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The Effects of Expected Transport Improvements on Housing Prices

C. Y. Yiu and S. K. Wong

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Summary. Improvements in transport were commonly found to have a positive effect on the price of housing. As the construction of infrastructure often lasts for years, it is plausible to assume that investors will take expected improvements into consideration when pricing and trading neighbourhood properties. However, there have been few investigations of such effects. This paper is an empirical study of whether premiums were paid for the expected benefits offered by a new tunnel before its completion. The results showed that there were positive price expectation effects well before the completion of the tunnel. The expectation effects allow the government to finance infrastructure projects by selling land in the affected districts in advance.

Introduction

Improving transport in a certain district helps to enhance accessibility by reducing both transport costs and commuting time. It is commonly believed that better transport links will bring benefits to nearby residents so that a premium will be reflected in housing prices. The belief was intensively studied and many empirical tests conducted using the hedonic pricing model with cross-sectional data revealed that there is a positive implicit price for better transport facilities. However, there have been very few intertemporal studies on the effects of improvements in transport on housing prices. Since the planning, design and construction of infrastructure usually take a very long time, it is plausible to posit that the effects on price should appear well before the completion of the project. This is because, under market competition, home-buyers will evaluate property prices on the basis of rational expectations. All information will be taken into consideration, including the expectation of the improvements in transport in the future. Bidders with higher expectations will outbid those with lower expectations, *ceteris paribus.*

In this study, we will carry out an empirical test to examine the effects of expected improvements in transport on housing prices. Both price index construction and price gradient analysis will be adopted for estimation and testing.

Literature Review

The importance of transport costs to property prices was raised by von Thünen (1826). Then, Haig (1926), Alonso (1965), Muth (1969) and Evans (1973) further developed their own urban economic models. Their

C. Y. Yiu is in the Department of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong. Fax: 852 2764 5131. E-mail: bscyyiu@polyu.edu.hk. S. K. Wong is in the Department of Real Estate and Construction, The University of Hong Kong, Pokfulam, Hong Kong. Fax: 852 2559 9457. E-mail: skwongb@hkusua.hku.hk. *The authors wish to thank the three anonymous referees for their comments, especially on the specifications of the models. The work described in this paper was fully supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China, Project No. RGC Ref. No. PolyU5119/03E.*

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models of urban rent predict that land values are derived from accessibility and transport costs. Miller (1982) reviewed some of the earliest empirical tests on the effects of transport on housing values and found a clear negative relationship between transport costs and housing values. Many recent studies on polycentric models have also stressed the importance of transport effects (Dubin and Sung, 1987, for example). Bajic (1983) found that the benefits of living in the vicinity of subway stations in Toronto, Canada, were capitalised into housing values. Cheshire and Sheppard (1995) showed that transport networks had a great impact on land prices in Darlington, UK.

In Hong Kong, So *et al.* (1997) studied the effects of public transport on housing prices. They found that the availability of subway stations produced significant positive price effects. RICS (2002) conducted a detailed review of about 150 recent studies on the issue of land values and public transport in the US and Canada. The review found overwhelming support for the hypothesis that the provision of a means of transport had a positive effect on land values. Besides the availability of a means of transport, improvements in transport also had strong positive effects on prices (Coulson and Engle, 1987; Damm *et al.*, 1980; Dewees, 1976; Goldberg, 1972; Poon, 1978; Stucker, 1975; Williams, 1989; Lai, 1991; Laakso, 1992; Chau and Ng, 1998; and Henneberry, 1998).

However, these studies focused only on the price effects of improvement works after they were completed. Almost all of them ignored the effects of *expectations* on property prices. In fact, Chau and Ng (1998) argued that expectations of transport improvements would be reflected in property prices before the actual completion of the improvements. RICS (2002) also highlighted the importance of expected improvements in transport infrastructure. Nevertheless, throughout the 150 studies reviewed, it was apparent that very few attempted to study the effects of expectations. For example, Henneberry (1998) found that housing prices fell after the announcement of the construction of tram lines. Henneberry argued that the negative impact was due to the anticipated nuisance caused by the construction works. But he ignored the possible expectation effects of the future enhancement of transport.

There have been a number of studies on expectations in the areas of finance and real estate. Cagan (1956) developed an adaptive expectation model, which assumed that people are backward-looking when forming their expectations. Many empirical studies (for example, Mullineaux, 1978; Poterba, 1984; DiPasquale and Wheaton, 1994) supported the adaptive expectation hypothesis. However, their conclusions were drawn from the econometric analysis of macroeconomic time series and any supporting evidence adduced may simply be the results of misspecification (Clayton, 1997; and Tsolacos and McGough, 1999). Muth (1961) proposed a rational expectation model, which argued that people would base their forecasts on all of the information available rather than simply on past information. Numerous attempts, such as those by Beladi *et al.* (1993), Revankar (1980), Shaw (1984), Lovell (1986), Abebayehu and Frederick (1993), Clayton (1996, 1997), Tsolacos and McGough (1999) and Hui and Lui (2002), have been made to test the rational expectation hypothesis econometrically on macroeconomic time series. Instead of arguing which model is correct, this paper adopts a panel data approach to let the data show when the price expectation effects are formed.

