The Division of Labor and the Formation of Industrial Clusters in Taiwan

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Abstract

While the role of clusters in promoting industrial development has been increasingly recognized in the literature, the locational choice of industrial clusters and the underlying factors affecting such a choice have seldom been analyzed, particularly in the context of industrial development in developing countries. In this article we hypothesize that industrial clusters tend to be formed in suburban areas, where the division of labor among enterprises producing diverse products is intense. We obtained supportive evidence through regression analyses of changes in employment and value-added ratio using township-level census data of selected industries in Taiwan from 1976 to 1996.

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1. Introduction

Applying Adam Smith's idea that the division of labor is constrained by the extent of the market, Stigler (1951) hypothesizes that firms in a growing industry become increasingly specialized in limited tasks and engaged in inter-firm transaction of intermediate products. Extending the same idea, Romer (1990) explores the theoretical possibility that specialization, economic growth, and R&D investments constitute a virtuous cycle leading to sustained economic growth. Becker and Murphy (1992), however, do not agree, arguing that the major constraint on the division of labor among firms is high transaction costs due to communication breakdowns, principal-agent conflicts, and holdup problems. Thus, there is no consensus in the literature on what limits the division of labor, even though there is general agreement with Marshall (1920) that the division of labor is pronounced in industrial clusters.[1] We believe that these theoretical debates are worth careful empirical scrutiny in the context of economic development in East Asia, where the division of labor is pervasive.

In industrial clusters in East Asia, firms tend to specialize in a narrow range of production processes and are often linked by subcontracting systems (Amsden, 1985; Levy, 1991; Kawasaki and Macmillan, 1987; Whittaker, 1997; Yamamura, Sonobe, and Otsuka, 2003; Sonobe, Kawakami, and Otsuka, 2003). A particularly interesting finding was reported by Amsden (1977, 1985) from the Taiwan machine tool industry that the division of labor became active in a short period from 1974 to 1981, when the industry achieved high export-led growth. The growth of this industry in the late 1970s, however, was just a prelude to the higher growth in the subsequent period up to the late 1990s,

[1] Using data from the US manufacturing sector, Holmes (1999) presents empirical evidence for such a positive association between vertical disintegration and localization.

during which further development of the division of labor was not observed (Sonobe, Kawakami, and Otsuka, 2003). An important empirical question is whether the division of labor continues to play a role in the sustainable development of industries.[2]

This paper examines how industrial locations and the division of labor evolved in the five selected manufacturing industries in Taiwan from the mid-1970s to the mid-1990s. We argue that while new industries tend to be born in urban areas, where a variety of skilled workers, materials, and intermediate goods are available, industrial clusters tend to be formed in suburban areas, where the costs of land and labor are lower. This is particularly the case in the early stage of industrial development when simple and standardized products are manufactured. In order for an industry to develop further, it becomes increasingly important to improve the quality of products and increase agility in response to the increasing and changing demands for high-quality products (Humphrey and Schmitz 1996; Schmitz and Nadvi 1999). According to recent case studies of the evolutionary processes of industrial development in East Asia, the "quantity expansion" phase was followed by the "quality improvement" phase (Sonobe, Hu, and Otsuka 2002; Sonobe, Kawakami, and Otsuka, 2003; Yamamura, Sonobe, and Otsuka, 2003). In this later stage of industrial development, transaction costs will become an important constraint on the inter-firm transactions of parts, because those parts are often product specific and high-quality. We hypothesize that the extent of vertical integration increases in the later stage of industrial development, except in industrial clusters where the transaction costs associated with inter-firm transactions of high-quality parts and components are lower than in other areas due to the geographical proximity among

[2] While the division of labor has also been intense in Japan since the prewar era, its strength might not have increased since the high-growth period extending from the mid-1950s to the early 1970s in view of the decentralization of industrial locations (Mano and Otsuka, 2000).

industrial firms. These hypotheses are subject to empirical testing using township-level data by industry over the last few decades in Taiwan.

2. Development of Industries in Taiwan

Growth Performance of the Selected Industries

For this study, we obtained data on the production and employment of manufacturing establishments, aggregated up to the township-level, by industry for 1976, 1986, and 1996, from the Director-General of Budget, Accounting and Statistics, Executive Yuan, Taiwan.[3] A townships is an administrative unit below the county level (and county-level city) and above the village level. The areas under study are limited to the western part of Taiwan, which consists of the northern, central, and southern regions. The mountainous eastern part is excluded because it accounts for only 5% of the total manufacturing employment in Taiwan. From 1976 to 1996, there were several subdivisions and mergers of townships. After adjusting for these changes by adding subdivided townships for the periods after the subdivision and merged townships for the periods before the merger to obtain consistent data, we obtained the data of 275 "townships" for this study.

Until the mid-1980s, the manufacturing sector of the Taiwanese economy had enjoyed relatively favorable growth led by expanding export markets. Wages of unskilled workers, however, increased sharply in the late 1980s, and the currency appreciated abruptly against the US dollar in 1986 and 1987. The contribution of net exports to the economic growth rate declined from 50% in the mid-1980s to 20% in the

[3] In Taiwan, manufacturing firms with multiple establishments are exceptional. The number of establishments per firm was less than 1.05 during the periods under study.

mid-1990s, and exported products have become increasingly skilled-labor intensive since the mid-1980s (Chan, Chen, and Hu, 1999).

