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The Relationship between the Growth of Central City and the Growth of Suburban Areas in U.S. Metropolitan Cities

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미국 대도시지역들의 도심지역과 교외지역 성장간의 관계에 관한 연구

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Abstract : The purpose of this paper is to explore the relationship between central city and suburban areas. In particular, we examine the relationship of construction activities in suburban areas with construction activities in central city. That is because if the construction activities in central city are correlated with those in suburban areas, the economic trends in those two parts would become interdependent. The construction permit data in 114 Metropolitan Statistical Areas (MSAs) for the past 11 years are used as a central explanatory variable of influencing the relationship, as construction permits issued would reflect population growth, economic growth and housing price in certain area. The main findings of our analysis are as follows. First, MSAs classified as showing high population growth has higher correlation between central city and suburban area than MSAs showing low population growth rate except for only office construction. However, there is little difference in correlation characteristic by the size of MSA. Second, most of the MSAs show little causality between the central city and suburban area in lagged situation. Therefore, it is hard to say that the past trend of construction activity in central city reflects in direct the future trend of construction activities in suburban area.
Key words : Central city, Suburban area, Suburbanization, Urban growth, Correlation, Causality

요약 : 본 연구의 목적은 미국 대도시지역들을 사례로 도심지역과 교외지역 성장간의 상관관계와 인과관계를 밝히는 것이다. 본 연구에서는 도시의 성장과 쇠퇴가 건설활동에서 반영된다는 점에 착안하여, 미국의 114개 대도시지역(MSAs)의 과거 11년간 건설 허가 자료를 가지고 분석하였다. 그 결과, 대도시 지역의 건설활동 동향에 있어 도심지역과 교외지역 간에는 정의 상관관계를 가지고 있으며, 특히 인구성장률이 높은 대도시지역일수록 상관관계가 높게 나타나는 것으로 밝혀졌다. 그러나, 이러한 도심과 교외지역 성장의 관계는 건설활동의 유형별로 상이한 인과관계 특성을 나타낸다. 즉, 도심지역의 주택건설활동 추이에 따라 교외지역의 주택건설활동이 직접적인 영향을 받는다는 사실은 미국 대도시지역들의 공통적인 현상이나, 상업 및 업무시설의 건설활동에 있어서는 그 인과관계가 일관적인 패턴을 가지고 나타나지 않는다. 따라서, 도심지역의 성장과 쇠퇴의 영향이 교외지역에 직접적인 영향을 미친다고 단정하기는 어렵지만, 미국 대도시들의 도심지역 성장과 교외지역의 성장은 서로 밀접한 상관관계를 가지고 있다는 점은 명백하다고 할 수 있다.
주요어 : 도심지역, 교외지역, 교외화, 도시성장, 상관관계, 인과관계

1. Introduction

For the past several decades, suburban areas have experienced rapid growth in population, employment and income while many central cities have been declining (Leichenko, 2001). The long standing question is whether interrelationships exist between these two areas. In relation to this, some critical questions can be raised Does the decline of central city directly or indirectly leads to the growth of suburban area or generates simultaneous decline? What are the affecting factors for the relationship? What are the characteristics of cities for specific relationship?

According to the urban literature, it is reported that they are intercorrelated but the relationship between the two is diminished

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(Teitz, 1997). Most of the literature tends to focus on the empirical test of a certain hypothesis to explain the relationship between the central cities and suburban areas, such as suburbanization, interdependence, suburban dependence and independence (Blair and Stanley, 1996; Burby and May et al., 2000; Hill and Wolman, 1995; Post and Stein, 2000). The hypothesis test is based on various factors of indicating the relationship such as population, housing demand and supply, employment and income (Hill and Brennan, 1998; Hill and Wolman, 1997a, 1997b; Kasarda and Appold, 1997).

A variety of explanatory variables can be used to explain this relationship. The variables most commonly used in the previous literature include real income growth, population growth, and housing price index. In this paper we use construction permit data as a central explanatory variable of influencing that relationship, as it is understood that population growth, economic growth and housing price in certain area are well reflected in construction permits issued and they are highly correlated with one another.