This study attempts to identify directly the effects of expected transport improvements on housing price. We posit that the timing of the effects depends on three factors: namely, the expected benefits of the transport improvements; the costs of bearing the nuisance of construction; and, the information cost of the improvements. At zero information cost, if the benefits exceed the costs, a price increase will occur even before the completion of the improvement works. Yet, a non-zero information cost may result in backward-looking behaviour and delay the price change.

Hedonic Price Modelling Approaches

Many previous studies have made use of the simple hedonic pricing model to measure the price effects of improvement works. In cross-sectional studies, a location dummy was added to measure the price of an improved property relative to an unimproved one. This approach is usually problematic because the location dummy may have captured property-specific effects other than those from transport improvements. To alleviate this problem, some studies have adopted an intertemporal approach by using a time dummy to measure the change in property prices after the improvement works have been completed. However, such an approach has at least two drawbacks. First, the designation of a particular completion date to test the price effects ignores price expectations. Secondly, in order to control for other time-varying effects (such as changes in economic conditions), the method requires the adoption of an 'external' price index to deflate the nominal prices. That is, the price index is estimated from housing transactions in other districts, which may not represent the general changes in price in the district being studied. Since both the cross-sectional and intertemporal approaches have their own limitations, Chau and Ng (1998) proposed a price gradient approach, which uses a location–time interaction term to measure the discrete change in price gradients between an improved property and an unimproved property after the improvement works have been completed. Their idea is useful and sound, but their empirical analysis still relied on an 'external price index' as a deflator.[1]

In this study, we extend the price gradient approach in several ways. First, we allow multiple changes in price gradients over time so that the effect of price expectations can be identified. Secondly, we allow transport improvements to affect the property price of more than one location. Thirdly, we estimate our hedonic pricing model simultaneously with price indices (time trends) so that an 'external' deflator is not needed. By keeping track of the changes in price gradients over time, our extended price gradient approach not only identifies the actual effects of transport improvements, but also their expected effects prior to completion.

Data

To use the hedonic pricing model, a large number of transactions and their corresponding housing attributes, including locational and environmental factors, are required. Fortunately, the housing transaction volume in Hong Kong has been high, due to the economic growth of the 1990s. In 1997, for instance, about 205 000 residential property transactions were registered in Hong Kong. Thus, the data requirement of the model can be satisfied.

Our focus is on how the development of a new cross-harbour tunnel, called the Western Harbour Tunnel (WHT), affected housing prices in Hong Kong. In order to reduce the number of independent variables used in the hedonic pricing model, we selected two very compact districts: Sheung Wan and Sai Ying Pun, which are the two major sub-districts of the Central and Western District in Hong Kong. In mid 1999, the Central and Western District had a residential population of about 267 000 (plus a transient population of about 300 000) and an area of about 1240 hectares (District Council, 2003). The compactness of the two sub-districts minimises the differences in environment and facilities. Furthermore, over 90 per cent of the population in the district resides in private housing (District Council, 2003), so the effects of public housing on private housing prices can almost be eliminated. Most importantly, Sheung Wan and Sai Ying Pun are fully developed districts on Hong Kong Island, so that the issue of the effects of housing supply on prices raised by Ball (1973) can be ignored.

The construction of the WHT began in August 1993 and was completed in April 1997.[2] The WHT infrastructure project was part of the Chek Lap Kok Airport Core Programme. The WHT, which connects western Hong Kong Island and the West Kowloon reclamation area, is the third cross-harbour tunnel to have been built in Hong Kong. Figure 1 shows the location of the WHT and its vicinity on Hong Kong Island. We divided the area within the two sub-districts into six smaller 'zones' to evaluate whether changes in price gradients, if any, are associated with distance to the tunnel entrance. The division of zones, although arbitrary, allows a non-linear bid-rent curve to be estimated.[3] Each zone is about 200 metres in diameter in order to cover fully the in-between areas. On the Hong Kong Island side, the entrance/exit point of the WHT is located in the Sai Ying Pun district (Zones 4–6), as shown in Figure 1. The Sheung Wan district (Zones 1–3) is the outer rim of the central business district of Hong Kong and is connected to the terminus of the Island Line of the subway—the Mass Transit Railway (MTR).[4] In other words, Zone 1 lies closest to the MTR station and farthest away from the new tunnel, whereas Zone 6 lies farthest away from the MTR station and closest to the new tunnel. Bus is the major public transport means between the two ends. Each zone represents approximately the location of a bus stop along the main road. Property prices among the six zones are therefore theoretically different in the light of the difference in transport costs.

