EVALUATING THE IMPACT OF LOCAL AMENITIES AND SPATIAL SPILLOVERS ON QUALITY OF LIFE

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Abstract

This article uses the Hedonic models proposed by Rosen (1979), Roback (1982), and Blomquist et al. (1988) to establish the framework for calculating and evaluating inter-townships quality of life in Taiwan. From view of local amenities, the results show that the quality of life index are less than zero, which represents that compensation wage is higher than capitalized housing value from the local amenities. The estimated quality of life by inference with the substitution of input data into model is used as the dependent variable of spatial regression model to investigate the spatial effects. The results show that the local amenities play various roles in the housing market and the labor market. Quality of life is quite geographically characterized with spillover effects, which consists with the Rosen's report (1979). In Taiwan, quality of life index does not meet economic development. Economic growth does not spill over completely to improve quality of life. Local amenities factors are more of a threat to quality of life than value addition on quality of life. Many natural disasters, unfavorable climate, unpleasant weather has been higher than positive expectations. The distribution of quality of life in space tends to be concentrated. The socioeconomic factors and quality of life in adjacent areas will spill over and affect the quality of life. This spillover spatial effect reminds urban planners and decision makers that improving the quality of life is urgent and efficient. As long as these independent variables in the model are adjusted, the quality of life in the overall space can be effectively improved. This study addresses the underexplored gap between local amenities and spatial spillover effects in shaping quality of life, particularly within the context of Taiwan's inter-township dynamics. By integrating Hedonic pricing models with spatial econometric analysis, it offers a novel and scalable framework for policymakers to spatially allocate resources more effectively.

Keywords: local amenities; spatial spillover effects; quality of life; Hedonic models; spatial regression model

1. Introduction

Rosen (1974) first proposed the classic literature on Hedonic model, and then Roback (1982) applied and extended this model to analyze the housing and labor markets and develop an inter-city quality of life index system. Roback's model integrates local amenities into the Hedonic model of housing prices and household wages to estimate the willingness to pay for these factors and further assembles them into quality of life index as a basis for evaluating the quality of life in American cities. It claims that residents living in cities with affluent amenities are willing to pay extra to live in this city to increase housing prices, but residents excessed move into this city to increase labor supply and reduce wages.

Based on the general equilibrium model proposed by Rosen (1979) and Roback (1982), this article applies it to construct two Hedonic equations for Taiwan to frame the evaluation system of inter-district quality of life. Krumm (1980), Graves (1983), and Smith (1983) proposed that amenity dimension of quality of life may even influence the decision of living, working, and migration. Residents compare amenities among cities as a reference for decisions where to live.

Despite extensive research on quality of life in urban economics, few studies have integrated Hedonic valuation with spatial spillover analysis at the inter-township level. This research fills that gap by applying a hybrid econometric model that captures both market-based valuation and spatial interdependence, offering a more nuanced understanding of how local amenities influence quality of life across administrative boundaries.

The most critical factor to consider in establishing quality of life index is to propose the method of local amenities weighting. Liu (1976) proposed overall quality of life system, but the method of arbitrarily assigning weights to amenity factors ignores theoretical basis. Rosen (1979) claimed that location should be regarded as a special combination of wage, rent, and amenities. Roback's (1982) model confirmed that local amenity causes differences in housing prices and wages.

This article uses the data from the database released by the government's web sites in Taiwan to establish evaluation index system of quality of life. The Hedonic price equation and Hedonic wage equation are applied to formulate the implicit price of local amenities. Predicted values of quality of life is applied to investigate the spatial effects of quality of life.

This study is guided by three main propositions: (1) Local amenities significantly influence quality of life through their capitalization in housing rents and compensation in wages; (2) Spatial spillover effects exist in the distribution of quality of life, meaning that the conditions in one township affect neighboring ones; and (3) Vulnerability and socioeconomic disparities mediate both direct and indirect impacts of amenities on quality of life. The novelty of this study lies in its fusion of Hedonic valuation with spatial econometric modeling to quantify and map quality of life across multiple jurisdictions. This approach not only identifies local amenity impacts but also uncovers how neighboring conditions influence outcomes—a perspective crucial for cross-boundary urban planning in both developed and developing contexts.

2. Causes and effects of quality of life and its' measurement

The valuation of urban housing has long been a central concern in spatial economics, particularly in assessing how diverse attributes of the built and natural environment influence market behavior. Since the seminal work of Rosen (1974), the hedonic pricing model (HPM) has served as a foundational approach to decompose property values into implicit prices of structural, locational, and environmental characteristics. Numerous studies have since expanded this theoretical foundation by incorporating spatial econometric techniques and contextual variables, especially in light of increasing urban complexity and data availability.

A substantial body of literature confirms that housing markets exhibit spatial heterogeneity, wherein similar attributes exert varying levels of influence across different geographic locales. Valdez Gómez de la Torre and Chen (2024) emphasize that traditional hedonic approaches often overlook the spatial dependencies and submarket dynamics inherent in rapidly urbanizing regions of Latin America. By comparing ordinary least squares (OLS) with geographically weighted regression (GWR), their work underscores the necessity of spatially explicit models to capture localized variations in housing determinants, such as segregation and infrastructure accessibility. This view is supported by Aziz et al. (2023), who argue that neighborhood amenities such as proximity to roads, parks, and healthcare facilities significantly alter property values, especially in contexts marked by

heterogeneous planning and irregular urban sprawl, as found in Gujrat, Pakistan.

Incorporating environmental considerations into housing valuation has also garnered increasing scholarly attention. Borja-Urbano et al. (2021) adopt an HPM-GIS framework to examine the economic consequences of air pollution in Quito, Ecuador, revealing that concentrations of PM2.5, NO_2, and SO_2 negatively affect residential property values. Their study confirms earlier findings in environmental economics that pollution acts as a disamenity capitalized into market prices. Similarly, Osland et al. (2020) integrate a rich suite of GIS-derived environmental variables—such as green space visibility, proximity to blue amenities, and urban public services—into a comprehensive hedonic model for Oslo. Their work reveals that environmental attributes, although implicitly priced, represent essential components of urban welfare and spatial equity. The combination of open geospatial data and sophisticated spatial techniques allows for fine-grained insights into the geography of housing desirability.

An emerging trend within this domain is the inclusion of perceived environmental quality and subjective experiences in formal housing models. Wang et al. (2024) extend traditional hedonic analysis by incorporating street-level visual perceptions using convolutional neural networks (CNNs) applied to Google Street View imagery. Their study in Eindhoven demonstrates that street aesthetics—captured through qualities such as beauty, livability, and visual comfort—exert spatially heterogeneous effects on property prices. This

innovative approach bridges the gap between objective environmental conditions and subjective human experience, a linkage often theorized but rarely operationalized in empirical studies.

In a related vein, the evaluation of urban quality of life (QOL) through housing markets has stimulated comparative methodological debates. Carlsen and Leknes (2021) juxtapose hedonic pricing models with subjective well-being (SWB) assessments to evaluate QOL in Oslo. Their findings indicate that while hedonic models align with SWB outcomes among highly mobile populations, discrepancies emerge for less mobile groups, highlighting the limitations of assuming perfect market mobility. These observations suggest that QOL is multi-dimensional, involving not only observable attributes like infrastructure or pollution but also latent constructs such as place attachment and perceived livability.