While the basic purpose of this research is consistent with the previous research, there are two main respects that distinguish the former from the latter. First, unlike previous research with similar purpose to explain the relationship between the central city and suburban areas, this paper uses construction permit data as an analytical tool for examining the relationship. Second, this paper attempts to reveal the causality of the relationship between central city and suburban areas, using causality test.

In this paper, we examine the relationship of construction activities in suburban areas with construction activities in central city. If the construction activities in central city are correlated with those in suburban areas, the economic trends in those two parts would become interdependent. Furthermore, this paper deals with whether the relationship complements or substitutes, and whether they have the cause and effect relationship.

2. Theoretical backgrounds

1) Review of urban-suburban relationship

It has long been believed that the central city and its surrounding regions are highly interdependent and much of research has been done to prove such relationship. Although the interdependency between two regions is not denied, there is a growing consensus in the recent literature that the central city's relevance to metropolitan area or suburban area has diminished (Cuciti, 1990; Ladd and Yinger, 1990; Bradbury et al., 1982).

As one of the early research for urban suburban relationship, Voith (1992) tried to find whether the two regions have substitutional relationship or complementary relationship. He used city and suburban population, per capita income, and employment growth data in 28 MSAs in US and the analysis suggested positive correlation, that is, complementary relationship. Successively, Voith (1998) tried to test whether city growth causes suburban growth using structural model relating city growth in income to suburban growth in income, population, and house values. He concluded that the city income growth results in higher suburban income growth, house value appreciation and to a much lesser extent, population growth.

For Savitch et al. (1993), the suburban area gets benefit when its center is viable by statistical analysis using per capita income and office space price data. They argued that the suburban per capita income is linked to central city per capita income, and the price of peripheral "edge city" office space is connected to the price of office space in the central business district. Using different data and somewhat different methodology from the existing research, Goetzmann et al. (1998) addressed the issue of how closely the fortunes of suburbs are tied to the fortunes of the central city. They developed housing price indices in California and tried to determine whether the housing markets in central city and suburban area aggregate or move separately by clustering procedure. They found that the central cities tend to group with their suburbs and the housing markets of central city and suburban area are closely linked.

2) Causality test

The method we adopt to test the causality between central city and suburban area is Bivariate Granger Causality Test, which was proposed by Granger (1977). Granger Causality Test is the statistical technique used to compare stock market prices with changes in GDP, allowing phased correlations between the two to predict future GDP based on prior stock market trends. It is thus primarily an econometric model. Testing causality involves using F test or Chi Square test to test whether lagged information on a variable y provides any statistically significant information about a variable x in the presence of lagged x.

Among several ways to implement a Granger causality test, the method used in this paper is using simple autoregressive specification of a bivariate vector autoregression. When an autoregressive lag of p is assumed, the unrestricted equation by ordinary least squares (OLS) is estimated as follows:

$$x_t = c_1 + \sum_{i=1}^{p} \alpha_i x_{t-i} + \sum_{i=1}^{p} \beta_i y_{t-i} + u_t$$

The restricted equation by ordinary least squares (OLS) is also estimated as follows:

$$x_t = c_1 + \sum_{i=1}^{p} r_i x_{t-i} + e_t$$

The null hypothesis on the test is $H_0 : \beta_1 = \beta_2 = \ldots = \beta_p = 0$ and the test statistic is

$$F_{p,T-2p-1} \sim S_1 = \frac{(RSS_0 - RSS_1)/p}{RSS_1/(T-2p-1)}$$

Where, $RSS_1 = \sum_{t=1}^{T} \hat{u}_t^2$ and $RSS_0 = \sum_{t=1}^{T} \hat{e}_t^2$.

