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Effects of High-Voltage Overhead Power Lines (HVOPLs) on Residential Property Prices

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Abstract

Research findings on the effects of high-voltage overhead power lines on values of neighborhood properties remain inconclusive and inadequately explored. This study aims to investigate the effects of HVOPLs on market values and sale-prices of residential properties in the vicinity. The empirical results based on a hedonic price model show that HVOTLs impart a significant negative effect on nearby residential properties. Results show that affected properties are selling at a discount price compared to properties without the influence of HVOPLs. The market value of a residential unit located within physical distance of 300-meters of power-lines, and pylon, are on average, 34.2% and 18% lower than comparable properties, respectively. Furthermore, results suggest that it is the physical distance to HVOPL structures that accounts more for the value diminution compared to the visual impact of the structure. The results imply that the market value of properties adjacent to HVOPL corridors is reduced significantly. This discourages potential property buyers. The study contributes to the knowledge in two-ways: (i) it shows the greater impact of HVOPLs on property prices with a larger reduction in valuation than previous studies; and (ii) effects of the different visual impact of pylons compared with that of cables are clearly distinguished.

Keywords: HVOPLs, Residential property price, Value diminution, Hong Kong.
JEL Classification: L94, R31.

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Contents

Contribution of this paper to the literature

This paper investigated the effect of HVOPL on market values and sale prices of residential properties. Accordingly, the study findings revealed that market value and the sale-price of residential properties which are at a close proximity to HVOPLs tend to be lower. This paper contributes to literature in two ways. Firstly, it shows the greater impact of HVOPLs on property prices with a larger reduction in valuation than previous studies. Secondly, the effects of the different visual impact of pylons compared with that of cables are clearly distinguished.

1. Introduction

The impact of high-voltage overhead transmission power lines (HVOPLs) on nearby properties has been in the public eye since the mid-1980s in a variety of countries. Since then, this issue has been studied extensively by many scholars and institutions across the globe. Some claim that there are serious negative effects on nearby properties due to various reasons. Some valuation studies claim a value diminution of between 2 and 10% in residential property (e.g., (Bond & Hopkins, 2000; Callanan & Hargreaves, 1995; Colwell, 1990; Hamilton & Schwann, 1995; Rosiers, 1998)). Sims and Dent (2005) for instance, find that housing property prices located within 100 meters radius of the power cables drop between 6-17% in value. They further found out that the negative influence on value for properties having a front view of a pylon (reduced by 14.4%) is greater than those having a rearview (reduced by 7.1%). Other studies also support the idea that value diminution is even larger in properties facing a pylon (Hamilton & Schwann, 1995) presumably only for visual reasons, but this is not specified. More recently, a more analytical investigation by Elliott and Wadley (2002) mention that transmission lines can cause serious negative externalities to surrounding properties mainly due to: (1) potential health hazards; (2) visual unattractiveness; and (3) disturbing sounds.

The most recent linkages to *health issues* include the study by Doukas, Karakosta, Flamos, and Psarras (2011) that found out that prolonged exposure to HVOPLs can cause a greater risk of leukemia in children. Negative externalities arise from the negative impact on the surrounding environment regarding aesthetic aspects, and the *visual unattractiveness* is mentioned in several studies (Hamilton & Schwann, 1995; Rosiers, 1998; Sims & Dent, 2005). For the *disturbing sounds* caused by overhead power lines, a New Zealand study already pointed to this problem 25 years ago, while a recent study clarified that electric noise may be produced when the cables carry electricity with greater than 400-800kv (Doukas et al., 2011). Most of these studies have been predominantly grounded in the US, with limited research in the UK, Canada, and New Zealand, while research in this area is extremely limited in the Asian region.

In the review of the literature overall, it is noted however that there is no *conclusive* evidence about the influence of HVOPLs on the nearby housing prices, but rather mixed findings. Whilst some researchers claim significant value reduction, others suggest no real value effects. For example, a significant body of studies suggest a negative effect of HVOPLs on the value of nearby residential housing properties (Hamilton & Schwann, 1995; May, Corbin, & Hollins, 2011; Mitteness, 1998; Rosiers., 2002; Sims & Dent, 2005) some scholars reveal that the impact is negligible (Bond & Hopkins, 2000). A few studies even suggest that there is no significant price difference between properties near overhead cables and those far away from them (Kung & Seagle, 1992) and point out that claimed health effects (by some other studies) due to living closer to HVOPLs have not been sufficiently verified (Sims & Dent, 2005) while some other studies find out that any negative effect would diminish as time passes by (Colwell, 1990) and as distance between electrical pylon/overhead cable and property increases (Hamilton & Schwann, 1995).

