Chapter 2

Theory and Literature Reviews

2.1 Theoretical framework

There are many studies related to hedonic pricing model which can be derived from Alonso's theoretical framework of the traditional consumer theory which is considered as a basic foundation in modern housing market. Lancaster then proposed a new approach of consumer theory to study on the consumption of the goods. Later Rosen combined with Lancaster's new approach to discuss the hedonic pricing model from the both consumer's and producer's side.

2.1.1 Alonso's theory

Alonso (1964) based on the land market which assumed that housing is a homogeneous product. This study considered that the differences of housing price solely attributed to the distance from the city center. As traditional demand theory, household choices of location and consumption bundles were described by the utility maximization model.

In Alonso's framework, the household was regarded as an individual, who has a certain disposal income, y, that he may spend between land and other goods and services consumed after paying for commuting costs c(t) to the location, where d represents the distance from the city center . The numbers of all other goods and services are packed into one composite good z. The expenditure on this composite good is $p_z z$. From the consumer side, price of land at the any distance t is P(t).

Moreover, the consumer's decision on the quantity of land is q. Thus, the

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expenditure on land is P(t)q. The commuting cost c(t) is assumed to increase with the increase in distance from the city center.

In this model, the household choice of a location and the amount of land depends on the tradeoff between land price and the distance to workplace. The consumer makes a decision by maximizing the utility subject to a budget constraint that includes the costs of housing, costs of transportation to city center and costs of the composite good. The budget constraint would depend on the household income, price of the other goods and price of land. So land, all other composite goods, and the distance to city center which included in the utility function.

The utility maximization function of the household with a combination of z, q, t in the utility function can be expressed as follows:

$$\text{Max } U(z, q, t)$$

Subject to the budget constraint:

$$y=p_z z+P(t)q+c(t)$$

Lagrange function:

$$L= U(z, q, t)+\lambda\{y-p_z z-P(t)q-c(t)\}$$

First Order Condition (FOC):

$$U_Z=\lambda p_z$$

$$U_q=\lambda P(t)$$

$$U_t=\lambda[P(t)q+c(t)]$$

Rewriting yields

$$U_q / U_z = P(t) / p_z \quad (1)$$

$$U_t / U_z = [P'(t)q+c'(t)] / p_z \quad (2)$$

According to the last two equations at equilibrium, the marginal rate of

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substitution between the two goods is equal to the ratio of the marginal costs. Equation (1) shows that the marginal rate of substitution between the consumption of housing and composite goods is equal to the ratio of their prices. Equation (2) indicates that the marginal rate of substitution between the distance to the city center and the consumption of composite goods, with the increasing distance to the city center, the price of land reduces to offset the increased travel costs.

It can be concluded from the Alonso's study of the traditional theory that the price of land increases or decreases with the distance from the center place and declines at a diminishing rate due to the diminishing rate of substitution between the two goods. The competition for central location will bid up the price of sites located closer to the center business district (CBD).

2.1.2 Lancaster's theory

Kelvin J. Lancaster (1966) posed a new approach to consumer theory based on the traditional approach. The traditional theory states that goods are the direct objects of utility and goods are consumed only because that they are goods. In other words, goods are just thought as goods. The new approach posed that the utility of the goods is derived from the several of attributes of the goods. It assumes that consumption, singly or in combination, is inputs, and the output is a collection of characteristics. A product has numerous characteristics, each of which may be shared by other products. The price of a product is constituted by the characteristics of that product.

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The essence of the new approach can be summarized as following three points (Kelvin J. Lancaster, 1966):

1. The good, per se, does not give utility to the consumer; it possesses

characteristics, and these characteristics give rise to utility.

2. In general, a good will possess more than one characteristic, and many characteristics will be shared by more than one good.

