附件一

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都市特徵與動態外部效果對都市成長與產業發展的實證分析

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計畫主持人：陳心蘋
共同主持人：
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都市特徵與動態外部效果對都市成長與產業發展的實證分析

中文摘要

本研究的主要目的，是實証分析城市內與產業間的兩種外部效果對都市成長的影響。 以台灣地區 1976 年、1986 年與 1996 年的 21 縣市資料，探討不同類型的外部效果與都市特徵，對都市與產業成長的影響。 實證結果顯示：(1) 都市內產業別的就業成長與都市內產業別的起始就業量成反向相關；(2) 都市內產業別的就業成長與起始年的產業內相互競爭水準成正向相關；(3) 都市內產業別的就業成長與起始年的都市內產業多樣化程度成正向關係。 都市內產業的多樣化程度對就業成長的影響，相對的比其他影響效果為大。 除此之外，(1) 城市內產業別的工資成長率，與城市內產業別的起始工資水準呈負向關係；(2) 城市內產業別的工資成長率，與起始年的城市內產業的多樣化水準成正向關係。 整體而言，實證結果顯示，城市內的產業競爭與產業多樣化都有助於就業與工資的成長；相反的，都市內產業專業化對就業與工資的成長有負面的影響。 此研究結果與 Jocobs 的理論一致：產業間交叉的外部效果與相互競爭，比產業內的外溢效果更有助於產業的成長。

陳心蘋

政大經濟系

關鍵字：都市外部效果、都市成長、多樣化、專業化

1. Introduction

Recent studies in the field of economic growth have sought to explain the income growth of different countries in accordance with their countrywide characteristics. In the literature on endogenous growth models, it has been argued that dynamic externalities (particularly knowledge spillovers) are the essential driving force behind economic growth (Romer, 1986). In such studies, much emphasis has been placed on the stock of accumulated knowledge. The effects of dynamic information externalities are often observed in places in which there is a focus on communication. Lucas (1988) noted that these externalities are more significant in cities. Besides knowledge spillovers and human capital, there are other important citywide attributes and externalities that affect the growth of economies across cities.

Unlike countries, cities are completely open as a result of increased labor mobility. Furthermore, cities are more specialized than national economies in that agglomeration economies are more important for growth. The focus in the study of standard externalities in the urban environment is on static externalities, which are generated from the current information spillovers given market conditions. Static externalities explain the formation of and degree of specialization within cities rather than city growth (Henderson 1986). Traditional static externalities are associated with the extent of localization and urbanization. Positive externalities in relation to both of these characteristics suggest that bigger cities give rise to greater benefits. By contrast, the generation of negative externalities, such as congestion and commuting costs, suggest the existence of an optimal city size (Henderson 1974, 1996).

Dynamic externalities deal with the impact of the accumulation of prior information on current productivity. There are three types of theories that seek to explain dynamic externalities, namely, the Marshall-Arrow-Romer (MAR), Porter (1990) and Jacobs (1969) theories (Glaeser et al. 1992). The MAR theory is concerned with the generation of knowledge spillover externalities for productivity purposes between firms within an industry. Such externalities arise from ongoing intra-industry communications. Marshall (1890) applied this theory to cities. The MAR theory also suggests that a local monopoly will enhance growth more than local competition since the externalities that are internalized will speed up the process of innovation and growth.

Porter (1990) argues that geographically concentrated industries stimulate growth as in the case of the MAR theory; however, in contrast to the MAR theory, Porter's theory suggests that local competition fosters innovation. Unlike the MAR and Porter theories, Jacobs (1969, 1984) suggests that knowledge spillovers are mostly derived among industries, and that the ease with which ideas flow in cities also

helps innovation. Furthermore, it is the geographical diversity of proximate industries rather than specialization that encourages innovation and growth. The heterogeneous features of modern cities have provided significant efficiency gains in economic growth. This kind of externality is both inter-industry and urbanized. Besides, Jacobs believes that local competition speeds up innovation. Both the MAR and Porter theories advocate localized dynamic externalities. They agree that regional specialization is good for growth. However, Jacobs believes in urbanized dynamic externalities, and predicts that industries located in highly industrially-diversified areas will grow faster.

In previous empirical studies of dynamic externalities, Jaffe, Trajtenberg, and Henderson (1993) find externalities to be more localized. Glaeser et al. (1992) finds evidence of the existence of Jacobs-type dynamic externalities based on a study of the six largest industries in the United States. Miracky (1992) finds evidence of both MAR and Jacobs externalities. Models based on the kinds of externalities available in cities emphasize the role of diversity in enhancing economic efficiency.

Quigley (1998) summarizes the possible reasons why diversity and city size influence the economic growth of cities. He suggests that heterogeneity or variety mostly correspond to the larger-sized urban areas, which would consequently encourage the growth of cities for various reasons, such as scale economies, shared inputs and reduced transaction costs, etc. A number of empirical studies confirm the presence of scale economies in urbanization, to the effect that city size encourages city growth (Shefer, 1973, Sveikauskas, 1975, Segal, 1976, and Nakamura, 1985). Furthermore, Bostic et al. (1997) find evidence that industrial diversity improves the city output level. Garcia-Mila and McGuire (1993) find that the industrial mix affects economic growth.