Apart from the fairly recent study by Doukas et al. (2011) there is no clear evidence that living in close proximity to HVOPLs causes bad health effects. Yet property buyers' perception of purchasing properties near HVOPLs seems to have a considerable negative influence on the market value of those properties. Conventional wisdom suggests that there is indeed a negative effect of HVOPLs on the value of residential properties (Delaney & Timmons, 1992) although many studies could not establish such a relationship. Thus, property professionals have realized the importance of taking into account the public perception in the assessment of properties (Sims, 2002). As mentioned by Goeters (1997: quoted in Rosiers (2002)) the US government has directly advised states to implement regulations and safety measures in regard to installing HVOPLs in areas near residential properties. However, the effect of HVOPLs on market and sale-value of properties in the vicinity in Hong Kong remains untouched. To the authors' knowledge, to date there has not been a single comprehensive study in this area, investigating the impact of high-voltage power cables on residential property value. This might be partly attributed to the lack of unavailability of reliable transaction information, and partly be due to the fact that most of the housing developments are located in the inner city where transmission lines mostly have been laid underground. However, there are many areas in Hong Kong that have high-powered overhead transmission lines that are located in closer proximity to housing developments. Hence, it is necessary to accurately evaluate marketability and the value of properties adjacent to HVOPLs in order for property developers and investors as well as buyers to make informed investment decisions.

The present study aims to evaluate the effects of HVOPLs on values of nearby residential properties. The study will be able to investigate if there is any negative public perception of properties closer to HVOPLs and if so whether it will be translated into lower property value or not. Specifically, the study investigates:

- The visual impact of the pylon and overhead power lines on adjacent residential property price.
- The effect of adjacent to the pylon and overhead power transmission lines on residential property price.

This study is a little different from other existing studies in the literature. Almost all the existing studies are based on low-rise and single-family house contexts. Research in this area in a high-rise residential setting is very limited. In fact, we have not come across a single study in the literature. The present research is based upon a high-rise residential context, in which the effect of HVOPLs on properties may be clearer, and hence may be a more serious issue for households and property owners. Therefore, potential property buyers and existing owners, as well as tenants, may have a different perception of properties adjacent to HVOPLs. This issue is important not only for property owners or buyers but also for property appraisers, mortgage underwriters, tax assessors as well as those who are involved with the valuation profession (Delaney & Timmons, 1992).

2. Review of Past Studies to Identify HVOTL Key Factors Influencing Property Values

There is a considerable body of literature focussing the possible impact of HVOTLs on various types of properties. Though there is an extensive literature investigating the impact of HVOTLs on values of residential properties, their quality is uneven, varying from unreliable reports to comprehensive research studies based on rigorous analyses (Chalmers & Voorvaart, 2009). The main body of research that investigates the effects of HVOTLs on values of property is grounded in the US (e.g., (Chalmers & Voorvaart, 2009; Colwell, 1990; Dear, 1992; Delaney & Timmons, 1992; Jackson & Pitts, 2010; Kinnard & Dickey, 1995; Kung & Seagle, 1992; Mitteness, 1998; Pitts & Jackson, 2007; Priestley & Evans, 1996; William, 1990)). There have also been some research studies undertaken in the UK in this area (e.g., (Dent & Sims, 1998, 1999; Gallimore & Jayne, 1999; May et al., 2011; Sims & Dent, 2005)) while limited studies were conducted in New Zealand (e.g., (Bond, 1995; Bond & Hopkins, 2000; Callanan & Hargreaves, 1995)) and elsewhere (e.g., (Doukas et al., 2011; Hamilton & Schwann, 1995)).

The literature review can be broadly divided into two categories, *namely*, property-based studies that explore the value effects; and studies that investigate the effects of living in properties adjacent to HVOPLs on occupant health. Most of the research studies investigating the impact on property value are based in the US, and are mainly aimed at investigating whether or not the negative public perception of living closer to HVOPLs has been converted into lower property values or not (Doukas et al., 2011). However, the results of these studies vary significantly, from significantly negative effects to no real effects. Some studies carried out in the 1970s claim that there is no value reduction in properties in proximity to HVOPLs. Certain studies even claimed that there is an increase in property value in properties adjacent to a power line corridor (Sims, 2002). This perhaps might have been due to the unsophisticated methods used in assessing the results.

Most studies carried out since the late 1970s, however, tend to claim a negative effect of HVOPLs on values of nearby residential properties. The negative market effect, according to these studies, is mainly attributed to the visual and aural pollution, but not because of any adverse health and safety reasons (Sims & Dent, 2005). Some of these studies (Bond & Hopkins, 2000; Hamilton & Schwann, 1995; Kauko & Peltomaa, 1998; Rosiers, 1998) claim a property value diminution of between 2 and 10%. In an early study, Peter and Foley (1979) based on a sales analysis for a 164 single-family housing sample in Illinois, showed that there are significant value differences of properties that are located in the distance of 50 and 200 feet (15 to 70m) from a power distribution line. Colwell (1990) in another study, concluded that the value diminution effect caused due to proximity to high-voltage power lines diminishes with the time as well as distance. It, however, mentions that the value reduction effect on residential properties near pylons (towers) was temporary. These findings were supported in a study done in Canada in the late 1990s. Rosiers (1998) find that properties located closer to transmission lines and pylons suffer only a little value diminution compared to properties located further away with a direct view on power lines or pylons. These two studies suggest that value diminution is mainly due to the visual impact.

Delaney and Timmons (1992) using a survey administered in 1990 together with a paired sales analysis, claim that the market property value of the residential properties closer to transmission corridors was approximately 10.01% lower than comparable properties within same market segment. Survey results indicate visual effect, health concerns, undesirable sounds and the feeling of unsafe perception as the most common reasons for this value diminution. Similar findings were reported by some other studies (Gregory & Winterfeldt, 1996; Hamilton & Schwann, 1995).