Building on this multi-dimensional perspective, Abdrabo et al. (2022) propose a spatial hedonic model to assess QOL in Alexandria, Egypt, using attributes spanning housing conditions, environmental aesthetics, and socio-demographic factors. Their findings affirm the explanatory power of such attributes in predicting housing values, with localized variations effectively captured through GWR. The study reinforces the notion that QOL is both spatially distributed and subjectively experienced, requiring integrated analytical approaches for meaningful policy translation.

Taken together, these studies demonstrate a shift from static, attribute-based valuation models to dynamic, spatially nuanced frameworks that

account for environmental, perceptual, and socio-political complexities. Whether focusing on pollution, aesthetics, or social infrastructure, recent literature emphasizes the importance of spatial heterogeneity, methodological pluralism, and data integration in understanding the interplay between urban amenities and housing markets.

Economists have used index that is a direct measurement to monitor social well-being since the 1970s. By monitoring the time series of social indicators, if it moves towards a change in the "right" direction means things have gotten better, or individuals have gotten better (US Department of Health, Education and Welfare, 1969, p. 97). Many countries including the European Union, America, New Zealand use social indicators monitor social well-being by collecting perceptions of the value of life that individuals care about as a basis for assessing quality of life (Noll, 2016).

Quality of life studies appear in almost a variety of fields, including international development, health care, politics, and employment. It boils down to measuring the person's subjective well-being which is influenced by personal feelings versus objective well-being which is not influenced by personal feelings as it relates to acceptable standards. The Netherlands Department of Psychology believes that the quality of life has three dimensions: material, psychological, and social (Forward, 2003). The substantive level is related to health, including the health of individuals and the overall health of the population. Psychological dimensions include love,

satisfaction, happiness, morale, self-esteem, control over life, self-comparison, life expectations, and self-belief. The social dimension includes private and public elements of life, social networks, social support, income levels, education, work, community, climate, social security, housing quality, pollution, surrounding traffic, crime, equality, and fairness.

The connotation that the quality of life pays special attention to is well-being. The interpretation of well-being can be divided into the Hedonic view of Hedonic pain avoidance and the Eudaimonic view of self-actualization (Ryan and Deci, 2001). The Hedonic model seeks to increase pleasant experiences and avoid negative ones (McMahan and Estes, 2011). Its origins can be traced back to the 4th century BC Greek philosopher Aristippus who believed that the goal of life is to experience the greatest degree of pleasure, and that happiness is what a moment of pleasure is all about (Ryan and Deci, 2011). Today, Hedonism is related to an individual's subjective well-being and broadly encompasses all experienced happiness (Ryan and Deci, 2011). From a social planning perspective, Hedonism is interesting because it means that individuals don't necessarily have to work or travel long distances all the time. It is imperative for individuals to achieve balance in their lives. One way to achieve this is to provide an environment that contributes to a sense of well-being. Eudaimonism encourages individuals to pursue true self-actualization (Waterman, 1993; Ryff and Keyes, 1995; Diener et al., 1998; Ryff and Singer, 1998; 2000), not necessarily emphasizing the feeling of pleasure but actual achievement.

In terms of economics, quality of life can be measured by analyzing the degree to which households and businesses prefer for the cities they live. In essence, both residents and manufacturers are attracted to local amenities. The amenity differential value affects wage and rent and population distribution (Gabriel and Rosenthal, 2004). Rosen (1974, 1979), Roback (1982, 1988), and Albouy and Lue (2011) all argue that high wages are offset by non-desirable amenities such as crime and pollution. If a city has the desirable amenity, which means that the city has the good quality of life, urban residents will either accept low wages or higher living costs (Albouy, 2012). Albouy (2012) has verified that quality of life is related to adequate sunlight and proximity to the coast. Nikolova (2015), Alvarez-Diaz, Gonzalez, and Radcliff (2010) demonstrates that public policy affects quality of life. Alvarez-Diaz, Gonzalez and Radcliff (2010) claims that economic intervention will positively affect the quality of life, and other studies have proposed more explanations about the relationship between social democracy and labor groups well-being (Radcliff, 2001).

Quality of life is residents' evaluation on the objective environment for the city where they live (Diener, 2006; Diener and Suh, 1997; Nefs et al., 2013). Political decision makers and planning professionals are increasingly paying attention to the degree of improvement in the urban environment (Lekwa, Rice, and Hibbing, 2007). Cities with job opportunities attract residents from other cities to move in. Akin to Hedonic theory, local amenities that affect quality of life have been shown to change residents' migration decision (Carruthers and Mulligan, 2008). Urban quality of life is the driving force behind workers' interconnected migration

behavior, which further drives urban growth (Lambiri, Biagi, and Royuela, 2007). Some reports focused on quality of life as a driver of residential choices (Russo et al., 2013; Royuela, Moreno, and Vaya, 2010), while others have analyzed whether population growth determines or favors quality of life (Baldassare and Wilson, 1995; Guneralp and Seto, 2008).

The relationship between population size and quality of life has been the focus of many reports. Leknes (2015) research has verified that the larger the population size, the higher the quality of life and the more attractive it is. A popular city often offers a variety of cultural services such as museums, sports venues, concert halls, and cafes and restaurants that are popular with residents of all stripes (Couture, 2014; Schiff, 2015). Cities offer better shopping opportunities. Places with large populations offer more social interaction and convenience (Carlsen and Leknes, 2014).

Population shrinkage has spread around the world (Martinez-Fernandez et al., 2016; Yang and Dunford, 2018). Population shrinkage is an important issue for European urban planning, as almost half of European metropolises are shrinking (Wolff and Wiechmann, 2018). The main causes of population shrinking are declining fertility, suburbanization, and economic transformation (Haase et al., 2013). Recent reports in southern Europe have pointed to population shrinkage (Martinez-Fernandez et al., 2016), especially in Portugal (Sousa, 2010; Sousa and Pinho, 2015; Barreira et al., 2017; Barreira et al., 2019; Barreira et al., 2017; Guimaraes et al., 2016b; Guimaraes et al., 2016a; Panagopoulos and Barreira, 2012). Urban shrinkage is often seen as poor quality of life for two reasons: one is

that urban attraction to residents and tourists is a function of quality of life, so quality of life is related to urban shrinkage, and the other is that population decline can cause political decision makers fear as it will trigger negative externalities such as tax base loss and reduced public spending.

3. Methodology

Quality of life index across the districts that is the sum of all full implicit price is as follows.

$$QOLI = \sum_{i}^{k} f_i a_i \tag{1}$$

where f_i is implicit price of the local amenity i for the township, and a_i is the quantity of local amenities i for the township. In equilibrium, implicit price of the local amenity is calculated by equation (2):

$$f_i = h\left(\frac{dp}{da_i}\right) - \frac{dw}{da_i} \tag{2}$$

where *h* is the demand of housing service, *p* is the housing rent, and *w* is wage. The fully implicit price of local amenity depends on the effect of local amenity on housing rents and wages[1].

Two equations are used to calculate the fully implicit price of local amenity: the Hedonic price model and the Hedonic wage model, as shown in equation (3) below:

$$hedonic_q = \alpha_q + \sum_{i=1}^{l} \beta_{qi}\, a_i + \sum_{k}^{m} \gamma_{qk}\, Z_{qk} + \varepsilon_q, q \in \{1,2\} \quad (3)$$

where $hedonic_{q=1}$ is the housing rent, $hedonic_{q=2}$ is the wage, a_i is quantity of the local amenity *i*, Z_{qk} is the non-local amenity variable *k*, ε_q is the error term, α_q, β_{qi}, and γ_{qk} is the parameter. Using the estimation of equation (3) to calculate the full implicit price f_i in equation (2), and then equation (2) is substituted into equation (1) to obtain the quality of life index, *QOLI*, of the township.