Overall, the empirical results show that larger city sizes and increased diversity promote the growth of cities and raise productivity. However, traditional models impose efficiency limits on city sizes due to the presence of negative externalities and higher land prices, housing prices and the costs of commuting (Mills, 1967, Henderson, 1974). Several empirical studies suggest that various economic costs increase with the scale of urbanization (O'Regan and Quigley, 1996). Nevertheless, Quigley (1998) argues that large cities will continue to be an important source of economic growth according to recent surveys on urban diversity.

The purpose of this paper is to identify the key dynamic externalities that drive city growth and industrial development. We empirically investigate how the growth of cities and industrial development have been influenced over the last 20 years in Taiwan by corresponding citywide and industrial externalities. The predictions of the various new economic growth theories are examined in this paper. Moreover, we ask

whether the effects of externalities change over time. This is the first empirical study in Taiwan that examines the effect of both citywide and industrial externalities on the growth of the city and city-industry.

The remainder of this paper is organized as follows. Section 2 introduces both citywide and city-industry externalities, Section 3 describes the data and estimation results, Section 4 concludes.

2. External Economies

The traditional production externality literature focuses on static externalities, which deal with various aspects of the conditions currently prevailing in cities. Dynamic externalities, which have been widely discussed recently (Glaeser et al., 1992, Henderson et al., 1995, Bostic et al., 1997), focus on certain aspects of the historical urban environment.

2.1 Static External Economies: Localization and Urbanization

Traditional static externalities arise from localization and urbanization. The static localized externalities are derived from current local own-industry employment, while urbanization externalities refer to the benefits a firm enjoys as a result of the current agglomeration of local industries as a whole within a city (Henderson 1986).

2.2 Dynamic Externalities: Industrial Externalities and Citywide Externalities

2.21 Industrial Externalities:

Dynamic externalities refer to different aspects of historical conditions. They are discussed in this paper both within the context of the city-industry and city. There are several different types of city-industry externality, namely, localization, specialization, competition and diversity within the environment

Localization

The externalities from which a firm benefits owing to agglomeration within the same industry are referred to as localization externalities. This would suggest that geographical specialization among firms within the same industry contributes to growth. The reasons for the existence of these externalities include access to natural resources, transportation advantages, and savings on moving inputs, etc. (Marshall (1890)). The dynamic industrial localization externality is measured on the basis of employment within the industry at some base period.

Specialization

Specialization within a certain industry in a city is measured as the fraction of the city's employment that this industry represents in that city, relative to the share of the

whole industry in national employment. This is the same measure as in Glaeser et al. (1992). This specialization measure represents the potential for MAR externalities.

$$\text{Specialization} = \frac{\text{Industry employment in city/total employment in city}}{\text{Industry employment in nation/total employment in nation}}$$

Competition

Local competition within an industry in a city is measured as the ratio of the number of firms per worker in the city-industry to the number of firms per worker in the national industry (Glaeser et al. (1992)). An industry has more firms relative to its size in the city than it does in the nation if the value of the competition variable is greater than one. This implies that the industry in this city is locally more competitive than it is elsewhere in the country. The competition variable measures the level of competition among firms in the city relative to firms in the nation. The smaller the size of firms in the city relative to those in the nation, the higher the value of the competition variable. This is a rough measure of the size of firms within the city relative to firms in the nation.

$$\text{Competition} = \frac{\text{Firms in city-industry/workers in city-industry}}{\text{Firms in national industry/workers in national industry}}$$

Diversity of the Environment

The city-industry diversity externality is a measure of the variety of industries in the city that are outside the industry. The diversity of all industries other than industry j in city i is measured by the Hirschman-Herfindahl index ($HHI_{ij,t}$):

$$HHI_{ij,t} = \sum_{k \in j}^{l} (E_{ik,t} / E_{i,t})^2,$$

where $E_{ik,t}$ is the amount of employment of industry k in city i at time t, and l is the total number of industries in the city. This index indicates the level of diversity in the environment. A larger value of $HHI_{ij,t}$ reflects more specialization and less diversity in the environment with respect to industry j in the city. This diversity measure represents Jacobs externalities.

2.22 City-wide Externalities:

The citywide externalities consist of two kinds: diversity and localization.

Citywide diversity

This measure indicates the degree to which a city's output is dominated by a

single or a number of closely related sectors. This externality is measured by the Hirschman-Herfindahl index ($HHI_{i,t}$): $HHI_{i,t} = \sum_{j=1}^{J} (E_{ij,t} / E_{i,t})^2$, where $E_{ij,t}$ is the amount of employment of industry j in city i at time t, and J is the total number of industries in the city. This citywide externalities index indicates the level of specialization or diversity within a city. An increase in $HHI_{i,t}$ reflects more specialization and less diversity in the city.