We chose five major manufacturing industries in Taiwan: apparel, plastic products, machines, electric appliances, and computer. The production processes of these industries can be subdivided into a number of sub-processes and the extent of vertical disintegration varies across firms, areas, and industries as well as over time. The five selected industries correspond roughly to the two-digit classification adopted in Taiwan's census data. To represent a new and growing industry, however, we selected the computer industry from the two-digit electric machinery industry. Moreover, the electric appliances industry does not include the sub-sector producing audio and visual equipments and parts, as the data of this sub-sector are not available for 1976. Likewise, the computer industry in 1976 is not included in our analysis because of the lack of data.

As Table 1 shows, these five industries had sharply contrasting growth records for the last few decades. The apparel industry is a declining industry: it accounted for nearly 12% of total manufacturing employment in 1976, but its share declined to less than 4% in 1996. Its extremely large negative growth rate of employment in the second period from 1986 to 1996 is accounted for mainly by the relocation of production base from Taiwan to Mainland China (Tu, 2000). The other industries except the machinery and computer industries were also increasingly affected by the competition with low-wage countries. The machinery industry lost employment share slightly in the first period, but it regained its employment share in the second period presumably because this industry succeeded in shifting from standardized and conventional machines to high-quality and often numerically controlled ones which the low-wage competitors could not produce (Sonobe, Kawakami, and Otsuka, 2003). In contrast, the computer industry grew rapidly in the second period.

Changing Division of Labor

Taiwan is known for the fine division of labor among assemblers and layers of parts suppliers and processors (e.g., Abe and kawakami, 1997; Amsden, 1985; Levy, 1991). Following Adelman (1955), Levy (1991), and Holmes (1999) among others, we measure vertical integration by value-added ratio, i.e., the ratio of value added to the value of production. This ratio tends to decrease as the number of establishments involved in the production processes increases. Note, however, that the value-added ratio is merely an imperfect measure of vertical integration, especially when it is used to examine its trends over time because it is affected by business cycle and changes in wage rates.

Keeping these reservations in mind, Table 2 examines changes in the value-added ratio every ten years from 1966 to 1996, which are taken from Directorate-General of Budget (various years). According to this table, the value-added ratio sharply declined from 1966 to 1976, which indicates that the division of labor became more common with an increase in the extent of the market. Compared with these steep declines in the early period, changes in the following decade from 1976 to 1986 were minor. In contrast, it is interesting to observe that the value-added ratios gradually increased in all the five selected industries from 1986 to 1996.[4] Such a reversal in the trend of value added ratio may indicate that the vertical integration became active in recent years as the transaction costs of parts and components increased with the improvement of their quality.[5]

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[4] Chen (1992) also observes that the value-added ratio of multinational enterprises in the electronics industry in Taiwan increased over time.

[5] In order to examine whether such changes in the value added ratio largely reflected changes in factor prices and business cycles, we computed correlation coefficients between the value-added ratio and the total employment size of industries at the township level separately in 1976, 1986, and

Changing Industrial Locations

In order to examine from where to where the spatial dispersion and concentration took place, Table 3 exhibits changes in employment shares in the urban, suburban, and rural areas in the total employment of each industry. The classification of the areas is based on the administrative classification as follows: (1) "urban" areas consist of the 44 wards of Taipei and Kaohsiung municipalities and Keelung, Taichung, and Tainan cities; (2) "suburban" areas consist of 104 townships which are either adjacent to the urban areas defined above or designated as (township-level) cities; and (3) "rural" areas consist of the remaining 127 townships. From this table, it is clear that the employment share of the suburban areas increased steadily throughout the two periods in every industry under study. In contrast, the share of the urban areas decreased in the first period in every industry, but it increased slightly in the second period in the apparel and electric appliances industries. On the other hand, the share of the rural areas increased in every industry in the first period but decreased in the second period in every industry except the machinery industry. The conclusion is that the suburban areas gained employment shares in all industries, suggesting that the center of manufacturing moved from the urban areas to somewhere in the suburban areas.

It is generally agreed in the literature that new industries are born in urban environments because of well-develpoed transportation and communication facilities and favorable access to new information, a variety of intermediate inputs, and skilled labor (e.g., Henderson, Kuncoro, and Turner, 1995). In the computer industry, however, the

1996. The correlation coefficients are all negative, ranging from -.24 to -.65, suggesting that the division of labor among firms is more developed in areas where an industry is geographically concentrated.

employment share of the urban areas was already low in 1986, even though the industry was new in Taiwan at that time. Computer technology was imported to Taiwan since the early 1980s, mainly by the direct investments of American manufacturers in the island. Also their placement of OEM orders to large-scale local electronics manufacturers and technological assistance spurred the diffusion of the new technology in Taiwan. These new movements took place mainly in the suburban areas between Taipei and Taoyuan, where the base of the electric and electronics industries had been established by the late 1970s (Chang, 1992; Kishimoto, 2003). Furthermore, the Industrial Technology Research Institute, which facilitated the international technology transfer to Taiwanese enterprises by providing training and scientific manpower, is located near Taoyuan. Thus, the employment share in the suburban areas in the computer industry was high from the beginning and continued to increase, which is consistent with our contention that the center of manufacturing is established in suburban areas.

