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Relationship Between the Housing Vacancy Rate, Housing Price, and the Moving Rate at the Township Level in Taiwan, in 1990 and 2000*

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In this research, cross-sectional data for the township level obtained from the 1990 and 2000 Population and Housing Census are used to study the phenomenon of high housing vacancy rates in Taiwan. Three simultaneous equations for housing price, vacancy rate, and moving rate are derived and estimated using 3SLS. The estimation results show that, in 1990, in a booming market situation, both expected housing price and current housing price had a strong, positive impact on the vacancy rate; however, the housing vacancy rate did not display a negative impact on housing price as expected. The results for 2000 show that housing price did not significantly affect the vacancy rate; however, the vacancy rate had a negative impact on housing price that was highly statistically significant. This result reflected the fact that housing market operation had swung to another extreme after the real estate bubble that started in the late 1980s and burst in the mid-1990s. The natural vacancy rate for each township can be obtained from the estimation results. The average rate for 2000 was 0.11 to 0.12, compared to an actual vacancy

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rate of 0.158, which implied that 75% of townships had an excess supply of housing. Only Taipei City, Kaohsiung City and townships in areas inhabited by Taiwan's indigenous peoples had, on average, a relatively low excess supply rate.

Keywords

housing vacancy rate; housing price; natural vacancy rate; Population and Housing Census; Taiwan

Introduction

The state of the housing market in Taiwan in 2000 was completely different from that in 1990. A bubble economy formed and burst during the period of late 1980s and mid-1990s. As a part of the bubble, in 1990, the housing market has been booming for several years. Housing prices in the Taipei Metropolitan area increased by 200% in just two years (1987-1988), with other areas around Taiwan soon following the price hike. This development of bubble was basically caused by the rapid growth of economy and the huge increase of money supply, which encouraged various kinds of speculative activities, for example, the arbitrage behavior of short term investors were common. In the early 1990s, the government adopted a selective credit control scheme which aimed at the real estate market in order to curb speculation. The housing price stopped to increase; however, it stayed in a high level. This high price encouraged a wave of the new housing construction in the first half of 1990s, with the result that, by 1998, a huge surplus of completed new housing units was appearing on the market.

Housing prices eventually could not be sustained and started to fall, with a dramatic decline during the late 1990s. The government increased the available funding for housing loans several times, in an effort to help get surplus houses sold. This also coincided with the economy's dip into serious recession in the second half of 2000; as a result, in most areas in Taiwan, housing prices fell by more than 50% compared with their highest point.

The 2000 census evidenced the results of the excessive housing market development of the 1990s, with the overall housing vacancy rate having increased from 13% in 1990, to 17.6% in 2000.

The impact of the bursting of the real estate bubble has continued to threaten economic stability over the past decade. Obtaining a clearer understanding of the phenomenon of housing vacancy has thus become an important issue for

both housing researchers and policy makers in Taiwan. The purpose of this paper is to explain and compare the variation in housing vacancy in Taiwan between 1990 and 2000 in order to understand the market forces and changes that lay behind this phenomenon.

A special feature of this paper is the use of township-level data. The Population and Housing Census (PHC) is the only source in Taiwan that provides reliable data for the township level, the third tier of government[1]. According to the 2000 PHC, the overall vacancy rate in Taiwan was 17.6%, the mean value of the county-level vacancy rates was 18.3%, and the mean value of the township-level vacancy rates was 15.9%. Not only was there a significant difference between the mean vacancy rates at different levels of aggregation, the variation between different counties and between different townships was also very pronounced. The highest value for the vacancy rate at the county level was 26%; at the township level, the highest value was 52.3%. Observing on smaller geographical units can thus not only provide a larger sample size, but also make it possible to obtain much richer insight from the data analysis. No prior study in the literature on housing vacancy in Taiwan has adopted this perspective.

In modeling housing market behavior, the notion of the natural vacancy rate is reexamined, leading to the adoption of a simpler natural vacancy rate model than that of Rosen and Smith (1983). In addition, the moving rate, which is the major factor affecting the natural vacancy rate, is treated as endogenous. In the end, a three-simultaneous-equation system covering the housing vacancy rate, housing price, and total moving rate is derived and estimated. Another special feature of this study is that, for the first time in the literature, a housing price data is constructed for every township in Taiwan.

Literature Review

In Taiwan, the only official source for housing vacancy rate data is the Population and Housing Census, which is implemented every ten years. As a result, research into housing vacancy rates in Taiwan has tended to focus on correctly estimating the total number of vacant housing units in two census years. Chang (1995) attempted to define vacant housing units as those

[1] Taiwan has three types of third-tier government, with four different names. The name *Hsiang* (Rural Township) is used in rural areas, while the names *Shih* (City) or *Chen* (Township) are used for urbanized areas. *Hsiang*, *Shih* and *Chen* are subordinate administrative units under the counties, the second tier of government. The *Ch'u* (District) is the subdivision used in second-tier major cities, which have a similar administrative status as counties. In this paper, we use the term "township" to denote all of the third-tier governments.

consuming electricity less than the level at which the minimum charge applies. This was found to be an efficient way of determining the dynamics of housing vacancy. Chang also constructed a two-equation structure model to estimate the natural vacancy rate at the county level, the second tier of government, which was found to be much lower than the actual vacancy rate for all 24 cities or counties studied. Peng (2004) used the same method to construct cross-sectional (every county in Taiwan) and time-series (1980-2001) data for the vacancy rate, and used a two-equation simultaneous model to estimate factors that affect the level of vacancy rates. He found that the vacancy rate fluctuated dramatically during the period from 1980 to 2001. His empirical results showed that house prices were the most important factor affecting the housing vacancy rate.

Chang et al. (2000) defined vacant units still held by developers or realtors as surplus houses, then used property registration data to estimate the total amount and characteristics of these surplus houses. Lin et al. (2000) sent out a questionnaire to developers who had secured loans from the Land Bank of Taiwan; on the basis of the information obtained, they estimated that, in 2000, there were approximately 181,000 surplus houses the construction of which had been completed between 1997 and 1999. Eighty percent of these were in the three metropolitan areas.

Hua (2001) was the first researcher to link the phenomenon of high home ownership rate with the high vacancy rate in Taiwan. He suggested that the high home ownership rate in Taiwan was another factor that positively affected the vacancy rate, because in a high ownership rate environment, house suppliers need a longer time to find a buyer. In other words, a high home ownership rate will tend to increase the natural vacancy rate in a region. Hua used time series data for the period 1982-1997 and a three-equation structural model to verify his hypothesis.

The literature on housing vacancy rates around the world has focused on the estimation of the natural (or equilibrium) vacancy rate, factors that affect the natural and actual vacancy rate, and the relationship between the vacancy rate and the rental market. Rosen and Smith (1983) were the first to develop the concept of the natural vacancy rate and to estimate the effects of vacancy rates on rents. Using time-series data for their empirical analysis, Voith and Crone (1988) subsequently found that unexpected changes in the macro-economy affected the natural vacancy rate, and that the vacancy rate was higher in more rapidly growing areas. Read (1997) theoretically derived a downward sloping market demand curve, under the assumption of imperfect information, and explained vacancies in a partial equilibrium model of a rental housing market.

Gabriel and Nothaft (2001) used inter-metropolitan and time-series data from

the US Bureau of Labor Statistics to derive and model the incidence and duration of rental vacancies and to assess the impact of these factors on the price adjustment mechanism for rental housing. This research also provided new estimates of equilibrium vacancy rates for a large set of metropolitan areas in the US over the 1987-1996 period.

Another vein of literature relates search behavior to housing vacancy. Wheaton (1990) developed a theoretical general equilibrium model. He expected that "greater vacancy will increase sales time, lower seller reservations, speed up search time, and lead to lower market prices." He called the vacancy rate at market equilibrium the "structural rate." Krainer (2001), Lundborg and Skedinger (1999), etc. extended Wheaton's model to incorporate the effect of other factors, e.g. liquidity, transaction taxes in determining the market equilibrium.

In this paper, the term "natural vacancy rate" will be used. It plays an important role in the process of model building; however, its role in the housing market is different than that of Rosen and Smith. This will be discussed in detail in the following sections.

