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A Link between East and West: How the Guangzhou–Shenzhen–Hong Kong Express Rail Link Affects Property Prices in Hong Kong

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This study examines the impacts of the Guangzhou–Shenzhen–Hong Kong Express Rail Link on the residential property prices in West Kowloon, in which the terminus and only station of the Hong Kong section of the high-speed rail link is located. The express rail is characterised as being a link between Hong Kong and her motherland, China, which is a major source of buyers of property in Hong Kong. We investigate if there is an east-west connection premium introduced by the project by examining the spatial and temporal changes of property prices in the affected areas. Based on a sample of 282,131 transactions, this study uses the hedonic pricing and repeat sales models to examine whether property prices in West Kowloon have increased because of the development of the high-speed rail which signifies a link between Hong Kong and China and whether they have dropped because of the 2019 political movements which emphasize a decoupling. We find significant and consistent evidence to support these hypotheses from both the hedonic price and repeat sales models. The accessibility premium has been capitalised into property prices since the announcement of the project, and the size of the premium is the largest during the announcement period. However, the east-west connection premium is significantly offset by the recent events of political unrest, with properties that are located nearest the West Kowloon Station being the most affected. We derive policy implications regarding practical implications for the design and implementation of land value capture schemes and urban planning.

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Keywords

Transit Accessibility, Hedonic Price Model, Repeat Sales, Real Estate Price, Property Value

1. Introduction

The Hong Kong section of the Guangzhou-Shenzhen-Hong Kong Express Rail Link (XRL) connects Hong Kong with the 16,000 km of high-speed rail network in China, with the West Kowloon Terminus as the only station in Hong Kong. The area around the West Kowloon Station is the figurative meeting point between the east and the west – the east being China, the Middle Kingdom, and the west being Kowloon West, which represents Hong Kong, an international financial centre. The project, commonly known as the West Kowloon Station project, has great strategic importance as it provides a link between Hong Kong and its motherland, which is a major source of buyers of property in Hong Kong. The purpose of this study is to examine the impacts of the West Kowloon Station project on residential property prices during the announcement, construction, and operation phase of the project, and the period of political unrest in Hong Kong.

Our study is set up to answer three research questions. First, have property prices in West Kowloon increased because of the project which signifies a link between Hong Kong and China or have they dropped because of the 2019 political movements which emphasize a decoupling? Secondly, when does proximity to the station translate into value in the property market? Finally, what is the aggregate increase in property value due to the transport development? To answer these questions, we use hedonic pricing and repeat sales models to examine the intertemporal and spatial variations in property prices.

This paper contributes to the literature in multiple ways. First of all, although there have been a few published studies on the Mainland China section of the XRL, this paper is the first to investigate the effect of the Hong Kong section of the XRL on the residential property market. Furthermore, this study uses 282,131 private residential property transactions within six kilometres of the station from 2000 to 2019, which is more comprehensive than the datasets used in similar studies. Most importantly, few studies have examined both the expectations and the actual effects of transport improvements on property prices; this study helps to shed light on how accessibility benefits are capitalised into property prices throughout the entire timescale of a project.

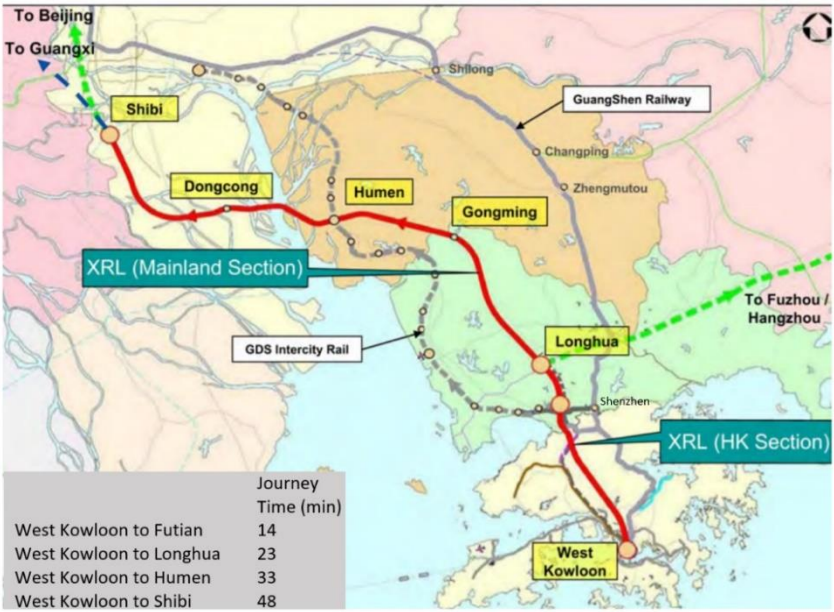
The paper is organised as follows: Section 2 provides the factual background of the project. Section 3 reviews the existing literature and explains how this study differentiates itself. Section 4 explains how the data are collected and

lays out the data descriptives of the variables. Section 5 describes the two methods employed in this study – the hedonic pricing and repeat sales models. Section 6 discusses the findings and presents the results of the diagnostic tests. Section 7 estimates the aggregate property price premium and discusses the practical implications. Finally, Section 8 concludes.

2. Background

The Hong Kong section of the XRL project crosses through the Western Kowloon area in Hong Kong (see Figure 1). West Kowloon is well served by transport facilities. The Western Harbour Crossing is a tube tunnel that connects Kowloon and Hong Kong Island. The West Kowloon Terminus is adjacent to the Austin and Kowloon Mass Transit Railway (MTR) Stations, which are well-connected to the West Rail Line, Tung Chung Line and Airport Express. The completion of the XRL well connects West Kowloon to the local and regional transportation networks, so that it has now become a major transport hub in Hong Kong.

Figure 1 XRL Route

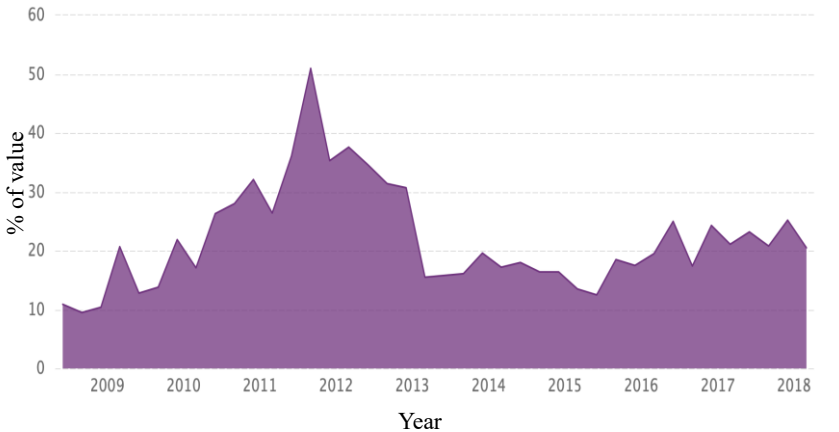


Source: The Hong Kong Institution of Engineers (2009).