If the test statistic is greater than the critical value, the null hypothesis is rejected. This means that y Granger causes x. It is worth noting that with lagged dependent variables, as in Granger causality regression, the test is valid only asymptotically. An asymptotically equivalent test is given by

$$\chi^2(p) \sim S_1 = \frac{T(RSS_0 - RSS_1)}{RSS_1}$$

As same with F test, if this test statistic is greater than the critical value, the null hypothesis is rejected.

3. Description of the data used

The data to be used in the analysis is the construction permit data obtained from U.S. Bureau of Census. Because the construction permits data has not been updated since 1995, we used 11 year data from 1985 to 1995 of many kinds of building uses for Metropolitan Statistical Areas (MSAs) and their central cities. The raw data set contains 151 MSAs among 316 MSAs. We selected 114 MSAs among the raw data for analysis after checking any missing values and unreasonable values. The construction permits have two types; the number of permits and the assessed sum of dollar values of the permits. Because using the number of permits has difficulty in representing the volume of building, the analysis in this paper uses the

Table 1. Unbalanced two way layout with replication of correlation data

Population / Growth rate	L	M	S	Ave.
L	Y_{Ll1} Y_{Ll2} Y_{Ll3} : : :	Y_{Lm1} Y_{Lm2} Y_{Lm3} : : :	Y_{Ls1} Y_{Ls2} Y_{Ls3} : : :	$\bar{Y}_{L}$
M	Y_{Ml1} Y_{Ml2} Y_{Ml3} : :	Y_{Mm1} Y_{Mm2} Y_{Mm3} : :	Y_{Ms1} Y_{Ms2} Y_{Ms3} : :	$\bar{Y}_{M}$
S	Y_{Sl1} Y_{Sl2} Y_{Sl3} : :	Y_{Sm1} Y_{Sm2} Y_{Sm3} : :	Y_{Ss1} Y_{Ss2} Y_{Ss3} : :	$\bar{Y}_{S}$
Ave.	$\bar{Y}_{l}$	$\bar{Y}_{m}$	$\bar{Y}_{s}$	$\bar{Y}$

Note: 'L' refers to more than 1 million in population or over 2% in growth rate,
'M' refers to 0.5 million~1 million in population or 0.5%~2% in growth rate,
'S' refers to under 0.5 million in population or under 0.5% in growth rate.

assessed sum of dollar values of permits as basic data.

In the data set, the construction permits are classified as 12 types by the type of building uses. We aggregated these 12 types as 4 classes; residential permits, office/bank/service permits, all non residential permits class and total permits class. The suburban areas permits are calculated by subtracting the central city permits from the MSA permits. In some cases, the calculated suburban permit value may be likely to become negative, due to the error in original data. Thus we excluded those MSAs from the original 151 MSAs which had those negative values.

4. Methodology

1) Test of correlation

Correlation test in this research is important as a basis for causality test. In this paper, unlike many previous works which tried to reveal just the correlation phenomenon itself between central city and suburbs, the correlation test tries to find if there is any structural and spatial characteristic of MSA for certain correlation.

lassified as S. Using the dataset with above manipulations, statistical analysis is performed to reveal whether there is any effect of population size and growth rate on the correlation between central city and suburban area. Analysis of Variance (ANOVA) with unbalanced two way layout of data with replication is adopted in this analysis because the test has two factors (pop. size and pop. growth) and the task is to test the significance of main effect of each factor and interaction effect between two factors. Because the data for each factor has unbalanced number, general linear model (GLM) is used instead of two way ANOVA. Table 1 represents the data structure for GLM test.

2) Test of causality

In our analysis, All 114 MSAs are considered for causality test. However, our basic assumption in causality test is that the causality test for MSAs having low correlation is not meaningful because although causality is proved to be high in the causality test, it is not justifiable if it has low correlation. We ran the test model from lag = 0 (no lag) to lag = 3 for possible causality. This is based on the assumption that the

$$x_{sub} = c_{coef} + \beta_1 x_{sub\_lag1} + \beta_2 x_{sub\_lag2} + \beta_3 x_{sub\_lag3} + e_{error}$$

causality lag would not be more than 3 years. In addition, due to the limitation of data availability, the test result for more than 4 year lag is less significant. For each degree of causality lag, the causality test is performed for four specific types of construction; residential construction, office type construction, non residential construction and total construction permits to find if there is any characteristics and difference in causality according to construction type. Figure 1 shows the structure of test for each selected MSA.

