TECHNOPOLIS AND REGIONAL DEVELOPMENT IN JAPAN: A STATISTICAL ANALYSIS

Aung KYAW

Abstract This paper examines the impact of the Technopolis Plan in Japan through an analysis of inter-Technopolis area development. It is found that, although industrial indicators show that the Technopolis as a whole has a higher development rate than the rest of Japan, this is because some Technopolis areas have competitive advantages due to their low production costs. Their development pattern also reveals that this development is natural rather than due to the impact of the Technopolis Plan, since there is no definite assistance from the National Government. This paper examines the issue of economic development only from the short term point of view (*gaihatsu-gata*); the impact of longer term economic development (*naihatsu-gata*), based on technological innovations, is left for future discussion.

Key words: Technopolis, high-tech industries, regional development, discriminant analysis

1. Introduction

With the changing economic and industrial production environment, all industrialized regions and nations have developed their own industrial policy, one way or another, to sustain their competitiveness, and to adjust to changes in the balance of their internal economic development. Some of these policies have been successful, but others have not. The Japanese Technopolis Plan has aimed both to promote its competitive power in world markets through technological innovation and to adjust Japan's internal socio-economic balance by relocating innovative industries to the remoter areas of Japan. In this paper, we will discuss the impact of the Technopolis Plan, through a comparative analysis of the industrial development of Technopolis areas in Japan. The next section of the paper reviews the background of industrial regional policy in Japan, and the third section is concerned with a comparative analysis of the development of Technopolis areas. Based on the results of section three, the final section will emphasize the context of Technopolis and make clear the actual impact of Technopolis Plan.

2. Background and strategies of Technopolis

Since the mid-1970s, the emphasis of Japanese industrial policy has shifted towards technological innovation, because of the remarkable success of Japan's industrial sector. In 1971, the Ministry of International Trade and Industry (MITI) has proposed a knowledge intensive industrial structure which has less environmental impact (Abe 1998). After the oil shocks of the 1970s, the heavy chemical industry suffered a crisis and new plant formation in this sector dramatically decreased. On the other hand, new plant formation in high-tech industries, particularly IC and its related industries, increased in the northern Kyushu and Kanto regions, along with the technological and micro-electronic revolution (Takeuchi 1996; Yamazaki 1997). Japanese industrial policy changed in accordance with this situation, and became focused on high-tech industries (Yamazaki 1997). The high-tech industries related regional development policies have been realized by the Technopolis Plan in 1983. In accordance with the Technopolis Plan, 26 areas were designated between 1984 and 1989. From the late 1980s to early 1990s, regional policies related to the development of information technology, the promotion of location of management, and the promotion of R & D functions in the remoter areas like Techno-mart and Brain Location Plans, were implemented (Itoh 1998).

Technopolis is a new type of urban development in which industries, academia, and high-class residential area are to be harmonized. In addition, high-tech industries, expected to play a central role in the plan, and also new high-tech industrial complexes, were encouraged to locate in the Technopolis area through an attraction and incubation approach. As a consequence, not only hard-infrastructure, like industrial sites and industrial water supplies, but also soft-infrastructure like research and development functions, work-training facilities and information distribution functions were developed (Itoh 1998). In other words, Technopolis Plan aimed to provide, not only the production center of high-tech industries, but also an innovative center of self-motivation. Both functions were intended to develop in two ways: firstly through relocation of high-tech industries from congested metropolitan areas (*gaihatsu-gata*), and secondly through the promotion of self-motivation systems from local industries (*naihatsu-gata*) (Castells and Hall 1994).

To realize the Technopolis development plan, a "Technopolis Development Organization (TDO)" was formed in each Technopolis area as the principal organization for advancing the construction of the Technopolis. To attract the high-tech industries, construction of new industrial estates and research parks is carried out as hard-infrastructure by the local government. To incubate local industries, loan guarantees for research development, financial assistance to the industry-university research cooperation and assistance to develop new technology, are provided by each TDO. In addition, some Technopolis areas attract private research facilities into the "Research Park", and provide for the formation of "Prefectural Industrial Technology Centers" at the prefectural level. Also, "Research Cooperation Centers" are formed at the national university in some Technopolis areas in accordance with laws passed to enable further technological development (Itoh *et al.* 1995).