3. Goods in combination may possess characteristics different from those pertaining to the goods separately.

2.1.3 Rosen's theory

Rosen (1974) combined Lancaster's new approach with the utility and competition theory, which applied to the heterogeneous product market, claimed that the price of housing is determined by a combination of numerous attributes of the housing unit. Consumers and producers are prone to maximize the utility and profit, respectively. When the price of consumers' willingness to pay (WTP) agrees with the producer's willingness to accept (WTA), the market has an equilibrium price. This price is of concern to both consumers and sellers which determined by the characteristics of housing unit. Rosen measured the amount of the *n* th characteristics exhibited in each good, where z_n is represented by a real-valued vector z = (z_1, z_2, …z_n). In particular, a price p(z) = p(z_1, z_2, …z_n) is defined at each point on the plane and guides both consumer and producer on the locational choices regarding packages of characteristics bought and sold.

(1). *The Consumption Decision: Utility Maximization*

The Consumer's primal problem is utility maximization. Suppose consumers purchase only one unit of a good with a particular value of z. The utility function, U(x, z_1, z_2, …z_n), is assumed to be strictly concave. In addition to the usual properties, where, x is all other goods consumed.

$$\text{Max } U(x, z_1, z_2, \ldots z_n),$$

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Subject to $y = p_x x + p(z)$

Where,

U is utility

x is all other consumption of goods

z_i is the amount of the house attributes , $i = 1,2 \ldots, n$

p_x is the market price of x

p(z) is the total price of the house for the all attributes

Setting the price of x equal to unity, $p_x = 1$, and the measure income y in terms of units of x, one can get the new function $y = x + p(z)$. Maximization of utility subject to the nonlinear budget constraint requires choosing x and $(z_1, z_2, \ldots z_n)$ to satisfy the budget and the first-order conditions as follows:

Max $U(x, z_1, z_2, \ldots z_n)$,

Subject to $y = x + p(z)$

Lagrange function:

$$L = U(x, z_1, z_2, \ldots z_n) + \lambda(y - x - p(z))$$

First Order Condition (FOC):

$$L_x = \partial U/\partial x - \lambda = 0 \quad => \quad \partial U/\partial x = \lambda$$

$$L_z = \partial U/\partial z - \lambda(\partial p/\partial z) = 0 \quad => \quad \partial U/\partial z = \lambda(\partial p/\partial z)$$

$$L_\lambda = y - x - p(z) = 0$$

We can get $\partial P/\partial z_i = U_{zi} / U_x = \lambda \quad (i=1, 2, \ldots n)$

To stress the essential spatial context of the problem, Rosen define a value of bid function $U(z_1, z_2, \ldots z_n, u, y)$ according to $U(y-\theta, z_1, z_2, \ldots z_n) = u$.

The expenditure a consumer is willing to pay for alternative values of $(z_1, z_2, \ldots z_n)$ at a given utility index and income is represented by $\theta(z; u, y)$. It defines a

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family of indifferent surfaces relating the z_i with money (i.e. with x foregone), has been widely used in urban economics (Alonso,1964). Consumer's utility maximum:

Max $U(y-\theta, z_1, z_2, \ldots z_n)$,

Subject to $y= x +\theta(z_1, z_2, \ldots z_n ; u, y)$

Lagrange function:

$$L = U(y-\theta,z_1,z_2,\ldots z_n) + \lambda\{y-x-\theta(z_1, z_2, \ldots z_n ; u, y)\}$$

First Order Condition (FOC):

$$L_\theta=-\partial U/\partial\theta-\lambda=0 \quad => \quad \partial U/\partial\theta=\lambda$$

$$L_z=\partial U/\partial z-\lambda(\partial\theta/\partial z)=0 \quad => \quad \partial U/\partial z=\lambda(\partial\theta/\partial z)$$

$$L_\lambda= y-x-\theta=0$$

From the First Order Condition we can get:

$$Uz_i/Ux =\partial\theta/\partial z \quad (i=1,2,\ldots n)$$

So when θ=p, we can get $\partial p/\partial z = Uz_i/Ux = \partial\theta/\partial z$ (i=1,2,…n), that is when the characteristic marginal price equals the marginal substitute rate, which also equals the characteristic bid price, consumers can get maximal utility.