Since the other two cross-harbour tunnels have reached their full capacity, the new WHT should make travel across the harbour much easier. If the construction of the WHT is beneficial to residents around the Sai Ying Pun district (Zone 6), then property prices in the district should increase, *ceteris paribus.* However, was this expectation for improvement capitalised into housing values before the completion of the construction work?

Transaction data for housing units in the Sheung Wan and Sai Ying Pun districts from May 1991 to March 2001 were collected. There were 2095 valid transactions during this period. The data were divided into three periods: from May 1991 to July 1993

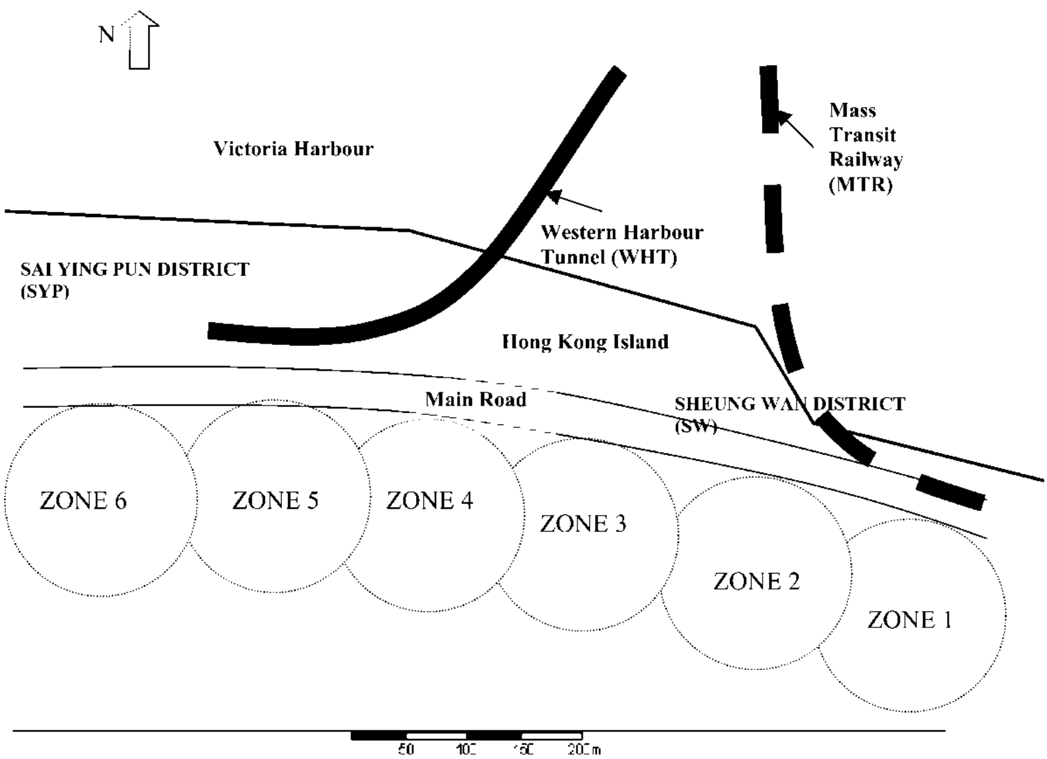

Figure 1. Site map of Zone 1–6 on Hong Kong Island.

(P1: 9105–9307); from August 1993 to April 1997 (P2: 9308–9704); and from May 1997 to March 2001 (P3: 9705–0103). P1, P2 and P3 represent the pre-construction period, the construction period and the post-construction period of the project respectively. Table 1 shows a summary of statistics drawn from the data, which include transaction prices, building age, floor levels and flat size. It also shows that the number of transactions among the six zones is quite evenly distributed.

Price Index Construction

Housing price indices measure the price changes of a group of properties over time, whereas housing price gradients measure the price differentials of different groups of properties at a point in time. These two concepts are interrelated, for the differential between the price indices of two groups of properties gives their price gradients over time.