As a practical example of causality test of this model based on the Bivariate Granger Causality test, causality test of residential construction permits between central city and suburban areas for 3 year lag will be shown.

First, a restricted model by OLS is set as.

Where, x_{sub} is suburban construction permits of year t, x_{sub_lag1} represents one year lagged (in year t-1) suburban construction, x_{sub_lag2} is two year lagged (in year t-2) permits and in a same way, x_{sub_lag3} is three year lagged (in

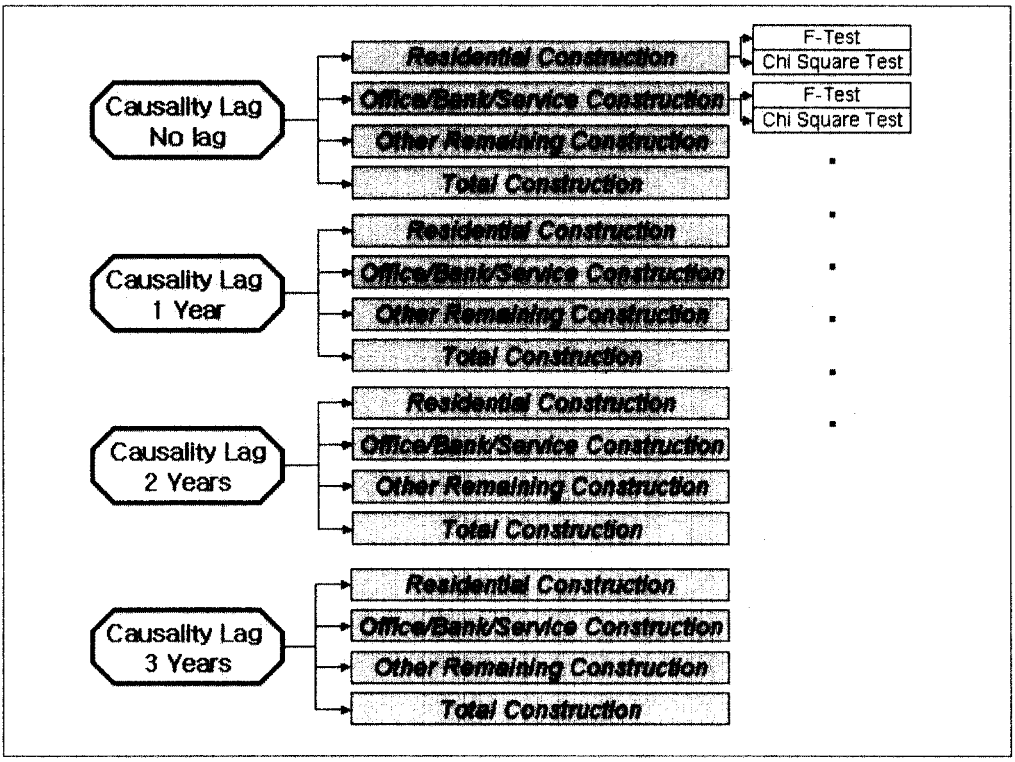

Figure 1. Structure of causality test from central city to suburban area

year t-3) permits. This model is based on the idea that current construction can be explained by the historical trend of construction permits. Second, an unrestricted model by OLS is set as

$$x_{sub} = c_{coef} + \beta_1 x_{sub\_lag1} + \beta_2 x_{sub\_lag2} + \beta_3 x_{sub\_lag3} + \beta_4 y_{cen\_lag1} + \beta_5 y_{cen\_lag2} + \beta_6 y_{cen\_lag3} + u_{error}$$

Where, y_{cen_lag1} represents one year lagged (in year t-1) central city construction permits, y_{cen_lag2} is two year lagged (in year t-2) central city permits and y_{cen_lag3} is three year lagged (in year t-3) permits. Other variables are same with the variables in previous restricted model. The null hypothesis on the test is $H_0 : \beta_4 = \beta_5 = \beta_6 = 0$ and H_0 : Not all of β_4, β_5, and β_6 are zero. Then, both F test and Chi square test will be performed for this null hypothesis.