With the predicted quality of life index, spatial regression model is used to investigate the spatial effects of quality of life as shown in equation (4) below:

[1] In the case of the housing market, when the indirect utility level of the resident is *v*, $a_i$represents amenity when $dv/da_i > 0$, $a_i$represents disamenity when $dv/da_i < 0$. As far as the labor market is concerned, when the production cost of the manufacture is *c*, it represents productive amenity, then $dc/da_i < 0$, when it represents the unproductive amenity, then $dc/da_i > 0$.

$$QOLI = \delta \boldsymbol{WQOLI} + \alpha \boldsymbol{i}_N + \boldsymbol{X}\beta + \boldsymbol{WX}\theta + \boldsymbol{u} \quad (4)$$

where $\boldsymbol{W}$ is spatial weight of adjacent township, N is number of observations, that is, number of townships, $\boldsymbol{i}_N$ is unit vector of the $N \times 1$ townships, X is vulnerability variable of townships, and $\boldsymbol{u}$ is error term, and mean is zero and variance is $\boldsymbol{\sigma^2 I}$. δ、$\alpha\beta$、θ is parameter. Rearranging these variables, equation (4) can be changed into the equation (5):

$$(\boldsymbol{i_N} - \delta \boldsymbol{W})QOLI = \alpha \boldsymbol{i}_N + \boldsymbol{X}\beta + \boldsymbol{WX}\theta + \boldsymbol{u} \quad (5)$$

The partial differential of QOLI with respect to explanatory variables $\boldsymbol{x_s}$ can be expressed as follows:

$$\frac{\partial QOLI}{\partial \boldsymbol{x_s}} = \left(\frac{\partial QOLI}{\partial x_{1s}} \frac{\partial QOLI}{\partial x_{2s}} \cdots \frac{\partial QOLI}{\partial x_{Ns}}\right) \quad (6)$$

$$= \begin{pmatrix} \frac{\partial QOLI_1}{\partial x_{1s}} & \cdots & \frac{\partial QOLI_1}{\partial x_{Ns}} \\ \vdots & \ddots & \vdots \\ \frac{\partial QOLI_N}{\partial x_{1s}} & \cdots & \frac{\partial QOLI_N}{\partial x_{Ns}} \end{pmatrix}$$

$$= (\boldsymbol{i_N} - \delta \boldsymbol{W})^{-1} \begin{pmatrix} \beta_s & \cdots & w_{1N}\theta_s \\ \vdots & \ddots & \vdots \\ w_{N1}\theta_s & \cdots & \beta_s \end{pmatrix}$$

where $QOLI_N$ is quality of life and x_{Ns} is explanatory variables of township N. $\partial \boldsymbol{QOLI}/\partial \boldsymbol{x_s}$ is $N \times N$ marginal effect matrix. Direct effect is average of the

diagonal elements of this matrix, while indirect effect is average of the non-diagonal elements of this matrix.

4. Results and Discussion

The official data of the Socio-Economic Database, the Central Meteorological Administration and the Real Estate Information Platform are used to construct the two Hedonic equations to evaluate quality of life of the townships. The housing price provided by the Real Estate Information Platform is based on the information of the home ownership market, and the imputed rent must be calculated by net present value method. The income tax declaration information of townships provided by the Statistics Department of the Ministry of Finance is the income information that is closest to the wage available (Table 1). Table 1 shows the variables used in this article including local amenities, housing attributes, socio-economic and vulnerabilities, the content of the variables, and the scale and numerical types of the data. Table 2 shows the descriptive statistics of the variables. The average annual rent is NT$129,000 and the average wage per year is NT$673,000. As far as the coefficient of variation is concerned, all variables are distributed between 0.051 and 1.234. Except for "low", "disabilities", and "brick", the degree of variation is large, while other variables are evenly distributed.

Table 1. Local amenity variables in the Hedonic Models.

variable	definition	unit	scale/numeric type
rent	Imputed annual rent ($R = V \times i$, V: Average housing price of Township, i: discount rate = 1.25% [a])	Ten thousand dollars	Ratio/Continuous
wage	Average wage	Thousand dollars	Ratio/Continuous
wind	Wind velocity	Meters/second	Ratio/Continuous
temp-I	The average days that monthly temperature is greater than or equal to 25℃	Day	Interval/Continuous
temp-II	The average days that monthly minimum temperature is less than or equal to10℃	Day	Interval/Continuous
temp-III	The average days that monthly maximum temperature is greater than or equal to 30℃	Day	Interval/Continuous
precipitation	Median monthly precipitation	Millimeter	Ratio/Continuous
sunshine	Average sunshine hours per month	Hour	Ratio/Continuous
humidity	The average monthly relative humidity	%	Ratio/Continuous
cloud	Average monthly cloud cover	Ten quantiles	Ratio/Continuous
brick	Number of houses made of brick, wood, and stone	House	Ratio/Discrete
age	The average housing age	Year	Ratio/Continuous
area	The average housing floor area	Ping	Ratio/Continuous
dependency	Dependency ratio	(Population aged 0~14 + population aged above 65)/ (Population aged 15~64) *100	Ratio/Continuous
child	Child dependency ratio	Population aged 0~14/ (population aged 15~64) *100	Ratio/Continuous
disabilities	Total population with disabilities	Person	Ratio/Discrete
low	Total number of low-income households	Household	Ratio/Discrete

Source: Refer to Official website database from Socio-Economic Database, Real Estate Information Platform, Central Meteorological Administration, and Ministry of Health and Welfare.

[a]: Average of the Central Bank's discount rate ranges from 2020 to 2022.

Table 2. Descriptive statistics of local amenities and related variables in the Hedonic Models.

variable	mean	standard deviation	minimum	maximum	coefficient of variation
rent	12.851	5.702	4.038	40.950	0.444
wage	672.998	109.099	519.370	1426.920	0.162
wind	2.332	0.971	0.600	7.600	0.416
temp-I	170.589	40.999	1.000	223.800	0.240
temp-II	6.217	5.326	0.100	24.600	0.857
temp-III	147.736	34.674	13.700	188.900	0.235
precipitation	1609.932	526.986	687.300	4017.500	0.327
sunshine	1869.806	313.989	956.400	2289.300	0.168
humidity	75.202	3.825	59.000	89.600	0.051
cloud	5.885	0.976	3.600	7.800	0.166
brick	4511.702	4782.249	0.000	35274.000	1.060
age	35.835	6.743	16.000	70.000	0.188
area	44.180	8.604	24.170	65.450	0.195
dependency	41.588	5.671	26.390	61.350	0.136
child	15.226	4.163	6.440	32.290	0.273
disabilities	3255.269	3481.588	19.000	23389.000	1.070
low	394.448	486.756	1.000	3906.000	1.234

Note: Data is calculated ed by this study.

4.1.Hedonic price model

In the Hedonic price model, the local amenities, the housing attributes, and vulnerabilities are added as independent variables. Parameters of linear regression are estimated by ordinary least square method (Table 3). Table 3 shows to reject $H_0: all\ parameters = 0$ by F test. Coefficient of determination exceeds 0.5, indicating that the overall goodness of fit of the model is moderate. All coefficients of the independent variables are significantly not equal to zero at a significant level of 1%. Negative coefficients of "temp-III", "precipitation", "sunshine", "humidity", and "cloud" mean that they are amenities that negatively affect housing rents. The coefficients of "wind", "temp-I", and "temp-II" are positive, showing that these variables represent dis-amenities. The coefficients of "age" and "area" are negative, which means that these two housing attributes will negatively affect the housing rent. The coefficient of "brick" is positive, showing that vulnerability does not negatively affect rents.