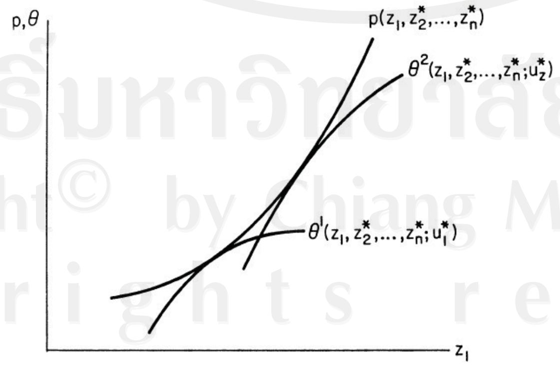

Figure 2.1 The Consumption Decision: Utility Maximization

Source: Rosen.S.(1974),"Hedonic prices and implicit markets: Product differentiation in pure competition", Journal of Political Economy, vol. 82, no. 1, pp. 35-55

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(2). *The Production Decision: Profit Maximization*

Assume that producers act as profit maximize. The profit function is

$$\pi = p(z) - c(z;\beta)$$

Where $c(z;\beta)$ is the cost function of the producer, β reflects underlying variables in the cost minimization problem, namely, factor prices and production function parameters. When the profit attains the maximization, the marginal profit equals to zero, so the first order condition is $0 = \partial p/\partial z_i - \partial c/\partial z_i \Rightarrow \partial p/\partial z_i = \partial c/\partial z_i$, that is, the marginal characteristic price equals marginal characteristic cost.

Symmetrically to the treatment of demand, Rosen defined an *offering* function $\phi(z_1, z_2, \ldots z_n; \pi, \beta)$ illustrating unit prices the producers are willing to accept on various designs at constant profit when quantities produced of each model are optimally chosen. A household production "indifference" surfaces is defined by ϕ.

$$\text{Max } \pi = \phi(z_1, z_2, \ldots z_n; \pi, \beta) - c(z;\beta)$$

When satisfying the first order condition, $\partial \phi/\partial z_i - \partial c/\partial z_i$, the marginal characteristic price equals marginal characteristic cost. So, when $\phi = p$, $\partial p/\partial z_i = \partial \phi/\partial z_i - \partial c/\partial z_i$ $(i=1,2,\ldots n)$, that is, when marginal characteristic price equals marginal characteristic bid price, which again equals marginal characteristic cost, the producers get profit maximization.

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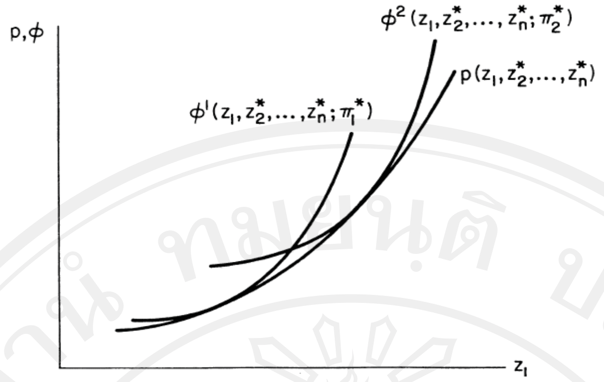

Figure 2.2 The Production Decision: Profit Maximization

Source: Rosen,S.(1974), "Hedonic prices and implicit markets: Product differentiation in pure competition", Journal of Political Economy, vol. 82, no. 1, pp. 35-55

(3). *Existence of Market Equilibrium*

The analysis of consumers' and producers' decisions has proceeded on the assumption of market is at an equilibrium. When the market at an equilibrium, the figure shows as the follows:

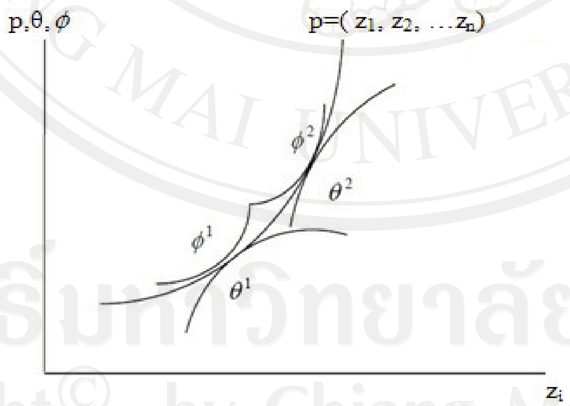

Figure 2.3 Existence of Market Equilibrium

Source: Rosen,S.(1974), "Hedonic prices and implicit markets: Product differentiation in pure competition", Journal of Political Economy, vol. 82, no. 1, pp. 35-55

