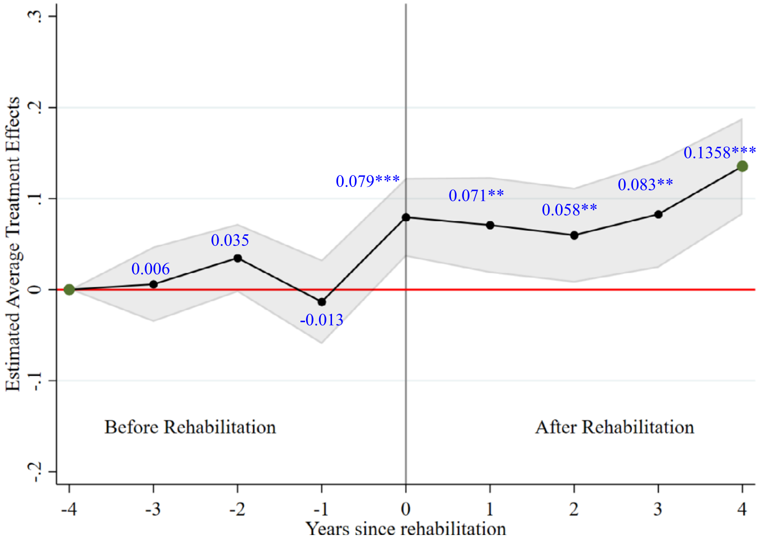

Fig. 3 Dynamic effects of building rehabilitation on neighboring properties. Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively

5.3 Dynamic effect of building rehabilitation on neighboring properties

In light of our baseline findings, which indicate that the spillover effect of building rehabilitation becomes insignificant beyond 300 m, we define transactions within a 300-m radius of a rehabilitated building as the treatment group, while those located farther than 300 m are designated as the control group. Figure 3 presents the event study results from Eq. (3), where each δ_k captures how the property price dynamically responds to proximity ($\leq$300 m) to a rehabilitated building in the k-th year before or after the project's completion.

The coefficients for δ_k prior to completion (i.e., $k = -4$ to -1) and the completion year ($k = 0$) are close to zero and not statistically significant, satisfying the parallel trend assumption of the DID framework. In contrast, the estimates for the subsequent years are all positive and showing progressively larger effects. This pattern indicates that building rehabilitation exerts a prolonged and increasing impact on adjacent property values over time, aligning with the hypothesis that upgraded neighborhood amenities and aesthetics attract homebuyers. These findings differ from the study by Ooi and Le (2013), which suggests that the appreciation of surrounding housing mainly occurs in the early stages of reconstruction, and that positive externalities diminish once projects are completed and new housing supply enters the market.

5.4 Heterogeneous effects

In this section, we delve into potential heterogeneity in the effects of rehabilitation based on the dimensions of building age and flat size. Initially, we categorize the sample into two groups (i.e., age $\leq$ 30 and age $>$ 30) to examine whether the spillover effects of building

Table 6 Heterogeneous effect

	(1)	(2)	(3)	(4)	(5)
	Building age (year)		Gross floor area (m^2)		
Sub-sample	≤ 30	> 30	< 50	[50–80]	> 80
$DRP_{i,j,t}^{radius}$	0.089***	0.040*	0.047***	0.062***	0.009
	(0.016)	(0.022)	(0.008)	(0.014)	(0.026)
Control variables	√	√	√	√	√
Building fix effects	√	√	√	√	√
Year fixed effects	√	√	√	√	√
Month fixed effects	√	√	√	√	√
Observations	33,267	6692	16,144	13,619	10,194
Adj. R^2	0.88	0.85	0.87	0.86	0.87

All regressions include a full set of control variables, as shown in Table 2. Standard errors clustered at the residential building level are presented in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively

rehabilitation vary across different age categories of buildings. As illustrated in Table 6 (columns 1 & 2), building rehabilitation demonstrates more pronounced spillover effects on surrounding buildings with a lower age. One plausible explanation is the competition among older residential buildings, particularly given that the average age of the renewed buildings exceeded 42 years. Individuals may prefer housing flats in an old building that has undergone restoration and renovation when faced with a choice between two adjacent old buildings with similar external environments and amenities. Consequently, the negative impact of building maintenance projects on the investment value of surrounding older neighborhoods might partially offset the positive external effects of building rehabilitation projects.