5. Results of testing for central city - suburban area relationship

1) Test of correlation

Test of correlation for 114 selected MSAs is done for each type of construction permits issued. The following Table 2 and Figure 2 demonstrate the results of the test. According to the result, it is difficult to generalize that the central city and suburban area are highly correlated at least just from the results of the analysis for construction permits relationships. That is, the correlation coefficient of construction permits of each MSA shows very unique value. Some MSAs show very high correlations and some MSAs show very low correlation or even negative correlations. In Table 2 representing the number of correlation coefficients of 114 MSA in each classified range of value, we can find that there is little difference in the distribution among the construction type. However, residential construction activities are more correlated between central city and suburban area than office construction or non residential construction and residential construction activity have higher number of high correlation coefficients over 0.8 than other construction activities have. In the total construction permit section in Table 2, the number of MSAs having correlation coefficient over 0.8 in total construction permits is 21 out of 114 and on the other hand, 29 MSAs have negative correlation. Although it is not proved that the majority of MSAs have a tendency of showing high correlation between central city and suburban area from the analysis of construction permits data, it is still noteworthy that a very significant number of MSAs show a tendency that they are somehow correlated regardless of the strength of the correlation. Assuming that correlation coefficient over 0.3 normally indicates that there is somewhat correlation between city and suburbs, almost 63% of total MSAs show correlation

Table 2. Correlation distribution in 114 MSAs by construction type

Correlation Classes	Residential	Office	Non residential	Total
Over 0.8	24	7	11	21
0.6~0.8	23	19	20	25
0.3~0.6	29	23	28	26
0~0.3	22	31	28	14
Under 0	16	34	27	28
Total	114	114	114	11

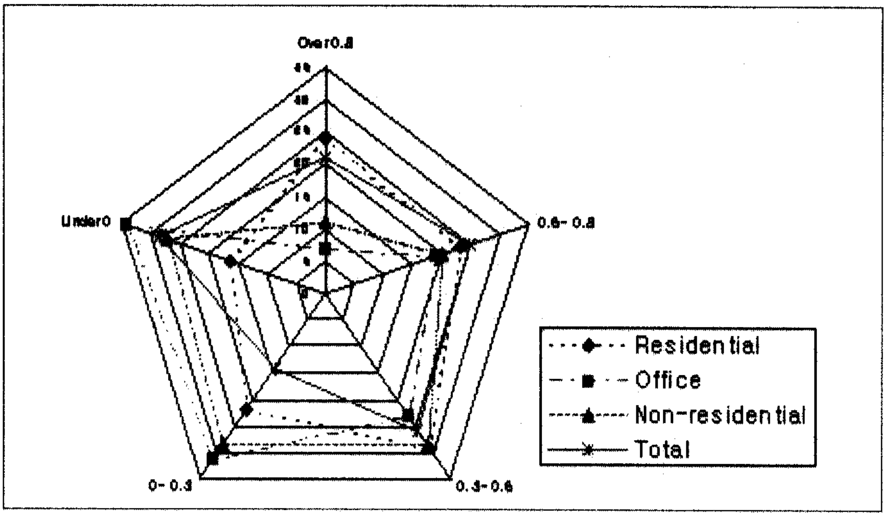

Figure 2. Correlation distribution in 114 MSAs by construction type

between those two areas in the analysis of total construction permits. Figure 2 shows in detail the degree of correlation coefficient for each construction type.