The housing price indices of Zones 1–6 were constructed by the semi-logarithm[5] hedonic pricing model defined by equation (1) below, which was estimated by the ordinary least-squares-technique

$$\ln P = \alpha_1 + \alpha_2 AGE + \alpha_3 SIZE + \alpha_4 FLOOR + \sum_{i=1}^{6}\sum_{t=1}^{119}\beta_{i,t} Z_i D_t + \varepsilon_1 \qquad (1)$$

where, $P =$ the nominal transaction price of the transacted property in HK dollars;

Table 1. Key property transaction data

	Minimum	Maximum	Mean	Standard deviation
Zone 1: May 1991–March 2001 (207 transactions)				
PRICE (HK$ million)	0.35	2.72	1.55	0.48
SALEABLE AREA (sf)	212.00	689.00	350.43	60.78
FLOOR	1.00	22.00	10.14	5.73
AGE (months)	42.00	413.00	160.53	91.63
Zone 2: May 1991–March 2001 (474 transactions)				
PRICE (HK$ million)	0.55	3.87	1.53	0.58
SALEABLE AREA (sf)	251.00	618.00	341.62	77.17
FLOOR	1.00	25.00	13.17	6.70
AGE (months)	26.00	414.00	162.07	64.17
Zone 3: May 1991–March 2001 (510 transactions)				
PRICE (HK$ million)	0.50	4.43	1.77	0.77
SALEABLE AREA (sf)	114.00	1356.00	392.73	143.16
FLOOR	1.00	25.00	12.30	5.74
AGE (months)	53.00	361.00	149.78	69.06
Zone 4: May 1991–March 2001 (314 transactions)				
PRICE (HK$ million)	0.44	3.35	1.52	0.57
SALEABLE AREA (sf)	174.00	875.00	390.34	114.87
FLOOR	1.00	27.00	12.33	6.94
AGE (months)	1.00	385.00	210.97	111.11
Zone 5: May 1991–March 2001 (276 transactions)				
PRICE (HK$ million)	0.46	2.98	1.52	0.51
SALEABLE AREA (sf)	240.00	428.00	327.74	38.45
FLOOR	1.00	24.00	10.87	6.80
AGE (months)	0.00	322.00	107.07	98.86
Zone 6: May 1991– March 2001 (314 transactions)				
PRICE (HK$ million)	0.40	2.92	1.42	0.49
SALEABLE AREA (sf)	164.00	580.00	289.46	72.08
FLOOR	1.00	23.00	12.20	6.23
AGE (months)	1.00	226.00	97.82	54.93

AGE = the age of the transacted property in months, which equals the difference between the date when the Occupation Permit was issued and the date of the transaction; $SIZE$ = the saleable floor area of the transacted property in square feet; $FLOOR$ = the floor level (height) of the transacted property by the number of storeys; D_t = time dummy variables that equal 1 when the property was transacted at time t (in months) and zero if otherwise, where $t = 1, 2, \ldots, 119$; Z_i = zone dummy variables that equal 1 when the transacted property is located in Zone i and zero if otherwise, where $i = 1, 2, \ldots, 6$; α_k, $\beta_{i,t}$ = the coefficients to be estimated; $k = 1, 2, 3$ and 4; and ε_1 = the stochastic term.

The coefficient α_1 serves as the intercept, while α_2 to α_4 capture the marginal effects of building age, flat size and floor level respectively. The AGE coefficient is expected to be negative due to deterioration. The coefficients of $SIZE$ and $FLOOR$ are expected to show positive effects. The coefficients $\beta_{i,t}$ represent the housing price indices of different zones. It should be noted that the use of dummy variables requires normalisation. We take the price index value of Zone 1 in May 1991 as the reference point so that Z_1D_1 was not entered into equation (1).

We only included three physical attributes in this study because of the relative homogeneity of other unmeasured housing characteristics in Hong Kong. For example, there is virtually no difference in the number of bedrooms and bathrooms for flats of the same size. This high degree of homogeneity has also been recognised in other hedonic studies of Hong Kong housing markets, such as those by Mok *et al.* (1995), So *et al.* (1997) and Tse and Love (2000). Their models obtained a very high explanatory power even using only a few physical attributes. Furthermore, in the Central and Western District, commercial properties block the harbour view of almost all residential properties. Therefore, the view variable does not affect the properties in our sample.

It is noteworthy that equation (1) does not require the use of an 'external' price index. The coefficients $\beta_{i,t}$ will automatically capture the common price changes within each zone. After constructing the price indices, the price gradients between any two zones can be calculated by differencing their respective index values for a given time-period. We will use t-tests to verify whether the development of the WHT resulted in any significant changes in price gradients.

Results: Price Index Construction

The results of equation (1) are shown in Table 2. Most of the coefficients are highly significant. Only 19 coefficients out of the 600 coefficients are not significant at the 10 per cent level. For the physical attributes,

Table 2. Results of the price index construction method

Independent variables[a]	Coefficients	T-statistics	P-value
Constant	−0.8471	−22.83	0.0000
AGE	−0.0016	−17.84	0.0000
SIZE	0.0022	22.92	0.0000
FLOOR	0.0071	10.52	0.0000
Adjusted R^2		0.83	
DW statistics		1.83	
Number of observations in White heteroscedasticity-consistent standard errors and covariance		2095	

[a]Results of time dummy coefficients are omitted but plotted in Figure 2.

the coefficients of *AGE, SIZE* and *FLOOR* are significant at the 1 per cent level with the expected signs. The explanatory power of the regression is also reasonably high (adjusted $R^2 = 83$ per cent), confirming that the three physical attributes we used have captured most of the variations in prices.