3. Analysis of impacts on regional development

Each Technopolis area has been set targets regarding four industrial indicators including manufacturing workers (MWR), manufacturing goods shipment (MGS), manufacturing value-added (MVA), and manufacturing productivity (MPY); and also population targets for each 5 — year planning period. Most of the previous studies related to the development of Technopolis areas used the achievement of their targets as the main comparative factors (see Japan Industrial Location Center 1997; Tanaka 1996; Yamazaki 1995). It is reasonable to use such data for analysis, since the targets were determined in accordance with the situation of each Technopolis area. All these studies, however, used 1980 as a start year for each Technopolis area, to evaluate the achievement of set goals. Actually, designation of Technopolis status began in 1984 and ended in 1989. Some prefectural governments had been making efforts to construct Technopolis-type industrial development areas before attaining official Technopolis status. However, development officers, and also institutions like TPO, came to realize this only after their official designation. It is difficult, therefore, to distinguish effects that occurred specifically because of Technopolis designation from those that stemmed from these pre-Technopolis actions by the prefectural governments for valid inter-Technopolis comparisons. In addition, as some studies have pointed out, the initial targets set for some of the Technopolis areas were unrealistically high; industries in these Technopolis areas were unlikely to achieve these figures (Tanaka 1996). The two points mentioned above create problems regarding the comparative analysis of actual inter-Technopolis development. This paper, therefore, will use the actual trends of the manufacturing indicators, rather than goal achievement, to examine the impact of the Technopolis Plan. The population indicator is, however, excluded from the analysis since population growth is related to many other factors besides manufacturing.

Figure 1 shows the trends of four manufacturing indicators of Technopolis, Technopolis' prefecture (the data of Technopolis' prefecture but excluding Technopolis itself), and Japan. Although the trend of each indicator is very similar, Technopolis areas themselves have generally higher trends than other two regions, from the beginning of 1984 — 1985. Since each Technopolis generally occupies the most industrialized areas of its prefecture, the indicators of each Technopolis seem to be higher than those of the prefecture generally. In addition, indicators of Japan as a whole include both its most industrialized areas (the three large metropolitan areas) and its least industrialized areas, the remote periphery. This results in an apparently lower development rate for Japan than for the Technopolis. The gaps among three regions, however, have increased since 1990 and Technopolis shows the highest level of industrial development. It can be concluded that Technopolis as a whole has showed a higher development rate in manufacturing indicators. However, the pattern of these indicators is probably different among various Technopolis areas; some Technopolis areas with favorable situations for high-tech development have advanced more than other Technopolis areas. Therefore, the next section will examine the trends of Technopolis areas, and the principal factors influencing these trends.

Manufacturing data used in this analysis were calculated from *Manufacturing Census of Japan (City, Town and Village)*. The sources of other social indicators are shown in

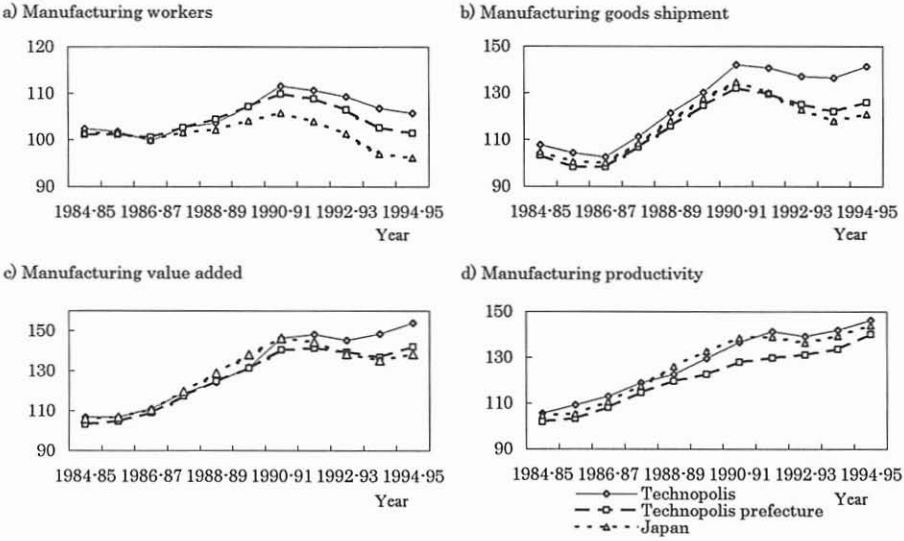

Fig. 1 Percentage change (in 1980=100) of manufacturing indicators of Japan, Technopolis prefecture (excluding Technopolis itself) and Technopolis. Source: Manufacturing Census of Japan.

