THE VALUE OF BUILDING SAFETY: A HEDONIC PRICE APPROACH

by

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Abstract
Theoretical and empirical studies on how building quality or performance is valued by the property market abound in the literature. While some of them investigate the changes in property price after building renovation, little has been done on the pricing of safety performance of buildings. In this regard, this preliminary research aims to explore if residential properties in safer buildings command higher market values in Hong Kong. Hong Kong provides a good laboratory for this study because it is a densely-populated city where high-rise buildings are common. In such an environment, building failures can pose a serious threat. A spate of building-related accidents in the city in recent years has demonstrated the painful consequences of neglect of building safety.

For the purpose of this study, the safety performance of a building is measured by the weighted number of unauthorized building works (UBWs) present on the external walls of the buildings. By their nature, UBWs are building works that are constructed without prior approval and consent from the government. A hedonic price model is developed for assessing the market value of building safety. For the model estimation, apart from the property transaction data, the number of unauthorized appendages (i.e., UBWs attached to the building facades) in each building under study is obtained through a building survey. Based on the analysis results, several hypotheses built upon the theories of self-protection and self-insurance put forward by Ehrlich and Becker (1972) are tested.

Keywords: Building safety; hedonic pricing model; self-protection; self-insurance; unauthorized building works

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INTRODUCTION

“A safe home is a good home,” as the saying goes. Safety is defined by the World Health Organization (1998: 6) as “a state in which hazards and conditions leading to physical, psychological or material harm are controlled in order to preserve the health and well-being of individuals and the community”. From an etymological perspective, safety is about the wholeness of physical life. It is because salvis and solvos, the Latin and Proto-Indo-European origins of word “safe”, mean “uninjured and healthy” and “whole” respectively (Nilsen et al., 2004). Therefore, it is sensible for scholars like Thygerson (1977) and Hunter (1992) to define safety as a state free from hazard or danger. With reference to these definitions, Yau et al. (2008: 503) interpreted building safety as “the achievement of a building in safeguarding its occupants and the general public from the harms originated from the built environment, which in turn reduces injuries and deaths”. To perform its function, a building should be safe in many senses. For example, the building should be structurally stable and fire-resistant, and the escape routes are free from any obstructions.

In order to ensure the safety of the building stock, governments usually adopt two approaches. The first approach is building control which makes sure the safety level of all buildings in a city meet the minimum acceptable standards through strict monitoring and enforcement of building codes or regulations (Crook & Hughes, 2001). For instance, building authorities enforce against properties in disrepair and illegal building works (Hattis, 1981; Yiu & Yau, 2005). On the other hand, subsidization is the second means of state intervention. Grants and loans have been offered to property owners for the improvements (including maintenance and rehabilitation) of their properties around the world (e.g. Boyne et al., 1991, Scanlon, 2010; Whalley, 1988; Yau et al., 2013). As a matter of fact, apart from law enforcement and subsidization, market forces may help motivate property owners to keep their buildings safe (Yau, 2009). In theory, safer properties should have higher values, keeping other things constant. There is a large volume of empirical literature on how an overall change in the building performance or conditions (e.g. by means of refurbishment and renovation) is reflected in property price or rental level (Chau et al. 2003; Fortes & McCarthy, 2010; Hui et al., 2008) but little has been done specifically on the pricing of safety performance of buildings. In this regard, this preliminary research aims to explore if residential properties in safer buildings command higher market values in Hong Kong.

For the purpose of this study, the safety performance of a building is measured by the weighted number of unauthorized appendages present on the external walls of the buildings. A hedonic price analysis is conducted for assessing the market value of building safety. Based on the analysis results, three hypotheses built upon the theories of self-protection and self-insurance put forward by Ehrlich and Becker (1972) are tested.

Hong Kong provides a good laboratory for this study because it is a densely-populated city where high-rise buildings are common. In such an environment, building failures can pose a serious threat. A number of terrifying building-related accidents in the city in recent years, including the sudden collapse of a 55-years-old apartment building in To Kwa Wan, Hong Kong which claimed four lives in January 2010 (Buildings Department, 2010). These accidents have vividly demonstrated the painful consequences of neglect of building safety. As for the safety performance of a building, it is proxied by the number of unauthorized appendages which are
essentially illegal or unauthorized building works (UBWs) for two major reasons. First, the problem of UBW proliferation has attracted much public attention in Hong Kong particularly since many top government officials and lawmakers found themselves embroiled in scandals of illegal structures in 2011 and 2012 (Foo, 2012; Luk, 2012; Ma, 2011). Second, unauthorized appendages are the most easily observable among all types of UBW.

This article is organized as follows. Literature on the quality-price link in the property market and self-protection and self-insurance theories will be first reviewed, followed by the outline of hypotheses and development of analytical model. The data sources will then be detailed. What come next are the analysis results. The implications of the analysis results will be discussed before the preliminary study is concluded and an agenda for further research is suggested.