The XRL is the first cross-border high-speed rail that links Hong Kong and Mainland China. The Hong Kong section of the XRL runs an underground rail of 16 km from the West Kowloon Terminus to the boundary at Huanggang, and the Mainland China section runs from Huanggang to Guangzhou. Passengers

can travel to 58 Mainland cities without any interchange, thus significantly reducing the journey time between Hong Kong and Mainland Chinese cities. The XRL also enhances cross-border connectivity in the Greater Bay Area, which is a megalopolis that mainly consists of Hong Kong, Guangzhou, and Shenzhen. The XRL has accelerated the realization of a "one-hour living circle" which will reduce the travel time between any of the major cities in the Greater Bay Area to within an hour. Consequently, properties in West Kowloon have become more appealing to both Hong Kong and Mainland individuals who cross the border frequently. As show in Figure 1, the proportion of Chinese buyers of private properties in Hong Kong have increased significantly between 2009 and 2011, and remained constant at around 20% in the last five years.

Figure 2 Chinese Buyers of Hong Kong Private Property (% of Value)



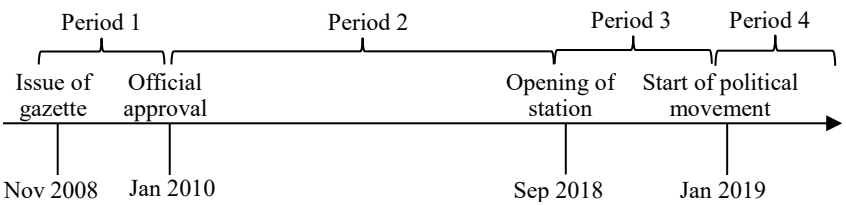
Source: www.ceicdata.com, *and Centaline Property Agent Ltd (https://www.ceicdata.com/en/hong-kong/residential-private-mainland-chinese-buyers-of-hong-kong-properties/chinese-buyers-of-hk-private-properties-primary--of-value).*

The XRL was first proposed by the Transport Bureau of The Government of the Hong Kong Special Administrative Region in the Railway Development Strategy 2000. The railway scheme of the Hong Kong section of the XRL (including the proposed land and strata to be resumed) was gazetted on 28 November 2008 and secured official approval from the Hong Kong Legislative Council on 16 January 2010. Construction of the XRL started on 26 January 2010 and the XRL came into operation on 23 September 2018. This gives us the opportunity to study the effect of transportation improvements over the entire project lifespan, i.e., the announcement, construction, and operation phases. We expect that an east-west connection premium to be incorporated in property prices in affected areas during these periods of time.

In February 2019, the Hong Kong government introduced a bill which would have allowed the extradition of wanted criminal suspects to territories with

which Hong Kong does not have extradition agreements, including Mainland China. This raised considerable concerns that the bill would subject Hong Kong residents to the legal jurisdiction of China and lead to negative sentiments of some people towards the Hong Kong and Chinese governments and even the Mainland Chinese in general. The first major protest against the bill took place on 9 June 2019, followed by a series of demonstrations that lasted until January 2020 when the new coronavirus outbreak started. The bill was withdrawn by the Hong Kong government in September 2019. This episode is defined as the last study period in this paper. We suspect that the east-west connection premium introduced by the XRL will suffer a significant discount during this period, because the attractiveness of the West (i.e., Hong Kong) is hampered by the political uncertainty introduced by the bill. The four study periods in this analysis are shown in Figure 3.

Figure 3 Timeline of Events

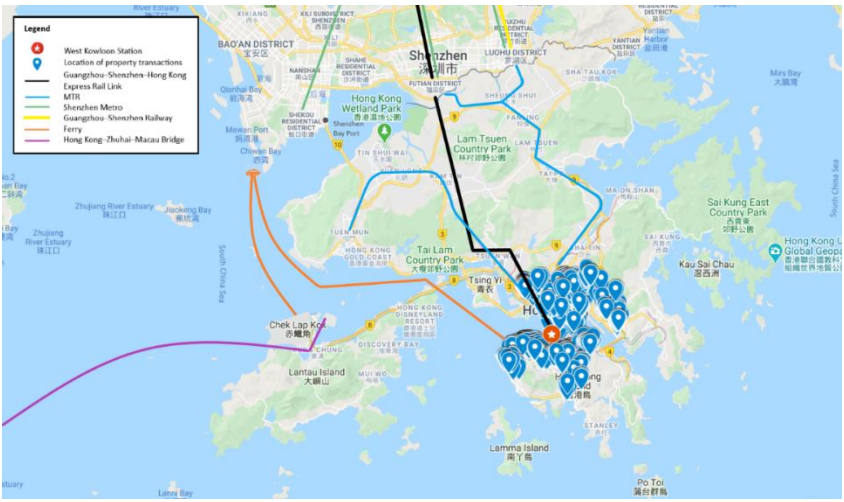


Adjacent to the West Kowloon Terminus sits the West Kowloon Cultural District. These two projects were the main developments in West Kowloon in the 2010s. A proposed development of the cultural district was submitted to the Town Planning Board in December 2011 and approved by the Executive Council in January 2013. Facilities were developed in phases and construction commenced in 2013. Phase 1 facilities were scheduled for delivery in 2020, with some facilities that opened in 2016, 2018 and early 2019, and the remaining facilities in 2020. As the announcement of the West Kowloon Cultural District project does not coincide with that of the West Kowloon Station project, the results of this study reliably captures the property price changes caused solely by the announcement of the XRL. However, since the operation period of the West Kowloon Station project overlaps with the opening of some of the facilities in the West Kowloon Cultural District, this paper will not attempt to merely attribute price changes to the project during the operation period.

Figure 4 presents the different transport routes from Hong Kong to Mainland China. For commuters based in the New Territories and Lantau Island, it is more convenient for them to travel by MTR, car/bus or ferry to the Mainland Chinese cities that border Hong Kong. For commuters who are travelling from Kowloon and Hong Kong Island, the XRL is the fastest route to Mainland China. The areas that directly benefit from the development of the XRL are Kowloon and

Hong Kong Island; therefore, the study area is confined to these two regions, i.e. 10 km from West Kowloon Station.

Figure 4 Cross-Boundary Transport Routes



We further divide the study areas into five zones. As shown in Table 1, the study area is divided into five zones according to their driving distance to the station. Road-network distance, instead of Euclidean distance, is used to reflect routes physically taken by commuters (Boscoe et al., 2012). Zone 1 covers Yau Tsim Mong, in which West Kowloon Station is located; Zones 2 and 3 include Kowloon City and Sham Shui Po, respectively; Zones 4 and 5 cover properties on Hong Kong Island as well as Wong Tai Sin and Kwun Tong in Kowloon, respectively.