Table 3. Estimation of Hedonic Price Model of Townships.

variable	coefficient	standard error
housing rent		
wind	0.611***	0.163
temp-I	0.028***	0.008
temp-II	0.224***	0.018
temp-III	-0.001***	0.0002
precipitation	-0.002*	0.001
sunshine	-0.009***	0.003
humidity	-0.122**	0.041
cloud	-1.154**	0.386
brick	0.001***	6.84E-05
age	-0.401***	0.050
area	-0.173***	0.042
constant	53.958***	11.242
Prob.>F	0.000	
adjust R^2	0.559	

Note: Data is calculated by this study.

***: p<0.001, **: p<0.005, *: p<0.01

4.2.Hedonic wage model

In the world of Rosen (1979), Roback (1982), and Blomquist et al. (1988), residents are attracted to a combination of better local amenities, i.e., a place with a better quality of life for work. Areas with lower housing rents and higher wages are attractive. Conversely, areas with higher housing rents and lower wages will force households to move out. When equilibrium approached, there is no incentive to move for the residents. Residents are willing to pay higher fees for higher local amenities combination. The implicit price of the combination of lower wages and higher housing rents shows that residents are driven to pay more to choose other more comfortable and attractive city. When the Hedonic model is in equilibrium, it illustrates that there is no incentive for the residents to move anymore. Because of the need to pay for the richer amenity areas by the move and to accept compensation to move for the poorer amenity areas. The fully implicit price of the local amenities is the sum of the Hedonic price and the negative Hedonic wage (Table 4). Table 4 shows that decision by F-test is to reject H_0: $all\ parameters = 0$, the adjust R^2 exceeds 0.5, and the overall model is well estimated. All coefficients of independent variables are significantly not equal to zero at the significant level of 1%. Negative coefficients of “temp-III”, “precipitation”, “sunshine”, and “humidity” which indicate that they are disamenities that negatively affects wages. Positive coefficients of “wind”, “temp-I”, “temo-II”, and “cloud” indicates that they are amenities. The coefficients of “dependency” and “child” are both positive, indicating that these two living-burden variables will not negatively affect wages.

The coefficient of “low” is positive, indicating that vulnerability positively affects wages.

Table 4. Estimation of Hedonic Wage Model of Townships.

variable	coefficient	Standard error
wages		
wind	15.720**	5.279
temp-I	0.550**	0.187
temp-II	2.346*	0. 831
temp-III	-0.133*	0.051
precipitation	-0.021**	0.007
sunshine	-0.054***	0.013
humidity	-2.294**	0.765
cloud	12.711**	4.030
dependency	2.270**	0.762
child	3.585*	1.337
disabilities	0.004***	0.001
low	0.041*	0.015
constant	594.818**	199.863
Prob.>F	0.000	
adjust R^2	0.504	

Note: Data is calculated by this study.

***: $p<0.001$, **: $p<0.005$, *: $p<0.01$

4.3.Hedonic Value of Quality of life

Using the equation (1), the local amenity is fully priced implicit, and the value of the local amenity can be obtained by multiplying the quantity of local amenities, the sum of the value of all the amenities representing the Hedonic value of the quality of life (Table 5). Table 5 shows that optimal quality of life in the township is approached due to the equilibrium in housing market and labour market of the district. Households have chosen to live and work in the townships with the greatest utility, that is, the highest quality of life, and there is no longer an incentive to move. “Wind”, “temp-I”, “temp-II”, and “sunshine” are not conducive to quality of life, while “temp-III”, “precipitation”, and “humidity” will improve the quality of life. Quality of life is a critical factor for decision-making, residents care about quality of life, must choose the township with good quality of life to live, and work in the selected area. Business managers that attach importance to the quality of life must choose the township with abundant labor to produce. The decision to live around abundant labor force is based on the district’s quality of life. Government policymakers are concerned about the quality of life to choose effective resource allocation to improve the quality of life and enhance social well-being (Table 6). Table 6 shows the Hedonic values and ranking of the quality of life across the townships. Hedonic values of all townships are less than zero, which represents that capitalized values of local amenities are lower than wages. Top ranked townships are located in areas rich in amenity factors. Townships with abundant amenity will attract people and labor to move in, which will lead excess labor to decline wages. However, retirees in an aging society are also attracted, which negatively offsets on

wages increase. This makes these amenity-rich townships have a higher quality of life than other townships. The quality of life of townships with high urbanization ranks at the lower end. More job opportunities attract more labor, excess supply of labors results in limited wage growth. In addition, the poor amenity of townships with high urbanization, which leads to low capitalized value. As a result, the quality of life in these townships is poor.

The geographical cluster of local amenities provide a visual interpretation of spatial concentration by GIS (Figures 1~ Figure 8). Figure 1 reports the hotspot areas of "wind" to be distributed in the townships of southwest and southeast regions. The townships in the central and southern regions are cold areas, and the townships in the surrounding areas are relatively more threatening. Figure 2 shows the hotspot areas of “temp-I”, long term suitable temperature, to be in the townships in the southern region, while threating adjacent areas to be in the townships of central region. Figure 3 reports the hotspot areas of “temp-II”, low term low temperature, to be in the townships of central and northern regions. Figure 4 shows the hotspot areas of “temp-III”, long term high temperature” to be in the townships of southern region, while threatening adjacent areas to be in the townships of central region. Figure 5 reports the hotspot areas of “precipitation”, median monthly precipitation, to be in the townships of northern and northeast regions, the cold areas to be in the townships of central and southern regions, and the threatening and threatened adjacent areas to be in the townships of other regions. Figure 6 shows the hotspot areas of “sunshine”, monthly sunshine hours, to be in the townships of central and southern regions, the cold areas to be in the townships of northeast and east regions.

Figure 7 shows the hotspot areas of “humidity”, monthly relative humidity, to be in the townships of central alpine and northeast regions. Figure 8 reports the hotspot areas of “cloud”, monthly cloud cover, to be in the townships of northern and east regions, and the cold areas to be in the townships of central and southern regions.

Table 5. Full implicit prices of local amenities of Township.

Regional comfort attributes	Full implicit price
wind	-9614.260
temp-I	-264.552
temp-II	-104.197
temp-III	125.596
precipitation	0.434
sunshine	-35.830
humidity	1073.084
cloud	-24247.200

Note: Data is calculated by this study.

Table 6. Ranking of quality of life across Townships.

