THE CAUSAL RELATIONSHIP OF POPULATION GROWTH AND LAND DEVELOPMENT: A CASE STUDY IN SOUTHERN TAIWAN

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ABSTRACT: Urban development is a long-term dynamic process in which arises the debate about the causal relationship of population growth and land development. That is, does population growth bring pressure on cities to plan new land developments, or land development cause population to increase? This study does an empirical research with 5 counties in southern Taiwan and sheds some lights on that debate. When cities review their city plans, they collect many kinds of data. Then they face an important decision about whether to allow new land developments. Hence city plan review offers a natural experiment to test the debate. This study built a model of two simultaneous equations. The two dependent variables are population size and land area respectively. Embedded in each equation is an adjustment parameter. Population adjustment parameter will measure whether population growth is sensitive to (or follows) land developments. On the other hand, land development adjustment parameter will measure whether land development is sensitive to (or follows) population growth. Test sample includes 95 city plan reviews. The model is run with the two-stage-least-squares method. The result shows that the population reaction parameter is a positive value which means population follows land development, and the land development reaction parameter is a negative value which means population increase will not always cause new land developments. This reflects that cities with suitable land for development may correlate with population growth, and cities with limited expandable land even experiencing population growth may cause migration flow due to no new land development.

1. INTRODUCTION

The work of policy planning is to develop a plan, a method and a strategy that will tackle the problems and serve the needs. (Jones, 1984) To fulfil policy, action strategy should be developed to deal with public issues (Anderson, 2003). With respect to city planning, the choice of city development strategy is a policy planning process. Local governments should refer to the upper-level plans (e.g. regional plans, county comprehensive development plans), policy guidance (e.g. industry development policy), local existing development and future development targets to formulate city development strategy.

City development is the process of mutual influences between supply (land development) and demand (population growth). Hirschman (1958) once pointed out that economic development is a series of the processes of unbalanced development. The past unbalanced development will bring out new unbalanced cause-effect elements and drive the economy forward. The development policy should keep the economy in the state of strain and unbalance. Similarly, city development is a long term dynamic process in which population growth and land development may occur in different stages and is hardly to keep those two directions balanced.

There are two types of city development (see Figure 1). Type 1 development refers to that population growth is the cause and land development is the effect. That is, land development comes after the city had gained population growth. Moreover, type 1 development has the advantage that the investment on land development is not going to fail easily. It will reduce the risk of land development and decrease financial burden on local government. However, when population increases rapidly and the city is not able to finance land development, population over a city's capacity would cause new problems. The disadvantage of this type of development is obvious that the provision of infrastructure is in shortage, traffic is congested, and residential quality deteriorates.

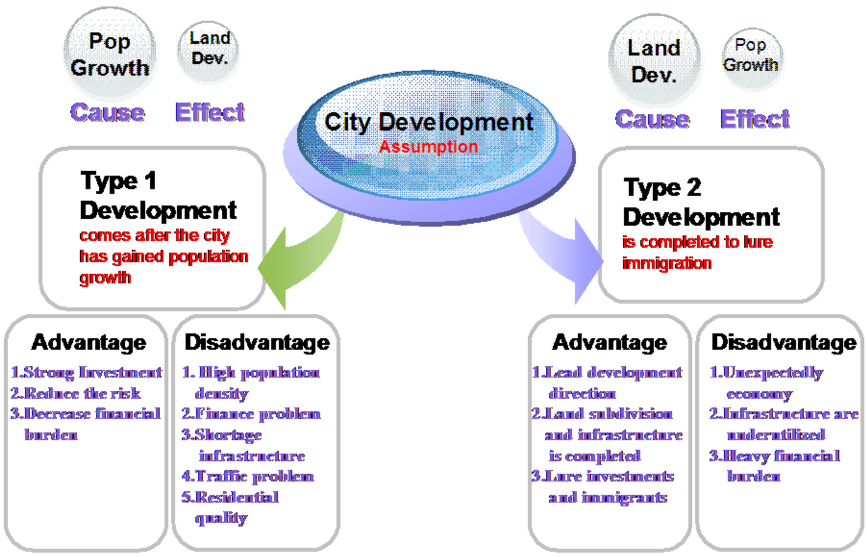

Figure 1. The Types of City Development

Type 2 development is that city land development is the cause and population growth is the effect. That is, land development is completed to lure immigration before population growth is realized. The advantage of this type is that local governments can lead the direction of land developments, land subdivision and infrastructure is completed well ahead to lure further private sector investments and immigrants, and traffic congestion can be ameliorated. The disadvantage may occur if the economy is unexpectedly in sharp decline. Population and industries do not come into the land development areas. Subdivision plots and infrastructure are underutilized. Cities will bear heavy financial burden.