LITERATURE REVIEW

Building Quality as a Determinant of Property Value

Building quality or performance has been regarded as an important determinant of property value. Baum (1991, 1994) and Ho (2000) showed that commercial buildings of better quality brought higher returns to the owners. In the residential property sector, Feijtem and Mulder (2005) asserted that quality of a dwelling can be ideally reflected in its value or price. In the broadest sense, the quality of a building embraces all the attributes related to the building. A survey of the empirical literature (e.g. Chau, et al., 2001; Mok, 1995; Mok et al., 1995; So et al., 1997; Tse & Love, 2000; Tse et al., 1997; Yau et al., 2008, 2009) suggests that apart from the time factors, the value of a residential property is determined by its structural characteristics (e.g. age, size and floor level), locational characteristics (e.g. accessibility to public transport) and external environment (e.g. view and proximity to park). Nonetheless, previous studies inclined to research the impacts of building design and environmental factors on property price. These factors are mostly intrinsic or not easily adjustable by the property owners, particularly after a property is in use. Building quality attributes like building conditions and presence of illegal structures, which are more easily adjustable or manageable by the property owners, have been have not attracted much attention from the academics.

In point of fact, similar to the design and environmental characteristics, building conditions have often been thought of being influential to property price. Without any empirical support, Arens (1997) analytically argued that defective properties (e.g. those with significant physical problems like cracked slabs or subsoil subsidence) should be valued at a discount in view of the potential costs of remediation, higher vacancies and extra insurance premiums. Kain and Quigley (1970) empirically evidenced that properties in better conditions (in terms of interior and external physical environments) were sold at higher prices. Similar findings were returned from other studies like Bourassa and Peng (1999), Bulter (1982) and Jimenez (1983) and which found that value was added to properties with better building conditions. On the other hand, Murdoch et al. (1993) found that the presence of substandard structural items in a building suppressed property prices. In another stream of research, property value is evidenced to change with building condition as a result of an improvement project. For example, Chau et al. (2003) carried out a hedonic price analysis to study how a refurbishment project affected property value in Hong Kong. Their research showed an approximately 9% rise in property values brought about by the refurbishment, implying that there was a significant positive relationship between building quality and property value. Another local study by Hui et al. (2008) uncovered that building
rehabilitation resulted in an average of 35.6% enhancement of property value. In New Zealand, property price was also found to increase by 1-8% after home improvement (Fortes & McCarthy, 2010).

As a whole, although empirical studies on relationship between building quality and property value abound, most of them are not specifically related to the safety performance of buildings. The improvement projects investigated by Chau et al. (2003) and Hui et al. (2008) were associated with upgrading of safety, hygienic and aesthetical quality of the buildings at the same time. These previous studies do not help us know whether the housing market values properties in a safer building with a premium.

Theories of Self-insurance and Self-protection

The price-safety connexion of housing can be conceptualized based on the theories of self-insurance and self-protection put forward by Ehrlich and Becker (1972). These two theories frame how rational individuals make choices among different actions when facing risks. Very often, individuals participate in an array of risky activities that may jeopardize their own safety (Blomquist, 2004). Driving a car and cycling are typical examples of these risky activities. Engaging in these activities, an individual may risk injury or property damage so he can take out insurance against the potential losses. Alternatively, the individual can choose to drive his car or ride on a bicycle slowly and carefully in order to reduce the chance of accident, or recourse can be made in the form of protective measures like seat belts and safety helmets to reduce losses in case of accident.

Choice among market insurance, self-insurance and self-protection

In their classic paper, Ehrlich and Becker (1972) devised a state-preference approach to explain an individual’s choices and behaviour under uncertainty by combining the indifference curve and expected utility analyses. In their premise, there are two states of the world – good states (or well-endowed states) and bad states (or less well-endowed states). Examples of the bad states include outbreaks of fire, earthquakes and many other man-made or natural disasters. Facing a prospective loss in a bad state, an individual can either insure against the loss, or take steps to lower the likelihood that the loss will occur. In this sense, individuals are required to determine their optimal expenditures on a set of alternative instruments, namely market insurance, self-insurance, and self-protection. In Ehrlich and Becker’s language, self-insurance refers to effort to reduce the sizes of prospective losses from bad states, given the probability of distribution of the corresponding bad states. Self-protection, in contrast, refers to effort to reduce the probabilities of bad states given the magnitudes of the corresponding prospective losses.1

In the characterization by Ehrlich and Becker (1972), market-insurance and self-insurance are similar. They aim to both lower sizes of loss in bad states by transferring an individual’s income from good states to bad states. By choosing not to insure through a market or self-insure, the

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1 Ehrlich and Becker (1972: 634) admitted that it was “somewhat artificial to distinguish behaviour that reduces the probability of the loss from behaviour that reduces the size of a loss since many actions do both”. This distinction is often blurred in actual practice. However, it remains a useful theoretical distinction, given the contrasting results in the models of self-insurance and self-protection.
individual has to bear by himself the losses from any bad states that realize. Sometimes, this is the only option available because the instruments for market insurance and self-insurance are not accessible. Market insurance, if available, can be purchased at a price which is usually called the premium. What makes self-insurance different from market insurance is the absence of an insurance market for self-insurance. An explicit price for self-insurance hence does not exist. Nonetheless, the price of self-insurance can be imputed to the costs incurred in self-insuring by the individual. Other than pricing, the mechanism of risk pooling also marks a significant difference between the two types of insurance. Risk is pooled across different individuals in market insurance but not in self-insurance. Unlike the two insurance options, self-protection does not involve any income transfer from good to bad states. It targets for the reduction of the probabilities of bad states rather than lowering the sizes of loss in bad states.

