Horizontal Linkages in Manufacturing Industries: A New Concept of Technological Complex in Medium-Sized Cities

Makoto Okumura and Kazuhiro Yoshikawa

INTRODUCTION

In Japan, processing or assembling technologies have been much emphasized so as to overcome the scarcity of raw materials or energy. The situation is similar in Sweden. Not only the historical inclination to technology, but also recent trends in industrial restructuring underlines the importance of research and development (R&D) activities. The belief that comparative superiority could be achieved by such means of cost reduction as the availability of material, transportation advantages, and a cheap labour force has gradually given way to a more technological belief in the development of new products. The Japanese government and most local governments are eager to develop R&D intensive regions to achieve success in the age of restructuring . R&D activities do not necessarily require accessibility to mass transportation. This is the reason that there is severe competition between many local governments for the assignment of the "Technopolis Plan". Is it true that R&D technology and so-called high technological industries are more footloose than the former heavy industries? We cannot answer "Yes" to this question on the basis of empirical data in Japan. The location of research activities has gradually been concentrated to the Greater Tokyo Metropolis in recent decades. Development activities are also to be seen in peripheral regions, but their locations are limited to the area where more than two of the three high-speed transportation systems, airlines, expressways and Shinkansen Train, are available. The engineers engaged in R&D activities require a high quality living environment, which is based on the size of city to some extent. In other words, R&D activities choose their locations, they are not always trump cards for local industrial policy in a poorly developed region.

It is seldom that medium-sized cities have sufficient manpower to enjoy different types of R&D activities in several industries at once. They have to concentrate their resources and endeavours to a few industries which are so selected as to utilize their local characteristics. Medium-sized cities usually possess an historical complex of local industries, some of which may be suffering from a recession or a decrease in demand at present. Various geographical or economical advantages can be found to explain their historical location, such as nearness to the source of raw materials, cheap energy or cheap labour. However these are just the characteristics of the region; many of them are no longer particularly significant. The rapid development of freight transportation systems and wider international competition have changed the comparative advantages and international division of labour.

In the future, the comparative advantage for the development of new products will gain in importance, and this may stem from technological characteristics or local market information. These characteristics have not really been discussed or analyzed to date because they do not directly correspond to the flows of materials or goods, which have been well analyzed as "vertical linkages" between industries to some extent. In the new concept of industrial policy, "horizontal linkages" has come to be a key term. This paper aims to discuss these horizontal linkages and their political implications for industrial developments in medium-sized cities. The next section gives an overview of industrial development policies in Japan; where only vertical linkages have been considered so far and some of the present difficulties are assumed to be due to the lack of consideration of horizontal linkages. The third section discusses horizontal linkages constituted in technological linkages and market information commonalities, and this is followed by a section where new indexes for measuring horizontal linkages are proposed. The fifth section considers the medium-sized city in empirical terms. Technological characteristics are depicted by means of the new indexes. New industries which can utilize and strengthen the existing technologies are also selected. The last section summarizes our discussion and points to some topics for future study.

OVERVIEW OF JAPANESE INDUSTRIAL DEVELOPMENT POLICIES

Since Japan geared up for accelerated economic growth in the 1950s, the concentration of population and industry in the big agglomerations, such as Tokyo and Osaka, has advanced further. As a result, on the one hand, regional disparities have spread and, on the other, many kinds of social costs – traffic congestion, environmental pollution, housing shortages, etc. – have become serious in those areas. So, to cope with urban problems and at the same time to reduce regional disparities, the idea of promoting regional economic growth in the less developed regions has been launched. Therefore, an important role was given to industrial development policy in the national development plan and policy system.

Until the oil-crisis in 1973, Japan experienced an economic growth miracle. In this period, regional development plans advocated the dispersion of industrial activities and proposed the adoption of a "growth pole" strategy in which efforts for regional development should be concentrated to certain strategic points in various parts of the country. To implement this strategy, fifteen New Industrial Cities and six Special Areas for Industrial Development were designated by 1966. Material plants such as iron and steel, petroleum refining, pulp or chemical processing plants were located in those coastal areas. In 1969 the second National Development Plan proposed the construction of extensive network systems of transport and communication to bring development potential even to peripheral areas. This proposal meant the nationwide extension of expressways, the further extension of Shinkansen. Against a background of high economic growth and improvement in transportation, the dispersion of industries, especially the production of heavy products or materials was promoted. These industries provided employment for people who could only find jobs in agriculture in the peripheral area. It can be recognized that these policies helped to weaken, to some extent, the migration flow from the periphery to the big cities.