Table 1 Zone Classification

Zone	Distance to West Kowloon Station (km)	Districts
Zone 1	0-2 km	Yau Tsim Mong
Zone 2	2-4 km	Kowloon City and Sham Shui Po
Zone 3	4-6 km	
Zone 4	6-8 km	Hong Kong Island, Wong Tai Sin
Zone 5	8-10 m	and Kwun Tong

3. Literature Review

Classical location theories set the foundations for the theoretical relationship between transport cost and land value. The land rent theory (von Thünen 1863) and access space trade-off model (Muth, 1969, Evans, 1985) state that the willingness to pay rent is determined by transport costs, including the direct

cost and opportunity cost of time spent on travelling. Hurd (1905) and Haig (1974) support the rent-distance hypothesis that rent declines with increasing distance to the central business district (CBD). The bid rent model (Alonso, 1964) shows a clear negative relationship between land rent and transport cost. Adopting a polycentric city model, Dubin and Sung (1987) find that employment centres, regardless whether they are in the CBD or suburban areas, are still of significant importance to the determination of property prices. In other words, proximity to the CBD or amenity centres can be understood as being situated near efficient transportation networks, and thus reducing transport costs. Thus, accessibility benefits should be capitalised into property prices in view of any transportation developments.

There are two main categories of empirical studies related to transport infrastructures – the effect of existing transport routes on property prices and the effect of new transportation developments on property prices. This study fall into the latter category. A rich body of empirical research has shown that public transport accessibility has a positive effect on real estate prices. However, only a minority of studies have shed light on how public transport affects property prices in densely populated metropolitan areas with high-rise apartment buildings. Hong Kong is one of the most densely populated places in the world, with a density of 6,940 persons/km^2. In particular, the Yau Tsim Mong District, which includes West Kowloon, has the highest population density in Hong Kong at 47,700 persons/km^2. Given the high density, public transportation plays an important role. In fact, public transportation accounts for around 80% of travel in Hong Kong. Hence, any improvements in transportation should arguably influence property prices in Hong Kong more than in cities that are sparsely populated.

Previous studies generally find a positive effect of transport accessibility on property prices in densely populated areas. In eastern Massachusetts in the US, a location premium of 10% was found for properties in the vicinity of commuter rail stations over those further away (Armstrong and Rodriguez, 2006). Hess and Almeida (2007) find a positive but weak effect on price for proximity to light rail stations in Buffalo, New York. However, a negative effect is found in the Summer-Best, Utica and Theatre stations. In Hong Kong, proximity to MTR stations is highly valued by residents due to the speed and convenience of the MTR service (Hui et al., 2007, So et al., 1997, Tse, 2002). Jim and Chen (2009) find an accessibility premium of 4.6% for properties within 0.5 km of an MTR station.

Most empirical studies that examine the impact of transportation improvements find an overall ex-post positive impact. Gibbons and Machin (2005) find a price premium of 1.5% per km for properties in the vicinity of new stations along the Jubilee Line Extension and Docklands Light Railway of the London Underground Network in 1999. Geng et al. (2015) find a price premium in properties up to 11.7 km from the Beijing high-speed rail station in China. The electrification of the Kowloon-Canton Railway in 1982 positively influenced

property prices near Sha Tin Station relative to the control zone in Hong Kong (Chau and Ng, 1998). However, some have found an insignificant or even a negative effect on property prices instead; for instance, in Taiwan (Andersson et al., 2010) and North England (Forrest et al., 1996).

The spatial variation in property prices is a combined result of positive and negative effects. The positive impacts include saving of time, attraction of business activities, increased accessibility to jobs, etc. Negative externalities for being too close to the infrastructure include noise pollution, crime and traffic congestion (Gibbons and Machin, 2005). Factors that may affect the direction and magnitude of property price changes include the mode of transportation under study (Mulley and Tsai, 2017), location of the transport infrastructure (Diao et al., 2017), cost of using the infrastructure (Andersson et al., 2010), ridership of service (Forrest et al., 1996), quality of transportation service in terms of frequency and coverage (Debrezion et al., 2011), property type (Golub et al., 2012, Cervero and Duncan, 2002), land use (Cervero and Kang, 2011), neighbourhood characteristics (Hess and Almeida, 2007), competing modes of transportation (Senior, 2009) and concurrence with a recession (Forrest et al., 1996).

While most studies explore the effect of transport infrastructure after their opening, the ex-ante effect on property prices is largely ignored. The adaptive expectation model by Cagan (1956) suggests that investors are backward-looking when predicting future outcomes, whereas the rational expectation hypothesis by Muth (1969) suggests that investors make decisions based on all available information in the market, and thus the property market should react to a transport development prior to completion of the project. Also, price may adjust after the opening of the transport facility if the perceived benefit (or nuisance) has been over- or underestimated (McMillen and McDonald, 2004). The timing of changes in property prices depends on the perceived time and cost savings, amenity improvement (e.g. attraction of retail activities), disamenity effect and information transmission efficiency (Yiu and Wong, 2005). In fact, there has been no consensus regarding the timing of changes in property prices. Jayantha et al. (2015) find a positive effect on property prices upon announcement of the Shatin to Central Railway Link in Hong Kong. However, the accessibility premium of Line 5 of the subway in Seoul was capitalised only during the construction phase and up to the year of completion (Bae et al., 2003). This is echoed by Yiu and Wong (2005), who conclude a positive expectation effect during the construction of a cross-harbour tunnel in Hong Kong, although the extent of increase was mitigated by the construction nuisance. In contrast, there was no significant announcement and distance effect of the Miami Metrorail in the US (Gatzlaff and Smith, 1993).

What differentiates this paper from other studies is that, first, we examine price changes during project announcement, construction and operation, and a period of social unrest. Few studies examine the impacts in all three phases of transport infrastructure projects. Hence, this study sheds light on how accessibility

benefits or negative externalities are capitalised into property prices along the entire timescale of the project. Secondly, there are only a few published studies on the high-speed rail in Mainland China, especially the impact on nearby property prices (Diao et al., 2017, Geng et al., 2015). This study is the first to examine the impact of the Hong Kong section of the XRL on property prices in the vicinity. Thirdly, there are significant practical implications of the study. The Hong Kong section of the XRL costed HK$85.3 billion (USD 11.01 billion), which is one of the most expensive infrastructure undertakings in the history of Hong Kong. The results of this paper can help with the design and implementation of value capture schemes for financing future transport infrastructure investments.

Finally, this study examines the impact of political events on the property market in Hong Kong, which is seldom explored in recent empirical studies. Similar research dates back to the 1990s and 2000s. Investigating the impact of the Tiananmen Square events, He et al. (1998) conclude that the Hong Kong property market is more sensitive to major political events than other non-real estate markets. Chau (1997) finds that the news of the handover of Hong Kong to China caused a significant increase in real estate risk premium in 1983. Using planning application statistics, Lai et al. (2006) find that the Sino-British Joint Declaration in 1984 and the Tiananmen Square incident are correlated with a lower probability of successful planning applications. However, these studies cover the aggregate property market, while this paper focuses on a particular area in Hong Kong.

4. Data

The data used for this study cover all private residential property transactions within 10 km of the station for 20 years from 2000 to 2019. These transactions are retrieved from a database maintained by Centaline Property Agency Limited. The data consist of structural attributes, including date of transaction, transaction price, saleable area, address and completion year of the property.

In terms of accessibility attributes, each address is geo-coded to geographical coordinates. Driving distances to the station and CBD are calculated by using Google API. The proxy chosen for the CBD is the International Finance Centre in Central, Hong Kong. Walking distance to the nearest MTR station is calculated by using ArcGIS and Google API. With the aid of Excel VBA, ArcGIS is used to calculate the straight-line distance to the coast.