Township	QOLI(NT$)	rank	Township	QOLI(NT$)	rank	Township	QOLI(NT$)	rank
Lugu Township	-124213	1	Mailiao Township	-169561	121	Luodong Township	-186427	241
Zhongliao Township	-126606	2	Daliao District	-169581	122	Xuejia District	-186454	242
Yuchi Township	-127297	3	Shimen District	-169920	123	Wanhua District	-186768	243
Jiaxian District	-132017	4	Shuishang Township	-170252	124	Zhuangwei Township	-187389	244
Yilan City	-132356	5	Liujiao Township	-170433	125	Zhongli District	-187668	245
Linbian Township	-134166	6	Taiping District	-170518	126	Beinan Township	-187806	246
Jiji Township	-135282	7	Changbin Township	-170552	127	Miaoli City	-187881	247
Puli Township	-137498	8	Wanluan Township	-170744	128	Jiali District	-187902	248
Zhushan Township	-139635	9	Linluo Township	-170864	129	Yanchao District	-187914	249
Shuili Township	-140051	10	Fengbin Township	-170913	130	Daan District	-188239	250
Shanlin District	-140174	11	Rende District	-170993	131	Zhonghe District	-188384	251
Renwu District	-142268	12	Tanzi District	-171142	132	S. District	-188402	252
Nantou City	-142837	13	Nanzi District	-171168	133	Xinyuan Township	-188520	253
Mingjian Township	-143226	14	Dali District	-171532	134	Huxi Township	-188606	254
Caotun Township	-143514	15	Dounan Township	-171637	135	Datong District	-188718	255
Guoxing Township	-146100	16	Sihu Township	-171821	136	Hunei District	-188754	256
Alishan Township	-149393	17	Qiaotou District	-172121	137	Daren Township	-189150	257
Guiren District	-150273	18	Erlin Township	-172418	138	Wujie Township	-189312	258
Mituo District	-150532	19	Taixi Township	-172778	139	Zhongxi District	-189353	259
Fanlu Township	-151796	20	Touwu Township	-172793	140	Fangshan Township	-189384	260
Xiushui Township	-152142	21	Gangshan District	-172809	141	Shiding District	-189563	261
Lucao Township	-152352	22	Dashu District	-173300	142	Qigu District	-189622	262
Niaosong District	-152552	23	Wufeng District	-173308	143	Yongkang District	-189822	263
Guanmiao District	-152712	24	Zhanghua City	-173348	144	Taimali Township	-190242	264
Fangyuan Township	-152798	25	Qianzhen District	-173529	145	Jinfeng Township	-190270	265
Xihu Township	-153352	26	Shanhua District	-173544	146	Sanxing Township	-190273	266

Township	QOLI(NT$)	rank	Township	QOLI(NT$)	rank	Township	QOLI(NT$)	rank
Zhutian Township	-154149	27	E. District	-173901	147	Banqiao District	-190330	267
Gaoshu Township	-154614	28	Beipu Township	-174007	148	Sanxia District	-190337	268
Jiuru Township	-154832	29	Waipu District	-174097	149	Beimen District	-190363	269
Yuanlin City	-155046	30	Heping District	-174196	150	Neihu District	-190417	270
Xingang Township	-155129	31	Chaozhou Township	-174225	151	N. District	-190523	271
Zhuqi Township	-155452	32	S. District	-174238	152	Yingge District	-190833	272
Dashe District	-155552	33	Dongshi District	-174304	153	Zhongshan District	-190849	273
Ligang Township	-155615	34	Beigang Township	-174627	154	Xinyi District	-191285	274
Liugui District	-155709	35	Jiading District	-174746	155	Chishang Township	-191593	275
Namaxia District	-156134	36	Nanzhuang Township	-175211	156	Ruisui Township	-191679	276
Tuku Township	-156381	37	Zuozhen District	-175330	157	Yonghe District	-191679	277
Shetou Township	-156402	38	Qijin District	-175345	158	Shoufeng Township	-191910	278
Bitou Township	-156770	39	Xinxing District	-175447	159	Sanzhong District	-192221	279
Xinshe District	-156822	40	Liuqiu Township	-175753	160	E. District	-192363	280
Yuanchang Township	-157066	41	Sanzhi District	-176112	161	Dayuan District	-192467	281
Minxueng Township	-157222	42	Danshui District	-176403	162	Danei District	-192585	282
Nantun District	-157244	43	Longqi District	-176406	163	Luzhu District	-192637	283
Kouhu Township	-157327	44	Douliu City	-176511	164	Zhongzheng District	-192755	284
Gukeng Township	-157328	45	Taibao City	-176511	165	Guanyin District	-192847	285
Zhutang Township	-157339	46	E. District	-176511	166	Yujing District	-193474	286
Neimen District	-157407	47	Xinying District	-176511	167	Mudan Township	-193600	287
Erlun Township	-157591	48	E. District	-176528	168	Qingshui District	-193622	288
Fuxing Township	-157695	49	Yancheng District	-177063	169	Shulin District	-194424	289
Zhongpu Township	-157847	50	Xinshi District	-177109	170	Tucheng District	-194429	290
Baozhong Township	-158014	51	Zaoqiao Township	-177279	171	Taishan District	-194627	291
Nanzhou Township	-158459	52	Zuoying District	-177473	172	Qidu District	-194628	292
Fengshan District	-158849	53	Beitou District	-177591	173	Dawu Township	-194935	293

Township	QOLI(NT$)	rank	Township	QOLI(NT$)	rank	Township	QOLI(NT$)	rank
Maolin District	-159470	54	Luzhu District	-177673	174	Zhongzheng District	-195021	294
Shanshang District	-159652	55	Zhubei City	-178226	175	Baisha Township	-195136	295
Luzhou District	-159727	56	Xinbi Township	-178781	176	Songshan District	-195180	296
Linkou District	-160354	57	Houli District	-179090	177	Suao Township	-195750	297
Beitun District	-160477	58	Toufen City	-179134	178	Dongshan Township	-195750	298
Dalin Township	-160588	59	Baoshan Township	-179207	179	Nanao Township	-195750	299
Meinong District	-160654	60	Xinyi District	-179334	180	Xianxi Township	-195767	300
W. District	-160981	61	Wulai District	-179529	181	Wuqi District	-195879	301
Shigang District	-161368	62	Annan District	-179629	182	Daan District	-195922	302
Dongshan District	-161469	63	Xiaogang District	-179769	183	Pingxi District	-196185	303
Dapu Township	-161533	64	Jianshi Township	-179803	184	Hemei Township	-196206	304
Baihe District	-161661	65	Anping District	-179869	185	Xinhua District	-196208	305
Xikou Township	-161724	66	Guanxi Township	-179889	186	Xinzhuang District	-196639	306
Puyan Township	-161891	67	Longtan District	-180000	187	Shenkeng District	-196835	307
Neipu Township	-162029	68	Xinyi Township	-180001	188	Xindian District	-196856	308
Fenyuan Township	-162417	69	Qionglin Township	-180251	189	Daxi District	-197215	309
Yongjing Township	-162435	70	Xiangshan District	-180252	190	Renai District	-197237	310
Ershui Township	-162685	71	Shengang District	-180800	191	Luye Township	-197665	311
Beidou Township	-163043	72	Zhongshan District	-180912	192	Guishan District	-197763	312
Shuilin Township	-163185	73	Gongguan Township	-180992	193	Pinglin District	-198256	313
Changzhi Township	-163609	74	Jinshan District	-181151	194	Zhuoxi Township	-198998	314
Zhong District	-163649	75	Hukou Township	-181436	195	Jian Township	-199067	315
Xizhou Township	-163740	76	Qishan District	-181624	196	Nuannuan District	-199091	316
Puxin Township	-163971	77	Pingzhen District	-181644	197	Datong Township	-200029	317
Wugu District	-164123	78	Pingtung City	-181912	198	Taoyuan District	-200029	318
Donggang Township	-164195	79	Sandimen Township	-181992	199	Shuangxi District	-200193	319
Yizhu Township	-164301	80	Guangfu Township	-182323	200	Chenggong Township	-200623	320