In a world where insurance markets do not exist, individuals can only resort to self-insurance and self-protection to mitigate any prospective losses. If market insurance is available, it is a close substitute for self-insurance as long as the premium of market insurance is independent of the extent of self-insurance taken (Ehrlich & Becker, 1972). The take-up of self-insurance will drop with an increasing availability of actuarially-fair priced market insurance.² For mitigating a ‘rare’ or low-probability loss, market insurance is preferred to self-insurance because the premium of market insurance decreases with the probability of loss while the costs incurred or the implicit prices of self-insurance do not (Ehrlich & Becker, 1972). In other words, to achieve the same level of reduction in the probability of a rare loss, the cost or the amount of effort paid for self-insurance generally exceeds market insurance premium. Therefore, the low cost-effectiveness will discourage people from self-insuring against rare losses. In other words, self-insurance is subject to crowding out (Simmons et al., 2002). This view is empirically supported by Fronstin and Holtmann (1994). Contrariwise, market insurance and self-protection complement each other provided that the former is available in the market at an actuarially fair rate (Ehrlich & Becker, 1972). The rationale for this complementary relationship is straightforward. In order to reduce the risk of moral hazard, the premium of market insurance should reflect the amount of self-protection effort taken by individuals to reduce the probability of loss. Any effort of self-protection perceived to be effective is recompensed by the market in the form of lower premium. Following this line of thought, the coverage of market insurance is not necessarily negatively correlated with the amount of effort paid for self-protection by individuals.³

Nevertheless, other literature illustrated that the premium of market insurance might not respond to the amount of self-protection effort due to information asymmetries (Arnott & Stiglitz, 1988; Ligon & Thistle, 1996) or market failures (Arnould & Grabowski, 1981; Kunreuther & Kleffner, 1992). Besides, the analytical model of Ehrlich and Becker (1972) does not thoroughly explain the interaction between self-insurance and self-protection under different conditions regarding the availability of market insurance (Boyer & Dionne, 1983). Boyer and Dionne (1983) argued that in the absence of market insurance, self-insurance should be favoured over self-protection by risk-averse individuals. However, this proposition was devised based on the assumption that the

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2 The price or premium of market insurance is considered actuarially fair if the probabilities of the losses concerned are fully considered in the pricing process.

3 However, as alerted by Ehrlich and Becker (1972), the complementary relationship between market insurance and self-protection depends critically on the responsiveness of the premium of market insurance to the amount of self-protection undertaken by individuals. In addition, the effort paid for self-protection should be observable to market participants.
two options brought equal reductions in the expected losses and were equally costly. As correctly pointed out by Chang and Ehrlich (1985: 577), these two mitigation options “might be varied continuously and chosen optimally”. By relaxing the assumption aforementioned, Chang and Ehrlich (1985) derived that self-insurance was not always preferred to self-protection in the absence of market insurance. Moreover, they analytically showed that the ratio of the former to the latter did not necessarily exceed unity.

**Self-insurance, self-protection and house value**

A large volume of empirical research has attempted to evaluate the market values of various self-insurance and self-protection measures. Literature such as Andersson (2005) and Boulding and Purohit (1996) studied how self-insurance measures affected the prices of a wide range of services and products like automobiles. In the real estate market, self-insurance usually appears in the form of mitigation measures which reduce the losses of life and property in natural hazards. For example, housing in earthquake-prone areas can be designed and constructed to become earthquake-resistant. Using the contingent valuation method, Willis and Asgary (1997) found that the prices of earthquake-resistant houses in Iran were significantly higher than those for non-resistant houses. Furthermore, Simmons *et al.* (2002) estimated the market values for hurricane blinds for beachfront buildings on the Gulf Coast in the United States. On average, a premium of US$4,000 was added to the value of a house equipped with hurricane blinds. Simmons and Sutter (2007) also unveiled that a tornado shelter increased the sale price of a home by approximately US$4,200 in Oklahoma City, United States.