Figure 2 shows the housing price index, calculated as $\exp(\beta_{i,t})$, of each zone. The indices are plotted in the form of contours because the contour surface in effect depicts the price gradients over time. From the graph, we observe that both the indices and gradients change over time, but it is visually very difficult to discern any significant changes in price gradients.

To produce a more discernable graph, we extracted the price gradients of Zones 1 and 6 and plotted them in Figures 3 and 4. These two zones were chosen because they are the farthest apart and should have the steepest (and thus more discernable) price gradients. The graph shows that the price gradient in the pre-construction period (P1: 9105–9307) is more or less the same as that in the construction period (P2: 9308–9704), but the price gradient becomes flatter in the post-construction period (P3: 9705–0103). The results from the *t*-tests, as shown in Table 3, confirm these observations. Panel A of Table 3 found no statistically significant difference (at the 10 per cent level) between the price gradients of P1 and P2, but that the price gradient of P2 is significantly steeper than the price gradients of P3. In other words, the price gradient was flattened only after the completion of the WHT. Before its completion, the *t*-test result cannot statistically show the existence of any price expectation effect. This is probably because of the nuisance caused by the construction works in Zone 6.

As mentioned before, potential investors should, on the one hand, try to minimise the construction nuisance and, on the other hand, attempt to bid for the potential benefits of transport improvements under market competition. This argument can be verified by finding a cut-off period in which the benefits outweigh the costs. Panel B of Table 3 gives

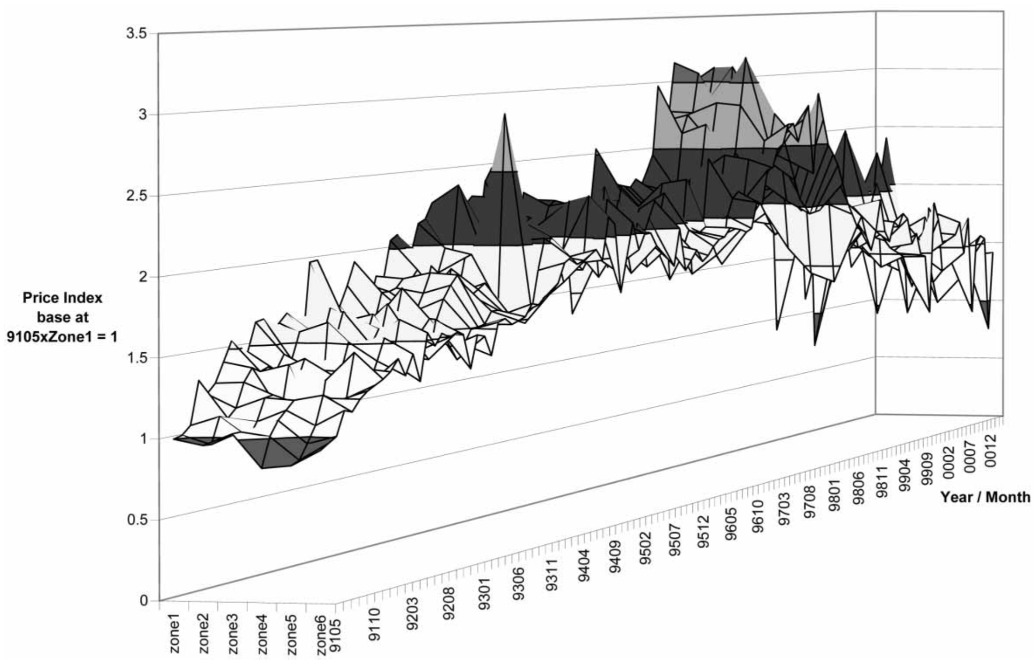

Figure 2. Price contours Zones 1–6 on Hong Kong Island, May 1991–March 2001.

Figure 3. Price indices of housing in Zone 1 and Zone 6. *Note*: Missing points refer to those periods when there were no valid housing transactions in either Zone 1 or Zone 6.

the results. We found that there is a significant difference between the price gradients of periods 9105–9412 and 9501–9704, but no significant difference between the price gradients of periods 9501–9704 and 9705–0103. In other words, the expectations of improvement have been capitalised into housing prices well before the completion of the construction work, although not necessarily at the commencement of construction.