Citywide localization

We measure the degree of industrial localization in city i at time t by the index $LOC_{i,t}$ as in Bostic et al. (1997). Let $\overline{LOC}$ denote the threshold level of a city-industry's share of national employment above which it is considered localized. The definition of the set of localized industries in city i is: $\Lambda_i \equiv \{j | LOC_{ij,t} \geq \overline{LOC}\}$ where $LOC_{ij} = E_{ij} / (\sum_i E_{ij})$. The measure for localization in city i is the share of the localized industries in the city: $LOC_{i,t} = \sum_{j \in \Lambda_{i,t}} E_{ij,t} / E_{i,t}$, where $E_{ij,t}$ is the amount of employment for industry j in city i at time t, and $E_{i,t}$ is the total employment in city i at time t.

3. The Data and Estimation

3.1 The Data

The analysis in this paper is based on a sample of 21 Taiwan cities covering the period 1976 to 1996 (1976, 1986, and 1996). Taiwan is divided into four regions (north, central, south and east) by the Directorate-General of Budget, Accounting and Statistics based on geographical conditions, industrial structure and transportation systems. These four regions were composed of 21 major cities in 1976 and two more cities were added in 1982. There have thus been 23 cities in the region since 1982. This study uses the original 21 cities as the observations in the regressions to maintain consistency during the period under study (1976~1996). It would have been the first best choice to use metropolitan areas as the unit of observation. However, there are only seven metropolitan areas in Taiwan, and this number of observations is too small for the regressions. Due to this constraint, we adopt the second best alternative, namely, the "city" as the unit of observation in this study. The city level data is

obtained from the Report on the Survey of Personal Income Distribution in the Taiwan Area, and the Taiwan-Fukien Demographic Fact Book. The industrial level data is collected from the Report on the Industrial and Commercial Census: Taiwan-Fukien Area. The industry data comprises all 2-digit industries in 21 cities in Taiwan. There is a total of 69 groups of 2-digit industries classified by the Report on the Industrial and Commercial Census: Taiwan-Fukien Area.

3.2 Estimation and Results

There are two groups of regressions performed in this section. The first group of regressions is concerned with investigating the relationship between city growth and citywide externalities. The second group of regressions investigate the relationship between industrial development and the corresponding industrial externalities. Both groups of regressions are estimated for two different time periods (1976~1986, 1986~1996); and both groups include the corresponding initial conditions and regional dummies as explanatory variables. In the case of the city growth regressions, the dependent variables include various city variables: city population, city output and city income. The citywide externalities include a diversity index (HHI) and localization. There are 21 observations in these regressions.

As for the industrial development regressions, the dependent variables include city-industry employment growth and city-industry wage growth. The industrial externality variables include specialization, competition and diversity. There are 69 2-digit industries within the 21 cities; in the regression, we drop observations with missing data.

We first use the ordinary least squares (OLS) procedure to estimate the city growth regressions. The estimation results are presented in Table 1 (1976~1986) and Table 2 (1986~1996). However, due to the small size of Taiwan, it is suspected that the spatial autocorrelation problem may exist. The *Moran I* statistics for spatial dependence are thus reported in Tables 1 and 2, and weak spatial autocorrelation is observed in Table 1. In order to correct the spatial dependence problem, we use the maximum likelihood estimation (MLE) procedure to reestimate Table 1. In the case of the industrial development regressions, we also first of all use the OLS procedure. Since the reported *Moran I* statistics also exhibit spatial dependence problems, we use the MLE procedure to estimate industrial growth.

Table 1 examines the relationship between city growth and certain initial conditions and citywide externalities using city-level data in Taiwan between 1976

and 1986. There are three regional dummies used as independent variables, the eastern region being excluded from the regression. The first column includes the regressions of city population growth on the initial population, initial income per capita, initial human capital level, initial citywide externalities and geographical dummies. All of the growth variables in this paper are measured in terms of the growth rate for the entire decade, and appear in decimal form. The human capital in each city is measured by the median years of schooling. The citywide externalities are represented by the degrees of diversity and localization. The degree of diversity is measured by means of the HHI index. The larger the index, the less diversity and more specialization there is in the city. The extent of city localization is measured by the share of the localized industries in each city. We use 10 percent as the threshold level to identify localized industries.

Regression (1) shows that the populations of larger cities increase more slowly; however, this finding is not significant. There is no evidence that the population of richer cities grows more slowly, which would not be consistent with the basic convergence idea. The results of Regression (2) show that the initial median years of schooling exert a positive influence on the subsequent output growth. Moreover, the stronger the degree of geographic localization in the city, the slower the growth of city output. This effect is significant and quantitatively large in the regression. Regression (3) shows that the larger the degree of specialization (the less degree of diversity), the slower the growth of city income. This result suggests that diversity speeds up income growth in the city. The external effect on the city income growth of city localization is negative, but is statistically insignificant.

The results of the test for spatial autocorrelation are shown by *Moran's I* in Table 1,[1] and reveal that there is weak spatial dependence in both Regressions (1) and (3). No spatial autocorrelation is found in Regression (2). We rerun the regressions using the MLE procedure, and the results are presented in Table 3.