Modeling

In this section, we will first discuss the role that natural vacancy rates play in the market and the factors affecting them, and then go on to discuss the interrelationship between the housing price and the vacancy rate. Finally, an empirical model for econometric analysis will be constructed.

Natural Vacancy Rate

Rosen and Smith (1983) used the analogue of the labor market to explain the natural vacancy rate. They stated that: "the housing market requires some normal stock of vacant units to facilitate the search processes of buyers and sellers in the market. The search process implied a process of profit maximization and cost minimization of the sellers and buyers." Hence, they postulated an empirical model of a natural vacancy rate as the function of rent for rental housing, rent dispersion, mobility rate, change in housing stock and change in population.

As Rosen and Smith see it, the concept of the "normal stock of vacant units" is the result of market operation. They specified the function of the natural vacancy rate to include all the variables that affect demand and supply of housing. However, we feel that if the role of natural vacant housing is to provide transitional needs, then the natural vacancy rate should not be related to the demand and supply of housing. Rather, it should only be related to the

factors that affect the transitional needs; of these, frequency of moving and the time spent in searching for a new residence are the two factors that are most commonly mentioned in the literature. See for example Rosen and Smith (1983), Wheaton (1990), and Peng (2004). The higher the moving rate and the longer the searching time, the higher the natural vacancy rate. Therefore, factors affecting the natural vacancy rate can be greatly simplified. In this paper, they are categorized as two types, i.e. factors affecting household moving, and factors affecting the speed of search for a housing unit. These factors will be discussed separately below.

The function of the total moving rate (TMR)

Vacant housing units are required in an area to provide for the transition of moving in and moving out of households. Since both moving in and moving out require a period of housing vacancy, we consider that a total moving rate, which adds together the rate of moving in and moving out, should be used to measure moving behavior.

In this paper, we will treat moving as an endogenous behavior. Total moving rate (TMR) is affected by the characteristics of the population, such as level of education, household size and age of household head. Households with more members (NUM) and with an older household head (HAGE) will have higher demand for stability; both factors are therefore expected to have a negative impact on the moving rate. The level of education of the household head (EDU) affects the ability to secure employment in different areas; it is therefore anticipated that a higher level of education will be correlated with a higher mobility rate.

The economic condition of a township will also affect the moving rate. When local economy cannot provide enough employment opportunities, people will move out. The relationship between employment (or unemployment) and mobility has been investigated in several different aspects in the literature. For example, Baffoe-Bonnie (1998) and Hsueh et al. (2003) used VAR model to investigate the inter-relationship between several macroeconomic variables of a city or region, e.g. moving rate, unemployment rate, housing price in the work of Hsueh et al., and housing price, employment growth, money supply, CPI, mortgage rate in that of Baffoe-Bonnie. Kan (1999, 2003) used PSID data to study the role of uncertainty in households' job and residential mobility decisions. In this research, we will include unemployment rate (UNEMP) of the county level in the TMR equation. We expect that a higher unemployment rate will cause a higher moving rate.

The share of rental housing (RR) with respect to owner-occupied housing will also affect the moving rate, because renters can be expected to move

much more frequently than that of owners. Hence, a higher vacancy rate is required to meet the transitional needs.

Summing up discussions of this sub-section, the function of total moving rate can be specified as Equation (1):

$$\mathrm{TMR} = \alpha_0 + \alpha_1 \mathrm{HAGE} + \alpha_2 \mathrm{NUM} + \alpha_3 \mathrm{EDU} + \alpha_4 \mathrm{UNEMP} + \alpha_5 \mathrm{RR} + \varepsilon_0 \qquad (1)$$

The measurement of searching time --Diversity of housing stock

It takes time to search for a new residence. The average searching time affects the equilibrium natural vacancy rate; a longer searching time will result in a higher natural vacancy rate. The degree of search effort and diversity of housing stock will determine the searching time. Wheaton (1990) theoretically specified search effort in his model, and defined it as "the number of visits per period." However, the measurement of search effort is not available in this data set. We assume the efforts are all the same across households.

On the other hand, in the literature, the diversity of housing stock has often been used as a proxy for the searching time. Rosen and Smith (1983), Guasch and Marshall (1985), Gabriel and Nothaft (2001), etc. all included a diversity index of housing stock in their research. They anticipated that a more diversified range of housing products would result in a longer searching time. However, the existence of a diversified market does not necessarily imply a longer searching time. When market information and brokerage services are readily available, greater housing product diversity may even facilitate market segmentation; the existence of a wide range of housing products can help to narrow down the range of objects to be searched, thereby shortening the searching time.

In the literature, several different ways have been used to measure the diversity of housing stock. For example, it can be measured by the types of construction, the floor space of housing units, or the prices of housing units, etc.[2] In this research, we use the variation of construction types in the empirical estimation of the model. The method of measurement used will be described in the section covering variable definition.[3]

[2] Rosen and Smith (1983) used rent dispersion and Peng (2004) used housing price dispersion to measure the diversity of housing.

[3] We have tried several other specifications, e. g. the variance of housing prices, the variance of the size of housing units, and the product of several measures. However, the estimated results using these measures were not satisfactory.

Housing Price, Expected Housing Price, and Housing Vacancy Rate

The interaction between demand and supply in the housing market determines the housing price and rate of vacant housing. When the actual housing vacancy rate is greater than the natural vacancy rate, that portion above the natural vacancy rate can be called "surplus vacancy", which is an excess of quantity supplied. When surplus vacancy exists, the housing price will be negatively affected. On the other hand, an increase in the current housing price will increase the opportunity cost of leaving existing housing stock idle, which will lead to an increase in the quantity of housing supply.

In addition, in a booming housing market, the expectation on the trend of future housing price will affect the behavior of people. With an adaptive type of expectation, as price is expected to increase, supply increases. This is a typical kind of speculation in the real estate market which will result in bubbles. (Malpessi and Wachter, 2005) Therefore, expected housing price (EP) should also be included in the housing supply equation to capture the effect of speculation. When EP rises, we expect that new housing construction will increase. This new housing construction will take one to two years to be transformed into available supply in the market, which finally resulted in an increase of housing vacancy rate.

We, therefore, anticipate that both the expected housing price (EP) and the current housing price have a positive impact on the quantity of housing supply. This implies that both of them have a positive impact on the vacancy rate.

Empirical Model Derivation

In this section an empirical model of the housing market for cross-sectional data taking the township as the observation unit is derived.[4]

Equation for vacancy rate

On the basis of the previous discussion, it is assumed that the natural vacancy rate (NVR) in the market is affected by the population moving rate (TMR), and by the diversity index of housing product (DIS). The TMR has a positive expected sign; the sign for the DIS is uncertain. The function of the natural vacancy rate (NVR) can be specified as Equation (2):

$$\mathrm{NVR} = d_1 \mathrm{TMR} + d_2 \mathrm{DIS} + \varepsilon_5 \qquad (2)$$

[4] In Taiwan, owner-occupied housing and rental housing are not segregated. Due to the high ownership rate, 85%, the size of rental market is quite small. This is the reason we study the housing vacancy rate in the owner-occupied housing market.

Next, the interaction between demand and supply in the housing market determines the housing price and the rate of vacant housing. Hence, the supply and demand function of housing quantity needs to be specified. The quantity of housing demanded (Q^d) and supplied (Q^s) for township *i* in a specific time period is described in Equation（3）and Equation (4)[5]:

$$Q^d = a_0 - a_1 P + a_2 Y + a_3 N + \varepsilon_1 \quad (3)$$

$$Q^s = b_0 + b_1 \mathrm{EP} + b_2 P + \varepsilon_2 \quad (4)$$

where *P*, EP, *Y*, and *N* represent housing price, expected housing price, average household income, and the number of households in a township in the census year. The quantity of surplus housing vacancy (SVQ) is the difference between the quantities supplied and demanded, which can be expressed as Equation (5).

$$\mathrm{SVQ} = Q^s - Q^d \quad (5)$$

Substituting Equation (1) and (2) in Equation (5) and rearranging the terms, the function of SVQ can be obtained as follows:

$$\mathrm{SVQ} = (b_0 - a_0) + b_1 \mathrm{EP} + (b_2 + a_1) P - a_2 Y - a_3 N + \varepsilon_3 \quad (6)$$

Dividing SVQ and N by the housing stock (S), we can express the Equation (6) as the surplus vacancy rate (SVR) as shown in Equation (7)：

$$\mathrm{SVR} = (b_0 - a_0) + b_1 \mathrm{EP} + (b_2 + a_1) P - a_2 Y - a_3 \mathrm{NS} + \varepsilon_4 \quad (7)$$

Where NS denotes the number of households divided by the housing stock.