Figure 2.3 shows that the bid curve stand at a certain utility standard, and the numerous characteristics of z is fixed, when the consumer's bid reduced, the utility of

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the consumers increased, similarly, in the same conditions, the producers' offer price raised, the profit also increased , the market price at an equilibrium is determined by θ and ϕ.

In Rosen's (1974) derivation of the hedonic function, it can be summarized that, the consumers pursue the utility maximization, the producers simultaneously seek for the profit maximization, and the house price is the sum of the each characteristic parameter multiplied by their implicit price respectively.

2.2 Literature Reviews

Housing has always been an eternal topic of concern for human being in the world. There are many studies that relate to the housing market using the hedonic pricing model, which cover both developing and developed countries as follows:

Ronald G. Ridker & John A. Henning (1968) focused on the metropolitan area in ST. Louis of North America. In this study, the variables were selected by relating to locational attribute, structural attribute and neighborhood attribute with 167 sample housing units. The empirical results can be summarized as follow:

The location characteristics that accessibility to highways (HWA) is the most important one, followed by associability to shopping (SAA), accessibility to industry (IAA) and school quality (SCH), which has the positive relationship with the median property value (MPV).

The structural characteristics specific to the property median number of room (MNR) assumed to be a proxy for house size, percentage recently built (PRB) and houses per mile (HPM) all turned out to be important explanatory variables. The MNR and PRB have a positive relationship with the MPV while the HPM has a

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negative relationship with the MPV.

The neighborhood characteristics yielded mixed results. The coefficient of crime rate (CRR) proved to be insignificant, no matter what standard form was tried. The property values were higher where school quality was above average level, but they were higher yet where school quality was below average. The coefficient percentage non-white (PNW) which partially reflects aspects of discrimination was insignificant. This means people wouldn't like to pay higher prices to purchase housing in a white-dominated neighborhood.

Hai-zhen Wen, Sheng-hua Jia & Xiao-yu Guo (2005) analyzed the housing price that depended on the housing characteristics which were divided by structure, neighborhood and location of the housing. The study selected 18 housing characteristics as the independent variables, and adopts the linear functional form to conduct the hedonic price model for the housing market in Hangzhou. The model was tested with 2473 housing samples and field survey data of 290 housing communities. As far as the whole housing market of Hangzhou is concerned, the model estimation and coefficient analysis results show that, 14 housing characteristics with different influence degrees on housing price were significant, which are arranged sequentially from great to small: floor area, distance to West Lake, inner environment, distance to CBD, traffic condition, garage, attic, decoration degree, environment, community management, housing story, entertainment facility, transaction time, university nearby. Four other variables: housing age, orientation state, life establishment and education establishment are not significant, where the coefficients were statistically not different from zero. In conclusion, the contribution rate of effecting on housing price of architecture characteristic, neighborhood characteristic, location characteristic and

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other characteristic were respectively 60.0%, 16.5%, 19.8%, 2.7% for the standard housing units. Thus the structural characteristic is identified as the highest impacting factor in this study, and which indicates that the hedonic model can be applied and performs well in Chinese residential housing market.

Linshi (2005) based on the preference of households and selects 17 key variables of the housing market in Stellenbosch, South Africa. Of which 3 were continuous: housing price, size of plot, and overall size of building; 3 were discrete: number of bedrooms, number of bathrooms, and number of garages; 11 were dummy variables: 9 related to the housing locations, and the rest identified the swimming pool availability and alarm availability.

The data derived from 220 single-family residential houses transacted in Stellenbosch during the year of 2002 and 2003, and 2004. It can be noted that the prices of 2002 and 2003 were not realistic for the present market price due to the high increase of housing price in South Africa, the author made the mathematical manipulation in order to make sure the data was applicable.