Table 2 presents the growth of the cities between 1986 and 1996. The result indicate that the city output and city income of larger cities increased more slowly. The larger the median number of years of schooling, the faster the growth of both city output and city income. The influence of human capital on the growth of city output is significant at the 5 percent level. Unfortunately, the geographic externalities do not exhibit a significant impact on city growth as recent studies have predicted. Based on the *Moran's I* test, the spatial autocorrelation problem does not manifest itself in Table

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[1] The *Moran's I test* is used to test for spatial dependence. It is defined as

$I = (N / S_0)e'We / e'e$

where $S_0 = \sum_i \sum_j w_{ij}$, and W is the spatial weights matrix. The distribution of this statistic is

2.

Table 3 depicts the MLE results using the same regressions as in Table 1. It is seen that the initial population has a significant effect on city income growth. However, the noticeable impact of citywide externalities on city growth as was observed in Table 1 is not significant in this table. This shows that the OLS estimator overestimates both the diversity effect in relation to city income growth and the localization effect in relation to city output growth.

Table 4 presents our results for employment growth across city-industries in Taiwan over the 1976-1986 period. We include the log of the initial wage and the log of initial city-industry employment, as well as dummy variables indicating city location, as control variables in the regressions. The regression results show that higher initial employment in a city-industry leads to slower growth of that industry's employment. Initial wages in a city-industry are not significantly correlated with employment growth. Equation 1 shows that industries that are more heavily concentrated in the city than they are in Taiwan as a whole grow more slowly. This effect is quantitatively small and not significant. This result does not support the predictions of the MAR model. In equation 2, the effect of the competition variable is positive and significant, indicating that more firms per worker in a city-industry relative to the national average leads to higher growth within that city-industry. This is consistent with Porter's and Jacob's hypotheses. Equation 3 shows that industries in cities with more diversified environments grow faster. This finding suggests that a greater variety of neighbors rather than dominant industries as neighbors help a city's own growth. This is consistent with Jacobs' theory that knowledge spillovers outside the industry are important. All of the measures of externalities are applied in equation 4. The effect of diversity remains statistically significant and quantitatively large. Competition within the city-industry continues to have a positive influence on the growth of employment. The overall results do not support the MAR theory. By contrast, the findings favor Jacobs' theory.

Moran's I statistic shows weak spatial autocorrelation in Regressions (1), (2) and (3). The MLE results for the same regressions in Table 4 are presented in Table 5, and are very similar to the results in the former table. They indicate that both the competition and diversity externalities effects are significant in relation to city-industry employment growth.

Table 6 presents the MLE results relating to wage growth across city-industries. The results show that high initial city-employment in industries helps wage growth; conversely, high initial wages in the city-industries reduce wage growth. Both influences are significant. The effect of the initial employment is statistically

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normal. See Anselin and Hudak (1992) for more details.

significant but quantitatively small. All of the regional dummies exhibit positive significant effects in relation to the growth of city-industry wages. Equation 1 tells us that city-industry specialization has no significant effect on wage growth. This result does not support the predictions of the MAR model. In equation 2, the effect of the competition variable is positive but still statistically insignificant. Equation 3 indicates that wages in city-industries with environments that are more diversified increase more rapidly. This finding suggests that a greater variety of neighbors rather than dominant industries as neighbors helps promote wage growth, and is consistent with Jacobs' theory that knowledge spillovers outside the industry are important. Equation 4 uses all of the measures of externalities simultaneously. The effect of diversity remains statistically significant. The overall results indicate that industrial diversity within a city helps promote the wage growth of the industry. In ways similar to the results in Table 5, these findings favor Jacobs' theory.

Table 7 presents the results of regressions similar to those in Table 5 except for the different time period data used. As in the case of Table 5, high initial employment in city-industries leads to slower growth of the industry's employment. The negative influence of this initial employment is stronger during this later decade than it is during the earlier decade. Furthermore, industries in the northern region are seen to have grown significantly as compared with industries in other regions. Equation 1 shows that industries that are more heavily concentrated in cities grow more slowly than those for Taiwan as a whole. However, this effect is quantitatively small and not significant as is the case in Table 5. This result does not support the predictions of the MAR model. In equation 2, the effect of the competition variable is positive and significant, a finding that is consistent with both Porter's and Jacobs' hypothesis. This effect in Taiwan is statistically significant but quantitatively small as in Table 5. Equation 3 shows that industries in cities with more diversified environments grow more rapidly. This finding suggests that a greater variety of neighbors rather than dominant industries as neighbors during this period helps cities with their own growth as was the case during the previous decade. Such a finding is consistent with Jacobs' theory. The effect of diversity remains statistically significant. Competition within the city-industry continues to have a positive but small influence on the growth of its employment. In ways similar to the results presented in Table 5, the overall results favor Jacobs. The influence of the diversity externality on employment growth has increased when compared with the previous decade. On the contrary, the effect of the competition externality on employment growth has decreased as compared with the previous decade.