However, the actual vacancy rate observed in the census data is constituted by both the natural vacancy rate and surplus vacancy rate. Therefore, by adding Equation (2) and Equation (7), we can obtain the total vacancy rate function (VAN) as Equation (8):

$$\mathrm{VAN} = (b_0 - a_0) + b_1 \mathrm{EP} + (b_2 + a_1) P - a_2 Y - a_3 \mathrm{NS} + d_1 \mathrm{TMR} + d_2 \mathrm{DIS} + \varepsilon_4 + \varepsilon_5 \quad (8)$$

Equation for housing price

At the natural vacancy rate, the market price remains stable. When the market vacancy rate is higher than the natural vacancy rate, the housing price will fall. In addition, factors that lead to an increase in market demand, such

[5] Subscripts are omitted in the equation for simplicity.

as household income, will also shift the price upward. The relationship can be described by Equation (9):

$$P = c_0 - c_1 (\mathrm{VAN} - \mathrm{NVR}) + c_2 Y + \varepsilon_6 \quad (9)$$

Substituting Equation (2) into Equation (9) and rearranging the terms, the function of housing price can be obtained as Equation (10). In addition, in order to properly identify Equation (10), we add three variables. They indicate geographical characteristics of townships that may also have an effect on the housing price, i.e. whether or not the township is an area inhabited by Taiwan's indigenous peoples (MOUN), whether or not the township is in a metropolitan area (METRO), and whether or not the township is in a sub-metropolitan area (SUB). Equation (10) can thus be stated as follows:

$$P = c_0 - c_1 \mathrm{VAN} + c_1 d_1 \mathrm{TMR} + c_1 d_2 \mathrm{DIS} + c_2 Y + c_3 \mathrm{MOUN} + c_4 \mathrm{METRO} + c_5 \mathrm{SUB} + \varepsilon_7 \quad (10)$$

Equations (1), (8), and (10) are the system of equations that we are going to estimate simultaneously using the 3SLS method. The rank condition and identification condition of this system are satisfied.

The estimated coefficients d_1, d_2 in Equation (8) can be used to calculate the natural vacancy rate in any of the townships in the sample, as $d_1 \mathrm{TMR} + d_2 \mathrm{DIS}$.

Variable Definition and Descriptive Statistics

Data from the Population and Housing Census (PHC) of 1990 and 2000 are used in this research. Township level data are aggregated from the individual household data in the Census. There are 349 and 353 observation units for 1990 and 2000 respectively; a number of very small townships that are not located on the main island of Taiwan were excluded. In the following subsections, variable definitions and data sources will be discussed first, after which the descriptive statistics will be presented.

Variable Definitions and Data Sources

Of the variables used in the model, the vacancy rate, number of households, housing stock, rate of rental housing, age of household head, and size of household can be directly obtained from the Census data. For the data for other variables, we have to turn to other sources.

The total moving rate is readily available from the officially published *The Overview of Population Statistics*. The unemployment rate (UNEMP) is also a government published statistics, but it is not available in township level. Therefore, county level data is used instead. The diversity index of housing stock is measured according to the type of buildings (DIS). Three types of building are identified, e.g. single housing units, apartment buildings with 2-5 floors, and high-rise buildings with 6 or more floors. A diversity index is calculated by using the equation $\mathrm{DIS} = 1 - \sum h_i^2$, where h_i is the share of *i* type of housing stock.

The land price index published by the Ministry of Interior is used to define the expected housing price. EP=1 if the growth rate of the land price index of the township in question was greater than zero in the previous year; otherwise, EP=0. This definition is used in the hope that it can capture people's expectations regarding the direction of changes in housing price.

The construction of housing price (*P*) and household income (*Y*) for every township in the data set is quite complicated. The procedures for obtaining *P* and *Y* are similar. First, we collected a sufficient amount of individual raw data for housing price and household income. Then, hedonic regressions for housing price or household income were estimated separately for every county, after which estimated coefficients from the hedonic regressions were applied to the housing units or household units in the Population and Housing Census to calculate the imputed *P* or *Y* for each unit. Finally, the *P* and *Y* values of individual units were aggregated to calculate the average *P* or *Y* at the township level. The details of this procedure are presented in the Appendix of this paper.

Definitions of all variables are summarized in Table 1.

Table 1: Definition of variables

Variable (notation)	Expected sign VAN	P	TMR	Definition	Data source
Housing price (*P*)	+			Average price for a residential unit in a township per ping[6] (unit: NTD10,000/ping)	The present study
Housing vacancy rate (VAN)		-		Residential units that no person lives in and that are not being used for any other purpose divided by total housing stock (unit: %)	Population and Housing Census, 1990 and 2000
Expected housing price (EP)	+			EP=1 if the growth rate of the land price index of township i between 1988-1989 (or 1998-1999) is greater than 0; otherwise, EP=0.	*Taiwan Land Price Index*, published by the Ministry of the Interior
Total moving rate (TMR)	+	+		Total moving rate = rate of moving out of the township + rate of moving into the township + moving within the township (unit: ‰)	*Overview of Population Statistics*, the Ministry of the Interior
Diversity index of housing type (DIS)	?	?		Housing stock is classified into three types: single unit housing, apartment buildings with 2-5 floors, and high-rise buildings with 6 or more floors. $DIS = 1 - \sum h_i^2$, where h_i is the share of *i* type of housing stock	Population and Housing Census, 1990 and 2000
Household income (*Y*)	-	+		Average household income in the township (unit: NTD10,000 per year)	The present study.
Number of households per residential unit (NS)	-			Total number of households divided by total housing stock	Population and Housing Census, 1990 and 2000
Rental housing rate (RR)			+	RR=number of residential units for rent/total housing stock (unit: %)	Population and Housing Census, 1990 and 2000
NUM			-	Average size of household (no. of members) in the township	Population and Housing Census, 1990 and 2000
HAGE			-	Average age of household heads in the township	Population and Housing Census, 1990 and 2000
EDU			+	Average years of education of household heads in the township	Population and Housing Census, 1990 and 2000
UNEMP			+	County level unemployment rate	Urban and Regional Development Statistics, by CEPD[7]
MOUN		-		=1, if the township is located in an area inhabited by Taiwan's indigenous peoples =0, otherwise	
Urbanization level dummies (METRO, SUB)		+		METRO=1, if the township is in a metropolitan area; SUB=1, if the township is in a sub-metropolitan area.	

[6] The *ping* is the most widely used unit for measuring building and lot area in Taiwan. One *ping* equals 3.3 m^2.

[7] CEPD is the abbreviation of the Council for Economic Planning and Development, Executive Yuan.

Descriptive Statistics of Variables

Descriptive statistics of all variables are listed by region in Table 2 and Table 3. From the data in Table 2 and Table 3, we can see that housing price per *ping* increased by 20% to 50% in ten years in nominal terms. The Northern region had the highest prices, while the Eastern region had the lowest. The housing vacancy rate increased in all regions over the ten-year period in question, with the northern region displaying the smallest increase, and the Eastern region the largest. Expected price is defined as 1 when the land price index of a township increased during the year before the census was taken. We can see that, in 1988-1989, land prices increased in more than 60% of townships in Taiwan. In the Northern region and Central region, more than 70% of townships experienced a land price increase. By contrast, in 1998-1999, only 33% of townships in Taiwan experienced a land price increase, with the highest percentage, 45%, being found in the Eastern region.

In nominal terms, household income nearly doubled in the ten years between 1990 and 2000; average household income was highest in the Northern region and lowest in the Eastern region.

The number of households per housing unit (NS) shows whether the housing supply available is sufficient. When NS is greater than one, this means that, on average, one housing unit is occupied by more than one household; the greater the value of NS, the more inadequate the housing supply, and vice versa. In 1990, NS values were very close to one in all four regions, with the Northern and Eastern region having average values of less than one, while the Central and Southern region had average values greater than one. In 2000, only the NS value for the Central region displayed a significant change compared to 1990, having fallen from greater than one to less than one.