As for self-protection, several hedonic studies examined the value of reducing the probability of a loss from a natural hazard by relocating out of harm’s way. Brookshire *et al.* (1985) studied the housing markets of Los Angeles and San Francisco and spotted that homes located outside earthquake-prone areas were sold at a premium. Shilling *et al.* (1985) found that homes located outside a floodplain in Baton Rouge in the US were sold at higher prices than those within the floodplain. Donnelly (1989), MacDonald *et al.* (1987) and Speyrer and Raga (1991) conducted similar studies in other parts of the US. Their results confirmed the findings of Shilling *et al.* (1985). Findings in other studies also manifested that self-protection mitigations were priced in property transactions. Prices of houses were higher when they were sited beyond the influence of potentially hazardous facilities such as nuclear plants (Gamble & Downing, 1982), chemical plants (Carrol *et al.*, 1996), landfills (Nelson *et al.*, 1992) and gas pipes (Kask and Maani 1992). Sometimes the hazards associated with the living environment are not known until relevant information is disclosed by some other parties. It was indicated by Bernknopf *et al.* (1990) that the announcement of hazards regarding earthquake and volcanic activities in the Mammoth Lakes area in the United States depressed house prices in that area. Comparable results were obtained by Montz (1993) who focussed on the disclosure of flooding risk in New Zealand. The house price differentials detected in these studies provide additional evidence for the values of self-protection mitigations in property markets.

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4 One should be mindful that locating a residence in the face of hazards is not always self-protective behaviour. For example, locating a residence farther away from the shoreline is a means of self-insurance on account of the fact that the size of the flood and storm damage is larger in the coastal areas. The chance of a flood or storm is not reduced by such a location-choice decision. On the other hand, it is a self-protection if a house is sited outside an earthquake-prone zone because the probability of an earthquake in the region where the house is located is significantly lower. In many cases, however, the distinction between these two alternatives is subtle.
While empirical research applying the theories of self-insurance and self-protection to property market abounds, nearly all focussed on ‘external’ hazards including natural hazards (e.g. floods, hurricanes and earthquakes) and technological hazards (e.g. nuclear plants and waste storage or treatment facilities). ‘Internal’ hazards associated with a property like the safety performance of a building such as fire hazards and structural failures have been largely ignored. Moreover, previous studies predominately focussed on low-rises, particularly single-family houses; little research worked on high-rises like apartment buildings.

**HYPOTHESES AND ANALYTICAL MODEL**

**Proliferation of Unauthorized Appendages as Building Safety Performance**

To study how safety performance of a building is valued by property market, this research takes the degree of proliferation of unauthorized appendages in the building as the measurement of the safety performance of the building. The unauthorized appendages are commonly found in Hong Kong and include unauthorized cages, drying racks, flower racks, lightweight canopies, and air-conditioner supporting frames that are attached to the external walls of buildings. Figures 1–3 show some examples of unauthorized appendages in apartment buildings in the city. These building works are unauthorized or illegal because they were constructed without any prior approval of the building plan or consent to work commencement as per the requirements stipulated under the *Buildings Ordinance* (Ho et al., 2008). The degree of proliferation of authorized appendages is used to proxy building safety performance for both practical and academic reasons. Practically speaking, as attached on the external walls of building, unauthorized appendages are very easily identified compared with other types of UBW. Besides, unlike structural stability and fire safety the evaluation of which usually involves sophisticated testing or assessment, the appraisal of authorized appendage proliferation in a building is straightforward and relatively less costly. Academically speaking, employing the degree of UBW proliferation as a measure of building safety performance can facilitate the valuation of self-protection mitigations and self-insurance mitigations in safeguarding a building’s safety in the absence of any influence by market insurance. It is simply because property losses, personal injuries and deaths caused by UBWs are not covered by the property-all-risk or third-party-liability insurance policies for buildings in Hong Kong. Therefore, the effect of market insurance can be ignored as long as unauthorized appendages are studied.

For increasing the amount of usable space or amenities for the building users, unauthorized appendages are relatively easier to construct compared with other types of UBW (Ho et al., 2008). Yet, such UBWs jeopardize building safety because their structural soundness is uncertain and they affect approved building works on or near which they are built (Choy, 1998). Proliferation of unauthorized appendages may also affect fire safety of a building adversely because the UBWs block firemen’s access to the building facades. From the perspective of health risks, unauthorized appendages often block natural light and ventilation from entering the building. As added by Chan (2000), the protruding unauthorized structures might indirectly aggravate the problems of building decay because they make repairs and maintenance of external walls more difficult. When an unauthorized appendage fails, it may bring about casualties, property losses, and social costs (e.g. hospitalization and legal costs). In fact, fatal accidents involving UBWs are not rare in Hong Kong. As reported by Leung and Yiu (2004), there were 21 deaths and 135 injuries inflicted by UBW-related accidents in Hong Kong during the period
between January 1990 and December 2002. Several court judgments have established that all co-owners of a multi-owned building are liable for the casualties and property losses caused by the failures of unauthorized appendages in the building.⁵

Figure 1: Solid extensions

Figure 2: Light-weight canopies

Figure 3: Metal cage

Unauthorized appendages pose safety hazards of various degrees on building occupants and the public. Some are more harmful than others. From the public authority’s perspective, those

⁵ For example, Aberdeen Winner Investment Co. Ltd. vs. The Incorporated Owners of Albert House and Another HCA3408/2003.
unauthorized appendages that are more hazardous should be accorded more attention. The Buildings Department (2005) categorized unauthorized appendages under two heads – actionable and non-actionable UBWs. The former were thought to bear an imminent danger to occupants and the public so they should warrant priority removal. According to the Buildings Department (2005), these high-risk unauthorized appendages included:

(i) cages, flower racks, structures, or canopies of solid construction on the external walls, re-entrants, and lightwells, irrespective of the extent of their projection;
(ii) dilapidated canopies and advertisement signs on the external walls, re-entrants, and lightwells, irrespective of the extent of their projection;
(iii) dilapidated or abandoned air-conditioning unit supporting frames, metal frames, or chimney cages, flower racks, structures, or canopies of solid construction on the external walls, re-entrants, and lightwells, irrespective of the extent of their projection;
(iv) lightweight canopies projecting more than 500mm from the external wall;
(v) air-conditioning unit supporting frames projecting more than 600mm from the external wall;
(vi) structures on or attached to approved canopies, or attached to approved balconies;
(vii) rooftop and flat roof structures with projections;
(viii) UBWs of two storeys or more; and
(ix) UBWs built on top of another UBW.

On the other hand, the non-actionable unauthorized appendages were those posing a relatively limited degree of hazard on occupants and the public. Common examples of these are drying racks and lightweight canopies that project less than 500mm from the external walls. Owing to the comparatively lower risks associated and the amenity offered to building users, these UBWs have been tolerated by the Buildings Department. Following the Buildings Department’s (2005) dichotomy of unauthorized appendages, this study measures the degree of proliferation of unauthorized appendages by taking a weighted average of the numbers of actionable and non-actionable unauthorized appendages per dwelling unit in a building. Mathematically,

\[
\text{Degree of proliferation} = 1 \times N_{\text{non-actionable}} + 5 \times N_{\text{actionable}}
\]

where \(N_{\text{non-actionable}}\) and \(N_{\text{actionable}}\) denote the numbers of non-actionable and actionable unauthorized appendages respectively. A heavier weighting is placed on the number of actionable unauthorized appendages because of the higher risks associated with this type of UBWs.

**Hypotheses for Empirical Testing**

Based on Ehrlich and Becker’s (1972) theory of self-protection, in case safety risks created by UBWs are not covered by market insurance, a rational individual should pay less to buy a property in a building with a higher degree of proliferation of unauthorized appendages because the probability of a building failure associated with unauthorized appendages is lower. Given the same degree of proliferation, according to Ehrlich and Becker’s (1972) theory of self-insurance,
a rational individual should pay less to buy a property in a building abutting on one or more busy streets. It is because when an unauthorized appendage fails and falls onto the street, the damage will be smaller. Founded on these theoretical predictions, two hypotheses are developed for empirical testing in this study:

H1: Properties in a building with a higher degree of proliferation of unauthorized appendages are sold at a discount, keeping other things constant.

H2: Properties in a building with unauthorized appendages and abutting on one or more busy streets are sold at a discount, keeping other things constant.

Model for Analytical Analysis

To test the two hypotheses above, an analytical model is broadly specified as follows:

\[ \text{PRICE} = f(S, L, T, U) \]  \hspace{1cm} (2)

In Equation (2), the sale price of a residential property, \( \text{PRICE} \), is taken as a function \( f \) of four vectors of determinants, namely \( S, L, T \) and \( U \). The vector \( S \) contains structural characteristics of the property, including building age and floor area of the property. As for the vector \( L \), it represents the locational factors of property, including the vertical location of the property in a building and the distance of the building from the nearest mass transit station. \( T \) is a vector of time dummies which indicate the date of transaction (in month) of the property, for controlling the time effects on property price. The focus of this study is placed on the vector \( U \) which encompasses factors related to risks associated with the proliferation of unauthorized appendages.

The operationalized independent variables under different vectors are reported in Table 1. Since the specification of the analytical model is not known \textit{a priori} in the absence of theoretical support, a semi-log functional form is used. This functional form is chosen for the practical reason because when there is the possibility of an omitted variable bias, semi-log model outperforms other functional forms (Cropper et al., 1988). Quadratic terms are also included in the model to cater for the non-monotonous effects of the continuous control variables on the dependent variable. The resultant hedonic price model established for this study to estimate the value of safety performance of a building is

\[
\ln \text{PRICE}_{st} = \alpha_0 + \alpha_1 \text{AGE}_s + \alpha_2 \text{AGE}_s^2 + \alpha_3 \text{FLOOR}_s + \alpha_4 \text{FLOOR}_s^2 \\
+ \alpha_5 \text{AREA}_s + \alpha_6 \text{AREA}_s^2 + \alpha_7 \text{MTRD}_s + \alpha_8 \text{MTRD}_s^2 \\
+ \beta_1 \text{UNAPP}_s + \beta_2 \text{UNAPP}_s \times \text{BSTREET}_s + \sum_{t=1}^{T} \gamma_t \text{TIME}_{st} + \epsilon_s
\]  \hspace{1cm} (3)

where \( \text{PRICE}_{st} \) denotes the transaction price of property \( s \) at time \( t \); \( \text{TIME}_{st} \) is a vector of monthly time dummies; \( \alpha, \beta \) and \( \gamma \) are coefficients to be estimated; and \( \epsilon \) is the stochastic term.
Table 1: Description of the independent variables used in the hedonic price model