Appendix I. Each Technopolis area has four indicators (MWR, MGS, MVA, and MPY) to evaluate its development. In addition, there is the length of time each Technopolis area has existed up till 1995 to be considered. The first step is to generalize this time span of Technopolis status up till 1995. In this step, the trend of manufacturing indicators for each Technopolis was represented by four indices. These indices are the average and standard deviation of annual development rate from starting year to 1995, the slope value of the regression line from start of Technopolis status up till 1995, and net growth from start till 1995 (1995 data/starting year data). Secondly, we can calculate 16 indices (4 indices for 4 indicators) to represent the development of each Technopolis area. Thirdly, cluster analysis was conducted in order to identify the development type of each Technopolis, and to group similar Technopolis areas based on the above mentioned 16 indices.

Three clusters can be identified from the analysis: the first cluster includes six Technopolis areas; the second and third clusters include seven and thirteen Technopolis areas, respectively. The characteristics of each cluster are shown in Fig. 2. It is clear that the first cluster has the highest development trend in four indicators. Although both the second and third clusters show stagnant development trends, the former has higher indicators regarding manufacturing productivity than the latter. The second cluster also indicates a decrease in manufacturing workers and manufacturing good shipment.

The spatial distribution of the clusters is shown in Fig. 3. Cluster 1 is generally distributed in the Kyushu and Tohoku areas. Cluster 2 is generally distributed around Tokyo and Osaka; it seems that the manufacturing activities with high productivity rate can only survive in the production environment of relatively high land prices and other living costs. Cluster 3 is generally located in the distant periphery from the large metropolitan areas.

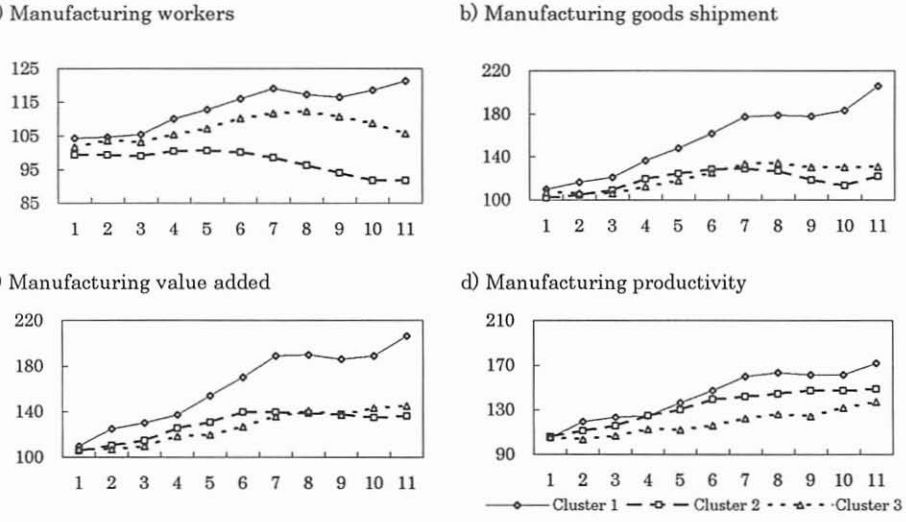

Fig. 2 Average values of manufacturing indicators of each cluster. Source: Manufacturing Census of Japan. Note: Horizontal axis indicates time span from the year of achieving technopolis status to 1995 and Vertical axis the percentage change.