In a study carried out in New Zealand, Callanan and Hargreaves (1995) claimed that there is a huge value reduction in properties closer to HVOPLs. According to the results, the value of properties located at a distance of 10m from the pylon was dropped by 27%; 13.6% at 20m; 5.4% at 50 meters; and 2.7% at a distance of 100 meters. In another study in the same residential location, Bond (1995) surveyed property valuers/professionals and owners in order to get their opinions of marketability of properties closer to HVOPLs. According to the study, both these groups have expressed a negative view of marketability of properties closer to HVOPLs. Hamilton and Schwann (1995) in a detached dwellings study in Vancouver, also showed a value reduction in properties near HVOPLs, but such effects are restricted to a narrow band. It is found that any negative impact is mainly due to the visual externalities of the transmission lines. A significant body of valuation studies using econometric methodologies (e.g., (Bond & Hopkins, 2000; Callanan & Hargreaves, 1995; Rosiers, 1998; Rosiers, 2002)) indicates a general reduction in housing value of between 2 and 10%. The impacts of pylons on the value of properties are even negative (Bond & Hopkins, 2000; Callanan & Hargreaves, 1995; Hamilton & Schwann, 1995; Rosiers, 1998).

In contrast, certain researchers find no value reduction (Kung & Seagle, 1992). In particular, early studies concluded that HVOTLs have little or no effect on property value. About half of the studies reviewed by Kroll and Priestly (1992) found no value diminution effects. Kinnard (1988: cited in Delaney and Timmons (1992)) reported more than seventy-five studies (published and unpublished) of this nature carried out during the mid-1950s to 1988. Another set of studies used statistical models to determine if HVOTLs have any impact on nearby properties Kinnard et al., 1984; Brown, 1976; Blinder, 1979; Sherman, 1974; Vredenburgh, 1974 (cited in Delaney and Timmons (1992)). Some studies find that negative effects disappear beyond 400-feet (Hamilton & Schwann, 1995). Likewise, for properties closer to newly installed transmission lines or modified prevailing lines, the drop in the value of those properties lessens over time, even tend to fade away after 4-10 years (Kroll 1994: cited in Kinnard (1996)).

To conclude, even though there is no conclusive evidence on what effect HVOPLs have on property prices and market values of nearby properties, there is a reasonable fear and concern (negative perception), among public and potential property buyers, of living in properties adjacent to high-voltage transmission lines and pylons due to various reasons such as visual unattractiveness, potential health hazards, safety concerns and disturbing sounds. The literature review shows that there are several important interplaying factors that can influence the effect of

HVOPLs on the residential property values: the distance and adjacent (closer proximity) to pylons and power lines; and the view of pylons and power lines. These are the main factors that the present study is aiming to analyze.

2.1. HVOTLs and Property Development in Hong Kong

In Hong Kong, power lines can either be overhead or underground lines. The overhead power lines, mostly found in the New Territories (NT) including outlying islands, are often interwoven among vegetation. This needs to be considered as a safety issue because trees in contact with lines may cause a voltage dip or even power interruption. Besides, most importantly, power lines and HVOPL structures can affect real property causing serious concerns about health hazards and safety issues. There are residential developments adjacent to these power transmission lines and towers (HVOPL structures) in the NT. Certainly, not many people like the idea of living closer to metal towers or power lines that carry high-voltage current. It is, therefore, a rationale to think that there might be at least some downward tug on home values in properties adjacent to transmission lines (Razzi, 2009).

The importance and gravity of this issue in Hong Kong are recognized, although no serious research efforts have been made yet. For instance, Lam and Au (1997) mention that although research results on effects of Electromagnetic fields (EMF) on humans are inconclusive, it is very important to have some measurement on EMF of the environment for precaution. In fact, Hong Kong, in 1990, adopts International Radiation Protection Association (IRPA) guidelines and, Electrical and Mechanical Services Department (EMSD) advised power companies by issuing these guidelines regarding the limits of exposure to the EMF (Research and Library Services Division, 1995). According to these guidelines, when an erection of overhead power lines is planned (in the case of open spaces), the following considerations should be taken into account: (i) the electric field should be set within 5 kV per meter; and (ii) the magnetic flux density cannot exceed 0.1 milli-tesla (Research and Library Services Division, 1995).

Furthermore, a working group, with the chairmanship of a directorate staff of EMSD, was established in 1993 to look into this EMF issue in detail (Research and Library Services Division, 1995). This group comprises of representatives from various institutions such as power companies, tertiary education institutions and a variety of government institutions. The recommendations of the working group, which was revealed in 1995, included the application of IRPA guidelines in Hong Kong; the implementation of careful avoidance in the planning of new developments; a suitable public education agenda and involvement in the WHO (Research and Library Services Division, 1995). All these initiations and recognitions indicate the significance of this issue. But, surprisingly a single comprehensive study examining the effect of power transmission lines on nearby properties has not been carried out to date. The present study fills this research gap.

3. Methodology

3.1. Hedonic Pricing Models (HPM) in Housing Research

The hedonic price model (HPM) remains the most appropriate and reliable tool in assessing the effects of various externalities on housing value, although it has its own drawbacks (Rosiers, 2002). A significant body of studies that investigates the effects of HVOTLs on properties has used a hedonic approach in the literature (Callanan & Hargreaves, 1995; Colwell, 1990; Hamilton & Schwann, 1995; Kinnard & Dickey, 1995; Rosiers, 2002). Studies, in particular, valuation studies that used robust methodologies such as econometric modeling or regression methods (Bond & Hopkins, 2000; Callanan & Hargreaves, 1995; Rosiers, 1998; Rosiers, 2002) have produced findings with a greater degree of reliability (Sims & Dent, 2005).