To find out the causal relationship between population growth and land development, this study draws a sample of local jurisdictions in five counties of southern Taiwan (see Figure 2) and builds a model of two simultaneous regression equations. The dependent variables are existing population and land use area in each jurisdiction. A reaction parameter is embedded in each equation. Population reaction parameter reflects the influences on population by land use area. Similarly land use area reaction parameter shows those on land use areas by population. Periodical reviews of city plans which would focus on population and land use area. This study put real world situation into modeling. Data for variables in the model reflect real world situation. I.e. they are not the forecasts of population and land use area which are usually seen in planning documents. Two-stages-least-squares is the presented method to estimate the relevant parameters of the model and test the reliability of the model.

Figure 2. The Case Study Region

The paper is organized in six sections. Section 1 is introduction. Section 2 is literature reviews. Section 3 deals with model building and with the rules of causality test. Section 4 gives definitions and descriptive statistics for variables in the model. Section 5 explains empirical results and makes a discussion. Section 6 is the concluding remarks and discussions of the study.

2. LITERATURE REVIEW

In urban planning, the development of commercial and industrial areas in planed districts attracts employment-seeking population and the entrance of merchants. Studies performed by Greenwood (1978), Greenwood et al. (1986), Juarez (2002), and Anjomani (2002) showed that the number of persons employed in and employment growth rates of secondary and tertiary industries have a significant impact on regional population migration.

As a cause and a consequence of social change, human migration is regarded as the key factor underlying the demographic and socioeconomic composition of regions. Thus, for anyone attempting to analyse the general process of regional change, an understanding of interregional migration is vital. Accordingly, policy makers have become increasingly aware of the role of migration in the context of such socioeconomic issues as regional growth, social well-being, and political representation (Cadwallader, 1992). Miller (1995) believes decision makers, in order to make good decisions, need to be aware of the relation between changing patterns of interstate migration and changes in regional and national economic growth as well as spatial patterns of economic activity. The growth of states and regions relates closely to population growth, which is mostly a result of migration.

Thus, it seems plausible that any study of migration flow would make it possible (1) to better understanding the growth of regions, the factors causing this growth, and the interrelationship of these factors; (2) to more accurately anticipate and prepare for the future growth in different regions (especially growth might cause problems or create new opportunities in many sectors of the economy); and (3) to study policies that could increase (or induce) the growth. (Anjomani, 2002).

Accurately modelling the local economic and fiscal impacts of employment growth requires knowledge of who actually gets those new jobs. Early fiscal impact models tended to assume often implicitly that local labour markets cleared internally in the sense that the new jobs that a firm or industry brings to a community are taken entirely by residents of the community (Renkow, 2003).

Studies by Harris and Michael (1970), Molho (1984), Jackman and Savvas (1992), Juarez (2000), Davies et al. (2001), Knapp et al. (2001), Ritsila and Marko (2001) showed that higher wages attract correspondingly larger amounts of population immigration and create regional population growth. When there is a large amount of population migration, the population residing in the planning area will increase, signifying that the current population in the planning area will increase.

3. THE MODEL AND THE RULES FOR CAUSALITY TEST

3.1 The Model

It is assumed that there exist reasonable levels of population P^E and land use area L^E for each jurisdiction. Their levels are determined by the respective equations.

Assumes that at the t[th] review of the city plan of jurisdiction i, the reasonable population level is $P_{i,t}^E$ which is related to land use areas L_{it} and other exogenous variables $Y_{i,t}^p$ affecting population growth. The population equation is as follows:

$$P_{i,t}^E = \alpha_1^p L_{i,t} + \alpha_2^p Y_{i,t}^p \qquad (1)$$

Where superscript *E* represents the reasonable level, superscript *p* represents population; subscript *i* represents the i^{th} jurisdiction, where $i = 1,2, \ldots, n$; α_1^p and α_2^p are coefficients. Since the coefficients are determined by the regression method with a sample of jurisdictions, the reasonable level means it reflects the common trends of the sample.