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$AGE_s$</td>
<td>months</td>
<td>The age of the building, which equals the difference between the date of the issue of the occupation permit and the date of the transaction</td>
</tr>
<tr>
<td>$FLOOR_s$</td>
<td>-</td>
<td>The floor level of the transacted property</td>
</tr>
<tr>
<td>$AREA_s$</td>
<td>square feet</td>
<td>The usable floor area of the transacted property</td>
</tr>
<tr>
<td>$MTRD_s$</td>
<td>metres</td>
<td>The distance between the transacted property and the nearest Mass Transit Railway (MTR) station</td>
</tr>
<tr>
<td>$UNAPP_s$</td>
<td>-</td>
<td>The weighted average of the numbers of actionable and non-actionable unauthorized appendages per dwelling unit in the building in which the transacted property is located</td>
</tr>
<tr>
<td>$BSTREET_s$</td>
<td>-</td>
<td>A dummy variable that equals 1 when the property is located in a building abutting on one or more busy streets and zero if otherwise</td>
</tr>
</tbody>
</table>

For the purpose of this study, a ‘busy street’ is defined as a street with a high pedestrian flow or high traffic flow. More specifically, if a street is classified as a busy street if it has four or more traffic lanes or a street market or similar feature is found on the street. This characterisation delineates buildings that are more hazardous in case of failure of any unauthorized appendage.

DATA: SOURCES AND DESCRIPTIONS

To estimate the empirical model, transaction data of residential properties in 64 developments in the ‘old district’ of Tai Po, Hong Kong were employed. This geographical area was selected because the building stock in the area was rather stable. There were not extensive development or redevelopment projects undergoing in the area in recent three years. Besides, buildings with different ages and configurations (e.g. single tenement blocks and high-rise apartment buildings) were available in the area. The data for property transactions dated between 1 July 2013 and 31 December 2013 were obtained from the Economic Property Research Centre.\(^6\) A study window of six months was chosen as a result of a balance struck between two different forces. On one hand, a wider study window entails more data points for more meaningful model estimation. On the other hand, the degrees of unauthorized appendage proliferation in the subject buildings vary over time, which makes the empirical investigation more complication. The longer is the time horizon being considered, the more likely will be the changes in the degrees.

It is assumed that the evaluated degrees of unauthorized appendage proliferation in the subject buildings held for the whole study period between 1 July 2013 and 31 December 2013,\(^6\)

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\(^6\) Established in 1991 by the Hong Kong Economic Times Limited with the support of the leading real estate agencies in Hong Kong, the Economic Property Research Centre was provides a database of most property transactions in Hong Kong since 1991. For each transaction record, the EPRC provides details about transaction price, date of transaction, address of subject property, the date of the occupation permit of a building, gross floor area, floor level, etc.
regardless of the dates of building surveys or inspections. Moreover, within the study window, there were no significant changes in the conditions of all the selected buildings. No large-scale refurbishment or rehabilitation works were undertaken to the buildings. Approved building plans of the 64 developments, retrieved from the Buildings Department, were studied. Inspections were carried out on these buildings for the identification and counting of unauthorized appendages.

Table 2 summarizes the statistics of unauthorized appendages in the 64 developments. 26 developments out of 64 (40.6%) abutted on at least one busy street. Within the study period, there were altogether 412 transactions. The descriptive statistics of the continuous independent variable are summarized in Table 3. Moreover, no significant correlations between the independent variables were spotted upon the scrutiny of the correlation matrix of the dataset.

<table>
<thead>
<tr>
<th>Type of Unauthorized Appendage</th>
<th>Maximum</th>
<th>Mean</th>
<th>Minimum</th>
<th>σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actionable Unauthorized Appendages</td>
<td>Solid canopy</td>
<td>4</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Light-weight canopy (projecting more than 500mm from external wall)</td>
<td>42</td>
<td>1.2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Air-conditioner support frame (projecting more than 600mm from external wall)</td>
<td>8</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Metal frame</td>
<td>27</td>
<td>1.5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Metal cage</td>
<td>8</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Solid extension</td>
<td>1</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Flower rack</td>
<td>19</td>
<td>0.8</td>
<td>0</td>
</tr>
<tr>
<td>Non-actionable Unauthorized Appendages</td>
<td>Light-weight canopy (projecting not more than 500mm from external wall)</td>
<td>189</td>
<td>9.5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Air-conditioner support frame (projecting not more than 600mm from external wall)</td>
<td>317</td>
<td>38.1</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Drying rack</td>
<td>287</td>
<td>16.4</td>
<td>34</td>
</tr>
<tr>
<td>Overall</td>
<td>542</td>
<td>178.4</td>
<td>19</td>
<td>129.0</td>
</tr>
</tbody>
</table>
Table 3: Descriptive statistics of the continuous independent variables \((n=412)\)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Maximum</th>
<th>Mean</th>
<th>Minimum</th>
<th>(\sigma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transaction price (HK$ million)</td>
<td>4.90</td>
<td>1.95</td>
<td>0.58</td>
<td>0.39</td>
</tr>
<tr>
<td>Flat size (square feet)</td>
<td>1,655.00</td>
<td>422.31</td>
<td>214.00</td>
<td>193.23</td>
</tr>
<tr>
<td>Floor level</td>
<td>26.00</td>
<td>9.98</td>
<td>1.00</td>
<td>5.13</td>
</tr>
<tr>
<td>Age (months)</td>
<td>534.00</td>
<td>343.14</td>
<td>199.00</td>
<td>62.14</td>
</tr>
<tr>
<td>Distance from MTR station (metres)</td>
<td>740.00</td>
<td>677.15</td>
<td>387.00</td>
<td>102.78</td>
</tr>
<tr>
<td>Weighted average of the numbers of actionable and non-actionable unauthorized appendages per dwelling unit</td>
<td>4.78</td>
<td>2.11</td>
<td>0.34</td>
<td>0.99</td>
</tr>
</tbody>
</table>