Table 8 presents the results of regressions similar to those in Table 6 using data for the later time period. As in the case of the results in Table 6, high initial wages at

the city-industry level reduce wage growth. The effect is statistically significant and quantitatively large as in the previous decade. By contrast, it is observed that the initial employment in a city-industry exhibits a weak influence on the wage growth. Moreover, the wages of industries in the northern region are still seen to grow significantly faster than in the other regions as was the case during the previous decade. In equation 2, the effect of the competition variable is negative but statistically insignificant. Equation 3 indicates that wages in city-industries with increasingly diversified environments grow more rapidly as was the case during the previous decade. This finding is consistent with Jacobs' theory that knowledge spillovers outside the industry are important. In equation 4, the effect of diversity remains statistically significant. The overall results indicate that diversity within a city helps wages grow within the industry. These findings are consistent with the results of the previous decade, and favorable Jacobs' theory.

Overall, in the cases of the regressions related to employment growth and wage growth during the two different time periods (Tables 5~8), we find that in general, instead of leading to the slower growth of that industry's employment, a high initial level of employment at the city-industry level on the contrary helps promote wage growth. High initial wages at the city-industry level reduce wage growth significantly, but are not significantly correlated with employment growth. Moreover, the regression results indicate that diversity is the most important externality in terms of explaining both wage growth and employment growth at the city-industry level for the two decades being studied, and becomes increasingly important in relation to the growth of employment.

Two hypotheses are tested to examine whether the parameters in both the employment growth and wage growth regressions vary through time. We first test to see whether the parameters in the employment growth regression (Regression (4) in Table 5 and Regression (4) in Table 6) are different between the two decades (1976~1986 and 1986~1996). The *F test* statistic is found to be 17.42, which is greater than the 1% critical value. We therefore reject the hypothesis that the parameters in the regression model are the same during the two time periods.[2] These results indicate that the influences of the initial condition and the externalities on the employment growth within industries are statistically significantly different from one decade to the next. The second hypothesis is tested to see whether the parameters in the wage growth regression remain the same during the two time periods. The *F test*

[2] The test statistics in relation to the hypotheses that the parameters of Regression (4) in Table 5 remain the same during 1976~1986 and 1986~1996 are as follows:

$$F = \frac{e_*' e_* - e' e / k}{e' e / (n-2k)} = \frac{[2601-(1028+1311)]/8}{(1028+1311)/1259-16} = 17.42 > F_{.01}(k, n-2k) = F_{.01}(8,1243) = 2.51$$

statistic equals 152.3, which is greater than the 1% critical value of 2.51.[3] We therefore reject the hypothesis that the parameters remain the same during both time periods. The results of these two tests indicate that the impact of dynamic externalities on the growth of both employment and wages change over time.

Table 9 presents the regressions in relation to wage growth across city-industries over the two decades for two different groups of city-industries. We group the city-industries into "fast-growing" industries and "other" industries. The "fast-growing" industries are defined as those industries whose wage growth rates fall within the top 25 percentiles, while the "other" industries are those industries whose wage growth rates fall outside the top 25 percentiles. We find that a high initial wage reduces wage growth in both industry groups. The effect is statistically significant, and also demonstrates the weak influence of initial employment on the growth of wages. Wages for "other" industries in the northern region increase significantly more than wages for "other" industries located outside the northern region. The northern region dummy variable does not exhibit a significant effect in "fast-growing" industries. As with the previous results, the effects of diversity externalities are significant in both "faster-growing" industries and "other" industries. Furthermore, it can be seen that diversity helps promote wage growth in both groups of industries and within each time period.

4. Conclusion

The results presented in this paper have shown that, at the city-industry level, high initial employment within a city-industry leads to slower growth in terms of that industry's employment in both decade-long time periods under study. Similarly, a high initial wage within a city-industry reduces wage growth significantly in both periods.

As for the effect of externalities, industry specialization does not exert a significant impact on either employment growth or wage growth in both decades. Our results in this regard do not support the predictions of the MAR model. The competition variable has a positive influence on employment growth in both decades, the effect being significant but quantitatively small. This indicates that more firms per worker within a city-industry relative to the national average leads to a higher growth of that city-industry. This result tells that the existence of more relatively small-scale industries within a city helps industry grow in that city. This is consistent with both

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[3] The test statistics in relation to the hypotheses that the parameters of Regression (4) in Table 6 remain the same during 1976~1986 and 1986~1996 are:

$$F = \frac{e_*' e_* - e' e / k}{e' e / (n-2k)} = 152.3 > F_{.01}(k, n-2k) = F_{.01}(8,2035) = 2.51$$

Porter's and Jacobs' hypothesis that local competition fosters innovation. Moreover, the diversity among city-industries improves both employment growth and wage growth in both decades. This positive effect of diversity is not only statistically significant but also quantitatively large relative to the effect of competition. Besides, the effect of diversity has increased from one decade to the next. The diversity externalities exhibit an increasingly greater impact on employment growth over time. Both competition and diversification among industries stimulate employment growth. Our results suggest that knowledge spillovers are mostly derived among industries. It is geographical diversity of proximate industries rather than specialization that encourages innovation and growth. Overall, we find that specialization hurts, competition helps, and city diversity helps both employment growth and wage growth in both study periods. Urban variety and local competition are more important for the growth of industries than is regional specialization. This result is consistent with the theories of Jacobs. We also find that the extent of the effects of the initial conditions and externalities on employment growth and wage growth vary through time.