If such a shift in the center of manufacturing occurred on a large scale, the size of manufacturing employment and its diversity ought to have increased in the suburban areas, in general, and suburban centers, in particular. The diversity is measured by an index similar to the ones used by Glaeser et al. (1992) and Henderson, Kuncoro, and Turner (1995). If a two digit industry j in township i employs E_{ij} persons, this measure of diversity for township i is given by

$$D_i = 1 - \Sigma_j \, (E_{ij}/\text{total manufacturing employment in township } i)^2 . \qquad (1)$$

According to Table 4, the urban areas had on average larger manufacturing employment per township and more diverse industrial structures than the suburban and rural areas in 1976. The suburban areas, however, surpassed the urban areas in average scale and diversity in 1986 and the difference in employment size widened in 1996. Furthermore, the employment size of the large suburban industrialized townships was significantly larger than that in the large urban industrialized townships already in 1976 and the gap widened thereafter. Moreover, the former had more diverse industrial structures than the latter. Thus, large industrial clusters with diverse conglomerates of industries emerged in the suburban areas, at least since the mid-1970s.

Differences in the Division of Labor

A major question is why industrial clusters were formed in suburban areas. While there can be many factors explaining such a phenomenon, the relatively low cost of inter-firm transactions of parts and components among enterprises located in the neighborhood is likely to be one of the important factors. Although urban areas are suited for the division of labor among enterprises, particularly for the production of new products with new designs, which often require new inputs and different types of skilled workers from other industries, high land prices and living costs are push factors from urban areas. Factor prices are lower in rural areas, but opportunities for inter-firm transactions are limited. It may well be that suburban areas have the advantages of relatively low factor prices and proximity to urban areas, where a variety of inputs and skilled labor are available.

Three important observations are made from the descriptive analysis of valued added ratio. First, the value-added ratio in urban areas was similar to that in suburban areas (i.e., the apparel, machinery, and electric appliances) or somewhat lower than in the latter (i.e., the plastic and computer industries). Such findings indicate that the division of labor was equally active in the urban and suburban areas or slightly more active in the urban than the suburban areas. Second, the value added ratio was, in general, consistently and substantially higher in rural areas than in other areas, suggesting that the division of labor was least active in rural areas. Third, the differences in the value added-ratio between the average of all townships and that of the five most industrialized townships were always positive and larger than .05 in 38 cases out of 41. The last finding suggests that the division of labor was more active in large industrialized townships than others.

3. Hypotheses

In order to form an industrial cluster in the rapidly growing stage of the industry, an urban metropolis is not necessarily an attractive location, as the costs of land and labor are generally high. In fact, major industrial clusters are generally formed in suburban areas not only in East Asia but also in other regions. Thus, it seems reasonable to postulate the following hypothesis:

Hypothesis 1: In a growing industry, industrial clusters tend to be formed in suburban areas.

We test the validity of this hypothesis by regressing the employment at the township level on the distance and distance squared from the major center in each of the three regions (i.e., Taipei, Taichung, and Tainang). If Hypothesis 1 is correct, the distance has a positive coefficient, whereas its squared term has a negative coefficient, when the industry grows. We also expect that the larger employment in the urban townships in the initial year would lead to less than proportional growth in employment in the later years, because of the "push" factors from congested urban areas.

A major "pull" factor attracting firms in suburban areas seems to be the opportunity to engage in the inter-firm transactions of parts and components. By measuring such advantages by the size of total industrial employment and its employment diversity, we propose the following hypothesis:

Hypothesis 2: The large size and diversity of industries attract the establishment of new enterprises and induce the employment expansion of the existing enterprises.

We test this hypothesis by estimating the employment function in each industry, in which the total size of industrial employment and the diversity are explanatory variables. We expect that the coefficients of these explanatory variables are positive.

Hypotheses 1 and 2 presume that the division of labor is more intense in clustered areas. As Becker and Murphy (1992) argue, however, the division of labor may be constrained by the transaction costs of parts and components among firms. Conflicts between suppliers and a user will become particularly serious when they try to shorten the production period from receiving an order to shipping a final product in order to respond to changing demands for products. It is important to emphasize that these attempts to improve quality and flexibility are likely to assume greater importance as an industry develops. Based on these arguments, we advance the following hypothesis:

Hypothesis 3: The division of labor is more active in larger industrial clusters with diverse industries than in non-clustered areas, particularly in later periods when the quality of products is improved.

We test this hypothesis by estimating the value-added ratio function in which the total size of industrial employment and the diversity are explanatory variables.