The oil crisis greatly altered the situation and the Japanese economy experienced a depression caused by the severe increase in cost for imported materials, and the loss of comparative advantages in international markets. Heavy industries and material industries which had the locomotive role suffered from the decrease in demand. The recession in those key industries resulted in a general slump in the regional economy and the emigration of the young labour force from the area. It is very ironical that this situation was more severe where the growth pole policy was successful, having a mono-central industrial structure. We called that a "structural slump problem".

Japanese industries groped a for way to regain the comparative advantage in severe international competition and hit upon the solution of restructuring to more technology-intensive and high value-added industries. By 1990, major industries had strengthened their function for R&D activities and enjoyed competitive power again. With the emergence of high technology industries and the development of information industries, the industrial structure of Japan has changed rapidly and this has caused the aggravation of regional economies in almost all areas except Tokyo. Laboratories or research departments were generally located in the Greater Tokyo Region. This is thought to be one of the most important factors causing the unipolar concentration to Tokyo as well as the growth of the international financial market. Against this background the Ministry of International Trade and Industry (MITI) proposed the Technopolis Program in 1983 and in the same year National Land Agency started to prepare the fourth Comprehensive National Development Plan, which was not published until 1987.

The idea of the Technopolis was formulated in order to create a high technology area like Silicon Valley or the North Carolina Research Triangle, where technological innovations in high-technology industries such as semi-conductors, new materials and biotechnology are expected. This also involves a regional development dimension, which is concerned with the promotion of economic development and industrial restructuring in peripheral regions. The basic objective of the Technopolis program is to create high quality living environments and provide the infrastructure that is needed to stimulate regional development and assist in economic restructuring. Many local governments welcomed the policy as a new way of obtaining subsidies for building local factories, without any particular concern for R&D. Since 1983 twenty-six Technopolises have been designated by MITI. The Technopolis must be an area where industries are not excessively concentrated, but MITI set a condition that there should already be enough local business to provide the nucleus of entrepreneurial skills for the project. It must have at least one university providing courses in high technology and must have good access to transport networks.

It is too early to evaluate the Technopolis program, it may be said, however, that the program itself fluently announced the importance of R&D activities also in peripherals. However, two major problems can be pointed out. One is that because of the severe condition set by MITI, the policy was more or less only open to a few cities with existing bases. The other problem is that all Technopolises are planned to develop so-called high technology industries such as semi-conductors, new materials and biotechnology. They are undoubtedly promising and growing industries at present, but with little relationship with the existing industries in each region. This situation is very similar to that when heavy industries or material industries were selected as promising industries for "New

Industrial Cities" about a quarter of a century ago. It is possible that Technopolises will face the problem of structural slump in a number of years.

IMPORTANCE OF HORIZONTAL LINKAGES

Because the medium-sized city does not have much resources or manpower, it is safe to assume that R&D activities will only grow in a small limited industrial area. In order to increase the chances of success in severe interregional or international competition, it would be better for it to concentrate endeavours and resources on a small number of target industries. These target industries should be selected so that they will utilize regional characteristics and strengthen them. They are also expected to receive manpower from the existing industries; current regional industries cannot always catch up with demand saturation or decline along the product-life cycle. It is expected that the decrease in employment in existing industries will be met by newly located industries. Therefore, a strong linkage to the existing industries is desirable for the target industries as well as high growth potential.

Linkages between industries are both vertical and horizontal. Vertical linkages are those achieved by the transition of goods or services, and they have been described as important aspects of industrial development policies to date. Growth pole industry is another term for industry which has strong vertical linkages with a wide variety of other industries. The material industry, such as the iron and steel industry, sells its products to almost all machinery industries; downward vertical linkages from the material industry have great power to attract other industries. Upward vertical linkages also produce growth poles. In order to provide materials, mechanical parts or energy to TOYOTA, one of the biggest automobile industries in Japan, steel industries, rubber industries, energy plants, and so on located near Nagoya City.