In relation to the city-level evidence, the regression results do not provide strong evidence of the externality effects. This may be due to the limitations on the number of observations in our data. In addition, the median years of schooling (human capital) helps city output growth. To sum up, we find that the effects of local competition and urban variety are becoming more and more important in the growth of employment in Taiwan. The results provide evidence that knowledge spillovers across industries, but not spillovers within industries, encourage employment growth in industries. As is the case with the study by Glaeser (1992), our findings favor Jacobs' theory that local competition and the cross-fertilization of ideas across industries helps industries grow.

Table 1

City Growth and Externalities (1976-1986) by OLS

(Dependent variable: Growth in city variable)

Dependent Variable	(1) City Population	(2) City Output ($'000)	(3) City Income
Intercept	0.617	-0.205	2.222
	(2.242)	(8.383)	(2.785)
Population 1976 (Log)	-0.007	-0.197	0.154
	(.184)	(.683)	(.236)
Per capita income 1976	0.00001	-0.0001	0.00004
	(.00001)	(.00007)	(.00003)
Human capital:			
Median years of schooling	-0.135	1.045*	-0.190
1976	(.094)	(.350)	(.128)
Externalities:			
Diversity (HHI)1976	0.174	3.072	-1.546**
	(.525)	(1.954)	(.749)
Localization 1976	0.657	-2.503**	-0.357
	(.360)	(1.340)	(.432)
Geographical dummies			
North	-0.106	0.871	0.542
	(.271)	(1.007)	(.362)
Central	-0.076	1.124	0.431
	(.248)	(.921)	(.353)
South	-0.080	1.105	0.102
	(.265)	(.988)	(.353)
N	21	21	21
Adj. R^2	.38	.47	.28
Moran's I	0.027**	-0.249	0.001**

Note: Numbers in parentheses are standard errors.

Diversity: Hirschman-Herfindahl index

Localization: Share of the city employment in localized industries, 10%

*Significant at the 5 percent level.

** Significant at the 10 percent level.

Table 2

City Growth and Externalities (1986-1996) by OLS

(Dependent variable: Growth in city variable)

Dependent Variable	(1) City Population	(2) City Output ($'000)	(3) City Income
Intercept	-0.838	1.634	5.743
	(.879)	(3.026)	(1.550)
Population 1986 (Log)	0.096	-0.272	-0.253**
	(.070)	(.242)	(.122)
Per capita income 1986	0.000006*	0.000007	-0.000009**
	(.000002)	(.000007)	(.000005)
Human capital:			
Median years of schooling	-0.100*	0.403*	0.067
1986	(.029)	(.100)	(.072)
Externalities:			
Diversity (HHI)1986	0.344	-0.212	0.595
	(.197)	(.680)	(.409)
Localization 1986	-0.185	-0.155	0.080
	(.145)	(.501)	(.267)
Geographical dummies			
North	-0.019	-0.574	-0.271
	(.119)	(.408)	(.253)
Central	-0.072	-0.724**	-0.443**
	(.110)	(.380)	(.245)
South	-0.106	-0.629	-0.301
	(.114)	(.393)	(.239)
N	21	21	21
Adj. R^2	.57	.77	.65
Moran's I	-0.105	-0.128	-0.335

Note: Numbers in parentheses are standard errors.

Diversity: Hirschman-Herfindahl index

Localization: Share of the city employment in localized industries, 10%

*Significant at the 5 percent level.

** Significant at the 10 percent level.

Table 3

City Growth and Externalities (1976-1986) by MLE

(Dependent variable: Growth in city variable)

Dependent Variable	(1) City Population	(2) City Output ($'000)	(3) City Income
Intercept	0.592	2.584	-1.259
	(1239603.8)	(2562531.8)	(2068735.3)
Population 1976 (Log)	0.005	-0.503	0.473*
	(.301)	(.834)	(.221)
Per capita income 1976	0.00001	-0.0001	0.00003
	(.00002)	(.0001)	(.00003)
Human capital:			
Median years of schooling 1976	-0.152	1.170	-0.234
	(206600.51)	(427088.4)	(344789.21)
Externalities:			
Diversity (HHI)1976	-0.050	2.858	-0.908
	(.626)	(2.732)	(.840)
Localization 1976	0.641	-2.046	-0.694
	(.466)	(2.821)	(.823)
Geographical dummies			
North	-0.106	0.846	0.333
	(.522)	(.932)	(1.188)
Central	-0.034	1.201	0.147
	(.528)	(.982)	(1.191)
South	-0.058	1.037	-0.112
	(.532)	(1.089)	(1.200)
N	21	21	21

Note: Numbers in parentheses are standard errors.

Diversity: Hirschman-Herfindahl index

Localization: Share of the city employment in localized industries, 10%

*Significant at the 5 percent level.