4. Regressions

Specification

In this section, we examine the relationship between changes in employment or value-added ratio and the locational characteristics of townships, as well as their past performance. Before the analysis, it should be noted that we do not intend to estimate the causal relationships between the two dependent variables. In fact, the instrumental variables necessary for disentangling the two-way causalities between them are scarcely available. Thus, we take a simple reduced-form approach which asks where local industries grew and where the division of labor became more pronounced. If local industries grew in townships where the size of total industrial employment was large and a variety of industries operated, it lends support to Hypothesis 2. If the division of labor is more pronounced in townships with larger and more diverse manufacturing sectors, particularly in the second period, it lends support to Hypothesis 3.

In this approach, the dependent variables are log employment size, $\ln E_{ij}$, and the value-added ratio V_{ij} in an industry j in township i. The independent variables include these variables ten years earlier, denoted by V_{-1ij} and $\ln E_{-1ij}$. Since we use the past dependent variables as explanatory variables, our analysis amounts to an identification of the factors affecting their changes, $V_{ij} - V_{-1ij}$ and $\ln E_{ij} - \ln E_{-1ij}$. We also used other independent variables to characterize townships. First, the scale and diversity of manufacturing in township i are represented by the log of total manufacturing employment, $\ln EM_{-1i}$, and the diversity index, D_{-1i}, in the past. Second, since the development of the same industry in the surrounding townships may strengthen the localization economies, we included the log of the average employment size of the industry per township in the neighborhood in the past, $\ln EA_{-1ij}$. Third, in order to control for unobservable fixed effects and to identify the advantages of the proximity to large cities, we used regional dummy variables, representing central and southern regions, and the road distance between township i and the center of the region it belongs to as well as its squared term.

In summary, we specify the employment and value-added ratio functions as follows:

$$\ln E_{ij} = \alpha_0 + \alpha_1 \ln EM_{-1i} + \alpha_2 D_{-1i} + \alpha_3 \ln EA_{-1ij} + \alpha_4 \ln E_{-1ij} + \alpha_5 V_{-1ij} + \alpha_6 Distance_i + \alpha_7 (Distance_i)^2 + \alpha_8 Central_i + \alpha_9 Southern_i + u_{ij}, \quad (2)$$

$$V_{ij} = \beta_0 + \beta_1 \ln EM_{-1i} + \beta_2 D_{-1i} + \beta_3 \ln EA_{-1ij} + \beta_4 \ln E_{-1ij} + \beta_5 V_{-1ij} + \beta_6 Distance_i + \beta_7 (Distance_i)^2 + \beta_8 Central_i + \beta_9 Southern_i + v_{ij}. \quad (3)$$

where $Distance_i$ is the logarithm of road distance between township i and the central city of its region, $Central_i$ and $Southern_i$ are dummy variables indicating the region of township i with the northern region being the default, subscript j refers to the j-th industry, and u_{ij} and v_{ij} are error terms. Since the effects of distance could be different in the three regions, we interacted the two distance variables with the three regional dummies in the final estimation. We estimate equations (2) and (3) for each of the two periods and the five industries separately.

Estimation Results

We report the OLS estimates of the employment function for the first and second periods in Tables 5 and 6, respectively. According to Table 5, the coefficients of the past dependent variable, i.e., own industry employment in 1976, are all positive but significantly less than unity, indicating that the employment in 1986 is greater but less than proportionally so in townships with greater own industry employment in 1976. In other words, employment growth, $\ln E - \ln E_{-1}$, is significantly slower where $\ln E_{-1}$ is greater, which strongly indicates the geographical dispersion of industries. It may well be that external economies arising from interaction with other firms in the same industry (i.e., localization economies) have limited impacts on the employment growth. This interpretation, however, has to be made with caution, as it may simply reflect "mean reversion." We also found positive effects of $\ln EA_{-1}$ on employment growth in the plastic products and machinery industries, suggesting that localization economies arising from the operation of firms in the same industry located in neighboring townships are at work in employment growth.

The elasticity estimates of $\ln E_{-1}$ became closer to unity if the other agglomeration variables ($\ln EM_{-1}$, D_{-1}, and $\ln EA_{-1}$) were excluded from the right-hand side of equation (2). This is because $\ln E_{-1}$ and these variables are correlated with each other. Despite such inter-correlation, the effects of other agglomeration variables on employment growth have been estimated to be positive and statistically significant in many cases. All the four coefficients of $\ln EM_{-1}$ are positive and significant, whereas two of the coefficients of D_{-1} are positive and significant. These results are consistent with Hypothesis 2 which insists that industry is attracted by external economies (or urbanization economies) emanating from the scale and diversity, as well as information spillovers and the availability of workers with desired skills and knowledge from other industries, even though we cannot deny the possibility that the industry is attracted by improved infrastructure and natural advantages reflected in large and diverse manufacturing sectors. All of these results are the same as the standard results obtained by the existing studies using US and Japanese data (e.g., Glaeser et al., 1992; Henderson, Kuncoro, and Turner, 1995; Ellison and Glaeser, 1997; Henderson, 1997; Mano and Otsuka, 2000).