Also assumes that the reasonable level of land use areas is $L_{i,t}^E$ which is related to jurisdiction *i*'s population $P_{i,t}$ and other exogenous variables $Y_{i,t}^l$ affecting land use areas. The land area equation is shown below.

$$L_{i,t}^E = \alpha_1^l P_{i,t} + \alpha_2^l Y_{i,t}^l \qquad (2)$$

Where superscript *l* relates to land; α_1^l and α_2^l are coefficients.

3.2 The Parameter of Adjustment

This paper takes population growth as an example to explain the relationship between the most recently overall reviews performed and the one preceding it, as shown in Figure 3. If the population size is $P_{i,t-1}$ in the *t*-1[th] overall review (as in point *a*) and the population size reaches the equilibrium value in the t^{th} review (as in point *f*), then, under ideal circumstances, the population size increase that was required to reach the equilibrium value is equal to the difference from the population size in the previous review ($P_{i,t}^E - P_{i,t-1}$). Population growth is influenced by factors such as local land development, industry, employment opportunities, and living environment conditions. These impact caused by these factors is influenced by the actual adjustment (λ) of the current environment; this coefficient represents the actual reaction to current development in the planning area.

When $\lambda_p = 1$, then the population size ($P_{i,t}$) of the urban planning area *i* will equal the reasonable value ($P_{i,t}^E$) in the t^{th} review; population growth has attained the reasonable scale, and the adjustment speed is also reasonable. When $\lambda_p > 1$, then land and supply of other variables impacting population have significant positive reactions (as shown in equation (1)), meaning that the adjustment speed is too fast, causing $P_{i,t} > P_{i,t}^E$ (as in point *g*). When $0<\lambda_p<1$, then population growth reaction coefficients have positive reactions toward supply, causing $P_{i,t} < P_{i,t}^{E}$, meaning that the adjustment speed is too slow (as in point *e*). When $\lambda = 0$, then $P_{i,t}$ has not been adjusted and is less than $P_{i,t}^{E}$ (as in point *d*). When $\lambda_p < 0$, then population growth reaction coefficients have no response to supply, causing $P_{i,t} < P_{i,t}^{E}$, meaning that the adjustment speed is the slowest (as in point *c*).

Past and current change relationships relating to land development can be explained in the same way as the change relationships relating to population size described above, as shown in Figure 4.

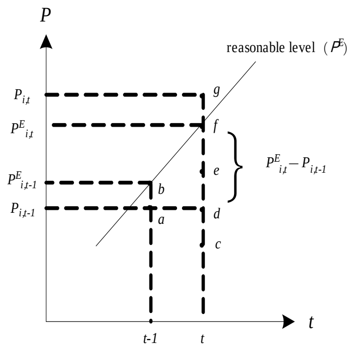

Figure 3. Past and Current Population Growth Correlation

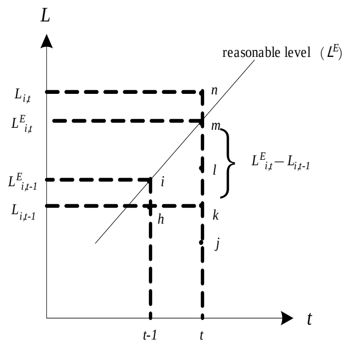

Figure 4. Past and Current Land Use Area Correlation

A jurisdiction's reasonable level of population, current population level and adjustment parameter determine the population level of the next time period. At time *t*-1, the population level is $P_{i,t-1}$. At time *t*, the reasonable level $P_{i,t}^{E}$ is at point *f*. Corresponding to the difference of the two levels, there exists an adjustment parameter λ_p. The adjustment mechanism is defined as in equation 3. By the equation, when λ_p=1, $P_{i,t} = P_{i,t}^{E}$, that is, the population level at time *t* will be the reasonable level.

$$P_{i,t} = P_{i,t-1} + \lambda_p \left(P_{i,t}^{E} - P_{i,t-1}\right) \quad (3)$$