Table 4

City-Industry Employment Growth and Externalities (1976-1986) by OLS

(Dependent variable: Growth in city-industry variable)

	City-Industry Employment Growth 1976-1986			
Dependent Variable (Logs)	(1)	(2)	(3)	(4)
Intercept	1.093	0.752	1.941	1.570
	(.027)	(.372)	(.507)	(.533)
City-industry employment				
1976 (Log)	-0.259*	-0.237*	-0.294*	-0.255*
	(.027)	(.027)	(.026)	(.032)
Wage in city-industry				
1976 (Log)	-0.054	-0.04	-0.077	-0.067
..	(.082)	(.081)	(.082)	(.082)
Geographical dummies:				
North	0.739*	0.763*	0.710*	0.692*
	(.214)	(.211)	(.213)	(.214)
Central	0.443*	0.450*	0.350	0.318
	(.209)	(.206)	(.212)	(.214)
South	0.485*	0.492*	0.374*	0.347*
	(.208)	(.205)	(.214)	(.215)
City-Industry externalities:				
Specialization 1976	-0.048			-0.05
	(.056)			(.056)
Competition 1976		0.05*		0.046*
		(.020)		(.020)
Diversity 1976			-7.863*	-7.308*
			(3.435)	(3.437)
N	662	662	662	662
Adjusted R^2	.16	.17	.17	.17
Moran's I	-0.0130*	-0.0128*	-0.0115**	-0.0110

Note: Numbers in parentheses are standard errors.

* Significant at the 5 percent level.

**Significant at the 10 percent level.

Table 5

City-Industry Employment Growth and Externalities (1976-1986) by MLE

(Dependent variable: Growth in city-industry variable)

	City-Industry Employment Growth 1976-1986			
Dependent Variable (Logs)	(1)	(2)	(3)	(4)
Intercept	1.019*	0.694*	1.747*	1.392*
	(.301)	(.337)	(.509)	(.548)
City-industry employment				
1976 (Log)	-0.264*	-0.242*	-0.293*	-0.255*
	(.028)	(.025)	(.025)	(.032)
Wage in city-industry				
1976 (Log)	-0.060	-0.047	-0.079	-0.069
	(.069)	(.071)	(.070)	(.073)
Geographical dummies:				
North	0.767*	0.785*	0.739*	0.724*
	(.193)	(.192)	(.198)	(.202)
Central	0.392*	0.395*	0.315	0.290
	(.190)	(.190)	(.202)	(.206)
South	0.551*	0.552*	-6.706*	0.425*
	(.193)	(.192)	(3.393)	(.213)
City-Industry externalities:				
Specialization 1976	-0.038			-0.036
	(.075)			(.075)
Competition 1976		0.047*		0.044*
		(.017)		(.017)
Diversity 1976			-6.706*	-6.200**
			(3.393)	(3.442)
N	662	662	662	662

Note: Numbers in parentheses are standard errors.

* Significant at the 5 percent level.

** Significant at the 10 percent level.

Table 6

City-Industry Wage Growth and Externalities (1976-1986) by MLE

(Dependent variable: Growth in city-industry variable)

	City-Industry Wage Growth 1976-1986			
Dependent Variable (Logs)	(1)	(2)	(3)	(4)
Intercept	4.890*	4.848*	5.290*	5.253*
	(.086)	(.095)	(.149)	(.157)
City-industry employment				
1976 (Log)	0.055*	0.059*	0.042*	0.046*
	(.009)	(.009)	(.009)	(.010)
Wage in city-industry				
1976 (Log)	-1.292*	-1.290*	-1.300*	-1.299*
	(.016)	(.016)	(.016)	(.016)
Geographical dummies:				
North	0.174*	0.175*	0.147*	0.146*
	(.060)	(.059)	(.059)	(.059)
Central	0.199*	0.198*	0.148*	0.146*
	(.060)	(.059)	(.060)	(.060)
South	0.172*	0.172*	0.113*	0.112*
	(.058)	(.057)	(.058)	(.057)
City-Industry externalities:				
Specialization 1976	-0.003			-0.002
	(.018)			(.017)
Competition 1976		0.007*		0.006
		(.007)		(.007)
Diversity 1976			-3.631*	-3.573*
			(.982)	(.986)
N	997	997	997	997

Note: Numbers in parentheses are standard errors.

* Significant at the 5 percent level.

Table 7

City-Industry Employment Growth and Externalities (1986-1996) by MLE

(Dependent variable: Growth in city-industry variable)

	City-Industry Employment Growth 1986-1996			
Dependent Variable (Logs)	(1)	(2)	(3)	(4)
Intercept	3.610*	2.443*	6.171*	5.066*
	(.745)	(1.009)	(.926)	(1.161)
City-industry employment 1986 (Log)	-0.507*	-0.490*	-0.572*	-0.558*
	(.037)	(.032)	(.033)	(.038)
Wage in city-industry 1986 (Log)	-0.060	0.159	-0.096	0.081
	(.157)	(.209)	(.168)	(.210)
Geographical dummies:				
North	0.639*	0.581*	0.604*	0.571*
	(.261)	(.254)	(.250)	(.249)
Central	0.492**	0.426**	0.106	0.085
	(.264)	(.259)	(.269)	(.267)
South	0.348	0.281	-0.215	-0.231
	(.263)	(.258)	(.283)	(.281)
City-Industry externalities:				
Specialization 1986	-0.0006			0.025
	(.122)			(.117)
Competition 1986		0.024*		0.019*
		(.009)		(.009)
Diversity 1986			-25.638*	-24.015*
			(5.432)	(5.467)
N	598	598	598	598

Note: Numbers in parentheses are standard errors.