The diversity of housing stock (DIS), in terms of the type of buildings, increased over the ten years from 1990 to 2000. The level of diversity in the Northern and Central regions was slightly higher than that in the other two regions. Over the ten-year period, the total moving rate decreased in ten years in all four regions, with the highest moving rate in the Northern region and the lowest in the Central region. The rental housing ratio increased in every region except the Northern region. However, the Northern region had the highest rental rate.

The demographic variables, HAGE, EDU, and NUM, changed substantially over the ten-year period. We can see that both HAGE and EDU increased, while NUM decreased. On average, household heads in the Northern region were younger and better educated. Overall unemployment rate (UNEMP) increased substantially in ten years from 1.55% to 2.98%. In 1990, no

obvious difference among regions can be found. However, in 2000, the unemployment rates in the Southern and Eastern regions were much higher than that of Northern and Central regions.

Table 2： Average of variables in 1990 by region

Variables	Northern	Central	Southern	Eastern	All
P	9.9849	8.3986	6.6694	5.9411	7.9627
VAN	0.1667	0.1109	0.0975	0.0964	0.1187
EP	0.7241	0.7358	0.6016	0.4643	0.6619
DIS	19.2037	40.2809	17.9835	13.7303	24.7187
DISF	0.4648	0.4645	0.4434	0.4324	0.4543
Y	45.7479	39.0268	37.1424	33.7939	39.5913
NS	0.9541	1.0144	1.0513	0.9915	1.0111
TMR (‰)	187.7299	138.9042	156.7098	161.3536	159.4072
RR	0.0860	0.0527	0.0466	0.0420	0.0579
CAGE	48.3681	50.2801	49.9929	51.3542	49.7843
NUM	4.0903	4.3711	3.8339	3.6771	4.0484
EDU	7.5734	6.9627	6.9316	6.7138	7.0836
MOUN	0.0690	0.0377	0.0938	0.2500	0.0831
METRO	0.6667	0.1792	0.3203	0.0000	0.3381
SUB	0.0920	0.0000	0.0234	0.0000	0.0315
UNEMP	0.0177	0.0127	0.0165	0.0141	0.0155

Note: 1. Regions are defined according to *City and Regional Development Statistics*, edited by the Council for Economic Planning and Development. 2. For the units of measurement, please refer to Table 1.

Table 3：Average of variables in 2000 by region

Variables	Northern	Central	Southern	Eastern	All
P	13.1809	10.3972	9.8766	8.9439	10.7894
VAN	0.1788	0.1622	0.1337	0.1822	0.1576
EP	0.2809	0.2830	0.3876	0.4483	0.3343
DIS	27.0873	47.4966	27.5500	24.4893	33.1715
DISF	0.5502	0.5219	0.5095	0.4824	0.5212
Y	94.4689	77.3539	75.4296	64.9822	79.9494
NS	0.9492	0.9850	1.0434	0.9452	0.9941
TMR (‰)	150.0315	117.2538	126.8880	134.2638	130.4360
RR	0.0856	0.0639	0.0532	0.0521	0.0645
CAGE	49.2897	52.0394	51.5435	53.1495	51.2561
NUM	3.3153	3.6403	3.3651	3.1868	3.4205
EDU	11.4416	10.8763	10.9747	10.9724	11.0627
MOUN	0.0674	0.0377	0.0930	0.2759	0.0850
METRO	0.6517	0.1792	0.3333	0.0000	0.3399
SUB	0.1124	0.0000	0.0310	0.0000	0.0397
UNEMP	0.0278	0.0277	0.0316	0.0349	0.0298

Note: See Table 2

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Discussion of Results

The equations for TMR, VAN, and *P* make up a complete simultaneous equation system. However, to test for different model specifications, TMR is also treated as exogenous. In Model 1, TMR is treated as an exogenous variable; in other words, only Equations (8) and (10) are estimated simultaneously. In Model 2, TMR is treated as endogenous. All models are estimated by 3SLS.[8] The natural vacancy rates of every township are also calculated using estimated coefficients in Equation (8). We will first discuss the estimated coefficients, and then go on to discuss the estimated natural vacancy rate.

Estimated Coefficients

First of all, we discuss the interaction between expected price, price, and vacancy rate. From Table 4, we can see that *P* had a strong positive effect on the vacancy rate in 1990, but this was not significant in 2000. EP had a significantly positive effect on VAN in Model 2 for 1990, and an insignificantly negative effect in 2000. However, the results show that VAN had a positive effect on *P* in 1990 and a strongly significant negative effect in 2000. These different results correspond to the different state of the housing market in 1990 and in 2000 as described in the introduction. In 1990, the general mood in the housing market was very optimistic; as a result, expected price and current price (as a signal to profit) strongly encouraged an increase in the supply of housing; people were not particularly concerned about the vacancy rate signal, so this had no significant effect (Model 1), or an unexpected positive effect (Model 2) on the price of housing. In 2000, however, in a depressed market situation in which the housing vacancy rate was already very high, VAN negatively and strongly impacted on *P*; at the same time, people evaluated the housing price signal cautiously, which in many cases resulted in no action taken, and hence, no impact on VAN.

Household income had a negative impact on VAN and a positive impact on *P* as expected in both the 1990 and 2000 models. The coefficients of NS were all in the expected sign and statistically significant in both years.

TMR had a significant positive effect on VAN and *P* as expected in both 1990 and in 2000, except for an insignificant negative coefficient in Equation VAN of Model 2 in 1990. Comparing the coefficients of TMR, we can see that, when TMR is treated as an endogenous variable, the values of the estimated coefficients are larger, and their *t*-ratios are also larger, as shown in Model 2 for both years.

[8] LIMDEP Econometric Software is used for estimation.

Table 4: Estimation result of simultaneous model, VAN and *P*

Explanatory variables	1990				2000			
	Model 1		Model 2		Model 1		Model 2	
	VAN	*P*	VAN	*P*	VAN	*P*	VAN	*P*
Constant	0.466	-2.944	0.480	-2.592	0.399	0.665	0.364	-1.465
	(6.97)***	(2.19)**	(8.36)***	(1.88)*	(10.46)***	(0.66)	(10.17)***	(1.44)
P	0.029	-	0.036	-	0.001	-	-0.006	-
	(2.84)***		(7.50)***		(0.28)		(2.04)**	
Y	-0.004	0.173	-0.004	0.060	-0.001	0.136	0.000004	0.133
	(1.90)*	(5.70)***	(4.42)***	(1.98)**	(1.4)	(13.87)***	(0.01)	(13.39)***
NS	-0.373	-	-0.351	-	-0.289	-	-0.262	-
	(6.92)***		(10.09)***		(12.12)***		(12.44)***	
EP	0.001	-	0.010	-	-0.001	-	-0.0022	-
	(0.26)		(1.85)*		(0.25)		(0.49)	
VAN	-	5.364	-	6.006	-	-11.045	-	-11.265
		(1.59)		(1.86)*		(3.56)***		(3.94)***
TMR	0.00006	0.008	-0.0005	0.028	0.0004	0.029	0.0008	0.048
	(0.34)	(2.05)**	(2.22)**	(4.34)***	(2.29)**	(6.95)***	(4.50)***	(7.94)***
DIS	-0.075	4.417	-0.117	5.949	0.12	-5.661	0.044	-5.396
	(1.08)	(2.67)***	(2.47)**	(3.69)***	(2.24)**	(2.68)***	(0.82)	(2.58)***
MOUN	-	-1.259	-	-1.321	-	0.178	-	0.244
		(3.30)***		(3.47)***		(0.43)		(0.58)
METRO	-	0.77301	-	0.929	-	0.595	-	0.034
		(1.79)*		(2.46)**		(2.00)**		(0.11)
SUB	-	-0.012	-	0.539	-	-1.904	-	-1.676
		(0.03)		(0.98)		(3.36)***		(3.07)***
Adjusted R^2	-0.196	0.344	-0.478	0.268	0.622	0.552	0.569	0.511
Samples	349	349	349	349	353	353	353	353
NVR	-0.025		(N/A)		0.1102		0.1212	

Notes:
1: Numbers in parentheses are coefficients divided by their standard error.
2: *, **, and *** denote significant at 10%, 5%, and 1% respectively.