The value of the residential property is determined by various attributes such as structural, environmental and locational (neighborhood) variables. Thus, the value of a residential property unit can be considered as a function of these different characteristics. These attributes can be broken down into smaller elements such as floor-area, size, view, location, etc., thus making it a non-homogenous product (Sirmans, Macpherson, & Zietz, 2005). The price value of a residential property unit can, therefore, be estimated as a function of these attributes. The HPM is considered as an ideal tool to analyze the value of this type of heterogeneous commodity.

The hedonic price model, as a tool to assess the effects of these attributes on housing price, has its own advantages. First, the HPM method is arguably the most reliable analytical method in assessing a variety of environmental externalities as it can show buyers' dis-utility arising from any apparent hazard through their actual pricing behavior (Rosiers, 2002). Second, it has its own strength to analyze the implied associations between the commodity (residential property in this case) and its attributes (Freeman, 1979). Marginal implicit prices of these various attributes can be effectively estimated with this tool, which would then help to approximate marginal willingness to pay. Third, a regression model has a greater benefit of being not totally dependent on the prejudiced judgment, but it also stands for an objective reflection of the data (Chalmers & Voorvaart, 2009).

Finally, an important thing of HPM is that it permits the total value of a property to be broken down into small components; allowing us to recognize the individual effects of each component/attribute (Hui, Lau, & Khan, 2011). Therefore, it can separate the contribution of the market value of each attribute of the property (Rosiers, 2002). The HPM is capable enough to give a broader picture of those property attributes that are normally consistently appreciated by buyers irrespective of the location (Hui et al., 2011). The present study also, therefore, uses the HPM to investigate the effects of high-voltage transmission lines (HVOPLs) on the values of residential properties in the vicinity. More specifically, the study aims at examining both positive effect and negative effects, if any, arising from immediate proximity to, as well as view (visual impact) on, an HVOPL corridor. Put different, the model will investigate whether the externalities, if any, (positive or negative) are transformed into changes in property values.

To investigate whether a potential home buyer will consider negative effects resulting from (and thus pay a low premium) residential property closer to an HVOPL corridor, the property transaction records of residential properties (adjacent to an HVOPL corridor) were used in the model. A variety of attributes (variables) determines the market price and value of a residential property unit. After careful consideration, the present research nevertheless selected only a few standard variables (attributes) with significant influence on residential property price, along with HVOPL and pylon-specific variables. Examination of these HVOTL-specific variables is the main task of the present study. Therefore, the HPM model consists of a combination of property-specific (structural), HVOTL-specific (environmental) and location-specific attributes. The study adopts a semi-log form of HPM. The logged residential price was regressed against a set of combined logged and unlogged variables. Those variables that have a non-linear relationship with the property are in the form of logged variables, whilst those are with a linear relationship with the price are in the form of unlogged ones.

The study proposed the following HPM model:

$$Ln\ (P)_i = \delta_0 + \delta_1\, Ln\ (SIZE)_i + \delta_2\, Ln\ (FLOOR)_i + \delta_3\, Ln\ (AGE)_i + \delta_4 (NORTH)_i + \delta_5 (EAST)_i + \delta_6 (SOUTH)_i + \delta_7 (WEST)_i + \delta_8 (GREEN)_i + \delta_9 (PVIEW)_i + \delta_{10} (LVIEW)_i + \delta_{11} (DPYLON)_i + \delta_{12} (DLINE)_i + \varepsilon_i$$

Where Ln (P) stands for logged residential property price, $\delta_{1 \ldots\ldots} \delta_{12}$ represent the coefficients of variables to be estimated; δ_0 represents the constant term and ε_i the error term. Descriptions of all the variables including variable definitions and other statistics are reported in Table 1.

Table-1. The attributes and their expected relationship with property price.

Attributes	Abbreviation	Characteristics	Definition	Expected sign (+/-)
	LnP	Transaction price	The transaction price of the apartment in HK$ in log form	/
Structural	LnSIZE	Gross floor area		+
	LnFLOOR	Floor level	Gross floor area in square feet in log form	+
	LnAGE	Floor	Number of floors above the ground in log form	-
			Age of the unit in the year at the transaction date	+
Location	*Orientation* NORTH	Facing north		
	EAST	Facing east	1 if the unit is facing the east direction; 0 otherwise	+
	SOUTH	Facing south	1 if the unit is facing the east direction; 0 otherwise	+
	WEST	Facing west	1 if the unit is facing the south direction; 0 otherwise	-
	View GVIEW	Green view	1 if the unit is facing the west direction; 0 otherwise	+
Environmental	PVIEW	Pylon view	1 if the unit has a green view (trees/mountains); 0 otherwise	+
	LVIEW	Transmission live view	1 if the unit is facing a pylon; 0 otherwise	-
	DPYLON	Distance from the pylon	1 if the unit is facing transmission lines; 0 otherwise	-
				-
	DLINE	Distance from the transmission lines	1 if the unit is located within 300m from the pylon; 0 otherwise	-
			1 if the property is located within 300m from the transmission line; 0 otherwise	

3.2. Description of Data Selection

The study area for this research is the Wong Tai Sin (WTS) district. Wong Tai Sin is one of the highly-dense populated districts in the Kowloon Peninsula with a median monthly domestic household income of HK$ 17,000 (Population Census, 2011). In this study, residential estates that are located within 300 meters of high-voltage transmission lines and pylons in WTS district were selected. Non-closer adjacent properties were also included from the same market area of residential developments in the district. Details of the selected residential estates are summarized in Table 2.