*Significant at the 5 percent level.

** Significant at the 10 percent level.

Table 8

City-Industry Wage Growth and Externalities (1986-1996) by MLE

(Dependent variable: Growth in city-industry variable)

	City-Industry Wage Growth 1986-1996			
Dependent Variable (Logs)	(1)	(2)	(3)	(4)
Intercept	6.604*	6.699*	6.909*	7.046*
	(.258)	(.277)	(.307)	(.343)
City-industry employment				
1986 (Log)	-0.003	-0.006	-0.012	-0.014
	(.011)	(.012)	(.011)	(.013)
Wage in city-industry				
1986 (Log)	-1.257*	-1.275*	-1.257*	-1.279*
	(.052)	(.055)	(.051)	(.055)
Geographical dummies:				
North	0.156*	0.165*	0.157*	0.161*
	(.064)	(.064)	(.066)	(.066)
Central	-0.016	-0.007	-0.060	-0.058
	(.055)	(.054)	(.069)	(.069)
South	0.007	0.015	-0.058	-0.056
	(.060)	(.060)	(.078)	(.078)
City-Industry externalities:				
Specialization 1986	-0.006			-0.004
	(.013)			(.012)
Competition 1986		-0.003		-0.004
		(.007)		(.007)
Diversity 1986			-3.148*	-3.327*
			(1.487)	(1.558)
N	1055	1055	1055	1055

Note: Numbers in parentheses are standard errors.

*Significant at the 5 percent level.

Table 9

City-Industry Wage Growth and Externalities by MLE

City-Industry Wage Growth

	1976-1986		1986-1996	
Dependent Variable (Logs)	(1)	(2)	(3)	(4)
Intercept	3.888*	5.112*	5.540*	2.431*
	(.297)	(.247)	(.439)	(.286)
City-industry employment				
1976 (Log)	0.044*	0.040*	0.008	0.025*
	(.011)	(.020)	(.017)	(.011)
Wage in city-industry				
1976 (Log)	-0.964*	-1.062*	-1.026*	-0.329*
	(.060)	(.030)	(.066)	(.051)
Geographical dummies:				
North	0.127**	-0.040	0.235*	-0.074
	(.068)	(.099)	(.076)	(.069)
Central	0.219*	-0.118	-0.002	0.038
	(.071)	(.099)	(.077)	(.070)
South	0.176*	-0.074	0.016	0.050
	(.066)	(.101)	(.091)	(.074)
City-Industry externalities:				
Specialization 1976	-0.006	-0.012	-0.044*	-0.009
	(.014)	(.034)	(.022)	(.016)
Competition 1976	0.003	0.010	-0.001	0.011*
	(.010)	(.014)	(.010)	(.002)
Diversity 1976	-2.227*	-3.454**	-4.057*	3.946*
	(1.107)	(1.837)	(1.810)	(1.721)
N	739	258	790	265

Note: Numbers in parentheses are standard errors.

*Significant at the 5 percent level.

** Significant at the 10 percent level.

Regressions (1) and (3) use city-industries with a wage growth rate lower than the top 25%.

Regressions (2) and (4) use city-industries with a wage growth rate within the top 25%.

Appendix: Description and Sources of Variables

Population (City): This variable is the number of persons living within the political unit of the city, and comes from the Taiwan-Fukien Demographic Fact Book, Republic of China

Per capita income: This variable is obtained from the Report on the Survey of Personal Income Distribution in the Taiwan Area, Republic of China

Median years of schooling: From the Taiwan-Fukien Demographic Fact Book, Republic of China

Employment (City-industry): This is the number of people employed in the city-industry, and is obtained from the Report on the Industrial and Commercial Census, Taiwan-Fukien Area, Republic of China.

Wage (City-industry): This variable is obtained from the Report on the Industrial and Commercial Census, Taiwan-Fukien Area, Republic of China

Output (City-industry): This variable is obtained from the Report on the Industrial and Commercial Census, Taiwan-Fukien Area, the Republic of China

Regions in Taiwan:
Northern region: The major city in this region is Taipei, and most of the industries are concentrated in this region; especially service and high-tech industries. There are two airports (one international and one domestic) in this region.
Central region: The major city in this region is Taichung. The major industries are services and manufacturing.
Southern region: The major city in this region is Kaohsiung. The major industries are mining and manufacturing. The mining industry is most concentrated in this region.
Eastern region: The major city in this region is Hualien. The major industries are service industries, especially tourism. This is the least-developed region in Taiwan.

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