Table 5 shows the estimation results of TMR in the endogenous TMR models. All variables had the expected sign and most of them were statistically very significant in their estimated coefficients. The 2000 models have higher adjusted R^2 than the 1990 models.

The estimation results of the housing diversity index were mixed. In all cases, the signs were different in the two equations VAN and *P*. They were also different in 1990 and 2000. In 1990, coefficients were negative on VAN and positive on *P*, whereas in 2000 they were positive on VAN and negative on *P*. This may have been due to the fact that DISF is still not a good proxy for searching time. Unfortunately, our attempts to find other definitions for housing diversity were no more successful.

In townships located in regions inhabited by Taiwan's indigenous peoples (MOUN), housing prices in general were lower than in other townships in

1990, but were not significantly different in 2000. Townships in the metropolitan areas had higher housing price in both 1990 and 2000. Townships in sub-metropolitan areas did not have significantly different housing price from other areas in 1990; however, they were significantly lower in 2000.

The average natural vacancy rate (NVR) was computed for every model using the coefficients of TMR and DISF in the equation for VAN. The results for 1990 were not in a reasonable range. This is probably because the housing market was not in a normal situation in 1990. The computed NVR for the 2000 models are very close, 11% and 12% respectively. The results of these two models are similar in other aspects too, so either of them should be acceptable. We choose the result of Model 2, the endogenous TMR, to further compare the actual and estimated natural vacancy rate of housing in every township.

Table 5: Estimation result of TMR in endogenous TMR models

Explanatory variables	1990 Model (2)	2000 Model (2)
Constant	200.108 (3.95)***	280.660 (7.51)***
RR	475.718 (7.69)***	234.397 (6.32)***
CAGE	−1.778 (2.43)**	−2.327 (5.83)***
NUM	−14.840 (3.55)***	−41.116 (13.32)***
EDU	7.739 (2.47)**	7.893 (4.09)***
UNEMP	1649.996 (4.01)***	244.536 (1.63)
Adjusted R^2	0.566	0.700
Samples	349	353

Notes: 1. Numbers in parentheses are coefficients divided by their standard error. 2. *, **, and *** denote significant at 10%, 5%, and 1% respectively.

Estimated Natural Vacancy Rate of Housing

Natural vacancy rates of every township were calculated using the estimated coefficients in Equation (8), and are summarized in Tables 6, 7, and 8. In Table 6, we can see that the overall average of the natural vacancy rate by county was 0.131, compared to an actual vacancy rate of 0.171; by comparison, the natural vacancy rate by township was 0.121, compared to an actual vacancy rate of 0.158. When the actual vacancy rate is greater than the natural vacancy rate, the housing market is considered to be in a state of

excess supply; when the natural vacancy rate is greater than the actual vacancy rate, the housing market is considered to be in a state of excess demand. Out of 353 townships, 75% were in a situation of excess supply. Excess supply of housing was very pervasive in 2000.

Table 6: Estimation of the natural vacancy rate in 2000

	Count by counties			Count by townships		
	V	V^n	$V - V^n$	V	V^n	$V - V^n$
Mean	0.171	0.131	0.04	0.158	0.121	0.037
Max	0.286	0.192	-	0.523	0.242	-
Min	0.115	0.095	-	0.023	0.071	-

Note: 1. V denotes the actual vacancy rate, V^n denotes the estimated natural vacancy rate.

Now we turn to the market situation at the county/city level. Table 7 shows that nine out of twenty-two counties/cities had over 90% of townships in excess supply of housing in 2000. However, Taiwan's two major metropolises, Taipei City and Kaohsiung City, had more districts in a state of excess demand than in excess supply. Table 8 shows the regional distribution of the excess supply of housing. The proportion of townships in excess supply was the lowest in the Southern region, at 61%, and highest in the Eastern region, at 93%. The excess supply rate, 20%, was relatively low in townships located in regions (mostly mountainous) inhabited by Taiwan's indigenous peoples (MOUN), which contributed to the lower excess supply rate in the Southern region.

To summarize, the phenomenon of excess supply of housing was very pervasive in 2000; this was true regardless of region, and was true for both rural and metropolitan areas. Only metropolises and townships located in regions inhabited by Taiwan's indigenous peoples, the two extremes, had a relatively lower rate of excess supply.

Table 7: Housing market status by county

unit: number of townships

County/city	All townships	MOUN	METRO	In excess supply	In excess demand	Proportion of townships in excess supply (%)
Chang-hua County	26	0	3	26	0	1.00
Tai-chung City	8	0	8	8	0	1.00
Hsin-chu City	3	0	0	3	0	1.00
Chia-yi City	2	0	0	2	0	1.00
Yun-lin County	20	0	0	19	1	0.95
Tai-tung County	16	5	0	15	1	0.94
Tau-yuan County	13	1	11	12	1	0.92
Hua-lien County	13	3	0	12	1	0.92
Tai-chung County	21	1	8	19	2	0.90
Kee-lung City	7	0	7	6	1	0.86
Tai-nan City	7	0	7	6	1	0.86
Yi-lan County	12	2	0	10	2	0.83
Nan-tau County	13	2	0	10	3	0.77
Taipei County	29	1	28	21	8	0.72
Kao-hsiung County	27	3	17	18	9	0.67
Miau-li County	18	1	0	12	6	0.67
Chia-yi County	18	1	0	12	6	0.67
Hsin-chu County	13	2	0	8	5	0.62
Tai-nan County	31	0	6	18	13	0.58
Ping-tung County	33	8	2	19	14	0.58
Kao-hsiung City	11	0	11	4	7	0.36
Taipei City	12	0	12	3	9	0.25

Notes: 1. MOUN: townships located in regions inhabited by Taiwan's indigenous peoples; METRO: metropolitan areas

Table 8: Housing market status by region

unit: number of townships

Districts	North	Central	South	Eastern	All
All townships	89	106	129	29	353
MOUN	6 (0)	4 (0)	12 (0)	8 (6)	30 (6)
METRO	58 (40)	19 (19)	43 (28)	0	120 (87)
Excess supply	63	94	79	27	263
Proportion of townships in excess supply	0.71	0.89	0.61	0.93	0.75

1. The figures in parentheses are the number of townships in excess supply.

Conclusion

In this research, we study the high housing vacancy rate phenomenon in Taiwan. Cross-sectional data taking townships as the observation units were obtained from the 1990 and 2000 Population and Housing Census. Three simultaneous equations for housing price, vacancy rate and moving rate are derived and estimated using 3SLS. The natural vacancy rate is calculated for all townships in the data.

The estimation results show that, in 1990, with a booming housing market, housing price positively affected vacancy rate, but the housing vacancy rate did not have a significant impact on housing price. In addition, expected housing price also had a significant positive effect on vacancy rate.
The results for 2000 showed that, in this year, housing price did not significantly affect the vacancy rate; however, the vacancy rate had a negative and (statistically very significant) impact on housing price. This result reflected the fact that housing market operation had swung to another extreme after the real estate bubble that started in the late 1980s and burst in the mid-1990s.

Probably because the housing market was not in a normal situation, we cannot find a natural vacancy rate in a reasonable range for the 1990 sample. The average township level natural vacancy rate for 2000 is 0.11 to 0.12, compared to an actual vacancy rate of 0.158, which implies that 75% of townships had an excess supply of housing. Only Taipei City, Kaohsiung City and townships located in regions inhabited by Taiwan's indigenous peoples had, on average, a relatively lower excess supply rate.

In this paper, the role of the natural vacancy rate is reexamined, leading to the adoption of a simpler model. The endogenous nature of moving behavior is taken into account; however the estimation results with endogenous TMR show only a slight difference. Although we tried several definitions to measure housing diversity index, none of them produced a satisfactory result. Further research will be needed to clarify the issue of what constitutes a good proxy variable in empirical research for searching time.

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Appendix

The Estimation of Housing Price at the Township Level

Data source

Since 1989, the prices of individual property transactions have been collected and published on a quarterly basis in the *Brief News of Land and Building Transaction Price* published by the Department of Land Administration, Ministry of the Interior. In each entry of transaction data, 14 items relating to the character of the property are included, such as: width of the road, construction type, construction materials, land-use classification, building size, lot size, etc. In the beginning, the number of data entries collected and geographical coverage were quite limited. However, both the sample size and geographical coverage have gradually been extended over the years.