An interesting finding from Table 5 is that the coefficients of the distance variable are positive except for one case and those of its squared term are all negative. Furthermore, a pair of the two distance variables are both significant in the four cases, which suggests that the suburban areas attracted employment in several regions. These finding are clearly consistent with Hypothesis 1.

Interestingly, the value-added ratio in the past has no significant effects in this table. Thus, the well-developed division of labor does not facilitate employment growth. The coefficients for the regional dummies suggest that employment tended to grow faster in the northern region.

In Table 6 which is concerned with the second period from 1986 to 1996, while the effects of lnEM_{-1} are again highly significant and their coefficients are comparable to those in Table 5, D_{-1} is no longer significant except in the electric appliance industry. In the computer industry, the effect of diversity on own industry growth is negative, although it is insignificant. This result is not peculiar to the computer industry in Taiwan, as Henderson (2003) finds that the effect of diversity on productivity is negative and insignificant in the US high-tech industries. The effect of lnEM_{-1} is particularly large in the computer industry, which was new and growing rapidly. These findings suggest that large industrial clusters tend to attract enterprises and stimulate the employment growth, which is consistent with Hypothesis 2, even though the effect of industrial diversity is not found to be significant. The elasticity of ln$E$ with respect to lnE_{-1} tends to be marginally greater in the second period than in the first period. These results are at least consistent with Henderson, Kuncoro, and Turner's (1995) finding that while urbanization economies tend to lose significance, localization economies tend to gain importance as an industry matures. However, the effect of $\ln E_{-1}$ is not significantly different from zero in the computer industry, which suggests that the location of enterprises tends to move from the original centers to other areas particularly when the industry grows fast.

The most important finding from Table 6 is that the distance variables tend to be insignificant except for the cases of the machinery and apparel industries. These results confirm our previous findings from Table 3 that the geographical spread of industry from urban to suburban and rural areas lost momentum in the second period. While the coefficients of the two distance variables have the expected signs in the case of the machinery industry, suggesting the formation of industrial clusters in suburban areas, they have unexpected signs in the case of the apparel industry. Employment in the machinery industry continued to grow in the second period (see Table 1) and, hence, the finding that clusters tends to be formed in suburban areas is supportive of Hypothesis 1. On the other hand, the apparel industry was the most rapidly declining industry, so that the estimation results indicate that employment was severely curtailed in formerly developed suburban areas.

Overall, the estimates of the employment function shown in Tables 5 and 6 conform to our expectations based on the descriptive tables in the previous section and the results of the existing studies on agglomeration economies.

The estimation results for the value-added ratio function are reported in Tables 7 and 8. Compared with Table 5, Table 7 has fewer significant estimates. In Table 7, changes in the value-added ratio, $V - V_{-1}$, are not significantly associated with those variables representing the urbanization and localization economies, such as lnEM_{-1}, D_{-1}, lnEA_{-1} and lnE_{-1}, many of which were significant in Table 5. Moreover, the variables measuring the distance from the regional centers do not have a significant effect with only one exception. These findings indicate that the growth of a local industry was not accompanied by an increase in the division of labor, suggesting that industrial clusters moved to suburban areas without significantly changing the structure of inter-firm transactions. This interpretation is consistent with the descriptive statistics shown in Table 6, which show the similarity of value-added ratios between the urban and suburban areas.

It is interesting to observe that the effect of V_{-1} on V is quite small in general and even insignificant in the case of the electric appliances industry in Table 7. Thus, given the levels of the other independent variables, V- V_{-1} tends to be positive if V_{-1} is low, and negative if V_{-1} is high. This implies that the value-added ratio tends to be equalized, which may not be surprising if products, production processes, and the use of intermediate inputs can be quickly imitated.

Table 8 looks very different from Table 7. A glance establishes that the scale and diversity of manufacturing have negative and significant effects on the value-added ratios in six cases. These results support Hypothesis 3 that the division of labor remains brisk in large and diverse clusters, whereas vertical integration tends to occur in other areas, as evidenced by the higher value added ratio in non-clustered areas. The effects of V_{-1} on V are generally stronger in terms of magnitude and significance in Table 8 than in Table 7. Thus, the distribution of value-added ratios in the cross section of townships is more persistent in the second period than in the first period. From the viewpoint of the transaction cost approach, the increased persistence seems to reflect the tendency that the long-term and stable relationship between transacting firms became important in keeping transaction costs low in the qualitative upgrading stage. In Table 8, no other consistent tendency is discernible from the estimation results.

5. Concluding Remarks

It is widely acknowledged that Taiwan has been the most successful among the East Asian countries in achieving decentralized industrial development (Ho, 1979; Skoggard, 1996, p. 53). This does not imply that agglomeration economies have not been at work in Taiwan. On the contrary, our analysis strongly indicates that the decentralization accompanied the formation of industrial clusters in suburban areas, in which the intensive division of labor among small firms is carried out.