As a second step, our interest is to reveal whether there is any difference in correlation among MSAs having different characteristics. That is, the 114 MSAs are classified into three

Table 3. Number of MSAs in individual category

Pop Size \ Pop Growth	Large	Medium	Small	Total
Large	11	5	7	23
Medium	18	11	28	57
Small	10	10	14	34
Total	39	26	49	114

Table 4. Test for residential construction permits

F-Test			Least Squares Means		
Source	F Value	Pr > F	Class	MSA Size	Growth
MSA Size	0.28	0.7539	L	0.45611963	0.52879567
Pop Growth Rate	3.03	0.0524	M	0.37598320	0.40758419
Interaction	1.45	0.2231	S	0.43463627	0.33035925

Table 5. Test for office construction permits

F-Test			Least Squares Means		
Source	F Value	Pr > F	Class	MSA Size	Growth
MSA Size	8.34	0.0004	L	0.42071538	0.25913772
Pop Growth Rate	0.43	0.6530	M	0.24360797	0.22200022
Interaction	0.53	0.7137	S	0.10118346	0.28436887

Table 6. Test for non-residential construction permits

F-Test			Least Squares Means		
Source	F Value	Pr > F	Class	MSA Size	Growth
MSA Size	5.93	0.0036	L	0.42185040	0.42626866
Pop Growth Rate	2.16	0.1201	M	0.36227606	0.28029019
Interaction	0.44	0.7817	S	0.17267127	0.25023889

Table 7. Test for total construction permits

F-Test			Least Squares Means		
Source	F Value	Pr > F	Class	MSA Size	Growth
MSA Size	0.18	0.8372	L	0.40849827	0.50977424
Pop Growth Rate	3.85	0.0243	M	0.36777138	0.35588517
Interaction	1.32	0.2689	S	0.34825843	0.25886868

groups by the population size of MSA and also classified into three groups by the average annual growth rate. Here, it is assumed that the average annual population growth rate between 1985 and 1995 represents MSA's overall growth, and the size of population in 1995 represents the MSA's physical size. We also assumed the possibility of interaction effect between the MSA's size and growth. The result of GLM test is shown in Tables 3 to 7. As we can see from the table, the results of the test among the three type of construction are not the same. In case of residential construction, the difference of correlation among different growth rate groups is proved significant under 90% confidence level. For office construction, the correlations are different among different MSAs sizes. As we can see in lease square means table, the average correlation of large MSAs is greater than that of small MSAs. However, among others, the result about total construction permits is our focus. As shown in Figure 2, only annual growth rate is proved to have great effect on the average correlations of MSAs. The average correlation coefficient of high growth (over 2%) MSAs is 0.51 in contrast to 0.26 for low growth (under 0.5%) MSAs.

2) Test of causality

The focus of this paper is to test causality between central city and suburban area. We assumed that causality test for low correlation MSA does not produce significant test result. However, this paper shows causality results for all 114 MSAs to show how the causality is

Table 8. Causality test summary: number of MSAs showing causality among 114 MSAs

(Under 1% confidence level)

	Residential	Office	Non-Resid.	Total
Lag=1 year	5 (4.4%)	7 (6.1%)	4 (3.5%)	7 (6.1%)
Lag=2 years	4 (3.5%)	1 (1%)	2 (1.8%)	5 (4.4%)
Lag=3 years	3 (2.6%)	4 (3.5%)	5 (4.4%)	4 (3.5%)
# of MSAs showing causality	9	10	7	12