By selecting transactions involving properties intended for ordinary [9]

[9] "Ordinary" here means that some obviously incorrect data entries were deleted, while housing units located in basement levels were excluded.

residential use, 1,110 data entries were obtained for 1990[10] and 7,032 for 2000.

Hedonic regression for housing price

As the sample size was not large enough to run a hedonic regression for every township, we ran a regression for each county instead; dummy variables were included to take account of locational differences within the county. For 1990, in several instances, data for neighboring counties had to be pooled to obtain a sufficiently large sample size for regression. For the biggest four cities in Taiwan, i.e. Taipei City, Kaohsiung City, Tainan City and Taichung City, dummy variables are included to represent each sub-district in the city. For other counties, dummy variables are used only to represent major, highly-urbanized cities falling directly under the county government. The regression results and definition of variables are listed in Table A1 and Table A2. Adjusted R^2s are at acceptable levels: between 0.21 and 0.77 in the 1990 regressions, and between 0.33 and 0.83 in the 2000 regressions.

Housing prices at the township level

Estimated coefficients from the hedonic regression are applied to each residential unit in the Population and Housing Censes to calculate the imputed housing price for each housing unit. Finally, average housing price for a township is obtained by averaging the housing prices of each residential unit in that township.

The Estimation of Household Income at the Township Level

A similar procedure is used to obtain the average household income at the township level. The data used for income regression is from the "Household Income and Expenditure Survey (HIES)," which is conducted annually by the Directorate General of Budget, Accounting, and Statistics (DGBAS). HIES is a national survey with more than 15,000 households included in the sample.

Individual household income (in natural log form) is regressed with the characteristics of the economic household head, e.g., age, sex, marital status, educational level, employment, etc., and family size for each county. Variables actually used in the regression are limited to those that are available in both HIES and the Censes. Unfortunately, we do not know the

[10] As the number of data entries for 1990 was quite small, we included transaction entries for 1989 in the 1990 hedonic regression.

exact location of each household in the county. Therefore, no location dummies are added in the regression. Definition of variables in the regression and estimated coefficients are listed in Table A3 and Table A4. Adjusted R^2s of these regressions are at acceptable levels, ranging from 33% to 63%. On average, the R^2s are higher in the 2000 sample.

The estimated coefficients are then applied to the data in the Censes to compute the income of each household. Individual household income is then aggregated to obtain average household income for the township level. The comparison of average income in the sample from the Income Expenditure Survey and the average predicted income from the Census at the county level is shown in Table A5. The predicted income is about 70% to 90% of the actual income. The predicted ratio is higher for 2000 than for 1990.

Table A1 Hedonic regression of housing price in 1990†

	LnBAGE B	lnSIZE	floorD1	floorD2	location	Location2	Location3	C1	C2	Adj R^2	Sample size
Taipei county	0.2345***	1.007***	-0.1769	0.22	0.5544***	0.4687**	-	-	-	0.46	110
I-lan, Hua-lien, and Tai-tung county	0.0083	0.6864***	-0.5357***	-0.1672	0.4034***	-0.4402**	-	0.07	0.0550	0.42	78
Tau-yuan county	0.1417**	0.8795***	-0.2241	0.24	0.4694***	-0.1967	-	-	-	0.54	76
Hsin-chu and Miao-li county	-0.0734	0.9477***	0.2464	-	0.492***	0.3546	-	0.17	-	0.53	61
Tai-chung county	0.2137	0.4604*	-0.3013	-	0.9489***	0.6016	-	-	-	0.29	45
Chang-hua county	0.2343**	0.7268***	0.3291	0.10	-	0.2738	-	-	-	0.25	42
Nan-tau county	-0.1321*	1.0289***	-	-	0.1663	-0.6781**	-	-	-	0.78	29
Yun-lin and China-yi county	0.1747*	1.1197***	0.0499	-	0.6916***	0.1461	-	-0.1520	-	0.66	54
Tai-nan county	0.2789**	1.0336***	-	-	-	-	-	-	-	0.71	37
Kao-hsiung city and county	0.0557	1.0274***	-0.0138	-0.4264*	0.8245***	0.6935***	-0.8309***	0.4061**	-	0.61	86
Ping-tung county	0.2157*	1.1663***	-	0.40	0.9534***	0.2367	-	-	-	0.55	37
Kee-lung city	0.0947**	0.5104***	0.0536	0.18	0.4348***	0.2151*	-	-	-	0.28	105
Hsin-chu city	0.0944**	0.6279***	-0.5450***	0.21	-	-	-	-	-	0.51	71
Tai-chung city	0.1141	0.4151**	-0.2418	-0.1957	-0.3398	0.0385	-	-	-	0.21	66
Chia-yi city	0.1345**	0.8850***	-0.6864*	0.06	-	-	-	-	-	0.28	89
Tai-nan city	-0.0356	0.8346***	-0.7598***	0.02	0.3106	0.2220	-	-	-	0.49	84
Taipei city	-0.0461	0.9598***	0.1738	0.3746**	0.3356**	0.2861	-	-	-	0.57	40

†Estimated coefficients (* significant at 10%; ** significant at 5%; *** significant at 1%)

†Variable definitions : lnBAGE= log of building's age ; lnSIZE= log of area ; floorD1= dummy for apartment buildings with 5 floor or less; floorD2= dummy for apartment buildings with 6 or more floors ; location= dummies for higher-level administrative divisions or high-priced sub-districts in metropolitan areas ; C= dummies for counties combined in the equation due to inadequate sample size .

Table A2: Hedonic regression of housing price in 2000†

	TFLOR	FLOR	lnBAGE	lnSIZE	STR	TWN1	TWN2	TWN3
Taipei County	0.0071***	-0.0041	-0.01670**	0.9190***	-0.0973***	0.0433**	-	-
Yi-lan County	-0.0064	-	0.0228	0.8445***	-0.1114	0.1368	-	-
Tau-yuan County	-0.0310	0.0216	0.1258***	0.8713***	0.1224**	0.1929***	-	-
Hsin-chu County	-0.1631***	-0.0903***	-	0.8879***	0.062	0.2755***	-	-
Miau-li County	0.0605	-0.1384*	-0.0096	0.4176***	0.0902	0.0819	-	-
Tai-chung County	-0.0419*	-0.0255	-0.0357**	0.7807***	-0.0335	0.1669***	-	-
Chang-hua County	-0.0474*	-	-0.01334	0.8947***	0.0955	0.2294***	-	-
Nan-tau County	-0.0089	-	-0.0318	0.6133***	0.0636	0.0462	-	-
Yun-lin County	-0.0627	-	0.0761**	0.7915***	0.2291**	0.0993	-	-
Chia-yi County	-0.0965***	0.0651	-0.0449**	1.190***	-0.1368**	0.1972***	-	-
Tai-nan County	0.0305	-0.1456*	0.0092	0.6812***	-0.0516	0.0485	-	-
Kao-hsiung County	0.0065	-	-0.0264*	0.8489***	-0.0061	0.3339***	-	-
Ping-tung County	-0.0731*	-	-0.0502	1.130***	-0.0182	0.1622***	-	-
Tai-tung County	-0.2027	-	-0.041	1.079***	0.0290	0.3326***	-	-
Hua-lien County	-0.1298**	-	-0.082***	0.9311***	-0.1269	0.0892	-	-
Kee-lung City	0.0170***	-0.0056	-0.0542***	1.001***	-0.0599	0.0197	-0.01	-0.003
Hsin-chu City	-0.0343	-0.1899***	0.0687***	0.8092***	0.0142	-	-	-
Tai-chung City	-0.0199***	-0.0164*	0.0088	0.8473***	-0.0771**	-	0.059	0.052
Chia-yi City	-.1403***	-	-.0246	1.004***	-.0186	-	-	-
Tai-nan City	-0.0222	-	-0.0296***	0.8904***	-0.068**	0.2739***	0.16***	0.152***
Taipei City	0.0071*	-0.0133***	-0.1208***	1.004***	-0.0173***	0.3772***	0.234***	0.358***
Kao-hsiung City	-0.0584***	-0.0001	0.0094	0.9647***	-0.0106	0.2277	0.385**	0.397**

†Estimated coefficients (* significant at 10%; ** significant at 5%; *** significant at 1%)
†Variable definitions : TFLOR= total floors ; FLOR= located floor ; lnBAGE= log of building's age ; lnSIZE= log of area ; STR= dummy for building with steel structure; TWN= dummies for sub-districts in metropolitan areas.