According to our observations, the production system based on the division of labor had been formed in many industries before the mid-1970s, when low-quality, standardized products were produced. This process was followed by a decade of growth period without deepening the division of labor and with the sprawl of industrial locations from urban to suburban areas. As Taiwan gradually lost the comparative advantage of labor-intensive, low-tech, and standardized products, Taiwanese manufacturers began upgrading the quality of their products and inputs. Since the mid-1980s, vertically integrated production has become pervasive in many industries, because the transaction costs of inter-firm transactions would have increased, as argued by Becker and Murphy (1992). Exceptions, however, are found in large and diverse clusters formed in the suburban areas, where the division of labor is sustained.

We believe that such evolutionary changes in the location of enterprises and the division of labor among them should be regarded as an integral part of the process of industrial development, as the efficiency of industrial production is likely to require changing industrial locations and production organization over time. We argue that the industrial cluster is formed in suburban areas in order to save the transaction costs of standardized and low-quality intermediate inputs. We also conjecture that the division of labor in the industrial cluster remains advantageous in the quality improvement stage because innovative enterprises introduce new products and production processes using inputs and manpower from various sources including other industries within a cluster. While the findings of this study suggest such evolutionary changes in the roles of industrial clusters, our analysis is admittedly crude and based exclusively on the case of Taiwan. In order to substantiate the evolutionary view of industrial development in developing economies, a compilation of similar studies in other economies, complemented by in-depth case studies, is called for.

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Table 1. Shares of Manufacturing Employment and Annual Growth Rates of Employment by Industry

	Apparel	Plastic products	Machinery	Electric appliances	Computer
Share (%)					
1976	11.7	9.1	4.8	1.3	n.a.
1986	9.1	11.6	4.5	1.4	1.2
1996	3.9	7.5	7.9	1.4	4.2
Annual growth rate (%)					
1976 – 86	1.1	6.1	2.9	3.9	n.a.
1986 – 96	-9.2	-5.1	4.9	-0.1	11.3

Note: Authors' calculation based on the employment data for the areas under study.

Table 2. Changes in Value-Added Ratio by Industry

	Apparel	Plastic products	Machinery	Electric appliances	Computer
1966	0.33	0.32	0.38	0.33	na
1976	0.22	0.22	0.29	0.28	na
1986	0.28	0.26	0.28	0.24	(0.14)
1996	0.33	0.32	0.32	0.27	(0.17)

Notes: Except for the computer industry, the data source is the Directorate-General of Budget, Accounting and Statistics, Executive Yuan (various years). The industrial classification of the census is slightly different from year to year. For the computer industry, the value-added ratios are calculated from our data set.

Table 3. Changes in Employment Shares by Area and Industry (%)

	Apparel	Plastic products	Machinery	Electric appliances	Computer
Urban areas					
1976	30.9	24.8	42.4	30.3	n.a.
1986	27.7	16.6	26.7	20.9	25.8
1996	29.0	15.9	20.9	22.0	25.2
Suburban areas					
1976	53.8	54.3	51.5	61.1	n.a.
1986	56.3	56.9	63.0	68.8	62.2
1996	57.6	65.1	65.1	70.7	69.4
Rural areas					
1976	15.3	21.0	6.1	8.5	n.a.
1986	16.0	26.6	10.3	10.2	11.9
1996	13.4	19.0	14.0	7.2	5.4

Notes: Authors' calculation. For each year, Urban + Suburban + Rural = 100 %.

Table 4. Average Total Industrial Employment and Industrial Diversity of Townships and Those of the Five Townships with the Largest Employment by Area

	Employment (1,000 persons)					
	Urban areas		Suburban areas		Rural areas	
	Mean of all urban townships	Mean of largest 5 townships	Mean of all suburban townships	Mean of largest 5 townships	Mean of all rural townships	Mean of largest 5 townships
1976	12.2	37.0	9.9	50.9	2.0	11.8
1986	13.6	40.1	15.2	68.0	3.5	18.0
1996	11.0	34.1	14.6	64.8	3.2	16.1

	Diversity					
	Urban areas		Suburban areas		Rural areas	
	Mean of all urban townships	Mean of largest 5 townships	Mean of all suburban townships	Mean of largest 5 townships	Mean of all rural townships	Mean of largest 5 townships
1976	0.81	0.85	0.75	0.86	0.65	0.81
1986	0.80	0.78	0.81	0.87	0.73	0.84
1996	0.81	0.78	0.81	0.82	0.74	0.86

Notes: Authors' calculation. The diversity index is defined in equation (1).

Table 5. Regressions of Employment on Township Characteristics by Industry, 1976-86