Only properties that are within 10 km of the station are extracted. A list of public housing estates and Home Ownership Scheme Courts is obtained from the Housing Authority so as to exclude public housing transactions from the study database. After extensive data cleaning, the database contains 550,656 property transactions and 330,986 residential units within 10 km of the station.

Table 2 Descriptive Statistics for Hedonic Pricing Model

Variable	Definition	Source	Mean	SD	Min	Max	Expected sign
Dependent variable							
ln price	Natural log of transaction price in HKD	Centaline Property	14.98	0.96	10.78	20.17	
Independent variables							
Structural features							
Age	Time between year of transaction and year of completion	Centaline Property	19.84	17.93	1	83	-
Age2	Age squared	Centaline Property	714.91	894.42	1	6889	+
Area	Saleable area	Centaline Property	549.59	304.75	72.00	7873	+
Area2	Saleable area squared	Centaline Property	394916	746232	5184	61984129	-
Floor	Floor number	Centaline Property	16.01	14.29	0	90	+
Floor2	Floor squared	Centaline Property	460.45	796.99	0	8100	-
Accessibility features							
StationDistance	Driving distance to West Kowloon Station (km)	Google API	3.75	1.38	0.30	6	-
CBDDistance	Driving distance to CBD (km)	Google API	7.97	1.76	1.60	33.70	-
MTRDistance	Walking distance to nearest MTR station (km)	Google API	0.78	0.66	0.00	3.50	-
MTRDistance2	Walking distance to nearest MTR station (km)	Google API	1.04	2.07	0.00	12.25	+
CoastDistance	Straight-line distance to shoreline (km)	ArcGIS	0.74	0.50	0.01	3.10	-
CoastDistance2	Straight-line distance to shoreline (km)	ArcGIS	0.80	1.10	0.00	9.63	+

(***Continued…***)

(Table 2 Continued)

Variable	Definition	Source	Mean	SD	Min	Max	Expected sign
Dependent variable							
Z1	Equals 1 if in Zone 1; 0 otherwise	Google API	0.15	0.36	0	1	+
Z2	Equals 1 if in Zone 1; 0 otherwise	Google API	0.40	0.49	0	1	+
Z3	Equals 1 if in Zone 1; 0 otherwise	Google API	0.45	0.50	0	1	/
Temporal features							
Ann	Equals 1 if transacted after the announcement date; 0 otherwise	Centaline Property	0.45	0.50	0	1	+
P1	Equals 1 if transacted in Period 1; 0 otherwise	Centaline Property	0.09	0.29	0	1	+
P2	Equals 1 if transacted in Period 2; 0 otherwise	Centaline Property	0.39	0.49	0	1	+
P3	Equals 1 if transacted in Period 3; 0 otherwise	Centaline Property	0.04	0.19	0	1	+
P4	Equals 1 if transacted in Period 4; 0 otherwise	Centaline Property	0.02	0.12	0	1	/
Year	19 time dummies representing 2001 to 2019	Centaline Property	/	/	0	1	/

There are in total 217,505 repeat sales pairs and 40% of residential units changed hands more than once in the 20-year period. To extract repeat sales from the database, each property is assigned an ID based on their address, and transactions with the same ID are matched into pairs. To remove flips, repeat sales pairs with less than four months are removed to avoid distortion by speculators. The definition of the variables and sources of the data are provided in Table 2.

5. Models

5.1 Hedonic Price Model

As the hedonic pricing model measures the relative contribution of each property characteristic to property prices, it is effective for isolating the effect of a particular characteristic from other attributes (Rosen, 1974). In this study, a semi-logarithmic function estimated by using the ordinary least-squares method is used. The model specification is as follows:

$$lnP = c + \sum_{i=1}^{N} \alpha_i S_i + \sum_{i=1}^{N} \beta_i A_i + \sum_{i=1}^{N} \gamma_i T_i + \varepsilon$$

The natural logarithm of transaction price (lnP) is a function of structural (S), accessibility (A) and temporal (T) attributes for N properties with c representing the intercept and ε the error term. As the dependent variable is in a logarithmic form, the coefficient estimates represent the percentage changes. Other functional forms, such as the linear, double log (log-log), exponential, and quadratic functions and Box-Cox transformation, have been estimated, but the semi-logarithmic function best fits the data according to the R^2, adjusted R^2, Akaike and Schwarz information criteria.

The hedonic pricing literature finds that analysing data within housing submarkets rather than at the aggregate market level greatly improves the accuracy of the hedonic predictions (Goodman and Thibodeau, 2003). As the study area expands, the level of heterogeneity of the properties included increases accordingly. This raises the concern of omitted variable bias. Therefore, we decide to include only properties located within 6 km of the station, or Zones 1 through 3, in the hedonic pricing models, This gives us a total of 282,131 transactions from the Yau Tsim Mong, Kowloon City and Sham Shui Po districts in Kowloon during the 20 year sample period. The descriptive statistics of these transactions are provided in Table 2. The independent variables are divided into the three categories mentioned above. The mean selling price of a residential unit in the sample is HK$3,204,286 (USD 413,454) which is obtained by exponentiating the mean of lnP (14.98). On average, a home in the sample is 20 years old and 550 square feet in size. Of the transactions, 15% lie within 2 km of the West Kowloon Station and 40% lies between 2 km and 4 km of the station.

5.1.1 Model I

Model I examines the relationship between distance from station ($StationDistance$) and $ln\ P$ pre- and post-announcement. A dichotomous categorical variable (Ann) is included, which equals 1 if transacted after the announcement date (16 January 2010), and 0 otherwise. A location-time interaction term ($Ann \times StationDistance$) is used to measure the temporal variation of the price gradients between the properties closest to the station and those further away.

Before announcement, the price gradient with respect to distance from station equals the coefficient of $StationDistance$. After announcement, the price gradient becomes the sum of the coefficients of $StationDistance$ and the interaction term $Ann \times StationDistance$. The sign of a pre-announcement gradient is uncertain: the station is located near the West Kowloon Waterfront Promenade and offers excellent views of the Victoria Harbour, but negative externalities generated by the Western Harbour Tunnel and highways may make the slope positive. In any case, a decline in the price gradient is expected due to the capitalisation of accessibility benefits into property prices.

5.1.2 Model II

Model II further examines the time path of the price gradient. Instead of using Ann, four period dummy variables are defined based on the four study periods shown in Figure 2. Specifically, Period 1 lasts from the issue of the gazette to one month after the approval date, which captures the announcement effect. As for the planning, the proposal and consultation process requires a very long length of time, so the announcement should not be a surprise to investors. It is anticipated that the effect has already been incorporated into the price before the approval date. Period 2 covers the construction period, and Period 3 captures the effect of the station opening, from one quarter before the opening of the station to the first major anti-extradition protest. Period 4 covers the period subsequent to the first large-scale protest, from June to December 2019. Transactions in 2020, which may have been influenced by the coronavirus outbreak, are excluded.