Table A2: Hedonic regression of housing price in 2000† (continued)

	TWN4	TWN5	TWN6	TWN7	TWN8	TWN9	TWN10	TWN11	Adj R^2	Sample size
Taipei County	-	-	-	-	-	-	-	-	0.6584	1004
Yi-lan County	-	-	-	-	-	-	-	-	0.3305	114
Tau-yuan County	-	-	-	-	-	-	-	-	0.6329	356
Hsin-chu County	-	-	-	-	-	-	-	-	0.6691	97
Miau-li County	-	-	-	-	-	-	-	-	0.3864	87
Tai-chung County	-	-	-	-	-	-	-	-	0.5743	233
Chang-hua County	-	-	-	-	-	-	-	-	0.6620	141
Nan-tau County	-	-	-	-	-	-	-	-	0.4811	130
Yun-lin County	-	-	-	-	-	-	-	-	0.4046	104
Chia-yi County	-	-	-	-	-	-	-	-	0.7034	135
Tai-nan County	-	-	-	-	-	-	-	-	0.5742	219
Kao-hsiung County	-	-	-	-	-	-	-	-	0.6982	304
Ping-tung County	-	-	-	-	-	-	-	-	0.6677	126
Tai-tung County	-	-	-	-	-	-	-	-	0.8336	29
Hua-lien County	-	-	-	-	-	-	-	-	0.4955	153
Kee-lung City	0.363***	0.061*	0.144***	-	-	-	-	-	0.7106	710
Hsin-chu City	-	-	-	-	-	-	-	-	0.6219	207
Tai-chung City	0.271***	0.009	0.158***	0.20***	-	-	-	-	0.7175	588
Chia-yi City	-	-	-	-	-	-	-	-	0.6103	353
Tai-nan City	0.116**	0.17*	0.044	-	-	-	-	-	0.6742	852
Taipei City	0.203***	.24***	0.031	-0.10*	.03	-0.064	-0.0123	0.17***	0.7985	665
Kao-hsiung City	0.297**	0.463***	0.55***	0.57***	0.39***	0.46***	-	-	0.7084	426

†Estimated coefficients (* significant at 10%; ** significant at 5%; *** significant at 1%)
†Variable definitions : TFLOR= total floors ; FLOR= located floor ; lnBAGE= log of building's age ; lnSIZE= log of area ; STR= dummy for building with steel structure; TWN= dummies for sub-districts in metropolitan areas.

Table A3: Regression of household income for data from income-expenditure survey (1990)†

	SEX	AGE	AGEsq	FMSZ	FMSZsq	job1	job2
Taipei County	-0.1112***	0.0044	-0.0000161	0.2425***	-0.00953***	0.41***	0.1613***
Yi-lan County	-0.0817	0.0392***	-0.00036817***	0.3476***	-0.01832***	0.7716***	0.3710***
Tau-yuan County	-0.1246***	0.0113*	-0.00010080	0.2566***	-0.00938***	0.5921***	0.2875***
Hsin-chu County	-0.0142	0.0156	-0.00011908	0.2454***	-0.00930***	0.4808**	0.1558*
Miau-li County	-0.0920	0.0577***	-0.00051978***	0.2931***	-0.01084***	0.1894	0.1470**
Tai-chung County	-0.2274***	0.0282***	-0.00022106***	0.1581***	-0.00257	0.7204***	0.3265***
Chang-hua County	-0.0688	0.0367***	-0.00031345***	0.2639***	-0.01033***	0.251**	0.1500***
Nan-tau County	-0.16661**	0.0549***	-0.00050677***	0.3627***	0-.01929***	1.0342***	-0.0234
Yun-lin County	-0.0155	0.0527***	-0.00049031***	0.4954***	-0.03454***	0.2447	0.0676
Chia-yi County	-0.0392	0.0460***	-0.00043420***	0.3718***	-0.02355***	0.4571***	0.2516***
Tai-nan County	-0.0312	0.0388***	-0.00037104***	0.4516***	-0.03068***	0.5539***	0.2585***
Kao-hsiung County	0.0183	0.0242***	-0.00021228***	0.3443***	-0.02026***	0.5797***	0.1886***
Ping-tung County	-0.1189**	0.0728***	-0.00066642***	0.4131***	-0.02515***	0.3953***	0.1680***
Tai-tung County	-0.1044	0.0243	-0.00018225	0.5086***	-0.04007***	0.9788***	0.0776
Hua-lien County	-0.0207	0.0193	-0.00023090*	0.3867***	-0.02324***	0.9818***	0.1278
Kee-lung City	-0.1990***	0.0314**	-0.00024929*	0.3348***	-0.01685***	0.5231***	0.2471***
Hsin-chu City	0.0135	0.0577***	-0.00053907***	0.2457***	-0.01090***	0.3976**	0.1713*
Tai-chung City	-0.2405***	0.0264***	-0.00018432**	0.2499***	-0.00965***	0.4259***	0.2834***
Chia-yi City	-0.1906*	0.0881***	-0.00076010***	0.3843***	-0.02659***	0.0357	0.2317**
Tai-nan City	-0.2404***	0.0499	-0.00045929***	0.2120***	-0.00870*	0.4642***	0.1371**
Taipei City	-0.1745***	0.0336***	-0.00027838***	0.1430***	-0.00264	0.3377***	0.1903***
Kao-hsiung City	-0.1861***	0.0297***	-0.00023244***	0.2072***	-0.00669*	0.3418***	0.2116***

† Estimated coefficients (* significant at 10%; ** significant at 5%; *** significant at 1%)
† Variable definitions : SEX= 1 for male economic head ; AGE= age of economic head ; AGEsq= square of AGE ; FMSZ= family size ; FMSZsq= square of FMSZ ; job1=1 for employer ; job2=1 for employee

Table A3: Regression of household income for data from income-expenditure survey (1990)† (continued)

	job3	job4	edu1	edu2	MARRY	Adj R^2	Sample size
Taipei County	0.1078***	0.2630***	0.1577***	0.4805***	0.0683**	0.3482	2000
Yi-lan County	0.2282***	0.1394	0.1156	0.4253***	0.0845	0.5325	352
Tau-yuan County	0.2264***	0.2746**	0.1188***	0.3801***	0.0301	0.4727	1109
Hsin-chu County	0.1140	-0.0211	0.1039	0.5731***	0.1313*	0.4349	275
Miau-li County	0.0294	-0.1948	0.4258***	0.6823***	0.0408	0.5459	402
Tai-chung County	0.1605***	0.1391	0.2328***	0.4973***	0.1138**	0.3575	990
Chang-hua County	0.0657	0.1297	0.3786***	0.6417***	0.0702	0.3873	915
Nan-tau County	0.0521	-0.1310	0.2787***	0.6405***	0.1738***	0.4858	430
Yun-lin County	-0.0104	0.0425	0.3868***	0.6102***	-0.0955*	0.5369	599
Chia-yi County	0.1330**	0.4097**	0.2156***	0.6454***	0.0042	0.5239	445
Tai-nan County	0.0940*	0.0219	0.2886***	0.4317***	0.0025	0.4945	866
Kao-hsiung County	0.1982***	-0.2031	0.1810***	0.4357***	0.0583	0.3995	943
Ping-tung County	0.0744	0.0322	0.3868***	0.6668***	0.0467	0.5009	714
Tai-tung County	0.1005	-0.2050	0.4527***	1.0770***	0.0013	0.4983	217
Hua-lien County	0.0040	-0.2134	0.2363**	0.6338***	0.1140	0.5289	299
Kee-lung City	0.1317	0.2877	0.1877**	0.5089***	0.0599	0.3931	309
Hsin-chu City	-0.0621	-0.3948	0.3150***	0.4526***	0.1780*	0.3904	270
Tai-chung City	0.1579***	-0.1412	0.2497***	0.4809***	0.2134***	0.4244	697
Chia-yi City	0.0983	0.6581**	0.4399***	0.7501***	0.1012	0.4848	216
Tai-nan City	0.0586	-0.2630**	0.2215***	0.5582***	0.2568***	0.3662	607
Taipei City	0.0934***	0.2154*	0.1689***	0.4477***	0.1309***	0.3209	2500
Kao-hsiung City	0.2006***	0.3904**	0.2095***	0.5210***	0.1337***	0.3511	1200

† Estimated coefficients (* significant at 10%; ** significant at 5%; *** significant at 1%)
† Variable definitions: job3=1 for self-employed ; job4=1 for unpaid jobs ; edu1=1 for educated to senior high school level; edu2=1 for educated to college level or higher ; MARRY=1 for married.