Township	QOLI(NT$)	rank	Township	QOLI(NT$)	rank	Township	QOLI(NT$)	rank
Yongan District	-164342	81	Xinwu District	-182343	201	Shalu District	-200757	321
Citong Township	-164636	82	Guantian District	-182485	202	Wanli District	-200828	322
Dabi Township	-164761	83	Qianjin District	-182496	203	Xizhi District	-200878	323
Fengyuan District	-164764	84	Nanhua District	-182508	204	Manzhou Township	-200898	324
Dacheng Township	-164864	85	Sanwan Township	-182531	205	Fenglin Township	-201106	325
Jiadong Township	-164921	86	Nanxi District	-182558	206	Lvdao Township	-201201	326
Sanyi Township	-165089	87	Tianliao District	-182564	207	Tongxiao Township	-201259	327
Dacun Township	-165165	88	Xigang District	-182651	208	Xincheng Township	-201327	328
Xiluo Township	-165328	89	Liujia District	-182656	209	Yuanli Township	-201585	329
Huwei Township	-165710	90	Majia Township	-182806	210	Xiyu Township	-201859	330
Wuri District	-165917	91	Gushan District	-182829	211	Gongliao District	-202055	331
Zhuolan Township	-166031	92	N. District	-182845	212	Dadu District	-202200	332
Anding District	-166236	93	N. District	-182865	213	Longjing District	-203306	333
Lingya District	-166327	94	Wenshan District	-182971	214	Checheng Township	-203436	334
Linnei Township	-166373	95	Madou District	-183426	215	Ruifang District	-203530	335
Dongshi Township	-166445	96	Emei Township	-183529	216	Yuli Township	-203581	336
Dongshi Township	-166815	97	Ziguan District	-183646	217	Taoyuan District	-203654	337
Wandan Township	-166983	98	Anle District	-183681	218	Lugang Township	-203887	338
Bali District	-167266	99	Xinpu Township	-183902	219	Taitung City	-204287	339
Puzi City	-167370	100	Tongluo Township	-183979	220	Magong City	-204522	340
Sanmin District	-167402	101	Fuli Township	-184066	221	Haiduan Township	-204667	341
Budai Township	-167748	102	Yangmei District	-184159	222	Chunri Township	-204814	342
Kanding Township	-167837	103	Wufeng Township	-184266	223	Hualien City	-205581	343
Huatan Township	-167892	104	Houlong Township	-184374	224	Taiwu Township	-205661	344
Xitun District	-168005	105	W. District	-184399	225	Lanyu Township	-205777	345
Lunbei Township	-168018	106	Jiaoxi Township	-184505	226	Dajia District	-205967	346

Township	QOLI(NT$)	rank	Township	QOLI(NT$)	rank	Township	QOLI(NT$)	rank
Tianzhong Township	-168045	107	Yuanshan Township	-184505	227	Wutai Township	-207260	347
Liuying District	-168064	108	Xiaying District	-184989	228	Shengang Township	-208067	348
Meishan Township	-168208	109	Renai Township	-185081	229	Wanrong Township	-208539	349
Yanpu Township	-168269	110	Donghe Township	-185383	230	Shizi Township	-209121	350
Hengchun Township	-168286	111	Toucheng Township	-185466	231	Xiulin Township	-209271	351
Shilin District	-168313	112	Fuxing District	-185636	232	Guanshan Township	-209851	352
Houbi District	-168541	113	Alian District	-185719	233	Nangang District	-210305	353
Yanshui District	-168741	114	Zhudong Township	-185769	234	Laiyi Township	-211399	354
Taian Township	-168865	115	Xinfeng Township	-185862	235	Fangliao Township	-213285	355
Hengshan Township	-168985	116	Zhunan Township	-185889	236	Yanping Township	-219158	356
Linyuan District	-169021	117	Jiangjun District	-186178	237	Wangan Township	-233351	357
Daya District	-169106	118	Bade District	-186210	238	Qimei Township	-238345	358
Tianwei Township	-169277	119	Shitan Township	-186332	239			
Dahu Township	-169322	120	Xihu Township	-186420	240			

Note: Ranking is calculated by this study.

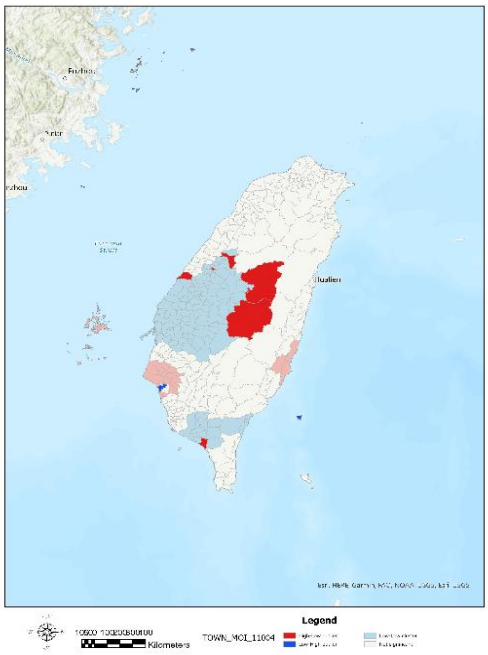

Figure 1. Hotspots areas of wind velocity

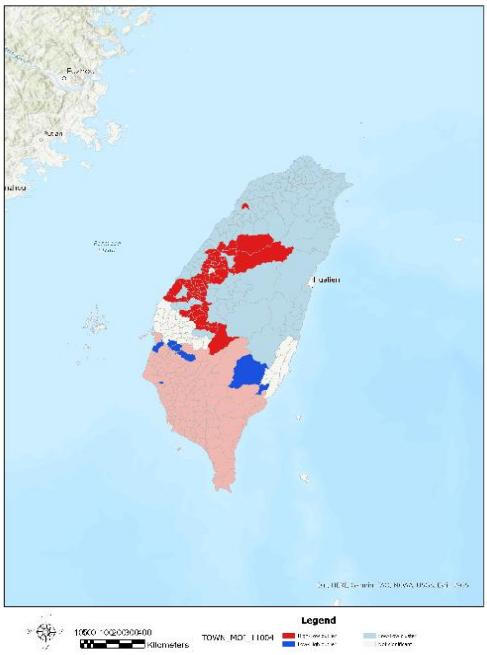

Figure 2. Hotspots areas of days with monthly temperature greater than or equal to 25℃

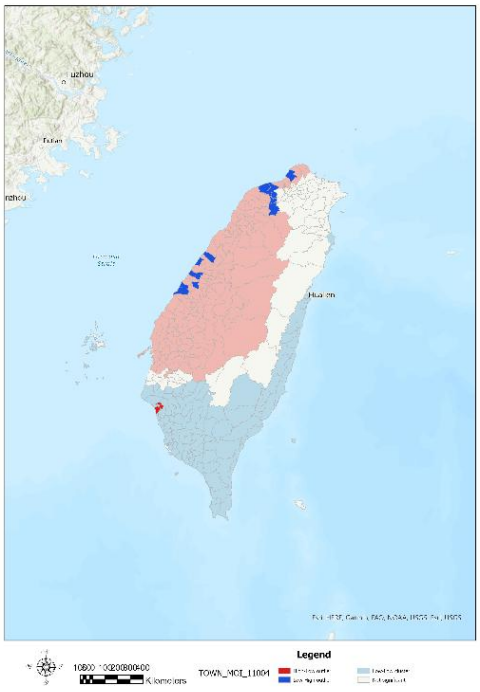

Figure 3. Hotspots areas of days with monthly minimum temperature less than or equal to 10℃