The four period dummies above are interacted with $StationDistance$. Similar to Model I, the pre-announcement price gradient is the coefficient of $StationDistance$. The coefficients of the location-time interaction terms represent the change in price gradient relative to the pre-announcement value. Hence, the price gradients for the 4 periods are the sum of the coefficients of $StationDistance$ and their respective interaction terms. To prove that Hypothesis 1 is true, the price gradient in Period 1 is anticipated to decrease in

support of the rational expectation hypothesis. To verify Hypothesis 2, the price gradient in Period 4 is expected to flatten compared to previous periods.

5.1.3 Model III

In the final step of hedonic price modelling analysis, we use zone dummies to capture the impact of the XRL project on affected properties. Three zone dummy variables are used and interacted with the dummy variable Ann to measure the extent of overall price changes in Zones 1, 2 and 3 after the announcement. The coefficient of interaction terms represents the overall percentage change due to the announcement of the station in the respective zones. Zones closest to the station are expected to exhibit a greater percentage increase in price than zones further away.

5.2 Repeat Sales Model

Bailey, Muth and Nourse (1963) use pooled ordinary least squares to estimate the following equation:

$$\ln\left(\frac{P_n^s}{P_n^f}\right) = \sum_{t=0}^{T} a_t D_n^t + \mu_n^t$$

where P_n^t represents the transaction price for property n in period t. f and s represent the time when the first and second sales occurred, where $0 \leq f \leq s \leq T$. μ_n^t is a homoscedastic error term. The dependent variable is the natural logarithm of the ratio of the price of the second sale to that of the first sale. The independent variable is a series of time dummy variables (D), which are measured in quarters. They equal -1 for the quarter that the first sale occurred, +1 when the second sale occurred, and 0 otherwise. The repeat sales model is used in each of the five zones to estimate their corresponding zonal price indices. The price index is obtained by exponentiating the time coefficient (a_t) as follows:

$$P = \exp(\widehat{a_t})$$

The repeat sales method circumvents a major challenge that faces hedonic price modelling methods, that is, omitted variable bias[1]. The strength of the repeat sales method is, unlike the hedonic pricing model, the data requirement is easily satisfied as only the transaction date, price and address are needed. Also, the method can control for time in-variant variables (e.g. physical characteristics), and is less subject to omitted variable bias and functional form misspecification

[1] To correct for this omitted measurement in quality change, Case and Shiller (1987) suggest a weighted least squares approach to give less weight to properties with longer holding periods. However, there has been no consensus as to which model is superior (Leishman and Watkins, 2002, Jansen et al., 2008). A Case and Shiller index was also calculated for robustness check. It is concluded that Bailey's method is not inferior.

in hedonic models (Rosen, 1974). As shown in the repeat sales equation above, housing attributes, whether they are observable or not, are cancelled out. Therefore, as long as there are no major changes in the housing attributes between sales, omitted variable bias is not a concern. An important assumption behind the repeat sale method is that the quality of flats shall remain unchanged between the first and second sales. As the holding period increases, the likelihood of changes in quality increases. However, in the case of Hong Kong, this should not be a major issue due to the high degree of homogeneity in the apartments, which has also been recognised by Mok et al. (1995) and Tse and Love (2000). Domestic properties are subject to regulations in the Buildings Ordinance and major alteration works are prohibited unless prior approval is obtained by the Buildings Department. Furthermore, the holding period is relatively short in Hong Kong. In this study, the average holding period is 4 years. Also, owing to the high land price policy of the government, land value accounts for a large portion of property prices, thus the impact of renovations on price should be relatively small. Therefore, we expect that the repeat sales models will give us a more accurate estimate of the house price index.

Nevertheless, the repeat sales method suffers from a reduced sample size, because usually only a small number of properties are transacted more than once. We need to include transactions from all zones in order to increase the sample size, because the proportion of repeat sales in less than 50%. Our final data set for the repeat sales analysis consists of 217,505 repeat sales pairs in the 20-year period.

The repeat sales method cannot give us specific estimates of the east-west connection premium because there are no coefficient estimates for distance measurements or zone dummies. Instead, the price gradients between the treatment zones, Zones 1-4, and control zone, Zone 5, can be indirectly estimated by finding the inter-zonal difference in their respective index values. T-tests are conducted to verify whether the events caused any significant changes in price gradients. To verify Hypothesis 1, zones closer to the station enjoy a larger magnitude of increase in price than zones further away in the announcement period. To prove that Hypothesis 2 is true, zones closer to the station suffer from a greater decrease in price than zones further away.

6. Empirical Results

6.1 Hedonic Pricing Model

Table 3 presents the output of the hedonic models. A base case is also carried out without variables related to the West Kowloon Station. The results show that Models I, II and III improve the explanatory power as they have a higher adjusted R-square, lower Akaike and Schwarz information criteria, and lower root-mean-square error than the base case. The overall predictive power of the 3 models is excellent as the R-square and adjusted R-square are around 0.91,

which means that the models explain for 91% of the variations in the transaction price. Also, all coefficient estimates are statistically significant at the 0.1% level. All time-invariant independent variables behave as expected, thus indicating a well-behaved model.

Before the announcement, the price gradient with respect to distance to station is -1.2% per km, which indicates that there was already a preference for living close to the (non-existent) station site. The location of the West Kowloon Station is close to the Kowloon station of the Tung Chung MTR subway Line. Therefore, the premium picked up by the pre-announcement dummy is the premium due to accessibility to the MTR. As there is no change to the MTR lines in the study area during our study period, this MTR accessibility premium has been held constant throughout the four study periods and hence will not affect our conclusions. After the announcement, the price gradient changed from -1.2% per km to -1.5%, which implies the amenity effect was capitalised into prices due to the West Kowloon project.

The temporal variation of the price gradient can be further examined in Model II. The price gradient changed from -0.66% per km before announcement, to -3.94% in Period 1, -1.49% in Period 2, -1.85% in Period 3 and 0.64% in Period 4. In the announcement period (Period 1), there is a change in the gradient of -3.28% per km, which means that the house price rose by 3.28% for every kilometre closer to the West Kowloon Station, ceteris paribus. As the mean property price is HK$3,204,286 (USD 413,454) in the hedonic sample, the price difference is HK$105,100 (USD 13,561). As the price gradient increased in the announcement period, it provides supportive evidence for Hypothesis 1 that the accessibility premium was capitalised upon the announcement of the project.

The slope gradually became linear in the construction period (Period 2) but slightly more negative in the operation period (Period 3), thus implying that the anticipated accessibility benefit might have been undervalued and property prices adjusted to reflect the actual improvement brought about by the XRL.

During the social unrest (Period 4), the slope of the distance-price relationship not only flattened, but changed from negative to positive. This supports Hypothesis 2 in that, due to the protests, property prices in areas closest to the station depreciated faster than areas further away.

The coefficient estimates of the location-time interaction terms show that property prices rose by 14% in Zone 1, 9% in Zone 2, and 7% in Zone 3 after the announcement of the project. This implies that the amenity effect was capitalised into property prices, and the effect diminished with distance away from the station. Nevertheless, as Ann covers the whole post-announcement period, this result may overestimate the benefit as it is difficult to attribute the price premium solely to the development of the XRL.