	Apparel	Plastic products	Machinery	Electric appliances
	(1)	(2)	(3)	(4)
$\ln EM_{-1}$	0.344**	0.341**	0.532**	0.414*
	(3.14)	(4.21)	(4.56)	(2.03)
D_{-1}	1.478*	2.417**	1.100	-0.053
	(2.10)	(4.20)	(1.40)	(-0.02)
$\ln EA_{-1}$	0.031	0.348**	0.178**	-0.157
	(0.41)	(4.34)	(2.93)	(-1.09)
$\ln E_{-1}$	0.373**	0.323**	0.309**	0.441**
	(5.49)	(4.14)	(4.14)	(4.13)
V_{-1}	-0.397	-0.690	-0.721	1.642
	(-0.54)	(-0.74)	(-1.08)	(1.22)
Distance(North)	-0.091	0.551*	0.307	0.879
	(-0.40)	(2.05)	(0.98)	(0.93)
Distance(North)^2	-0.011	-0.054	-0.036	-0.114
	(-0.21)	(-1.04)	(-0.61)	(-0.52)
Distance(Central)	0.114	0.781	1.405**	4.858**
	(0.27)	(1.44)	(2.74)	(3.00)
Distance(Central)^2	-0.009	-0.062	-0.326**	-1.124**
	(-0.09)	(-0.57)	(-2.62)	(-3.46)
Distance(South)	1.050*	1.549**	1.380**	3.805
	(1.67)	(3.40)	(3.56)	(1.46)
Distance(South)^2	-0.120	-0.183**	-0.222**	-0.656
	(-1.26)	(2.54)	(3.42)	(-1.31)
Central region	-0.934*	-0.156	-0.361	-3.300
	(-2.11)	(-0.23)	(-0.59)	(-1.62)
Southern region	-2.561**	-1.662*	-1.281*	-3.843
	(-2.56)	(-2.19)	(-1.92)	(-1.34)
Intercept	0.323	-3.444**	-2.773*	-1.417
	(0.36)	(-3.54)	(-2.26)	(-0.45)
Number of observations	185	212	167	57
Adjusted R^2	0.61	0.70	0.74	0.40
Peak/Bottom in North				
Peak/Bottom in Central			Peak 8.6	Peak 8.7
Peak/Bottom in South		Peak 69.0	Peak 22.3	

Notes: Dependent variable is $\ln E$ in 1986. The explanatory variables take the values as of 1976. The *t*-statistics based on White standard errors are reported in parentheses. * and ** indicate significance at the 5 and 1 percent levels, respectively (one-sided tests).

Table 6. Regressions of Employment on Township Characteristics by Industry, 1986-96

	Apparel	Plastic Products	Machinery	Electric appliances	Computer
	(1)	(2)	(3)	(4)	(5)
lnEM_{-1}	0.348**	0.459**	0.559**	0.451**	0.744**
	(3.83)	(3.58)	(5.68)	(2.36)	(3.11)
D_{-1}	0.454	0.896	1.152	3.040*	-3.324
	(0.51)	(1.44)	(1.54)	(1.79)	(-1.12)
lnEA_{-1}	0.156	0.647**	0.113*	0.116	0.132
	(1.47)	(4.16)	(1.96)	(1.21)	(0.46)
lnE_{-1}	0.461**	0.349**	0.341**	0.460**	0.376
	(5.43)	(4.35)	(4.94)	(4.27)	(1.55)
V_{-1}	-0.178	-1.619*	-0.215	-0.282	-0.484
	(-0.36)	(-1.97)	(-0.40)	(-0.39)	(-0.36)
Distance(North)	-0.777**	-0.196	0.093	0.184	0.039
	(-4.00)	(-0.70)	(0.35)	(0.29)	(0.07)
Distance(North)^2	0.120**	0.027	-0.020	-0.079	0.007
	(3.07)	(0.49)	(-0.41)	(-0.69)	(0.06)
Distance(Central)	0.598	0.699	1.186**	0.009	5.079
	(1.21)	(1.11)	(3.08)	(0.01)	(0.44)
Distance(Central)^2	-0.087	-0.100	-0.247**	-0.011	-1.235
	(-0.79)	(-0.84)	(-2.76)	(-0.03)	(-0.41)
Distance(South)	-0.521	0.469	0.711*	-0.556	2.410
	(1.40)	(1.06)	(2.00)	(-0.51)	(1.06)
Distance(South)^2	0.121*	-0.065	-0.117*	0.064	-0.496
	(1.87)	(-0.91)	(-1.94)	(0.32)	(-1.08)
Central region	-2.046**	-1.324	0.856	-0.019	-5.941
	(-3.58)	(-1.63)	(-1.52)	(-0.01)	(-0.60)
Southern region	-1.027*	-0.797	-0.826	0.923	-2.947
	(-1.68)	(-1.34)	(-1.40)	(0.66)	(-1.10)
Intercept	-1.023	-2.898**	-2.499*	-4.748*	-0.645
	(-0.92)	(-2.56)	(-1.96)	(-1.92)	(-0.19)
Number of observations	216	220	201	108	48
Adjusted R^2	0.61	0.73	0.80	0.54	0.58
Peak/Bottom in North	Bottom 25.3				
Peak/Bottom in Central			Peak 11.0		
Peak/Bottom in South	Bottom 8.6		Peak 20.8		

Notes: Dependent variable is ln$E$ in 1996. The explanatory variables take the values as of 1986. The *t*-statistics based on White standard errors are reported in parentheses. * and ** indicate significance at the 5 and 1 percent levels, respectively (one-sided tests).