Subsequently, we segment the samples into three groups based on the gross floor area of housing flats and investigate the heterogeneous impact of building rehabilitation projects on residential units of different sizes. The results from columns 3 to 5 indicate that the spillover effects for the < 50 m^2 group and [50–80 m^2] group remain positive and significant, while the estimated treatment effect is not significantly different from zero for apartments with larger floor areas (i.e., > 80 m^2). This outcome is attributed to the fact that apartments with larger sizes (i.e., > 80 m^2) are typically situated in communities with better environments and facilities, making their prices less sensitive to the renewal of surrounding properties.

6 Internal effects of building rehabilitation projects

6.1 Benchmark result

The benchmark results for internalities—the direct impacts of building rehabilitation on the values of the renewed buildings—are presented in Table 7. In column (1), we include the DID term along with two-way fixed effects to account for time and property-specific unobservables. The estimated coefficient for the DID term is positive and statistically significant at the 1% level, providing initial evidence that building rehabilitation positively impacts

Table 7 Benchmark results of internalities

	(1)	(2)	(3)
Control group	[0–800 m]		[400–800 m]
DID	0.160***	0.081***	0.082***
	(0.016)	(0.016)	(0.017)
lnage		0.233***	0.306***
		(0.018)	(0.064)
(lnage)^2		−0.222***	−0.267***
		(0.008)	(0.023)
lngfa		−1.481***	−1.721***
		(0.118)	(0.210)
(lngfa)^2		0.109***	0.119***
		(0.009)	(0.016)
lnfloor		−0.264***	−0.122
		(0.027)	(0.078)
(lnfloor)^2		0.214***	0.149***
		(0.012)	(0.037)
Building fix effects	√	√	√
Year fixed effects	√	√	√
Month fixed effects	√	√	√
Adj. R^2	0.86	0.88	0.88
Observations	42,590	42,590	8,714

Robust standard errors, clustered by the building level, are reported in parentheses. ***, **, and * denote significance at 1%, 5%, and 10%, respectively

housing values. To ensure robustness, we incorporate a comprehensive set of control variables in column (2). The results remain highly significant, although the magnitude of the effect is slightly reduced. Specifically, the estimates indicate that building rehabilitation projects increase the value of renewed buildings by 8.4% (= [exp(0. 081) − 1]). This finding underscores that rehabilitating aging buildings leads to measurable increases in value by addressing structural deficiencies, improving safety, and enhancing the physical appearance of the property—a conclusion consistent with findings in prior studies. For instance, Horman et al. (2006) and Adams and Hastings (2001) highlight that renovation enhances building longevity, comfort, and capital value, which directly translates to increased housing prices.

As previously discussed, building rehabilitations also generate positive externalities for nearby properties, raising concerns that the estimated DID coefficients may understate the true internalities of rehabilitation due to spillover effects. To address this potential issue, we use an alternative control group consisting of housing transactions located 400 m away from the nearest rehabilitated buildings. This distance-based approach helps isolate the direct benefits of rehabilitation on the renewed buildings by minimizing the confounding impact of spillovers on surrounding properties. The results, reported in column (3), reveal that the estimated DID coefficient is slightly larger compared to column (2). This subtle increase reinforces the idea that the internal benefits of building rehabilitation are likely underestimated when external spillover effects are not fully accounted for. Similar spatial spillover corrections have been implemented in studies on urban renewal effects, such as Zheng et al., (2020a, 2020b) and Koster and van Ommeren (2019), where researchers emphasize the importance of carefully delineating the radius of influence to distinguish direct and indirect impacts.