Table 2 Hedonic Regression Results

	Model I	Model II	Model III	Base Model
Constant	13.8918	13.8710	13.6614	13.8637
Structural				
Age	-0.0282	-0.0282	-0.0283	-0.0283
Age2	0.0002	0.0002	0.0002	0.0002
Area	0.0025	0.0025	0.0025	0.0025
Area2	-0.0000004	-0.0000004	-0.0000004	-0.0000004
Floor	0.0077	0.0078	0.0079	0.0076
Floor2	-0.00004	-0.00004	-0.00005	-0.00004
Accessibility				
StationDistance	-0.0116	-0.0066	0.0292	
CBDDistance	-0.0264	-0.0263	-0.0253	-0.0270
MTRDistance	-0.1028	-0.1010	-0.0588	-0.1196
MTRDistance2	0.0178	0.0173	0.0067	0.0213
CoastDistance	-0.5035	-0.5008	-0.4789	-0.5039
CoastDistance2	0.2407	0.2395	0.2291	0.2363
Z1			0.1906	
Z2			0.0431	
Z3			Ref category	
Temporal				
Ann	0.0971			
Interaction Terms				
Ann×StationDistance	-0.0034			
P1×StationDistance		-0.0328		
P2×StationDistance		-0.0083		
P3×StationDistance		-0.0120		
P4×StationDistance		0.0130		
Ann×Z1			0.1366	
Ann×Z2			0.0913	
Ann×Z3			0.0710	
R-square	0.9118	0.9122	0.9132	0.9115
Adjusted R-square	0.9118	0.9121	0.9132	0.9114
Root MSE	0.2851	0.2845	0.2829	0.2856
Akaike criterion	-708029	-709242	-712534	-707027
Schwarz criterion	-707671	-708863	-712144	-706700
F-statistic	88344	83691	82413	96800

Note: All coefficient estimates and F test statistics are significant at the 1% level unless stated otherwise.

6.2 Repeat Sales Model

The quarterly repeat-sales price indices from 2000 Q1 to 2019 Q4 in Zones 1-5 are depicted in Figure 5. Property prices in this period rose by more than threefold, which is in line with the macroeconomic property market trend

presented by the Midland Property Price Index and Centa-City Leading Index. Property prices dropped in 2003 due to the SARS outbreak, in 2008 due to the global financial crisis, in 2016 owing to the economic slowdown in Hong Kong and the first US Fed interest rate hike since 2008, in late 2018 because of the US-China trade war and in late 2019 due to the social unrest.

The price indices and appreciation rates of Zones 4 and 5 are very similar in most periods, as shown by Figures 5 and 6. In Figure 7, the price differential between Zones 4 and 5 is very small, except for the protest period, which is because Zones 4 and 5 mainly cover properties on Hong Kong Island. The results from Table 4 show that there is no statistically significant mean difference (at the 10% level) between the price indices of Zones 4 and 5. Thus, it can be concluded that the impact of the development of the station extends to only 6 km from the West Kowloon Station.

Before the railway scheme was gazetted, the price indices of all 5 zones perform similarly and appreciation rates of Zones 1 to 3 are even lower than those of Zones 4 and 5, i.e. the price gradient is upward sloping. In the announcement period, property prices in Zones 1 to 3 appreciated at a faster rate than Zones 4 and 5 and the price gradient becomes downward sloping. The expected accessibility premium is 0.5% in Zone 1 relative to Zone 5. This offers supportive evidence for Hypothesis 1 that, first, the anticipated amenity effect of the West Kowloon Station was capitalised into property prices upon announcement, and secondly, properties closest to the station benefited more from the expected amenity effect compared to those further away.

Figure 5 Repeat Sales Indices in Zones 1-5

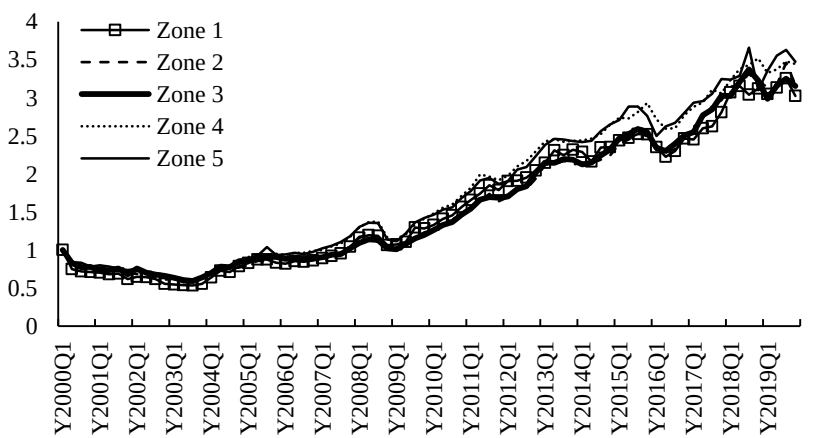


Figure 6 Average Quarterly Appreciation Rates in Property Prices

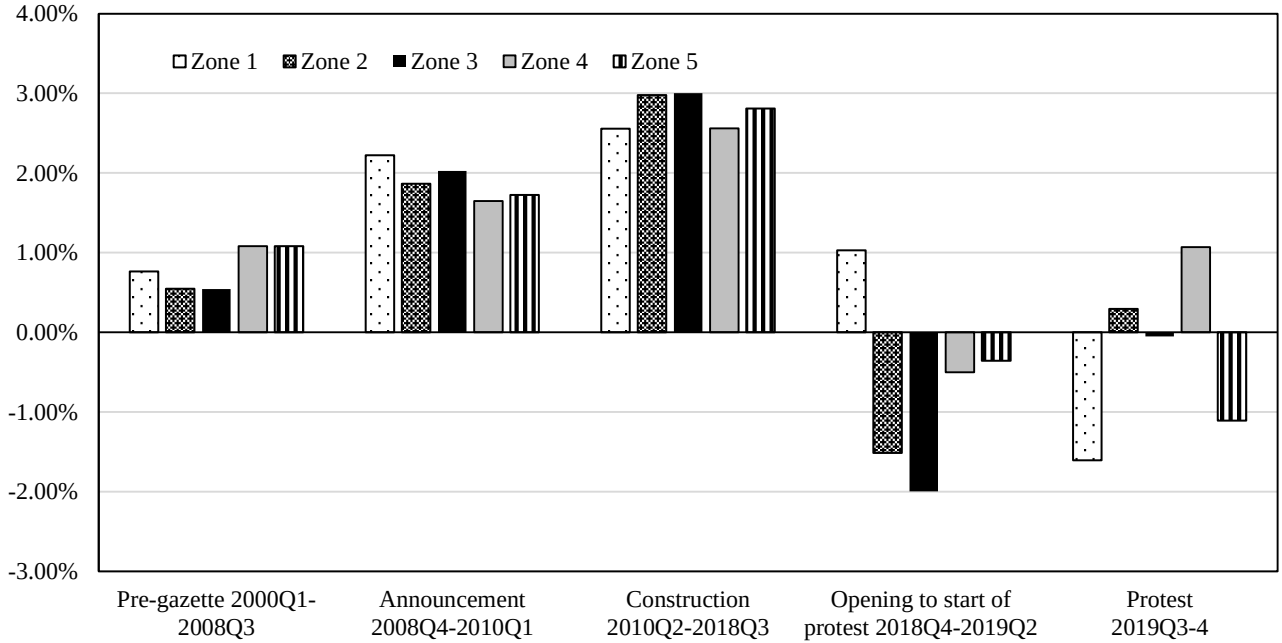
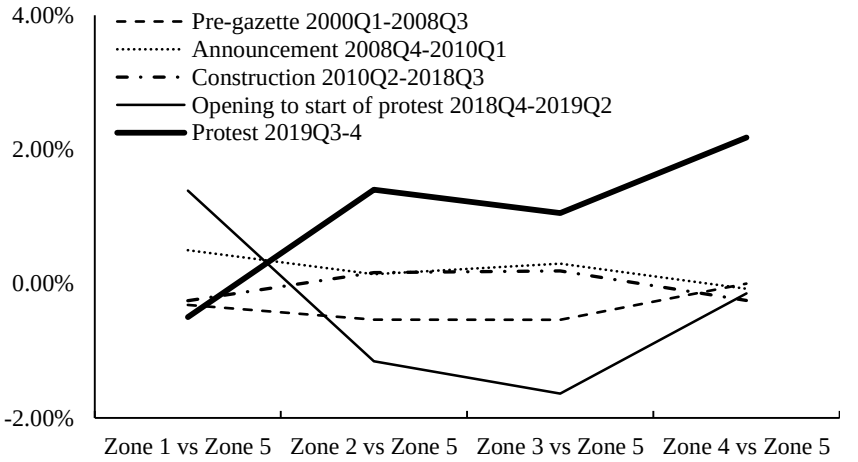