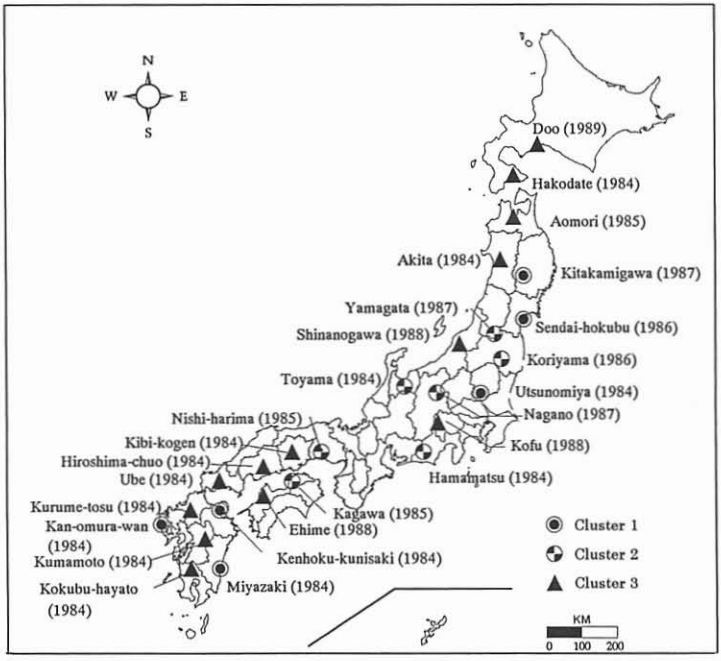

Fig. 3 Distribution of Technopolis Clusters. Number in the parenthesis is year of Technopolis establishment.

This periphery includes northern Tohoku, Hokkaido, some parts of Kyushu and western Honshu. It can be said that the Technopolis areas included in the "Pacific Industrial Belt" also belong to this group, with some exceptions like Hamamatsu Technopolis, which is located between Tokyo and Nagoya, and Nishiharima Technopolis with its proximity to the Osaka-Kobe area.

The characteristics and distribution of Technopolis clusters can be explained, to some extent, by the concept of the "Product Life Cycle Theory" (Vernon 1966). According to this theory, newly developed products, which are untested in the marketplace, are generally first introduced in large urban areas. When product enters the commercialized production stage, it needs a low cost production base, and manufacturing of it moves to the periphery. In the case of Japan, Tokyo, Osaka and its adjacent areas seem to be the venue for the initial testing stage of products and quality-oriented goods. As a consequence, manufacturing productivity per person there is higher than in the peripheral areas. On the other hand, the number of manufacturing workers generally decreases in large urban areas since highly skilled technicians are needed here, and there is competition from the third, or services, sector (Cluster 2). The development of the semi-periphery (Cluster 1) seems to benefit from its relative intermediate location. In other words, good transportation and relatively low production costs, compared to the areas of Cluster 2, are probably the principal factors of development. On the other hand, Cluster 3 includes both types of industrialized areas, especially in the "Pacific Industrial Belt", and remote areas. The former areas have low development trends for losing competitive advantage due to high production cost brought by industrialization; and the low development trends of the latter areas are ascribed to the problems of these areas due to their remoteness.

To find the factors contributing to classify each cluster, a discriminant analysis was conducted. In this analysis, each cluster becomes the group and various social indicators shown in Appendix I become discriminant variables. These discriminant variables are generally derived from the factors considered in the designation of Technopolis areas, and in previous studies (Sternberg 1995; Japan Industrial Location Center 1997). Since the starting time of each Technopolis area varies from 1984 to 1989, it is difficult to determine the base time that is to be used for discriminant variables. It is, therefore, better to used two time points (1990 and 1995) as a base time and the final results will be considered on the effective contributing variables from these two time points.

The results of discriminant analysis for 1990 and 1995 are shown in Tables 1 and 2, respectively. Percentages correctly classified in both time points are more than 80 percent. Based on the standardized coefficients of Functions 1 and 2, and average values of effective contributing variables, the degree of discrimination between clusters could be interpreted.

Table 1 Results of stepwise discriminant analysis (1990). F-value to enter a significant variable is 2.0 and F-value to remove an insignificant variable 1.9.

Independent variable	Standardized coefficient		Average value		
	Function 1	Function 2	Cluster 1	Cluster 2	Cluster 3
DMET	0.985	0.292	64	27	52
SHTT	−0.145	0.968	35	31	21
MTDT	0.987	0.103	362	202	380
Percentage of correctly classified	80.77%				

In the case of 1990 indicated in Table 1, the existing industrial agglomeration of each Technopolis in the previous year of Technopolis designation (DMET) and the minimum traveling-time from Tokyo to each "Mother City" by railway (including *Shinkansen*) (MTDT) are the most effective discriminant variables of three clusters in Function 1. Clusters 1 and 3 have larger average values in these two variables than Cluster 2, which sets apart the former two clusters from the latter. In Function 2, the share of high-tech industry in all newly located plants in the area between the year of Technopolis designation and 1990 (SHTT) in each Technopolis is an effective variable in discrimination. SHTT is calculated by dividing the total area of high-tech industrial landuse occupied during the period between the started year of each Technopolis and 1990 or 1995, by the total area of land occupied by all industries in the same period. Clusters 1 and 2 with larger average value of this contributing variable are distinguished from Cluster 3 with its smaller average value.