Table A4: Regression of household income for data from income-expenditure survey (2000)†

	SEX	AGE	AGEsq	FMSZ	FMSZsq	car1
Taipei County	0.10697***	0.01830***	-0.00012914**	0.25733***	-0.01493***	0.19768**
Yi-lan County	0.01744	0.02718***	-0.00021050*	0.31806***	-0.01860***	0.19346**
Tau-yuan County	0.14489***	0.02524***	-0.00021650***	0.20897***	-0.00896***	0.10114
Hsin-chu County	0.14215**	0.01022	-0.00000634	0.19917***	-0.00637*	0.34085***
Miau-li County	0.12903*	0.03972***	-0.00033986***	0.29813***	-0.01470***	0.34526***
Tai-chung County	0.08680**	0.02728***	-0.00020387***	0.22705***	-0.01055***	0.29684***
Chang-hua County	0.8202*	0.03171***	-0.00028094***	0.25263***	-0.01040***	0.24823***
Nan-tau County	0.01852	0.02479**	-0.00021974**	0.30678***	-0.01744***	0.20343**
Yun-lin County	0.05785	0.04211***	-0.00039260***	0.37085***	-0.02401***	0.25805***
Chia-yi County	0.10127*	0.03601***	-0.00029297**	0.41989***	-0.02764***	0.16221*
Tai-nan County	0.16892***	0.02432***	-0.00019738**	0.27017***	-0.01236***	0.28050***
Kao-hsiung County	0.05401	0.00890	-0.00003475	0.29963***	-0.01749***	0.37832***
Ping-tung County	0.15081***	0.01285	-0.0000627	0.37304***	-0.02548***	0.36435***
Tai-tung County	0.07091	0.01436	-0.0000613	0.31473***	-0.02019***	0.23113**
Hua-lien County	0.05154	0.01980	-0.00012448	0.41342***	-0.02783***	0.11254
Kee-lung City	0.13250**	0.02319**	-0.00012784	0.29523***	-0.01960***	0.7566***
Hsin-chu City	0.15470**	0.00942	0.00000333	0.17820***	-0.00672*	0.80623***
Tai-chung City	0.06542	0.00411	0.00004027	0.27230***	-0.01429***	-
Chia-yi City	0.10022	0.02791**	-0.00021528*	0.24444***	-0.01418*	0.63772***
Tai-nan City	0.07850*	0.01829**	-0.00013439*	0.23100***	-0.00870	0.42360***
Taipei City	0.08419***	0.03360***	-0.00026159***	0.25763***	-0.01576***	0.31705*
Kao-hsiung City	0.11367***	0.03253***	-0.00023102***	0.25367***	-0.0121***	0.79037***

† Estimated Coefficients (* significant at 10%; ** significant at 5%; *** significant at 1%)

† Variable Definitions : SEX= 1 for male economic head ; AGE= age of economic head ; AGEsq= square of AGE ; FMSZ= family size ; FMSZsq= square of FMSZ; car1=1 for employment in primary industry

Table A4: Regression of household income for data from income-expenditure survey (2000)† (continued)

	car2	car3	edu1	edu2	Adj R^2	Sample size
Taipei County	0.57431***	0.58593***	-0.57406***	-0.36869***	0.5107	1502
Yi-lan County	0.34984***	0.47807***	-0.77026***	-0.44803***	0.5819	347
Tau-yuan County	0.64557***	0.58639***	-0.45912***	0.26760***	0.5579	830
Hsin-chu County	0.77831***	0.77316***	-0.64849***	-0.47350***	0.5997	350
Miau-li County	0.56710***	0.60755***	-0.68121***	-0.38412***	0.6339	292
Tai-chung County	0.65660***	0.67912***	-0.45162***	-0.27948***	0.5581	745
Chang-hua County	0.49589***	0.564***	-0.61235***	-0.34605***	0.6134	573
Nan-tau County	0.54014***	0.57202***	-0.592***	-0.3847***	0.6511	300
Yun-lin County	0.50884***	0.45158***	-0.65311***	-0.33639***	0.6974	388
Chia-yi County	0.37298***	0.43410***	-0.64246***	-0.39062***	0.6233	298
Tai-nan County	0.56996***	0.60731***	-0.67975***	-0.44834***	0.6270	612
Kao-hsiung County	0.67921***	0.69268***	-0.61790***	-0.37836***	0.6163	695
Ping-tung County	0.46838***	0.58718***	-0.62498***	-0.41560***	0.6132	477
Tai-tung County	0.71367***	0.81330***	-0.67686***	-0.38523***	0.5986	258
Hua-lien County	0.28324**	0.48048***	-0.70254***	-0.32165***	0.4853	350
Kee-lung City	0.61787***	0.64579***	-0.79799***	-0.51045***	0.5156	310
Hsin-chu City	0.89412***	0.91842***	-0.67754***	-0.34875***	0.5634	300
Tai-chung City	0.53288***	0.58920***	-0.56598***	-0.30827***	0.5293	556
Chia-yi City	0.50167***	0.49096***	-0.71929***	-0.40336***	0.5338	290
Tai-nan City	0.41654***	0.40189***	-0.66918	-0.35325***	0.5589	508
Taipei City	0.45231***	0.47184***	-0.56134***	-0.28988***	0.4933	2500
Kao-hsiung City	0.68249***	0.74565***	-0.61703***	-0.27606***	0.5780	1200

† Estimated coefficients (* significant at 10%; ** significant at 5%; *** significant at 1%)

† Variable definitions: car2=1 for employment in secondary industry ; car3=1 for employment in the service sector ; edu1=1 for educated to junior high school level or lower ; eud2=1 for educated to senior high school (or colleges and schools for vocational training) level.

Table A5： Comparison of actual and predicted household income in 1990 and 2000

Unit:N D10,000/year

	1990			2000		
County/city	Sample mean*	Predicted mean**	Predicted/ sample	Sample mean*	Predicted mean**	Predicted/ sample
Taipei County	62.26	45.91	0.74	109.3525	91.7729	0.84
Yi-lan County	51.36	39.77	0.77	97.1477	87.2719	0.90
Tau-yuan County	58.77	43.68	0.74	120.9704	98.2328	0.81
Hsin-chu County	58.45	45.36	0.78	123.2636	101.7341	0.83
Miau-li County	59.16	44.81	0.76	93.5444	80.1203	0.86
Tai-chung County	59.00	43.95	0.74	97.5194	84.2533	0.86
Chang-hua County	49.38	35.16	0.71	89.4191	78.6563	0.88
Nan-tau County	48.69	37.80	0.78	87.3833	74.0203	0.85
Yun-lin County	42.19	33.81	0.80	80.8598	79.82	0.99
Chia-yi County	39.38	33.66	0.85	84.9898	75.5721	0.89
Tai-nan County	47.09	35.33	0.75	87.4169	74.2381	0.85
Kao-hsiung County	53.17	39.84	0.75	86.3045	73.183	0.85
Ping-tung County	46.80	35.09	0.75	90.9098	82.0129	0.90
Tai-tung County	40.78	30.43	0.75	77.798	67.8844	0.87
Hua-lien County	52.36	40.79	0.78	93.2464	75.9404	0.81
Kee-lung City	58.54	43.39	0.74	105.1438	87.8501	0.84
Hsin-chu City	67.94	48.60	0.72	139.7127	108.341	0.78
Tai-chung City	68.51	48.64	0.71	112.1373	78.5646	0.70
Chia-yi City	60.72	43.78	0.72	100.5919	84.9395	0.84
Tai-nan City	61.02	43.87	0.72	101.1772	85.4871	0.84
Taipei City	76.58	58.50	0.76	153.0636	120.912	0.79
Kao-hsiung City	68.30	46.69	0.68	115.8762	92.256	0.80

*Sample mean is calculated from the Household Income-Expenditure Survey.
**Predicted mean is calculated from predicted income in the Census data.