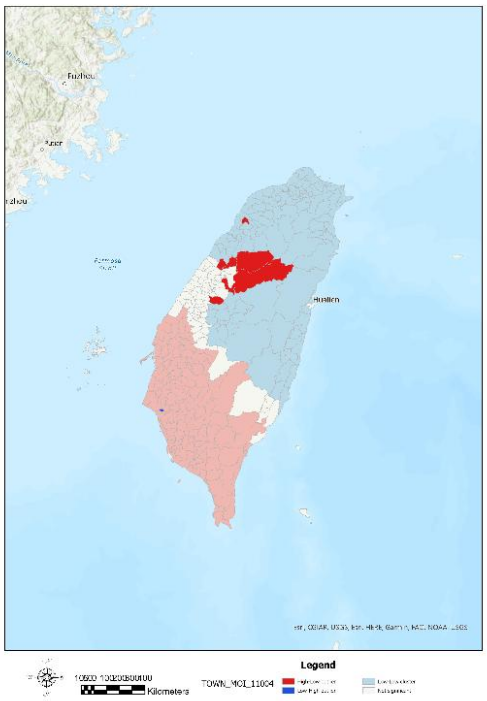

Figure 4. Hotspots areas of days with monthly maximum temperature higher than or equal to 30℃

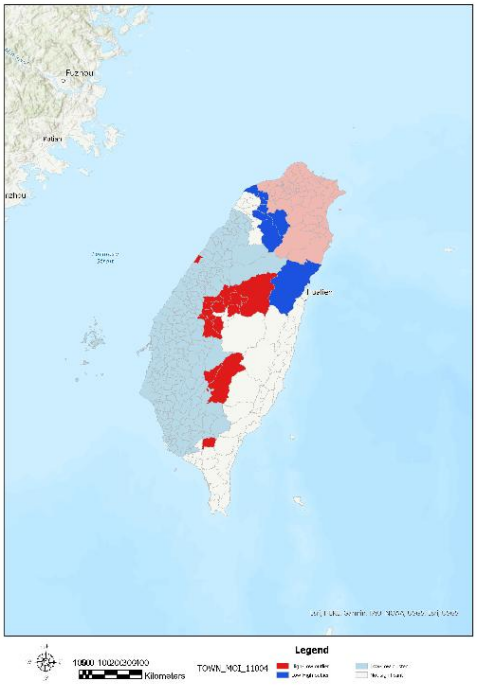

Figure 5. Hotspots areas of median of monthly precipitation

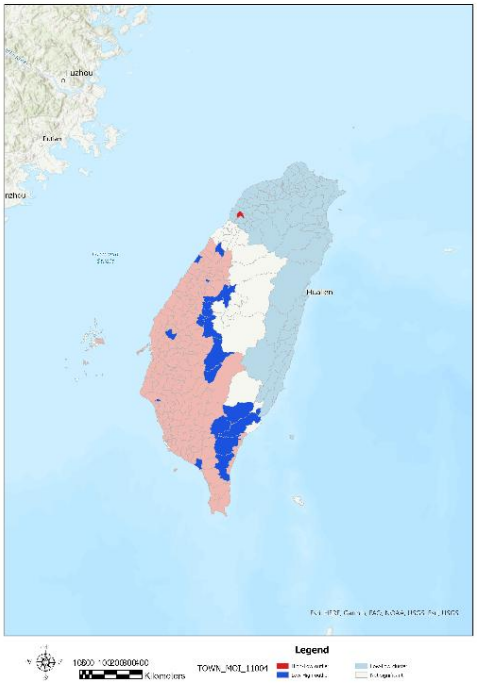

Figure 6. Hotspots areas of sunshine hours per month

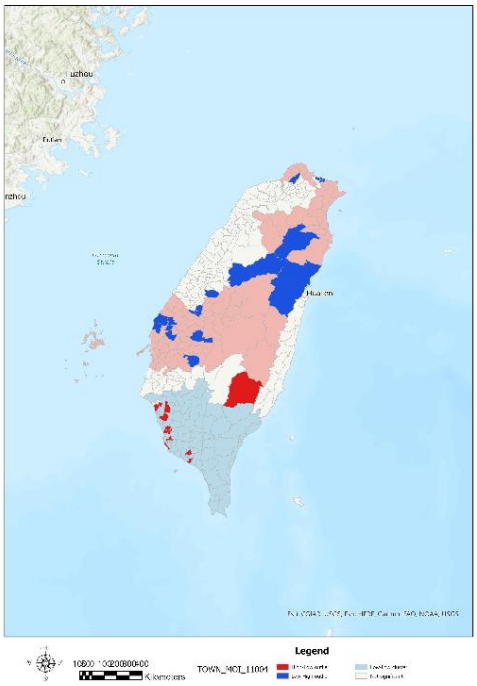

Figure 7. Hotspots areas of monthly relative humidity

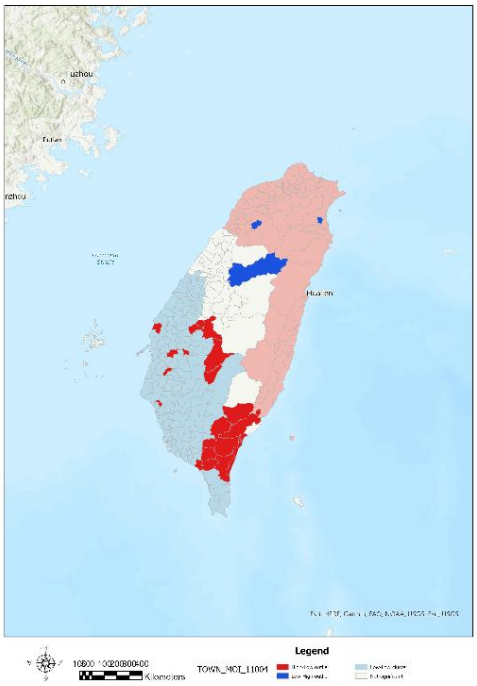

Figure 8. Hotspots areas of monthly cloud cover

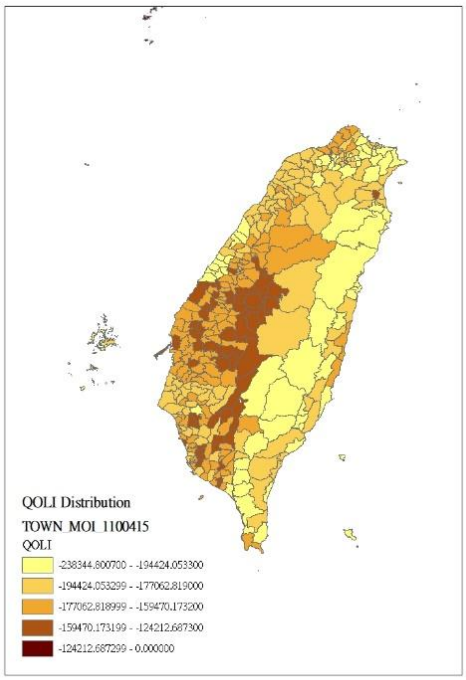

Figure 9. Spatial distribution of quality of life index

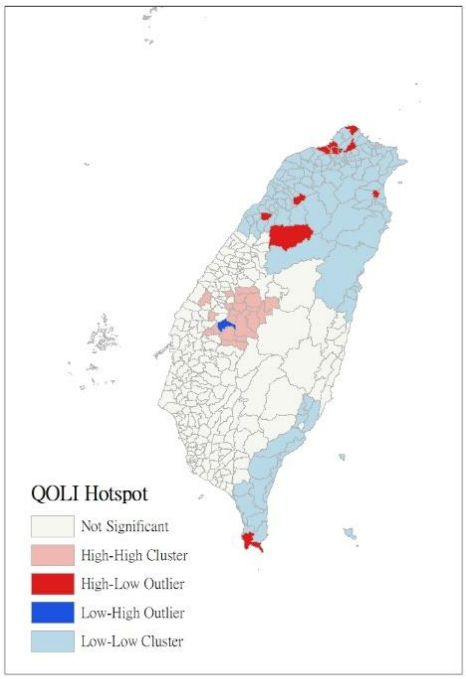

Figure 10. Hotspots areas of quality of life index

4.4.Space regression model

The improvement of urban conditions and socio-economic factors in adjacent areas will not only improve the quality of life, but also spill over to improve the living standards of adjacent areas. Prediction of quality of life by two Hedonic equations to be applied to investigate its' spatial effects (Figure 9, Figure 10). Figure 9 shows the townships with high quality of life to be in central as well as southern regions. Figure 10 provides the distribution of hotspot areas of quality of life to be in the townships nearby central region, while cold areas to be in the townships of northern and southeast region. The locations where the quality of life spillover benefits are

located in the towns in the central region and the towns in the extreme north and the extreme south. Predicted quality of life that is used as dependent variable of the spatial regression model is substituted into equation (4) to formulate the interdistrict spatial effects (Table 7 and Table 8). Table 7 reports the variables as well as definitions of them in the spatial regression model. Table 8 shows the “density”, population density, and “elderly”, elderly and living alone people, to be highly discretely distributed, while “age”, household headship age, “person”, persons per household, and “aging index”, population aging, to be trended to concentration. How pursuit of the self interest to fall on others’ benefits or costs is long run economics theme. Quality of life can be thought of as a local public good by virtue of principle of healthy competition between districts and face to face information communicated that benefits residents in the district as well as nearby neighboring districts (Table 9). Table 9 shows except for “income” the negative correlation between “age”, “elderly”, “person”, “density”, “aging index”, and “QOLI” with a high goodness of fit whose R^2 equals to 0715. It represents vulnerabilities in the city harms quality of life as well as capacity for individual in the city to expand utility favors quality of life. Positive coefficient of “e. QOLI”, autocorrelation parameter, shows spatial concentration trend at the significance level of 10%. Besides, “age” and “elderly” of adjacent districts spillover negative externalities into this district. The excessively high average household headship age and the excessive solitary elderly population in the adjacent districts are not conducive to the improvement of the quality of life in this district. Other variables including “person”, “density”, “income”, and “aging index” of adjacent districts positively

influence “QOLI”. It must be noted that negative effects of “density” and “aging index” on “QOLI” is offset by the positive effects of them from adjacent districts.

Spatial effects can be divided into direct, indirect, and total effects (Table 10). Table 10 shows spatial effects of independent variables on quality of life. For example, "age", when the household income increases by 1,000 NT$, the quality of life in this district increases by 33.8 NT$. Furthermore, when the household income from nearby neighboring district increases by 1,000 NT$, the quality of life in this district will increase by 82.6 NT$ through spillover effects. Overall, an increase of the household income of 1,000 NT$ leads to increase the quality of life by 116.4 NT$. The intuitive meaning of "doubling the result with half the effort" is that through effective methods, the cost of achieving the goal can be saved or the benefit of the result can be increased. In the context of space, "doubling the result with half the effort" means finding the policy to increase the benefit directly and indirectly under the complex interactive interrelationship.