Table-2. Summary of selected estates.

Name of the property	Address	Date of occupation	Transaction data (during 2007-2016)
Kingsford Terrace	8 King Tung Street	07/2003	439
Scenic View	63 Fung Shing Street	09/1999	565
Hilltop Gardens	33 Fung Shing Street	06/1990	725
Sun Lai Garden	2 King Tung Street	06/1985	846
Tsui Chuk Garden	8 Chui Chuk Street	09/1989/ 07/1991	680

Note: As Sun Lai Garden, Kingsford Terrace and Tsui Chuk Garden were built under the PSPS scheme, only transactions with premium paid to the Housing Authority were taken into analysis.

These private residential developments were selected for 3 characteristics: all these residential estates are located close to HVOPL corridor; residents of these estates are in a similar income group, and they are a similar distance to the Mass Transit Railway (MTR) station. This approach would certainly cancel out price effects that might be caused by these facilities in the model. On the other hand, a variety of other amenities that are available around these residential developments, that are also similar and most importantly are shared by residents in these developments. These amenities consist of a library, swimming pool, urban parks, and sports center. As all the residents have access to all the amenities equally, there is no need for us to introduce these attributes to the model, and that makes the model simple and easy to handle.

A sample of 955 residential transactions was used in the study Table 2, which consists of small-large residential property units (GFA of 447 – 955 sq. ft.). The value range of the properties (per unit) in the sample is HK$0.58M and HK$4.71M. The data were obtained from the Economic Property Research Centre (EPRC) limited, which is a web-based database, and a variety of governmental publications. The transaction records of all selected housing estates in the period of 1st January 2007 and 31st December 2016 were obtained from the EPRC. The selling price of the unit recorded in the EPRC is taken as the transaction property price. All the records of Sale and Purchase agreements (ASP) of the chosen properties during the above time period were chosen for the study. Property specific attributes such as building age, floor level, floor area, orientation, and view were also obtained from the EPRC database. In addition, the information about pylon and transmission line (power line) views were obtained from Google maps (maps.google.com) and GeoInfo maps. The distances to pylons and transmission lines were calculated using GeoInfo map information from the Lands Department. Time effects of property price needed to be removed in order to obtain the real property price. This was done by using a price index built up by the Rating and Valuation Department.

The study proposes three models in order to better understand what, if any, effects HVOPLs have on market values of nearby residential properties. Model 1 incorporates all the variables: property-specific, location-specific and HVOPL-specific. Model 2 incorporates power line-specific variables along with other standard variables (property and location-specific), and Model 3 is performed with pylon-specific variables along with other standard variables see Table 3 for a summary of variables in these models. In this way, we will be able to better understand the price and value effects of properties, if any, resulting from being adjacent to an HVOPL corridor. All three models are based on a sample of 3255 transactions.

Table-3. Variables used in models.

Variables	Model 1	Model 2	Model 3
LnP	√	√	√
Ln (SIZE)	√	√	√
Ln (FLOOR)	√	√	√
Ln (AGE)	√	√	√
North	√	√	√
South	√	√	√
West	√	√	√
East	√	√	√
GREEN	√	√	√
PVIEW	√	√	-
LVIEW	√	√	-
DPYLON	√	-	√
DLINE	√	-	√

3.3. Analysis of the HPM Results

There is a variety of standard statistical techniques to verify and interpret the results of a regression (HPM) model. The most commonly used ones are R^2, adjusted R^2, simple *t*-test, and *F*-test. R^2 reflects how well real data can be approximated with a regression line. On the other hand, the adjusted R^2 reflects how well new variables improve the overall performance of the model. Thus, adjusted R^2 is more important in an interpretation of the results of a regression model. The value of adjusted R^2 ranges from 0 to 1, with values closer to 1 being the best and vice versa.

Similarly, the student *t*-test is very important in interpreting the results of a regression model. This is basically used to test individual variables. The *t*-statistic tests the hypothesis of every single parameter of variables. The absolute value of the *t*-statistic is compared with the critical *t*-value in order to test the significance of each variable. The null hypothesis is rejected if the estimated *t*-statistic is larger than the critical *t*-value, which suggests that the selected particular variable performs well in the model. Similarly, the *F*-statistic reflects the overall performance of the model. The overall model is said to be significant and perform better if the estimated *F*-value larger than the critical value.

4. Empirical Findings

4.1. Analysis of Hedonic Price Models (HPMS)

The estimated empirical results of HPMs are analyzed in this section. Descriptive statistics of the variables used for the models are summarized in Table 4. The analyses for three hedonic pricing models were performed. The model 1 analysis was performed with all the variables: property-specific, location-specific and HVOTL-specific. Next, HVOTL-specific variables were divided into power line-specific variables and pylon (tower)-specific variables. Accordingly, Model 2 analysis was performed with power line-specific variables along with location and property-specific variables, whilst pylon (tower)-specific variables along with location and property-specific variables were included in Model 3. The reason why this classification is made (between Models 2 and 3) is to reaffirm the results obtained from Model 1.