Similarly, the jurisdiction's reasonable land area $L_{i,t}^{E}$, current land area $L_{i,t-1}$ and adjustment parameter λ_l determine the land area of the next time period. This is shown in equation 4.

$$L_{i,t} = L_{i,t-1} + \lambda_l \left(L_{i,t}^{E} - L_{i,t-1}\right) \quad (4)$$

Substitute (1) in (3), and (2) in (4) respectively and we have equations for population and land areas as in (5) and (6).

$$P_{i,t} = \lambda_p \alpha_1^p L_{i,t} + \lambda_p \alpha_2^p Y_{i,t}^p + (1-\lambda_p) P_{i,t-1} \tag{5}$$

$$L_{i,t} = \lambda_l \alpha_1^l P_{i,t} + \lambda_l \alpha_2^l Y_{i,t}^l + (1-\lambda_l) L_{i,t-1} \tag{6}$$

To estimate (5) and (6), we need to include an intercept and an error term in each equation. The complete regression models are (7) and (8).

$$P_{i,t} = \alpha_0^p + \lambda_p \alpha_1^p L_{i,t} + \lambda_p \alpha_2^p Y_{i,t}^p + (1-\lambda_p) P_{i,t-1} + \varepsilon_{i,t}^p \tag{7}$$

$$L_{i,t} = \alpha_0^l + \lambda_l \alpha_1^l P_{i,t} + \lambda_l \alpha_2^l Y_{i,t}^l + (1-\lambda_l) L_{i,t-1} + \varepsilon_{i,t}^l \tag{8}$$

Where α_0^p and α_0^l are intercepts; $\varepsilon_{i,t}^p$ and $\varepsilon_{i,t}^l$ are the error terms and $\varepsilon_{i,t}^p \sim N(0,\sigma^2)$, $\varepsilon_{i,t}^l \sim N(0,\sigma^2)$. Both $\varepsilon_{i,t}^p$ and $\varepsilon_{i,t}^l$ have zeros as their means and have the same variance σ^2.

3.3 The Subdivision Model

This paper discriminated land use from residential, commercial, and industrial. To further realized the causal relationship between different land developments and population growth. We have equations for population and different land areas as in (9), (10), (11) and (12).

$$P_{i,t}^E = \alpha_1^p \left(L_{i,t}^1 + L_{i,t}^2 + L_{i,t}^3\right) + \alpha_2^p Y_{i,t}^p \tag{9}$$

$$L_{i,t,1}^E = \alpha_{1,1}^l P_{i,t} + \alpha_{2,1}^l Y_{i,t}^l \tag{10}$$

$$L_{i,t,2}^E = \alpha_{1,2}^l P_{i,t} + \alpha_{2,2}^l Y_{i,t}^l \tag{11}$$

$$L_{i,t,3}^E = \alpha_{1,3}^l P_{i,t} + \alpha_{2,3}^l Y_{i,t}^l \tag{12}$$

In the same way, we made adjustments in equations (3) and (4), and the results are shown below.

$$P_{i,t} = P_{i,t-1} + \lambda_p \left(P_{i,t}^E - P_{i,t-1}\right) \tag{13}$$

$$L_{i,t}^1 = L_{i,t-1}^1 + \lambda_{l,1} \left(L_{i,t,1}^E - L_{i,t-1}^1\right) \tag{14}$$

$$L_{i,t}^2 = L_{i,t-1}^2 + \lambda_{l,2} \left(L_{i,t,2}^E - L_{i,t-1}^2\right) \tag{15}$$

$$L_{i,t}^3 = L_{i,t-1}^3 + \lambda_{l,3} \left(L_{i,t,3}^E - L_{i,t-1}^3\right) \tag{16}$$

Substitute (9) in (13), (10) in (14), (11) in (15), and (12) in (16) respectively and to estimate the subdivision model, we need to include an intercept and an error term in each equation. The complete regression models are (17), (18), (19), and (20).