Distance from Tokyo (MTDT) and existing industrial agglomeration before Technopolis designation (DMET) are also effective variables of Function 1 in the case of 1995 (Table 2). In addition to these two variables, the basic salary of a high-school graduate as a manufacturing worker in each Technopolis' prefecture (BSTP) and the average industrial land price of each Technopolis (ILPT) also contribute to discriminate the clusters in Function 1. These four variables set apart clusters 1 and 3 from cluster 2. Clusters 1 and 3 have larger average value in the former two variables (MTDT and DMET) than Cluster 2; the average values of latter two variables related to production cost (BSTP and ILPT) of Clusters 1 and 3 are smaller than Cluster 2. In Function 2, the share of high-tech industry in all newly located plants during the year of Technopolis designation and 1995 (SHTT) is a principal discriminator of the clusters. The average values of this variable in Clusters 1 and 2 are larger than Cluster 3, which distinguishes the former two clusters from the latter.

From the results of discriminant analysis, it can be said that the development of Cluster 1 was supported by location of high-tech industries, and by relatively low production costs. Cluster 2, with its proximity to large urban areas, is very low in industrial agglomeration and has high production costs compared to the other two clusters. On the other hand, Cluster 3 is generally located far away from Tokyo and comparatively small number of high-tech plants located there. Since Cluster 3 includes both industrialized areas and remoter areas (see Fig. 3), it has higher industrial agglomeration than Cluster 2 and higher land price and labor costs than Cluster 1.

Table 2 Results of stepwise discriminant analysis (1995). F-value to enter a significant variable is 2.0 and F-value to remove an insignificant variable 1.9.

Independent variable	Standardized coefficient		Average value		
	Function 1	Function 2	Cluster 1	Cluster 2	Cluster 3
DMET	1.244	−0.024	64	27	52
SHTT	0.132	−0.86	31	25	18
MTDT	1.352	0.407	362	202	380
BSTP	0.895	0.612	138	146	141
ILPT	−0.835	0.357	77,817	130,682	88,945
Percentage of correctly classified	80.77%				

4. Discussion and conclusion

The results of cluster analysis and discriminant analysis show that the impact of Technopolis designation has less effect than might be expected regarding industrial development. In this section, therefore, we will look back to the context of the Technopolis plan and discuss its impact. In particular, we will emphasize two points, the changing industrial environment and the inherent weakness of the plan.

As Yamazaki (1997) has pointed out, the nature of high-tech industries and their locational requirements, and the economic situation of some local/peripheral areas, induced regional planners to produce the Technopolis schemes. However, the production environment has drastically changed since 1980s. As many studies (Itoh *et al.* 1995; Takeuchi 1996) have pointed out, the appreciation of the Yen as a consequence of the "Plaza Accord" in 1985 has had a great impact on Japanese firms, and overseas relocation of production functions by these firms has increased. This is the one of the main reasons for the failure of the Technopolis Plan. It is true that, without new firm formation, the economic development of remote areas is difficult, and that new plant location and the increase in industrial indicators are directly related. If one goes further, however, the reason for new firm formation is not solely a result of the appreciation of the Yen and the consequent overseas relocation of some industries. As pointed out earlier, Technopolis as a whole has a higher development rate than its local prefectures, and the rest of Japan. Some Technopolises have a higher development rate than others: some like Kitakamigawa and Miyazaki Technopolises included in Cluster 1 have relatively high development rates while Technopolises like Kibikogen and Akita have lower rates of development. What is the main cause of such uneven development?

According to Yamazaki (1995), relatively developed Technopolis areas like Miyazaki and Kitakamikawa have industrialized relatively recently, and have low production costs as their main competitive advantage. The high development rate of Utsunomiya Technopolis is a result of extension of the Tokyo-Yokohama (*Keihin*) industrial belt. Actually, new plants are seeking out low-production cost sites, rather than looking for the availability of public research institutions and technicians. The results of discriminant analysis substantiate this point. In general, of all the Technopolis areas, some with favorable conditions have developed but others have not.