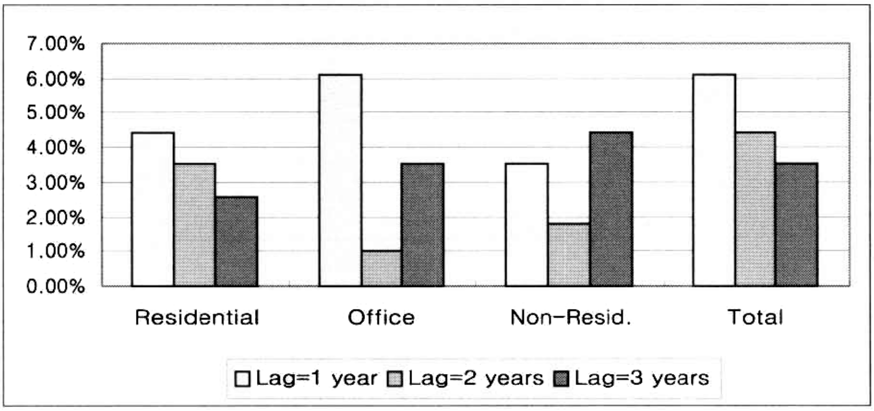

Figure 3. Percentage of MSAs showing causality for each lag (Under 1% confidence level)

different for the level of correlation. The analysis here is based on F test results. Compared to the cases of lag = 1 through lag = 3, more MSAs are diagnosed as having no lag. For residential construction, 4.4% of all MSAs show one year lag under 1% confidence level, for office construction is 6.1%, and for just non residential construction, 3.5% show one year lag between central area's construction activity and suburban area construction activity. In total construction activities including every type of construction, 6.1% of MSAs show one year lag. One of our interests is to see whether there is any difference in lag between the residential construction activity and office construction activity or between residential construction activity and non residential activity. Among the years of lag from 1 year to 3 year, there is no conspicuous difference in the number of causality among the different length of lag. Our basic assumption is that a significant number of MSAs would show causality in construction activity but according to the analysis only small portion of MSAs are proved to show causality. If the main purpose of the causality is just to see the existence of causality, we need to count the number of MSAs showing causality of any time lag. That is, some MSAs are proved to have causality in two or in all of the three time lags. Table 8 has the number of MSAs showing causality of any lag time for each construction type. The result shows that less than 10% of total 114 MSAs have causality. Because from our test, few MSAs show significant causality with lagged situation, we performed causality test without giving any lag.

Our assumption is that if it is proved that there is no causality in lag 1 through lag 3, significant number of MSAs may show causality in the causality test with no lag. Table 9 shows the summary of causality test without any lag. As we can see, only 21 MSAs among 114 show

Table 9. Causality test with no lag

	Residential	Office	Non-residential	Total
#of MSAs with P-val < 1%	21	8	10	12
#of MSAs with P-val < 5%	35	12	22	29

causality in residential construction with no lag situation. In office and non residential construction, the number is smaller.

6. Conclusions

According to the correlation test between the central city and suburban area, it is proved that almost 63% of total MSA show correlation between those two areas. By construction type, residential construction activity shows higher correlation than other types of construction activity. However it is still difficult to generalize for all MSAs that the central city and the suburban area have strong correlation in construction activities. In our test to reveal whether there is any characteristic in correlation by the population growth rate and population size of MSA, it is proved that the correlations are significantly different for MSA group belonging to different category of population growth. In our analysis, MSAs classified as showing high population growth has higher correlation between central city and suburban area than MSAs showing low population growth rate except for only office construction. There is little difference in correlation characteristic by the size of MSA.

The causality test, from the beginning, has an embedded problem of data deficiency. Using 11 year data is statistically difficult to show reliable result of the test. For reliable result of the rest, we need at least 20 years data or monthly data. However, the application of Granger Causality test developed in econometrics area to the planning is meaningful in itself. In our analysis, most of the MSAs show little causality between the central city and suburban area in lagged situation. That means it is difficult to say that the past trend of construction activity in central city helps to predict the future trend of construction trend in suburban area due to data deficiency.

From a policy perspective, by revealing the correlation and causality between central city and suburban area, it is possible to improve their development through cooperative actions to prevent urban decline. For example, if it is proved that there is high correlation and causality between two areas, the suburban area's development may be partially achieved through the collaboration with central city and the central city's current conditions could give ideas to plan for the suburban area in the future. In private sector, the real estate developers may use this idea in forecasting future space demand in the suburban area.

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