Figure 7 Price Difference between Zones 1 to 4 and Zone 5



During the construction phase, Zone 1 had a slower price increase compared to the other zones. Upon opening of the station, the price gradient is increased and only Zone 1 enjoyed a price increase whereas the other zones suffered from a drop in price. The accessibility effect of the station might be underestimated prior to the completion of the project, and the construction nuisance ceased after the opening of the station, thus leading to an upward adjustment of price in Zone 1 relative to the other areas. In the period of social unrest, Zone 1 experienced the greatest reduction in price compared to the other zones. The price decrease in Zone 1 is 0.5% more than the control zone, which supports Hypothesis 2 that the protests adversely affected properties closer to the station more than those further away.

Table 3 Two-sample T-tests on Price Index Differentials between Zones 1 to 4 and Zone 5

	Zone 1 vs Zone 5	Zone 2 vs Zone 5	Zone 3 vs Zone 5	Zone 4 vs Zone 5	Zone 5
Mean	2.2044	2.1830	2.1908	2.4374	2.4306
Variance	0.3804	0.4814	0.4709	0.4799	0.5092
***T*-statistic**	-1.6093	-1.6689	-1.6255	0.0454	
P-value	0.0556	0.0493	0.0538	0.4819	

6.3 Summary of Findings

Both the hedonic and repeat sales models show supportive evidence for the two hypotheses proposed. Regarding Hypothesis 1, the hedonic model shows that the price gradient with respect to distance from the station in the pre-

announcement period was -0.66% per km and became -3.94% in the announcement period, a change of -3.28%. The increase in the price gradient implies that the anticipated accessibility premium has been capitalised into property prices. The repeat sales model shows that the expected location premium is 0.50% in Zone 1 relative to Zone 5, which supports the rational expectation proposition in this study.

In the construction period, the hedonic model shows that the price gradient flattened by 2.45% per km relative to the announcement period and became -1.49% per km. Zone 1 suffered from a price discount of -0.25% compared to the control zone, as shown by the repeat sales model. Apart from the construction nuisance at the station site, which is a major factor identified in the literature (Dube et al., 2011, Landis et al., 1994), the widespread media coverage on the substantial delay in completion and extensive cost overrun raised public concern. The initial cost estimated by the government was HK$65 billion (USD 8.39 billion) in 2010, but the actual cost turned out to be HK$85.3 billion (USD 11.01 billion). The abrupt announcement of extensive delay in completion by the MTR Corporation Limited (MTRCL), the general construction contractor, also caught the public (and even the government itself) by surprise. The project was originally scheduled for completion in 2015, but was postponed to 2018. Also, as properties in Zone 1 are located very close to the station, traffic disruptions, as well as noise and air pollution caused by the construction are non-negligible externalities from the XRL project. In fact, the negative externalities of infrastructure projects on property prices have been well documented in the literature (Kilpatrick et al., 2007, Swoboda et al., 2015, Theebe, 2004). Therefore, it is not entirely surprising to observe a accessibility discount in Zone 1 during the construction period.

In the operation period, the price gradient slightly increased. The hedonic model suggests that the price gradient was -1.85% per km, a change of -0.37% relative to the construction period, whilst the repeat sales model suggests the effect of actual transportation improvement was 1.39% in Zone 1 relative to Zone 5. It would not be surprising if property prices adjusted in realisation of the ex- post improved accessibility to Mainland China and when the previous concerns of the public regarding cost overrun and co-location arrangement subsided or seemed to be resolved. Nevertheless, as the operation period of the station coincides with the opening of some of the facilities in the West Kowloon Cultural District, the price premium might have been overestimated.

Regarding Hypothesis 2, the hedonic model shows that during the social unrest, the price gradient changed by 2.49% per km relative to the operation period and became 0.64% per km, while there was a price discount of 0.50% in Zone 1 relative to Zone 5 in the repeat sales model. This supports Hypothesis 2 that property prices suffered from a greater depreciation in areas closer to the station. Mainland China has long been a major source of buyers of property in Hong Kong, and accounted for 10-50% of all private residential purchases by value in 2007-2017. The protests in 2019 were accentuated with anti-Mainland China

sentiments. The XRL is seen as a link between Hong Kong and its motherland, China. As the Hong Kong property market is more sensitive to political events than other sectors (He et al., 1998), property prices in West Kowloon, which is particularly coveted by the Mainland Chinese, suffered from a greater reduction compared to other districts during the social unrest.

7. Policy Implications

With reference to the approach adopted by McMillen and McDonald (2004), the aggregate increase in property value post announcement in Zones 1 to 3 is estimated by using the results from the repeat sales model. As not all residential units are sold in a given year, rateable values in Yau Tsim Mong, Kowloon City and Sham Shui Po are obtained from the Rating and Valuation Department. The number of private residential units in these three districts is 329,560 (Rating and Valuation Department, 2020). Rateable values are translated into market values by using the sample average ratio of price to rateable value of 49 (i.e. sample average rental yield is 2%). Thus, the aggregate residential property market value in Zones 1 to 3 is calculated to be HK$1.4 trillion (in 2008$; $180.65 billion).