Table 7. Variables in the spatial regression models.

variable	definition	unit	scale/numeric type
age	average of household headship age	year	Ratio/Continuous
elderly	number of elderly people living alone	person	Ratio/Discrete
person	persons per household	Person/household	Ratio/Continuous
density	Population density	Persons/square kilometer	Ratio/Continuous
income	Income from salaries and wages per household	Thousand dollars/household	Ratio/Continuous
aging index	(Population aged over 65)/ (Population aged 0~14) *100	%	Ratio/Continuous

8. Descriptive statistics of variables in the spatial regression models.

variable	observation	mean	standard deviation	minimum	maximum	coefficient of variation
age	368	55.595	3.228	47	63	0.058
elderly	368	2256.106	3029.206	8	19594	1.343
person	368	2.734	0.370	1.95	5	0.135
density	368	1356.276	2881.146	2.15	24606.30	2.124
income	368	672.998	109.099	519.37	1426.92	0.162
aging index	368	195.673	101.892	37.21	722.22	0.521

Table 9. Estimation of spatial regression model.

		Coefficient	Standard error
QOLI			
	age	-2582.716***	1033.634
	elderly	-0.855**	0.386
	person	-55818.060***	5313.476
	density	-0.711**	0.284
	income	29.672**	14.388
	aging index	-149.615***	32.514
	constant	-200507.800***	48655.440
W			
	age	-1623.882**	713.604
	elderly	-0.816***	0.145
	person	26731.420**	12614.510
	density	3.370***	1.156
	income	150.544**	72.578
	aging index	53.169***	13.027
QOLI		0.390***	0.126
e. QOLI		0.661***	0.123
Var (e. QOLI)		5.55×10^8	4.35×10^7
Prob.>chi2		0.0001	
$Pseudo\ R^2$		0. 715	

Note: Data is calculated by this study.

***: $p<0.01$, **: $p<0.05$, *: $p<0.1$

Table 10. Direct effects, indirect effects, and total effects of quality of life by independent variables.

Variable	Direct effects	Indirect effects	Total effect
age	-3027.668	-3491.29	-6518.958
elderly	-0.824	0.615	-0.209
person	-58919.01	-61881.7	-120800.7
density	-0.513	-2.918	-3.431
income	33.811	82.582	116.393
aging index	-162.969	-266.487	-429.456

Note: Data is calculated by this study.

5. Conclusions

The quality of life in this article is not an evaluation of subjective feelings, but an objective commodity with a price in market transactions. Quality of life is the capitalized value of the local amenities into the housing price plus the negative capitalized value into the wages. It is found all local amenities significantly to affect quality of life which represents the result consists with conclusion of Rosen (1979). In this article, the calculation of the weights between factors encountered in estimating the quality of life is based on the preference base weight, which is obtained based on two constructed Hedonic equations. The predicted quality of life indices of 358 townships are all lower than zero, which reminds decision makers that the negative threat of local amenities to the quality of life is higher than their positive extra value. The improvement of the quality of life must strengthen the adjustment policy of local amenities.

Another important finding is that local governmental policies spread spillover effects on quality of life. Some urban policies, such as an increase in household income, will improve the quality of life in nearby neighboring districts. Other urban policies, such as increased population density, will negatively spread spillover effects on the quality of life in nearby neighboring urbans. The improvement of the quality of life is a local public affair, but under the complex and interactive spatial relationship, urban policies will affect each other's goals that have been set.

The analytical framework developed in this research is globally applicable for regions where spatial heterogeneity and administrative fragmentation challenge equitable development. By demonstrating how indirect spatial effects shape quality

of life, this study contributes to the broader discourse on regional resilience, making it relevant to urban scholars and planners worldwide.

Disclosure statement

Conflict of interest. The author has no conflicts of interest to disclose.

Ethical approval. This article does not contain any studies with human or animal participants performed by any of the author.

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