$$P_{i,t} = \alpha_0^p + \lambda_p \alpha_1^p \left(L_{i,t}^1 + L_{i,t}^2 + L_{i,t}^3\right) + \lambda_p \alpha_2^p Y_{i,t}^p + (1-\lambda_p) P_{i,t-1} + \varepsilon_{i,t}^p \tag{17}$$

$$L_{i,t}^1 = \alpha_{0,1}^l + \lambda_{l,1} \alpha_{1,1}^l P_{i,t} + \lambda_{l,1} \alpha_{2,1}^l Y_{i,t}^l + (1-\lambda_{l,1}) L_{i,t-1}^1 + \varepsilon_{i,t,1}^l \tag{18}$$

$$L_{i,t}^2 = \alpha_{0,2}^l + \lambda_{l,2} \alpha_{1,2}^l P_{i,t} + \lambda_{l,2} \alpha_{2,2}^l Y_{i,t}^l + (1-\lambda_{l,2}) L_{i,t-1}^2 + \varepsilon_{i,t,2}^l \tag{19}$$

$$L_{i,t}^3 = \alpha_{0,3}^l + \lambda_{l,3} \alpha_{1,3}^l P_{i,t} + \lambda_{l,3} \alpha_{2,3}^l Y_{i,t}^l + (1-\lambda_{l,3}) L_{i,t-1}^3 + \varepsilon_{i,t,3}^l \tag{20}$$

Where α_0^p 、 $\alpha_{0,n}^l$ are intercepts; $\varepsilon_{i,t}^p$ and $\varepsilon_{i,t,n}^l$ are the error terms and $\varepsilon_{i,t}^p \sim N(0,\sigma^2)$, $\varepsilon_{i,t,n}^l \sim N(0,\sigma^2)$. Both $\varepsilon_{i,t}^p$ and $\varepsilon_{i,t}^l$ have zeros as their means and have the same variance σ^2.

3.4 The Rules of Causality Test

To perform a causality test, previous papers chose to compare the parameters of relevant explanatory variables (Steinnes, 1974; Cooke, 1978; Edmiston, 2004). By comparing the parameter $\lambda_p \alpha_1^p$ of $L_{i,t}$ in (7) with that of $\lambda_l \alpha_1^l$ of $P_{i,t}$ in (8), the causality of population and land use area can be determined. The rule for the determination is as follows:

a. For the two parameters, if one of them is statistically significant and the other is not, the significant one determines the causality. For example, $\lambda_p \alpha_1^p$ is significant and $\lambda_l \alpha_1^l$ is not. Then pick (7) to describe the causality. That is, an increase in land use area is the cause and will bring in an increase of population that is the effect.
b. If both of the two parameters are not significant, the causality is undetermined.
c. If both of them are significant, we have three cases to classify further:
    i. If the signs of them are one positive and one negative, the positive one determines the causality for the negative one is not conducive to ex ante experience.
    ii. If both of them have positive signs, the one with bigger value determines the causality. Or, by another viewpoint, the pair of population and land use area is determined simultaneously. (Cooke, 1978)
    iii. If both of them have negative signs, the existing theory has to be modified or supplemented.

4. DEFINITION OF VARIABLES AND DESCRIPTIVE STATISTICS

4.1 Variables

This paper selected urban planning overall review cases from urban planning districts in the five counties, 95 samples were taken from 70 urban planning districts. The variables used in the model and their definitions are explained below:

4.1.1 Endogenous Variables

Endogenous variables were the current population size and land use area in the previous and current overall reviews of the various urban planning districts.

4.1.2 Exogenous Variables

(a) Level of Salary

This study determined salary levels by dividing total salaries by total employment. The data was obtained from trade and industry census data of Executive Yuan Directorate-General of Budget, Accounting, and Statistics; units are $1000 NTD/person.

(b) Social Increase of Persons

Net immigrant population data from the overall review surveys performed by each urban planning area was selected to represent the social increase of persons in each urban planning area. The source of data was the urban planning overall review reports; units are individuals.

(c) Unemployed Rates

This study determined the unemployment rate by dividing the number of unemployed persons by the number of economically active individuals of at least age 15. The data was obtained from the statistical reports of each province or city; units are in %.

(d) Land Prices

Higher land prices mean higher land development costs. In order to understand the effect of land prices on land use and development, this study selected the average area land values of the residential areas, commercial areas, and industrial areas of each urban planning area as the average area land value for each urban planning area. The source of information was the Department of Land Administration of the Ministry of the Interior; units are in $NTD/meter2.