Table-4. Summary of descriptive statistics.

Variable	Mean	STD	Min	Max
LnP	0.5631	0.3262	-0.5444	1.5489
Ln (SIZE)	6.4305	0.1857	6.1026	6.8617
Ln (FLOOR)	2.5806	0.8587	0	3.8286
Ln (AGE)	2.6516	0.4242	1.6094	3.2581
North	0.4681	0.4992	0	1
South	0.3885	0.4877	0	1
West	0.3717	0.4835	0	1
East	0.4681	0.4992	0	1
GREEN	0.6126	0.4874	0	1
PVIEW	0.1298	0.3363	0	1
LVIEW	0.2702	0.4442	0	1
DPYLON	0.5183	0.4999	0	1
DLINE	0.5539	0.4973	0	1

4.2. Analysis of Model 1

Table 5 reports the empirically-estimated statistics of the Model 1, including coefficients of variables and the R^2 along with goodness-of-fit statistics. Empirical results show that all the independent variables included in the model are statistically significant and also carry the anticipated theoretical signs. The 0.84 of adjusted R^2 indicates that 84 percent of the variation of the residential property price is explained by the selected independent variables. The F-statistic of that reflects the overall performance of the model is found to be 419.2, which comfortably exceed the critical value, suggest that the chosen explanatory variables in the model are jointly statistically significant. This suggests that the overall model performs very well.

Table-5. Coefficients of model 1.

Variable	Coefficient	Sig.
Constant	-5.6591*	0.000
Ln (SIZE)	1.1297*	0.000
Ln (FLOOR)	0.0582*	0.000
Ln (AGE)	-0.4943*	0.000
North	0.1132*	0.000
South	0.1367*	0.000
West	0.1300*	0.000
East	0.1294*	0.000
GREEN	0.0401*	0.001
PVIEW	-0.0172	0.342
LVIEW	-0.0801*	0.000
DPYLON	0.1780*	0.000
DLINE	-0.3427*	0.000
Adj. R^2	0.8402	
F-value	419.2	

Note: *indicates significant at 1% level.

Results reveal that all HVOPL-specific variables (except PVIEW) in the model are statistically highly significant. For instance, the negative coefficient of (-0.342) DLINE with t-statistic of 9.8266 suggests that this variable is highly significant (1% level). This suggests that if the residential unit is located within physical distance of 300 meters of power lines, the residential property price experiences a significant drop by {100[exp(0.342)-1]} percent = 34.2 percent. In other words, buyers tend to pay significantly less for these properties (a significant discount) compared to similar properties located further away from power lines. The other variable, that represents the distance to HVOPL, DPYLON is also highly significant. The coefficient 0.178 of DPYLON implies that the price of properties located within 300 of pylon drops by {100[exp(0.178)-1]} 18 percent. However, the negative impact of living in close proximity to a pylon is less than living directly adjacent to power lines. This suggests that people seem to think about living in close proximity to power lines more problematic (due to safety/health concerns) than proximity to pylons (towers). It is clear from the results that affected properties (within 300 meters of HVOPLs) are selling at a discount compared to properties without any influence of HVOPLs.

Turning to variables that represent the visual impact or view of HVOPL structures, one variable (LVIEW) is significant while the other (PVIEW) is not. The variable LVIEW is found be highly significant with a coefficient of 0.08 and also with the expected sign suggesting that the value of a property located with a view of power lines (that is, a view facing power lines) drops by{100[exp(0.08)-1]} 8 percent. According to the results, visual encumbrance of transmission lines appears to exert a stronger negative impact on property value compared to the visual encumbrance of pylons. This is a bit surprising because generally, a tower can cause a severe visual obstruction compared to power lines.

Overall, results suggest that it is the distance to HVOPL structure (power lines and pylons) that accounts more for the value decline compared to the view of HVOPL structures. In other words, potential buyers seem to consider physical distance to power lines (location of power lines) more seriously compared to the physical distance to pylons when deciding to buy a property. However, one thing is certain from the results. Whether it is power lines or pylons, HVOPLs impart a serious negative effect on nearby properties, suggesting that the market value of residential properties can be adversely affected if the properties are adjacent to HVOPL corridors.

The reason is straightforward. A house is a durable commodity, and it is a significant and major lifetime investment for many people. In purchasing a commodity like that, people usually consider many factors including environmental, location and other physical attributes when purchasing a property. Among environmental attributes, safety and health issues, as well as electric noises, play an important role. Potential property buyers not only consider the interior quality of a housing property, but also the outside environment, in particular, the quality and safety of the neighborhood and a better environment over the other factors. Even if the buyers do not have any previous bad experience living in close proximity to an HVOTL (and also not known about such experience to others), a property adjacent to an HVOTL corridor is still valued lower compared to one far away from an HVOTL corridor. Certainly, not many people enjoy visual encumbrances or other safety and health burdens. Thus, people may discount the value of these types of properties, which are in closer proximity to power lines and pylons. The results thus very clearly reflect that the quality of the neighborhood (no visual encumbrance and health hazards) is an important element in making a property purchase decision.