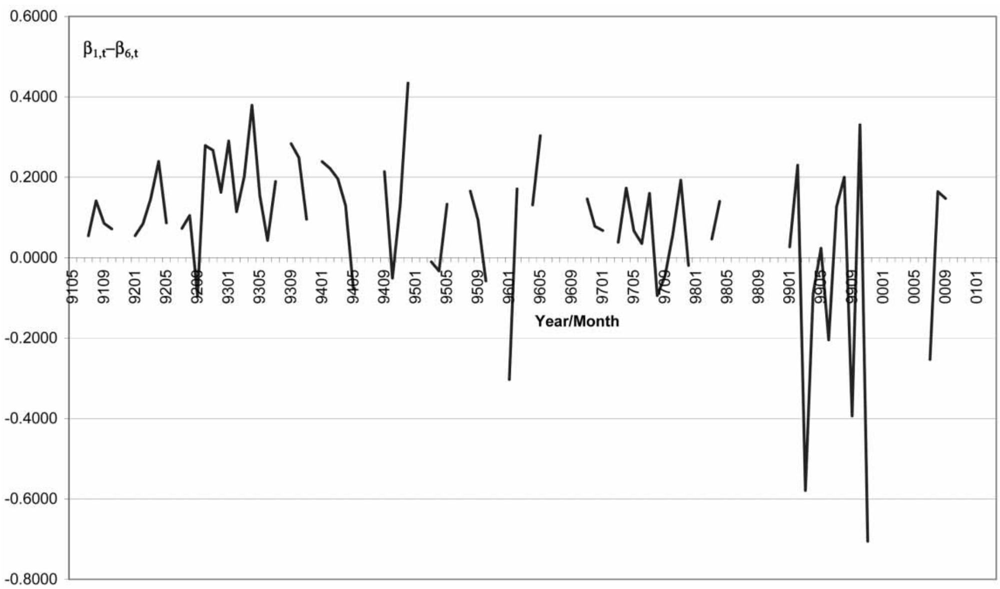

Figure 4. Price gradients between Zone 1 and Zone 6. *Note*: Missing points refer to those periods when there were no valid housing transactions in either Zone 1 or Zone 6.

Table 3. *T*-test on the price differentials between Zone 1 and Zone 6: two-sample assuming unequal variances

	Period		
Panel A	9105–9307	9308–9704	9705–0103
Mean	0.1385	0.1087	0.0035
Variance	0.0108	0.0227	0.0712
Observations	23	29	27
Hypothesised mean difference	0		0
Degrees of freedom	49		40
T-statistic	0.8426		−1.7974
P ($T <= t$) one-tail	0.2018		0.0399
T Critical one-tail	1.6766		1.6839
Panel B	9105–9412	9501–9704	9705–0103
Mean	0.1500	0.0639	0.0035
Variance	0.0136	0.0210	0.0712
Observations	35	17	27
Hypothesised mean difference	0		0
Degrees of freedom	26		41
T-statistic	2.1343		−0.9702
P ($T <= t$) one-tail	0.0212		0.1688
T critical one-tail	1.7056		1.6829

The Extended Price Gradient Approach

The above analysis separates the estimation of price indices and the computation of price gradients into two stages. In fact, they can be combined into a single estimation using our extended price gradient approach, which pools the full set of panel data, including all zones and all time-periods, for the joint estimation of price indices and price gradients. This extended approach is preferred to the two-stage approach in terms of statistical efficiency, among others. It was estimated by the semi-logarithm hedonic pricing model defined by equation (2) below using the ordinary least-squares technique

$$\ln P = \phi_1 + \phi_2 AGE + \phi_3 SIZE + \phi_4 FLOOR + \sum_{t=2}^{119} \gamma_t D_t + \sum_{i=2}^{6} \lambda_i Z_i + \sum_{i=2}^{6} \sum_{p=2}^{3} \theta_{i,p} Z_i T_p + \varepsilon_2 \qquad (2)$$

where, P, AGE, $SIZE$, $FLOOR$, D_t and Z_i have the same definitions as before; T_p are period dummy variables, which equal 1 when the property was transacted during period p, and zero if otherwise; $p = 1$ stands for the pre-construction period (9105–9307), $p = 2$ stands for the construction period (9308–9704) and $p = 3$ stands for the post-construction period (9705–0103); ϕ_k, γ_t, λ_i and $\theta_{i,p}$ are the coefficients to be estimated; $k = 1, 2, 3$ and 4; and ε_2 is the stochastic term.