These findings are consistent with broader theoretical arguments. Savini (2011) and Chan (2014) argue that rehabilitation improves the functional and aesthetic value of existing buildings, resulting in direct economic benefits. Moreover, case studies such as Alba-Rodríguez et al. (2017) in Spain demonstrate that rehabilitating multi-family housing incurs substantially lower costs than reconstruction while delivering meaningful increases in property values.

6.2 Dynamic internal effects of building rehabilitation

Similar to Sect. 5.3, we adopt an event study framework to capture the dynamic internal effects of building rehabilitation on the value of renewed buildings. As illustrated in Fig. 4, the estimated coefficients δ_k for the years preceding completion are statistically insignificant, confirming the parallel trend assumption. Immediately after rehabilitation ($k=0$), the effect becomes positive, and subsequent years exhibit progressively larger and significant coefficients. These results align with prior studies highlighting the long-term economic gains of building upgrades, such as enhanced structural integrity, improved energy efficiency, and heightened market appeal (Horman et al., 2006). They also resonate with the argument that building rehabilitation represents a cost-effective and environmentally responsible pathway to urban renewal—particularly vital in high-density cities like Hong Kong, where obsolete housing stock poses significant social and economic challenges (Chan, 2019). By demonstrating that value appreciation accelerates after project completion and persists over time, our findings reinforce the notion that rehabilitation not only mitigates deterioration but also generates sustained benefits for property owners in rapidly urbanizing contexts.

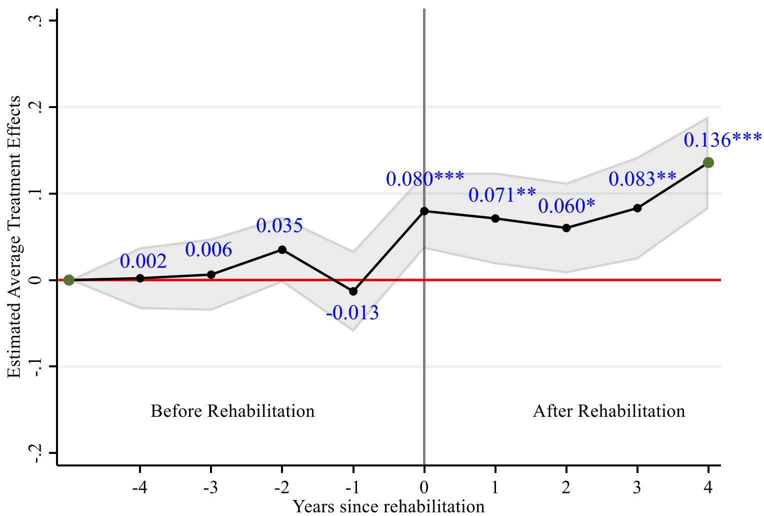

Fig. 4 Dynamic effects of building rehabilitation. Note: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively

7 Concluding remarks

This study examines the effects of government-subsidized building rehabilitation in Hong Kong, assessing both its property value externalities and internal effects. By applying the Hedonic DID model to housing transaction data from Hong Kong Island, we uncover substantial and positive spillover effects of building rehabilitation on the property values of nearby housing within a 300-m radius. Specifically, residential units within this radius experience an average transaction price increase of 3.2%. The magnitude of this effect diminishes with distance, becoming statistically insignificant at a 400-m radius.

Further analysis reveals significant heterogeneity in property value externalities based on the age and size of the buildings. For instance, buildings aged 20 years or younger exhibit more pronounced spillover effects than older structures. This is likely due to heightened competition among older properties, with potential buyers preferring rehabilitated units over those that remain in disrepair. Additionally, smaller apartments (under 80 m^2) show greater sensitivity to these externalities than larger apartments (over 80 m^2), possibly because smaller units are more likely to be in less attractive areas and, thus, more affected by the improvements brought about by building rehabilitation. These findings suggest that rehabilitation projects in Hong Kong generate significant positive externalities on neighboring properties, particularly for those located closer to the renovation, benefiting from improvements in both the aesthetic quality of the surrounding area and the elimination of safety hazards.