This finding is very much in line with some previous studies in the literature (e.g., (Bond & Hopkins, 2000; Callanan & Hargreaves, 1995; Delaney & Timmons, 1992; Hamilton & Schwann, 1995; Rosiers, 2002; Sims & Dent, 2005)) although the negative effect of HVOTL is seemingly stronger in the present study. This is to be expected since the setting and the context for the present study is entirely different from most of the previous studies. As several studies note and as common sense obviously dictates, findings of a particular study may not be applied to every property because different studies are based on different settings. While most of the existing studies are single-family house or detached houses, Hong Kong is considered a metropolitan city full of high-rise buildings. So, people living in high-rise residential buildings may have some serious visual obstructions (compared to single and low-rise settings) due to power lines and may experience safety, noise and health hazard burdens more acutely and differently. Hence people tend to discount these properties at a higher rate. On the other hand, Hong Kong's property market is so volatile and sensitive to many factors, and thus people tend to take extra precaution in making decisions to select their home. In particular, this is true when it comes to long-term investment decisions, such as buying properties.

All the other variables (property and location-specific variables) included in the model were also found to be statistically highly significant. The positive coefficient 1.129 of LnSIZE suggests there is a positive relationship between housing price and the size of the unit. It is evident that a unit with a larger floor area would be more expensive compared to a smaller unit since the demand for these is high compared to the available supply. The variable LnFLOOR represents the level of the floor that a unit is located. The positive sign suggests that the potential buyers are certainly willing to pay a higher premium for a unit in a higher level as the higher floor levels are better in many aspects, in particular in a busy and noisy city like Hong Kong. In such a highly densely populated (and busy) city like Hong Kong, it is not surprising that people would be happy to pay more to live in a higher floor to enjoy fresh air, stronger airflow, and better view. The negative coefficient of LnAGE indicates the property prices decrease as time goes by since the building structure deteriorates with time. Obviously, as the aged buildings need higher maintenance costs the potential demand for these buildings would be lower and hence the price.

Orientation is another important factor that buyers take into account when purchasing a property in Hong Kong. SOUTH is usually considered as a better orientation as units facing south would enjoy a better prevailing airflow (ventilation) and optimum natural lighting. The positive coefficient of SOUTH indicates this. People also consider EAST as relatively a better orientation, though not better than SOUTH. The positive coefficient implies this situation. In contrast, as housing units facing West can expose occupants to hot weather more severely in summer and a lot cooler in winter (though Hong Kong winter may not be that cold), the WEST is normally is considered as the worst orientation. Finally, flats facing NORTH will be cooler in winter, but this may not be a big issue as Hong Kong has only a mild winter. The worst part of NORTH is that those flats may not get enough sunlight. But, in the model, however, WEST and NORTH have positive coefficients. This might perhaps be due to the fact that people do not take the orientation WEST as that bad as long as the unit has a green view (good view). This clearly reflects from the results of the model: the estimated positive coefficient (0.040) of the variable GREEN suggests a clear positive impact on property prices. Having a green (or sea view) view is preferred by many people whilst units with views that are blocked by surrounding high rise buildings and structures are considered negatively.

Table-6. Coefficients of the model 2.

Variable	Coefficient	Sig.
Constant	-5.0426*	0.000
Ln (SIZE)	0.9934*	0.000
Ln (FLOOR)	0.0549*	0.000
Ln (AGE)	-0.3783*	0.000
North	0.0203	0.287
South	0.0376*	0.013
West	0.0591*	0.001
East	0.0534*	0.003
GREEN	0.0522*	0.000
PVIEW	-0.0165*	0.384
LVIEW	-0.0760*	0.000
Adj. R^2	0.824	0.000
F-value	448.3	0.000

Note: *indicates significant at 1% level.

4.3. Results of HPM - Models 2 and 3

To reaffirm the results obtained from Model 1, (in particular the effect of HVOTL-specific factors, which is the main aim of the study), the study performed two more models (Models 2 and 3). The estimated HPM results of the Models 2 and 3 are summarized in Table 6 and Table 7, respectively. As found in the results of Model 1, these two models have explanatory powers, and all the explanatory variables (except PVIEW in Model 2 and GREEN in Model 3) are found to be highly significant with the anticipated signs. The results also suggest that about 83 percent of the total variation of the residential property price is described by these two models (almost the same as in Model 1). This is reflected through the adjusted R^2 values (0.82 and 0.83). The corresponding p-values (0.000) of F-statistic of both models suggest that all the explanatory variables are jointly statistically significant.

Table-7. Coefficients of the model 3.

Variable	Coefficient	Sig.
Constant	-5.8317*	0.000
Ln (SIZE)	1.1576*	0.000
Ln (FLOOR)	0.0561*	0.000
Ln (AGE)	-0.4876*	0.000
North	0.1069*	0.000
South	0.1409*	0.000
West	0.1398*	0.000
East	0.1173*	0.000
GREEN	0.0126*	0.178
DPYLON	0.1314*	0.000
DLINE	-0.3401*	0.000
Adj. R^2	0.833	0.000
F-value	478.1	0.000

Note: *indicates significant at 1% level.