Similar to equation (1), the coefficient ϕ_1 serves as the intercept and the coefficients ϕ_2 to ϕ_4 capture the effects of physical attributes. The three terms with the summation operator are the innovations made by equation (2). First, a price index, γ_t, was used to capture the price trends that are common to all six zones. Each γ_t ($t > 1$) was measured relative to the base period at $t = 1$ (i.e. month 9105), for D_1 was taken out of the equation for normalisation. Secondly, a location index, λ_i, was used to capture the price variations of the six zones due solely to locational differences. It can be interpreted as the price gradient in P1, which is the pre-construction period. Since Z_1 was not entered into the equation, each λ_i ($i > 1$) was measured relative to the base location (i.e. Zone 1). Thirdly, the coefficient $\theta_{i,p}$ was used to estimate any zone-and-period-specific variations in prices that had neither been captured by the price index nor by the location index. In our case, these uncaptured price variations, if any, are attributed to the differential effects exerted by the development of the WHT on each zone and in each time-period. Therefore, the coefficients $\theta_{2,p}$ to $\theta_{6,p}$ in effect represent the differential movement of the price gradient in period p ($p > 1$) relative to the price gradient in P1. In other words, the price gradient in period p is simply $\lambda_i + \theta_{i,p}$. Again, the interaction term Z_1T_1 is dropped out for normalisation.

Results: the Extended Price Gradient Approach

Table 4 presents the results of equation (2). Even though far fewer variables were used in equation (2) than in equation (1), the explanatory power of equation (2) still attained 82 per cent. The three physical attributes are also highly significant at the 1 per cent level, with the same signs and almost the same magnitudes as the estimates in equation (1). Most importantly, the coefficients of the zone dummies are negative and significant, indicating that properties in Zones 2–6 were sold at a discount to the properties in Zone 1 in the pre-construction period. This is consistent with the fact that Zone 1 is closer to the MTR and enjoys better accessibility. These differential locational effects also justify the segmentation of the two districts into six smaller zones.

Figure 5 plots the price gradients from Zones 1–6 over the three periods. In general, all three price gradients show a downward trend. However, during the construction period of August 1993–April 1997 (9308–9704), the price gradient in P2 became less steep than that in P1, implying an expectation effect on the price of the improvements in

Table 4. Results of the extended price gradient approach

Independent variables[a]	Coefficients	*T*-statistics	*P*-value
Constant	−0.8250	−18.66	0.0000
AGE	−0.0017	−23.92	0.0000
SIZE	0.0023	25.48	0.0000
FLOOR	0.0068	11.33	0.0000
$Z_2{}^*T_2$	0.0513	1.69	0.0915
$Z_2{}^*T_3$	0.1224	3.22	0.0013
$Z_3{}^*T_2$	0.0612	1.71	0.0883
$Z_3{}^*T_3$	0.0978	2.30	0.0216
$Z_4{}^*T_2$	0.0144	0.37	0.7082
$Z_4{}^*T_3$	0.0495	1.11	0.2665
$Z_5{}^*T_2$	0.0643	2.00	0.0456
$Z_5{}^*T_3$	0.0717	1.61	0.1079
$Z_6{}^*T_2$	0.0406	1.28	0.1991
$Z_6{}^*T_3$	0.1006	2.53	0.0115
Z_2	−0.0742	−3.98	0.0001
Z_3	−0.0953	−3.85	0.0001
Z_4	−0.1008	−3.71	0.0002
Z_5	−0.1564	−7.49	0.0000
Z_6	−0.1361	−6.47	0.0000
Adjusted R^2		0.82	
Number of observations in White heteroskedasticity-consistent standard errors and covariance		2095	

[a]Results of time dummy coefficients are omitted for simplicity.