ANALYSIS RESULTS AND DISCUSSION

The estimation results of the hedonic price model, expressed in Equation (3), are shown in Table 4. The adjusted \(R^2\) of the estimation was 0.59. The coefficients of \(AGE\) and \(AGE^2\) were statistically significant at least at the 10% level, though their signs were different. With a negative coefficient for the first-order term and a positive coefficient for the second-order term, the effect of the variable \(AGE\) on property price decreased at a diminishing rate but the rate of change was negligibly small. Conversely, opposite results for the effect of floor area on property price were returned from the hedonic price analysis. The coefficient of \(AREA\) was found to be positive whereas negative for \(AREA^2\), and both coefficients were statistically significant at the 1% level. Similarly, the diminishing trend in the positive relationship between floor area and property price was trivial.

Regarding the coefficients of \(FLOOR\) and \(FLOOR^2\), the former was found positive and statistically significant at the 5% level, with the latter being insignificant even at the 10% level. These findings confirmed the findings of my other hedonic price analyses (e.g., Mok, 1995; So et al., 1997; Yau et al., 2008) in which a significant positive relationship between floor level and property price was evidenced. As for the variables concerning the distance between the subject property and the nearest MTR station, only the first-order term was found to be statistically significant at the 10% level. The coefficient of \(MTRD\) was found to be negative, implying that properties with better accessibility were sold at a higher price.

With an eye to the aim of this study, vast interests should be placed on the estimated coefficients of the variable \(UNAPP\) and interaction term \(UNAPP \times BSTREET\). The coefficient of the variable \(UNAPP\) (i.e., \(\beta_1\)) gives an indication about the impact of the degree of proliferation of unauthorized appendage in a building on the selling prices of dwelling units in the building. In other words, the estimated coefficient of the variable measures the value of self-insurance mitigation with regard to building safety – buying a property in a building with less risk created by unauthorized appendages. As for the coefficient of the interaction term \(UNAPP \times BSTREET\) (i.e., \(\beta_2\)), it measures the price differential between properties in a building bearing unauthorized appendages and facing one or more busy street and those in a building bearing unauthorized appendages but not facing any busy street. The coefficient assesses the value of self-protection mitigation with regard to building safety – buying a property in a building with smaller probable
losses (e.g. losses of properties or damages for the injured) in case of an unauthorized appendage failure.

Table 4: Estimation results of the hedonic price model

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTANT</td>
<td>–1.04</td>
<td>–4.12</td>
</tr>
<tr>
<td>AGE</td>
<td>–3.13 x 10^{-3}</td>
<td>–2.20</td>
</tr>
<tr>
<td>AGE^2</td>
<td>3.34 x 10^{-6}</td>
<td>1.93</td>
</tr>
<tr>
<td>FLOOR</td>
<td>0.03</td>
<td>2.01</td>
</tr>
<tr>
<td>FLOOR^2</td>
<td>–7.12 x 10^{-4}</td>
<td>–0.96</td>
</tr>
<tr>
<td>AREA</td>
<td>2.11 x 10^{-3}</td>
<td>6.89</td>
</tr>
<tr>
<td>AREA^2</td>
<td>–6.14 x 10^{-7}</td>
<td>–3.62</td>
</tr>
<tr>
<td>MTRD</td>
<td>–3.30 x 10^{-4}</td>
<td>–1.95</td>
</tr>
<tr>
<td>MTRD^2</td>
<td>1.03 x 10^{-6}</td>
<td>1.02</td>
</tr>
<tr>
<td>UNAPP</td>
<td>–0.09</td>
<td>–2.07</td>
</tr>
<tr>
<td>UNAPP x BSTREET</td>
<td>–0.02</td>
<td>–1.69</td>
</tr>
</tbody>
</table>

From the analysis results shown in Table 4, these two elements were found to have significant and negative effects on property price (at the 5% level at least). That means that, keeping other things constant, dwelling units in a building with a higher degree of proliferation of unauthorized appendages are sold at a discount and dwelling units in a building with unauthorized appendages and abutting on one or more busy streets are sold at a discount. In other words, both hypotheses of the research were not rejected by the empirical findings. The results of the hedonic price analyses indicated that dwellings in buildings with a lower probability of loss were sold at a higher price, ceteris paribus. At the same time, the loss reduction feature of the buildings under investigation, i.e., locating away from a busy street, was found to have a positive market value. These findings concurred with Ehrlich and Becker’s (1972) prediction that in the absence of market insurance, loss prevention and loss reduction mitigations were valued positively by the market.