The results of regression showed that all the independent variables were significant at the 5 percent level or better, except the size of plot and the Mostertsdrift dummy variables (MOSTER). The size of building, the number of bedrooms and the number of bathrooms, the amount of garages spaces, the availability of a swimming pool and the availability of an alarm system are significant determinants which positively contribute to the residential housing prices in Stellenbosch. There are 6 locational dummy variables that are significant and negative in assessing the residential house price, indicating that the price of a residential house located at such area is lower than one which is in the center of town. The result also shows that, the

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availability of a swimming pool or alarm system has a significantly positive relationship with the residential housing price in Stellenbosch.

In Andres Jauregui (2006)'s essay, the housing market segments consist of the seven major metropolitan statistical areas (MSA) in Ohio: Akron, Cincinnati, Cleveland, Columbus, Dayton, Toledo, and Youngstown, there are 36 variables related to the transaction housing price which are considered as independent variables by the hedonic model.

The result shows that the increasing number of rooms, size of house and lot size, as well as the number of full and half bathrooms has a positive impact on house prices. Houses with garages and pools also have higher selling prices. Housing age has a negative impact on house prices. The distance from the closest hazard variable is positive and significant in all areas, while the square of the distance is negative. Housing price increases at a decreasing rate of distance to the source of environmental risk, so the residents prefer a good environment quality around the condominium. The total emissions in air which from all industries are significant in just three areas, it is not a consistent variable for this study.

People's preferences on the characteristics of housing are quite similar in terms of the similar background such as age, income level, education, and race. The percentage of black population in census block group (CBG) had a negative relationship with the housing price. Similarly, the greater percentage of population lived in poverty in a census block group (CBG) in seven cities are significant and negative consistently, which implies that neighborhoods with greater percentages of people living in poverty have lower house prices.

Monika Bazy (2009) measured the impact of certain location characteristics on

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housing prices by applying the hedonic model in the Warsaw housing market, altogether there were 2300 observations. According to the estimation based on the hedonic model, green areas increase flat price if they are within one kilometer distance. New metro stations increase prices of flats if they are located within one kilometer distance. The industrial areas decrease the prices of flats if they located within one kilometer distance. However, these are 'implicit prices' which do not account for spatial autocorrelation of flat prices. That is the price of a flat depends on its characteristics as it was assumed in the basic model, yet it is not influenced by the neighboring flats.

Chihiro Shimizu, *et al.*(2010), applied several variations of the Hedonic Model in their study, such as the restricted hedonic model (RHM), un-restricted hedonic model (URHM), and overlapping-period hedonic model (OPHM). The observation data consist of 211,179 samples collected between January 1986 and September 2006. On estimated characteristics, the signs of each coefficient turn out to be the same and the results are quite similar as the previous studies.

Among the property characteristics specific to condominiums, *FS* (floor space), *BS* (balcony space), and *NU* (number of units) have positive values. Age (age of building), *TS* (time to nearest station), and *TT* (travel time to CBD) have the negative values. First, regarding *FS*, the unit price was shown to increase with increasing floor space. A similar tendency was observed for *BS* and *NU*. Consumers have a strong preference on the floor space of the entire condominium. As age increases, there is deterioration on the housing quality compared with the improvement of facilities in newer condominiums. The independent variable *TS* (time to nearest station) and *TT* (travel time to CBD) increase, there is a decrease on the convenience because of the

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greater distance from populated and flourishing areas, which result in a decrease in housing price.

In summary, hedonic pricing model has been applied in various housing market of different courtiers to measure the relationship between housing price and related housing characteristics. Even though these studies selected various housing characteristics and measured these characteristics in different methods, the results of studies were quite similar. The result of studies which applied the distance to CBD and floor area as independent variables mostly showed that the distance to CBD has a negative relationship and floor area has a positive relationship with housing price. Especially, many studies applied hedonic pricing model on housing market in various cities of China and the results performed well, which indicated that hedonic pricing model can be applied in Kunming.

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