(e) Secondary Industry and Tertiary Industry of Employed Persons

This paper examines the impact relationship between growth trends of employment in secondary and tertiary industries and population growth. The source of data was industry and commercial census data from the Executive Yuan Directorate-General of Budget, Accounting, and Statistics; units are individuals.

4.2 Descriptive Statistics

In terms of endogenous variables, current population size was the highest in the Douliou (Datan District) urban planning district during its second overall review. The district with the smallest population size was the Manjhou urban planning district during its third overall review. For population size in the preceding period, the Douliou (Datan District) urban planning district had the largest population size in its second overall review. The Jhongpu urban planning district had the smallest population size during its second overall review.

For land use area, the Renwu urban planning district had the largest land use area in its third overall review, while the Manjhou urban planning district had the smallest land use area in its third overall review. In the preceding period, the Renwu urban planning district had the largest land use area in its third overall review, while the Shueishang urban planning district had the smallest land use area in its second overall review. Descriptive statistics of model variables are as shown in Table 1.

This paper performed screening of variables through relevant coefficient analysis to select appropriate variables and avoid estimation deviations due to excessive collinearity. After Pearson relevant coefficient testing, it was shown that secondary industry employment and tertiary industry employment have significant degrees of correlation (0.874). As a result, this study removed the tertiary industry employment variable and kept only the secondary industry employment variable.

Table 1. Variables and Descriptive Statistics

Type	Variable	Min	Max	Mean	Std. Error
Endogenous Variable	Current population	1,936.0	46,811.0	12230.1	9,282.4
	Current land development area	12.4	276.5	75.6	57.6
	Previous population	1,741.0	46,069.0	11901.3	8,943.0
	Previous land development area	8.3	258.1	63.7	48.0
Exogenous Variable	Level of Salary ($1000 NTD/person)	127.7	429.7	323.4	94.8
	Social Increase of Persons	-772.0	970.0	66.6	287.4
	Unemployed Rates (%)	0.3	5.1	2.1	1.1
	Secondary industry of employed persons	499.0	34,445.0	4408.4	4,305.2
	Residential land prices ($NTD/meter^2)	4,304.0	50,396.0	18932.4	10,024.1
	Commercial land prices ($NTD/meter^2)	4,889.0	105,995.0	42745.60	19,685.6
	Industrial land prices ($NTD/meter^2)	1,400.0	27,474.0	8888.1	5,391.7

5. EMPIRICAL RESULTS

This study made use of the SPSS quantitative analysis software to establish a simultaneous equation model and test the parameters and reliability of the model. Models of Formulas (7) and (8) can be used to discuss the causal relationship between population growth and land development. Results of establishing the empirical model are explained as follows.

5.1 Population Growth

As shown in Table 2, the R^2 value of this model after adjustment is 0.982, indicating excellent explanatory power. Results show that increasing the land use area in an urban planning district by 1 hectare (ha) will produce an increase in population of 12.265 people. It is shown that opening of total land use area in the urban planning district will stimulate population growth in the district. An increase of one person in gross immigration will lead to an increase of 1.454 people in current population in the district. An increase of one person in the population of the preceding period leads to an increase of 0.963 people in the current population.

5.2 Land Development

As shown in Table 3, the R^2 value of this model is 0.896, indicating excellent explanatory power. Results show that an increase of 1 person in the current population of an urban planning district will lead to a decrease of 0.002 ha in land use area. This shows that growth in the current population of the planning district will reduce district overall land use area and opening. An increase of one person in secondary industry employment will lead to an increase of 0.007 ha in planning district land use area. Opening an additional 1 ha of land use area in the preceding period increases land use area in the current period by 1.149 ha.