In spite of its preliminary nature, this research has important findings that entail far-reaching policy implications. The analysis results suggested that loss prevention and loss reduction
measures with respect to failures of unauthorized appendages were rewarded by the housing market in the absence of market insurance. These findings basically support the use of market forces to motivate building owners to keep their buildings safe. Properties in safer buildings command a high value so a value league on building safety performance can be established. With an eye for higher property values, homeowners are incentivized to remove UBWs in their buildings and keep them UBW-free. Instead of coercion and subsidies, governments can institutionalize measures to facilitate a smooth exchange of information about safety performance of buildings among different players within the housing market. For example, governments can make the information about UBWs present in each building available to the public. By doing so, the market players can benchmark the safety performance among buildings more readily and confidently. The benefits of reduction in the probability of loss and prevent of loss will be more likely fully priced in property transactions.

On the other hand, the option of market insurance for loss reduction was omitted in the current research. When market insurance is available, the price differentials between properties in safer and not-so-safe buildings may depend on homebuyers’ or building owners’ decisions to take out a building-related insurance policy (e.g. property-all-risk and/or third-party liability insurance). If a homebuyer plans to take out insurance for a property after its acquisition, he or she is willing to pay more for a safer property (or, more precisely, a property with a lower likelihood of building-related accidents) in view of the lower insurance premium. In this regard, the monetary returns from loss prevention measures regarding building safety will be more evident, or even amplified, if building-related insurance is made compulsory for all residential buildings in a city.

CONCLUSION AND AGENDA FOR FURTHER RESEARCH

This study was motivated by urgent need to find ways for sustainably managing our building stocks apart from law enforcement and subsidization. Market approach can be a probable resort given that market players put a value on the safety performance of buildings. Nonetheless, economics of building safety has been largely ignored in the literature. In order to examine whether a market approach can motivate building owners to keep their buildings safe, this study evaluates the value of building safety performance in Hong Kong. Testable hypotheses were developed based on Ehrlich and Becker’s (1972) theories of self-protection and self-insurance. For the research purpose, the safety performance of a residential building was measured by the degree or extent of proliferation of unauthorized appendages in the building. For hypothesis testing, hedonic price analysis was conducted on a set of panel data which consists of property transactions in buildings with different degrees of unauthorized appendage proliferation and locational characteristics.

The analysis results showed that properties in more unsafe buildings were transacted at a discount, compared with those in relatively safer buildings. This exemplified the positive market value of loss prevention effort. Moreover, given the same level of building safety, properties in a building abutting on one or more busy street were sold at a discount, compared with those in a building not abutting on any busy street. Loss prevention mitigation is thus valued positively by the market in the absence of market insurance. As a whole, better safety performance of a building was found to command a positive value in Hong Kong’s housing market.

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7 For example, reports about illegal building structures in Taipei, Taiwan have been made available for retrieval by the public through the online portal (http://qservice.dba.tcg.gov.tw/squatter/squ_dlg.asp).
Frankly speaking, this study is rather preliminary one on account of the research limitations like the small number of observations. Yet, the author hopes that this study can stimulate more empirical studies on the economics of building safety. The findings of such further research could offer very valuable insights to the public administrators in formulating better-informed policies with regard to the sustainable management of building stock in different parts of the world. For example, the testing of the self-protection and self-insurance theories can be extended by investigating more types of UBW. Some UBWs like erections of unauthorized appendages and alterations of load-bearing structures increase the chance of building failure while some other UBWs like installations of gates which obstruct escape routes amplify the casualties (i.e., potential losses) in case of fires and other emergencies.

Furthermore, other aspects of building safety like fire safety and freedom from external safety hazards (e.g. by locating further away from a petrol filling station) can be researched. Based on different mitigation measures embodied in either better building design and proper building management and maintenance, a loss prevention index and loss reduction indicator index can be developed. With the two indices or indicators, market insurance can be taken into account and various premises of Ehrlich and Becker (1972) can be testified. For instance, when market insurance for building safety (say third-party liability insurance) is available, the market value of loss prevention (or self-protection) mitigations is theoretically expected to capture the capitalized value of the savings in market insurance premium. In additions, it is expected that self-insurance is subject to crowding out by market insurance available at actuarially fair prices.

ACKNOWLEDGEMENT

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REFERENCES