All results mentioned above are linked to the nature of Technopolis Law. According to the "*Technopolis 90 Report*" issued in 1980, the initial stage of the plan aimed to construct only one symbolic project supported by the National Government. However, due to the movement of "Technopolis fever" MITI intended to offer Technopolis status to all areas applying that fulfill the specific requirements, with the restriction of national assistance (Yamazaki 1997). Therefore, the concept of Technopolis itself has greatly changed in the light of the above situation, as described in the report of "*Trend of Technopolis 90 Construction*" issued in 1981 (Itoh 1998). This change of Technopolis status had many consequences. If the Technopolis Plan had designated only one area, as a national project, the subsidies and grants for its construction would have come from National Government, as in the case of Tsukuba Science City. As Glasmeier (1988) has pointed out, a Technopolis plan with many designated areas will have difficulties in achieving its goals, since the national

project at Tsukuba City has already shown difficulties in attracting technical staff and private research facilities. Then, Technopolis Plan was stopped by the National Diet in December, 1998 (*Asahi-shinbun*, 19 December, 1998). According to a recent survey carried out by the Nikkei-sangyou-shouhi Research Center, 70% of the Technopolis areas have attained their targets for new plant formation, but more than 70% of the Technopolis areas have not achieved their targets for industrial shipments (*Nihon Keizai Shinbun*, February 1, 1999).

As discussed earlier, the Technopolis Plan itself has no distinctive effort regarding high-tech regional development, and the changing global production environment has also generated a "hollowing out" of Japanese industry. As a result, the impact of the Technopolis Plan is not clear. However, as Castells and Hall (1994) have pointed out, there are two ways to evaluate the success of Technopolis Plan: in terms of targeted numbers, and in terms of the creation of innovation in the Technopolis regions. This paper has examined only the short-term development aspect (*gaihatsu-gata*), and the long-term (*naihatsu-gata*) development based on technology development of Technopolis areas awaits further analysis.

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(*: in Japanese)

Appendix I: Variables and their data sources used in discriminant analysis. (P) indicates data relating to the Technopolis prefecture and (T) indicates data relating to Technopolis itself; * indicates that data are used for 1990 and 1995, respectively, in discriminant analysis.

Basis high-tech industries functions		
MTDT	· Minimum time-distance from Tokyo station to 'Mother City' by railway (T)*	*Japanese Railway Timetable (1990,1995)*
APDT	· Presence or absence of airport in the Technopolis area (dummy variable) (T)*	*Japanese Railway Timetable (1990,1995)*
NICT	· Number of interchanges within the Technopolis (T)	*All Japan Map (1993)*
DEYT	· Time in years from the establishment of the Technopolis to 1995 (T)*	
DMET	· Percentage of manufacturing workers in the population in the year before the Technopolis was established (T)	*Manufacturing Census of Japan*
PPDT	· Population density of Technopolis (T)*	*Population Census (1990, 1995)*
PMCT	· Population of 'Mother City' (T)*	*Population Census (1990, 1995)*
Research Functions		
PTWP	· Share of professional and technical workers, in manufacturing (P)*	*Statistical Year book of Japan (1993, 1998)*
ESSP	· Share of science and engineering university students in Technopolis prefecture (P)*	*Report of School Basic Statistics (1990, 1996)*
RIUP	· Number of industry/university/government research organizations (T)*	*Survey report of Technopolis Development (1997) published by JILC (J)*
NBPP	· Number of books per 1,000 people in public libraries (P)*	*Statistics of Regional Economic (1992,1997)*
Production functions		
SHTT	· Share of area of high-tech industry in all newly located plants (T)*	*Survey report of Technopolis Development (1997) published by JILC (J)*
BSTP	· Basic salary of a training-school graduate as a manufacturing worker (P)*	*Statistics of Wages Structure (1990, 1995)*
BSUP	· Basic share of university graduates in the manufacturing sector (P)*	*Statistics of Wages Structure (1990, 1995)*
ILPT	· Average industrial land price (T)	*Average Industrial Land Pricee in Technopolis (Dec. 1998) available from JILC web site.*
Recreation functions		
PPAP	· Area of public parkland per person (P)*	*Regional Economic Statistics (1992,1997)*