The main emphasis of the study is on the HVOPL-specific variables. Empirical results of both models (2 and 3), as shown in Table 6 and Table 7, are very much consistent with the results of the Model 1. As in the case of Model 1, all the HVOPL-specific variables (except PVIEW) are highly significant along with the anticipated negative sign. The coefficient of LVIEW is -0.0759 (Model 2), which is almost same (0.080) as in Model 1. The corresponding t-value and the p-value are -4.857 and 0.000, respectively. Likewise, the variable DLINE (model 3) is highly significant and carries the coefficient of -0.34, which is again same as in Model 1. This implies that the HVOPLs have a strong negative impact on the values of residential properties. This finding reaffirms the findings of Model 1 with regard to the significance of HVOPLs variables on property price. This suggests that people are aware of the negative possible link between power line proximity and health and safety, and this concern is being incorporated into the price determination of a property. This concern (by potential buyers), therefore, in turn, has already been capitalized into lower property values.

The coefficients of all HVOPLs variables in all the models are highly significant. This undoubtedly indicates that property buyers tend to pay a lower price for properties nearby HVOPLs. However, the magnitude of coefficients of variables that represent the physical distance to power lines (DLINE) and pylons (DPYLON) is larger than that in visual impact variables (LVIEW and PVIEW). That means people seem to think that a property with a far view of power lines or pylons is better than a property located physically adjacent to power lines or towers. Findings of the present research suggest that value diminution of property is mainly due to the physical proximity to power lines, but due very little to their visual impact. This implies that prospective buyers are health conscious.

5. Summary and Conclusions

The primary objective of this study was to investigate the effects of HVOPLs on the values of residential properties in Hong Kong. The study adopted a hedonic price model to empirically investigate what effects if any, power lines and pylons have on the value of nearby residential properties. The study finds that HVOPLs impart a significant negative effect on residential properties. The empirical results suggest that physical proximity and the visual presence of pylons, as well as transmission lines, have a significant adverse effect on property values of the nearby properties.

It was found that the market price and value of residential properties located adjacent to HVOPL structures are less than comparable properties in the same market area. The price of a residential unit located within a physical distance of 300 meters of power lines decreases significantly, by 34.2 percent. Likewise, the price of property located within 300 meters of a pylon drops by 18 percent. Also, the market value of property facing power lines is, on average, 8 percent lower than comparable properties in the area. Therefore, it is clear from the results that affected properties are selling at a discount to similar properties which are without any influence of HVOPLs. For example, for a property worth of HK$ 4 million, one is willing to pay only HK$ 2.632 million when the property located within 300 meters of power lines and HK$ 3.28 million when the property is located within 300 meters of a pylon. Similarly, the figure for a property facing power lines would reduce to HK$ 3.68 million. The results show that the adverse effect of living in properties adjacent to high-voltage power lines is greater than living closer to pylons. High-voltage transmission lines can cause undesirable electric noise and also cables carrying a high-volume of electricity can produce electric noise (Doukas et al., 2011). The presence of overhead power lines may create an undesirable aesthetic image to the surrounding environment which would certainly cause a negative effect to the surrounding properties. The results also indicate that it is the physical distance to HVOPL structure (lines and pylon) that accounts more for the value diminution compared to the view (visual impact) of the structure.

Several implications can be drawn from the findings. First, properties located in closer proximity to an HVOPL corridor not only affect potential buyers in the first-hand housing market but also distract people buying or renting properties in the second-hand property market. As there is a negative public perception of the impact of HVOPLs due to various reasons as discussed in the literature review, potential buyers or investors are reluctant to invest in these properties. The presence of HVOPLs provides a negative image of the property in the eyes of the prospective buyers. This can significantly lower the market potential of the property and hence competitiveness of the property in the market can be adversely affected, leading to a lower price.

Second, the undesirable quality level and the unhealthy living atmosphere that HVOPLs bring to the property may increase the awareness of the general public. Therefore, potential property buyers and existing owners, as well as tenants, may have a serious negative perception of properties adjacent to HVOPLs. This issue is important not only for property owners or buyers but also for property appraisers, mortgage underwriters, tax assessors as well as those who are involved with the valuation profession.

Some important implications can be drawn from the findings of this study for local planning authorities, developers and stakeholders within the electricity supply industry. As per policymakers, the findings of the research may shed light on the main phenomenon underlying the widespread negative public perception regarding the presence of HVOPLs: the necessity of the market to take public perception of the HVOPLs into consideration in investment decisions. Although it may cost relatively less to purchase land (for constructing residential developments) near HVOPLs corridors, developers perceive that increasing public awareness on unhealthy living environments brings their attention to HVOPLs and leads to an uncompetitive business environment. It may also help authorities to further refine the planning and installation of HVOPLs away from residential areas in the future. In particular, knowledge about the effects of transmission lines and in particular its effects on property values are important when new projects are initiated. Therefore, this study would be useful for those stakeholders who are involved with making these decisions.

The research findings could be useful for planning authorities and developers in deciding to initiate new development schemes where there are HVOPL corridors. This research, it is hoped, may well inform concerned establishments in their discourses with property developers in the future. Finally, such authorities can also take account of measures in their development plans regarding new property developments and the effects of HVOPLs. The findings of this study may also help to increase the awareness of potential issues related to health and safety concerns, in Hong Kong, of living closer to transmission lines.

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