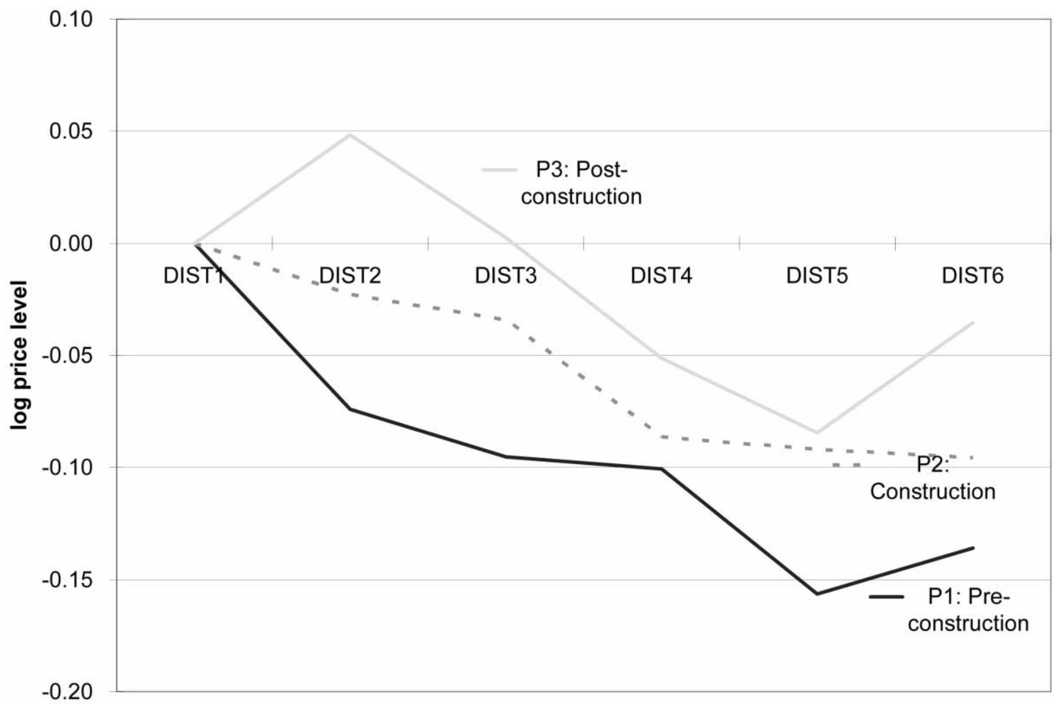

Figure 5. Price gradients between Zone 1 and Zone 6.

transport. The overall price increase in this period was very minimal in light of the expected construction nuisance. As can be seen from Table 4, only the price gradient for Zone 5 shows a significant increase at the 5 per cent level, while the price gradients for Zones 2 and 3 are only marginally significant at the 10 per cent level. After the completion of the WHT (Period 9705–0103), the price gradient became even flatter. Significant rises in the price gradients were observed in more zones (i.e. Zones 2, 3 and 6) at the 5 per cent level. This meant that Zone 6 became much more attractive to home-buyers, probably due to improvements in transport and the removal of the construction nuisance.

Conclusions

Most previous studies have confirmed the positive price effect of improvements in transport on neighbourhood residential properties. However, very few studies have focused on the expectation effects of such improvement works on housing prices, although rational expectations have been commonly recognised. It is implausible to assume that the effects of improvements exist only after their completion. We have put forward two methods, the price index construction method and the extended price gradient approach, to identify the price effects due to expected and actual improvements. The two methods can be considered the two sides of the same coin, although the latter one is preferred in terms of statistical efficiency. The area is divided into six zones for price gradient analysis. First, we found that there are six significantly different price gradients in the six zones before the price capitalisation effect. Secondly, our results also showed significant increases in price well before the completion of the works, although not necessarily at the commencement of the works. This lends support to the rational expectation proposition in this microeconomic setting.

Admittedly, the rational expectation proposition is only one convincing explanation for the phenomenon. A time-series study always shares the limitation of events occurring uncontrollably at the same time. For example, Figure 3 shows that the housing market was much more volatile during the post-construction period, probably as a result of the Asian financial turmoil. Any changes in the price gradient may also be produced by other changes in the environment and neighbourhood or changes in consumer tastes. More recently, spatial autocorrelation has also been widely recognised in research. More studies are required to examine these possible explanations.

Our endeavour has two more practical implications. First, the methodologies devised allow the traditional panel data price gradient analysis to be applicable to studies on improvements in transport. Secondly, the findings have far-reaching implications for government policies on land sales. The expectation effects will enable the government to finance infrastructure projects by selling land parcels in the affected districts in advance. This method of raising funds for government infrastructure projects is better than many other project-financing methods, such as issuing government bonds. However, the government of Hong Kong may not have learnt this price capitalisation effect from the previous two tunnels because of insufficient transaction information. In fact, land sales income in Hong Kong has long been a major source of capital funding for infrastructure developments (Wong *et al.*, 1998). It enables a city with almost zero tariffs on imports and very low rates of taxation to survive with world-class infrastructure. As an analogy, the government sells a US call options contract to land bidders who have the right to enjoy the future benefits of improvements in transport. Undeniably, considerable skills and attention to risk management are required to run such a real option market, particularly in a volatile market like Hong Kong.

Notes

1. For example, Chau and Ng (1998) used the price index estimated from the whole territory of Hong Kong to deflate certain districts located in the vicinity of railway stations.
2. The Airport Core Programme was announced in the 1980s. A joint venture, the Western Harbour Tunnel Company Limited, was formed in early 1992. The official dates for the commencement and completion of construction are August 1993 and April 1997 respectively. The construction project cost about US$1 billion (Western Harbour Tunnel Company Ltd, 2003).
3. The division of the two districts into six submarkets is based on the belief that each zone commanded different locational premiums in the pre-construction period. This will be justified by empirical tests later.
4. The MTR is a rapid public rail transport and has become the dominant mode of travel in Hong Kong.
5. The semi-logarithm function is used in the light of the findings from most of the studies on functional form by means of the Box–Cox transformation (Linneman, 1980; Edmonds, 1985; and Mok *et al.*, 1995). Semi-logarithm function also produces a much smaller Akaike criterion (AIC), Schwarz criterion (SC) and sum of squared residues (SSE) estimates than linear and log-linear functions.

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