Table 7. Regressions of Value-Added Ratio on Township Characteristics, 1976-86

	Apparel	Plastic products	Machinery	Electric appliances
	(1)	(2)	(3)	(4)
lnEM_{-1}	-0.031	0.011	-0.004	0.011
	(-1.61)	(1.07)	(-0.26)	(0.22)
D_{-1}	-0.173	-0.054	-0.053	-0.327
	(-1.08)	(-0.63)	(-0.49)	(-0.55)
lnEA_{-1}	-0.009	-0.016	-0.010	-0.018
	(-0.53)	(-1.21)	(-1.08)	(-0.77)
lnE_{-1}	-0.018	-0.017*	-0.008	-0.009
	(-1.49)	(-2.08)	(-0.88)	(-0.69)
V_{-1}	0.289*	0.131*	0.142*	0.085
	(2.22)	(1.91)	(1.73)	(0.37)
Distance(North)	0.040	-0.010	0.005	0.003
	(0.93)	(-0.37)	(0.18)	(0.02)
Distance(North)^2	-0.003	0.003	-0.001	-0.0005
	(-0.30)	(0.54)	(-0.22)	(-0.02)
Distance(Central)	-0.013	0.056*	0.009	-0.375
	(-0.17)	(1.89)	(0.10)	(1.49)
Distance(Central)^2	0.005	-0.012	0.002	0.086
	(0.26)	(1.65)	(0.12)	(1.62)
Distance(South)	0.083	-0.055	-0.075	-0.139
	(1.05)	(-0.92)	(-1.33)	(-0.51)
Distance(South)^2	-0.012	0.006	0.012	0.030
	(-0.89)	(0.61)	(1.22)	(0.54)
Central region	-0.010	-0.030	-0.066	0.293
	(-0.12)	(-0.75)	(-0.77)	(1.00)
Southern region	-0.080	0.094	0.058	0.008
	(-0.69)	(1.19)	(0.78)	(0.03)
Intercept	0.820**	0.392**	0.451**	0.567
	(3.58)	(3.50)	(3.68)	(1.16)
Number of observations	184	211	166	55
Adjusted R^2	0.26	0.11	0.11	0.10

Notes: Dependent variable is V in 1986. The explanatory variables take the values as of 1976. The t-statistics based on White standard errors are reported in parentheses. * and ** indicate significance at the 5 and 1 percent levels, respectively (one-sided tests).

Table 8. Regressions of Value-Added Ratio on Township Characteristics, 1976-86

	Apparel	Plastic Products	Machinery	Electric appliances	Computer
	(1)	(2)	(3)	(4)	(5)
$\ln EM_{-1}$	-0.031**	-0.025*	-0.062**	0.002	-0.022
	(-2.53)	(-2.17)	(-4.47)	(0.06)	(-0.64)
D_{-1}	-0.232**	-0.108	-0.144*	-0.478*	0.462
	(-2.44)	(-1.58)	(-2.06)	(-2.13)	(1.48)
$\ln EA_{-1}$	-0.021	-0.0004	-0.011	-0.009	-0.013
	(-1.64)	(-0.05)	(-1.49)	(-0.78)	(-0.25)
$\ln E_{-1}$	-0.003	0.005	0.016*	-0.023*	-0.032
	(-0.45)	(0.61)	(1.75)	(-2.04)	(-1.07)
V_{-1}	0.119*	0.204**	0.277**	0.177**	-0.063
	(1.76)	(2.88)	(3.69)	(2.36)	(-0.33)
Distance(North)	-0.013	0.006	0.032	-0.084	-0.061
	(0.46)	(0.27)	(-1.22)	(-1.55)	(-0.79)
Distance(North)^2	0.006	0.001	-0.007	0.015	0.016
	(0.99)	(0.36)	(-1.24)	(1.19)	(0.96)
Distance(Central)	0.064	0.076	0.065	-0.087	0.141
	(0.96)	(-1.08)	(1.57)	(-0.46)	(0.10)
Distance(Central)^2	-0.011	-0.017	-0.013	0.012	-0.071
	(-0.79)	(-1.26)	(-1.37)	(0.32)	(-0.19)
Distance(South)	0.093*	-0.074	-0.059	-0.046	0.137
	(1.99)	(-1.35)	(-1.43)	(-0.45)	(0.36)
Distance(South)^2	-0.012	0.013	0.006	0.010	-0.040
	(-1.46)	(1.46)	(0.91)	(0.57)	(-0.50)
Central region	-0.122	-0.023	-0.081	0.010	-0.058
	(-1.36)	(-0.25)	(-1.64)	(0.05)	(-0.05)
Southern region	-0.123	0.138	0.102	-0.073	0.005
	(-1.65)	(1.64)	(1.64)	(-0.50)	(0.01)
Intercept	0.966**	0.498**	0.932**	0.933**	0.396
	(6.68)	(4.59)	(7.13)	(3.14)	(1.08)
Number of observations	216	220	201	105	48
Adjusted R^2	0.35	0.24	0.35	0.18	0.08

Notes: Dependent variable is V in 1996. The explanatory variables take the values as of 1986. The t-statistics based on White standard errors are reported in parentheses. * and ** indicate significance at the 5 and 1 percent levels, respectively (one-sided tests).