Table 2. Results, Population Growth Equation

Variable	Parameter Estimate(t value)
Intercept	-985.318(-1.909)
Current land development area	12.265(3.807)**
Salary levels	1.240(0.682)
Social Increase of Persons	1.454(3.037)**
Unemployment rates	36.928(0.248)
Secondary industry of employed persons	0.053(1.602)
Previous population	0.963(49.354)**
Adjusted R^2	0.982
Samples	95

Notes: *Indicates significance at the 95% confidence level; **Indicates significance at the 99% confidence level

Table 3. Results, Land Development Equation

Variable	Parameter Estimate(t value)
Intercept	-0.217(-0.044)
Current population	-0.0002(-1.760)*
Residential land prices	0.00009(0.352)
Commercial land prices	0.00003(0.273)
Industrial land prices	-0.0001(-0.234)
Secondary industry of employed persons	0.0007(1.765)*
Previous land development area	1.149(16.552)**
Adjusted R^2	0.896
Samples	95

Notes: *Indicates significance at the 95% confidence level; **Indicates significance at the 99% confidence level

5.3 Individual Land Developments

As shown in Table 4, the R^2 value of residential regression is 0.922, the R^2 value of commercial regression is 0.882, and the R^2 value of industrial regression is 0.760. Each of three regressions indicated excellent explanatory power. In residential regression, result shows that the variables of current population and previous land development area are significant. In commercial regression, result shows that the variable of current population is significant. In industrial regression, result shows that no variable is significant.

Table 4. Results, Individual Land Development Equations

Variable	Residential	Commercial	Industrial
Intercept	0.944	-0.097	-3.878
	(0.36)	(-0.20)	(-0.76)
Current population	0.001	0.000086	0.000
	(3.91) **	(2.74) **	(-0.63)
Residential land prices	0.000	-0.0000063	0.001
	(-1.96)	(-0.23)	(1.76)
Commercial land prices	0.000	0.000014	0.000
	(1.80)	(1.10)	(-0.78)
Industrial land prices	0.000014	0.000029	0.000
	(0.05)	(0.63)	(0.97)
Secondary industry of employed persons	0.000	-0.000018	0.001
	(-0.98)	(-0.19)	(0.74)
Previous land development area	0.834	0.838	0.876
	(11.98) **	(14.80) **	(13.40) **
Adjusted R^2	0.922	0.882	0.760
Samples	95	95	95

Notes: *Indicates significance at the 95% confidence level; **Indicates significance at the 99% confidence level

5.4 Causality Test

It can be seen from Table 2 that the parameter of current land development is significant and positive (12.265). Table 3 shows the parameter of Current population is significant but negative (-0.0002). Based on the rule of causality test, if the signs of them are one positive and one negative, the positive one determines the causality for the negative one is not conducive to ex ante experience. The result illustrated that land development is the cause and population growth follows where land development occurs. In the same way, the causality test shown that the individual land developments have same effects. For example, the residential, commercial and industrial developments belong to supply-oriented development pattern. Residential, commercial and industrial developments are the cause and population growth follows where individual developments occur.

6. CONCLUSION AND DISCUSSION

Taking regular or contingent reviews of city plans is one of the great job for local governments. Most often city planners have to formulate development strategy for land use aspect of the city plan. The choice arises when city planners try to devise the strategy, to provide a larger space to attract population to move into the city or to wait for population growth to a high enough level to expand land use area. In other words, in terms of population and land use areas, the question is that which is the cause and which is the effect.

When local governments release the annual reports of the city plan reviews, the latest data of population and land use area will be on the list. This study takes the data from five counties in southern Taiwan to test the causality of population and land use area. A model of two simultaneous equations is built to obtain the parameters of the two relevant variables. With the rules for the determination of the causality, the result clearly shows that land use area is the cause and population growth is the effect. How does it fit the reality?

Our explanation is showing below. Major actions which are taken to change the city plan by local governments should be submitted for the approval by central government. The proposal to expand the city boundary for new development area is a good example. In some cases, land use is not a local affair. It is under tight control by the central government. Proposals for new developments should include a feasibility study for reference and offer a clearly financial plan. In such study the general economic viability and the historical trend of population growth for the city are evaluated. It is not surprised that the historical trend of population growth has more weight in obtaining the approval from the central government.

In short, the development proposals seeming likely to succeed will get pass and those seeming unlikely to succeed will not. Cities with development proposals being approved prepare land subdivision and population comes in while cities without developments stay the same way. Hence land use area is the cause and population is the effect. Land use control predetermines the outcome that is embedded in the system. The model correctly reveals the mechanism of land use control in Taiwan.

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