In terms of internal effects, our results indicate that building rehabilitation projects increase the value of the rehabilitated buildings by an average of 8.4%. This result remains robust through various sensitivity analyses, including the use of alternative control groups to isolate spillover effects. These internal benefits underscore the economic advantages for property owners who undertake rehabilitation projects, emphasizing the value of such initiatives in enhancing the quality and marketability of existing buildings.

The insights drawn from the Hong Kong case are widely applicable to other cities facing similar challenges. In many rapidly developing urban centers, the need for urban renewal is pressing, but traditional redevelopment often gives rise to social problems such as displacement and gentrification. Rehabilitation offers a more sustainable and socially harmonious alternative, preserving the original urban fabric while fostering organic revitalization. This approach addresses not only the physical transformation of buildings but also the preservation of cultural heritage, ecological balance, and social structures—elements vital for maintaining community identity and cohesion.

Rehabilitation has gained increased attention, particularly in high-density cities like Hong Kong, where land scarcity, high costs, and the potential for social disruption make traditional redevelopment problematic. This strategy underscores the growing recognition that urban renewal efforts should prioritize sustainability, community preservation, and minimal disruption to established social patterns. As noted by Chan and Yung (2004), Lelévrier (2013), Uysal (2012), and other scholars, rehabilitation offers solutions that meet evolving social needs while tackling social exclusion and benefiting vulnerable groups, such as the elderly and minority populations.

Despite these advantages, challenges remain in the market-driven approach to rehabilitation, as developers and residents may be reluctant to initiate projects due to high costs, low profitability, and collective action barriers (Helms, 2012). As a result, government-led or subsidized rehabilitation is critical. The positive externalities and internal benefits highlighted in this study provide a strong rationale for government subsidies, ensuring that public investments yield tangible benefits for communities and promote social efficiency.

Future research should explore the social externalities of building rehabilitation, including its impact on quality of life, social inclusion, and community cohesion. Longitudinal studies could provide valuable insights into the long-term effects of rehabilitation on both property values and the well-being of residents. Comparative studies across different cities and regions would also help determine the broader applicability of the findings and the effectiveness of various rehabilitation strategies.

Aligned with these principles, building rehabilitation has witnessed a surge in popularity, particularly in high-rising, high-density cities like Hong Kong. This approach addresses critical challenges such as land scarcity, substantial costs, and the potential disruption of the established urban way of life. The emphasis on building rehabilitation reflects a broader recognition of the need for sustainable and thoughtful urban renewal strategies that prioritize the preservation of community identity and social cohesion. As emphasized by Chan and Yung (2004), Lelévrier (2013), Uysal (2012), and various other scholars, rehabilitation not only accommodates evolving social needs but also tackles the issue of social exclusion, particularly benefiting vulnerable groups such as the elderly and minority populations.

While building rehabilitation may mitigate issues such as social exclusion and displacement, a notable challenge arises as market-driven initiatives often result in inadequate rehabilitation from a social efficiency perspective. Both private developers and residents display reluctance to initiate rehabilitation projects due to substantial costs, limited profitability prospects, and challenges associated with collective actions (Helms, 2012). Consequently, government-led or subsidized rehabilitation becomes necessary. In this context, the evidence regarding the positive externalities and internal effects of rehabilitation projects provides a strong justification for government subsidies and ensures accountability to taxpayers.

Future research should investigate the social externalities of building rehabilitation, such as improved quality of life, reduced social exclusion, and enhanced community cohesion. Longitudinal studies are also needed to assess the long-term impacts of building rehabilitation on property values and community well-being. Moreover, comparative studies across different cities and regions can provide insights into the generalizability of the findings and the effectiveness of various rehabilitation strategies.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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