From the repeat sales model, the weighted average of the difference in the appreciation rate of price in the post-announcement period is 2.5%, which means that the appreciation rate of properties in Zones 1 to 3 was 2.5% higher than comparable properties more than 6 km away from the station. Hence, the aggregate increase in property value due to the transportation intervention is HK$34.6 billion (in 2008$, USD 4.5 billion). Using the consumer price index (Census and Statistics Department, 2019), the aggregate increase in market value (in 2018$) is HK$46.6 billion (USD 8.39 million), which is approximately 55% of the project construction cost of HK$85.3 billion (USD 11.01 billion). However, the aggregate increase may be underestimated if the effect of the XRL extends beyond 6 km from the station.

Given the scale of the Hong Kong section of the XRL, the advantages brought about by the XRL are far-reaching. The direct economic benefit of the project is the effect of enhanced connectivity to Mainland China, which is estimated to be HK$46.6 billion (USD 8.39 billion). Also, the transportation infrastructure bestows time-saving benefits to passengers, which are estimated by the government to be 42 million hours, i.e. HK$87 billion (USD 11.2 billion), over a 50-year period. The enhanced cross-boundary accessibility can help reinforce the status of Hong Kong as the southern gateway to Mainland China and the Greater Bay Area.

Quantifying the spatial variations in property prices owing to transport improvements can guide authorities in urban planning design. Zheng et al. (2019) find that high-speed rail stations in 97 Chinese cities have strong spatial

spillover effects. Similarly, it can be expected that significant spillover effects also exist in West Kowloon. The XRL acts as a catalyst for generating business opportunities, spurring commercial, retail and cultural activities and assisting tourism and hotel sectors in areas around the station. Due to increased connectivity, collaboration between Hong Kong and other Mainland Chinese cities becomes easier, benefiting the four pillar industries of Hong Kong, namely financial services, trading and logistics, tourism, and producer and professional services. Furthermore, synergies are created between the West Kowloon Station and the nearby West Kowloon Cultural District – as the station has direct access to the cultural district, it can facilitate more visits to the arts and tourism facilities, thus enhancing the status of the district as a regional cultural hub, which would in turn attract more Mainland Chinese visitors to Hong Kong via the XRL. Thus, careful planning of land use and public investments are required to optimise the accessibility benefits brought about by the XRL.

Given the significant economic benefits, it is justifiable for governments to invest in transportation developments. However, the high cost of construction may be a cause of concern in terms of public finance. Thus, land value capture policies are important in funding transport infrastructure developments. Infrastructure projects, such as the West Kowloon project, generate positive externalities to property values in the vicinity, which would become windfall gains for related property owners. Land value capture schemes seek to identify and capture these value increases (Mathur, 2016).

The most effective way for the Hong Kong government to capture land value increases and meet transport funding needs is through land sales. A large proportion of government revenue comes from land sales. For instance, land sales accounted for 27% of government revenue in 2018, whereas profits tax accounted for 22%. Thus, revenue from land sales has long been a major source of funding for infrastructure projects (Yiu and Wong, 2005). It allows Hong Kong to maintain a fiscal balance despite having one of the lowest tax rates and levies in the world. This study sheds light on the temporal and geographical variations in private residential property prices due to a massive transport infrastructure project, which helps authorities to more accurately price future government land sales for similar transport developments and better predict future cash flows.

However, when it comes to transport infrastructure projects, governments may not have to provide all the funding. The rail plus property ("R+P") development business model adopted by the MTRCL in Hong Kong is an example. The MTRCL is responsible for constructing, financing and operating the mass transit system in Hong Kong. The government grants development rights to the MTRCL on some of the station sites at prices based on "before rail" land values. By developing the land around the station sites, the MTRCL can fully capture the accessibility premium and capitalise it into property prices, which would allow the MTRCL to cover the construction costs of railway projects (Cervero

and Murakami, 2009). This study provides a theoretical basis for the government to determine real estate premium returns, and thus the "before rail" land values, which can support the R+P model design and implementation.

8. Conclusion

The purpose of this study is to investigate the expected and actual effects of the West Kowloon Station project on property prices within 10 km of the station from 2000 to 2019. Unlike the majority of transport-related literature, this study employs both the hedonic and repeat sales models to examine the temporal and spatial variations in property prices. This study differentiates itself by exploring the price changes throughout the entire timescale of the project, including the period of social unrest.

The results are in line with conventional urban economic theories and confirm the two hypotheses of this study. First, the announcement of the project generated a location premium for properties closer to the station, thus indicating an increased preference for residential properties in proximity to the station. Both the hedonic price and repeat sales models show that there is a significant increase in willingness to live closer to West Kowloon due to the development of the XRL. Also, the properties closest to the station exhibit a greater price appreciation than those further away, as illustrated by the increases in the price gradient in the hedonic price model estimates and the repeat sales indices among the five zones. The accessibility premium was the lowest in the construction period due to public concerns about cost overrun, delays in completion, and pollution and inconveniences caused by the construction. However, the premium improved in the operation period owing to the materialisation of actual accessibility improvements.

However, the political unrest in 2019 caused properties in the vicinity of the station to depreciate at a faster rate. For example, the hedonic price models show a price discount of 0.6% per km within 6 km of the station and 0.5% within 2 km of the station relative to the control zone. The repeat sales indices among the five zones also reveal a similar pattern. The XRL project is effectively "the link between east and west", bringing Hong Kong and China closer together. Since in recent years, most of the foreign buyers of properties in Hong Kong are from China and account for a major share of all property transactions in Hong Kong, the "link" could be a blessing or a curse in terms of property prices in the vicinity of the West Kowloon Station. Before the protests, the XRL provided incentives to buyers from Mainland China to choose areas close to the West Kowloon Station. After the protests which are aimed at the Hong Kong and Chinese governments and even the Mainland Chinese themselves, there are incentives for the Mainland Chinese who own properties in Hong Kong to sell and disincentives for would-be Hong Kong property owners from China to avoid buying.

As the XRL is one of the most expensive infrastructure undertakings in the history of Hong Kong, it has significant practical implications for the design and implementation of land value capture schemes and urban planning. The findings of this study provide policymakers with insights into the significant magnitude of aggregate accessibility premium, which is estimated to be HK$46.6 billion (in 2018$, USD 8.39 billion), i.e. an average increase of HK$141,282 (USD 18,229) per property, as a result of the West Kowloon project. As this study only focuses on the West Kowloon Station of the XRL, it would be insightful to study the accessibility premiums in other stations along the XRL in Mainland China, thus offering an overview of the total price premium generated from the development of the XRL.

Our analysis also sheds light on the significant impact of political uncertainty in the property market of Hong Kong. As the link between the east and west, the effect of the XRL on property prices in nearby neighbourhoods depends on the nature of the relationship between Mainland China and Hong Kong. When the relationship is cosy, i.e., during Periods 1 through 3, there is an east-west connection premium attached to properties nearby the West Kowloon Station. However, when there is tension between Mainland China and Hong Kong during the political unrest period, proximity to the station actually attracted a price discount. This demonstrates that the degree of connectivity and sensitivity of the Hong Kong property market to Mainland China. This is a factor that both policy makers and investors should bear in mind when making decisions about the property markets in Hong Kong.

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