An industrial complex based on vertical linkages has an advantage when it comes to the transportation cost of goods or materials. However, this advantage has become less important recently, because transportation costs have decreased relative to the other costs such as labour costs. Increases in labour costs in Japan have caused process decomposition and the subrogation of labour-intensive parts to the developing countries. The importance of vertical linkages, as a result, declined in these two decades.

The other critical point in industrial development based on vertical linkages is, as we mentioned above, the fear of "structural slump". The growth pole industry with much vertical linkage has the power to gather related industries. However, if the economic environment around the pole industry becomes worse, all industries are influenced very negatively; a decrease in the production of the pole industry reduces demands on related industries upper-stream, or, a higher price for or lower quality in a key product results in the reduction in the competitive advantages of the down-stream industries. In other words, vertical linkages make industrial structures less substitutable and weaker in the face of a structural slump. It was a nice proof that most of the New Industrial Cities in Japan suffered from the whole slump in the regional economy.

After these considerations, horizontal linkages will be highlighted; these are the other part of industrial linkages, without direct transition. They may have many constituents. Technological similarity and market information commonality are considered to be the most important components. Local technologies used to produce a certain product can be possibly utilized for some other products. If the original local products meet with depression, technologies are still alive as seeds for new products. It can be emphasized that technologies have a longer life and are more substitutable than goods or products. If the variety of industries or products was expanded, based to some extent on technological similarities, the regional economy would be better able to meet a structural slump. Local technologies have usually been accumulated through the shape of the skills of the workers, including some badly formulated ones. These skills can be only achieved by long and intensive experience of the job. Standardization or documentation is very difficult for such ill-defined skills of experts. Because improvement and inheritance can only be accomplished when the workers and experts are engaged in the job, using local technology for new products is nothing other than taking jobs which are suitable for regional skilled experts. It is necessary to discover a new field where the existing technology can be useful, thus bringing new fields of activity to people in the region, and enabling them to settle.

Our concept of local technology is very much like that of the "gene" in biology. Each firm makes profits from production based on technological information. On the other hand, each individual creature grows by means of a variety of biochemical processes which were printed in genes. Some biologists refer to the "Replicon Model" insisting that each life lives and grows in order to increase the copies of its genes. Though the individual has very short life, genes can enjoy a longer life usually over many generations. Furthermore, adaptation or the process of evolution makes the life of genes much longer. Now, we can draw an analogy between products and individuals, industries and species, technology and gene, and research activity and evolution. Industries may enjoy their life by continually renewing their products, technologies may survive much longer by wandering over many industries. Technological similarity is very important for long-term industrial policy. This biological analogy of the firm's behaviour only has a short history but much interesting literatures has appeared on the subject. Nelson and Winter (1982) produced the first monograph where the behaviour of firms was discussed from the standpoint of evolutionary theory. The growing process of a new technology is usually represented by the logistic model which describes the growth process of a biological population. The competitive interaction of firms can be expressed in terms of an ecological predator-prey model. Furthermore, the concept of ecological niche suggests an approach to analyzing the interactions of firms. (Nishiyama, 1985)

Here, we can rephrase the above discussion to refer to market information, the other factor in horizontal linkages. It is sometimes the case that market information achieved by continuous transactions is a great help for new product development.

ANALYSIS OF HORIZONTAL LINKAGES

One reason for the few studies on horizontal linkages is that analytical methods have not been established for horizontal linkages. This is a great drawback in comparison with vertical linkages which can be easily assessed by the input-output model.

Studies on Industrial Linkages to Date

An input-output table is a table of values corresponding to goods or service transactions. It is no more than the table of vertical linkages in monetary terms, though it is used to analyze horizontal linkages, such as the commonality of market information, to some extent. Similarity between the rows in an input-output transaction table shows the commonality of the selling markets of the two industries, similarity between the columns shows that of input markets. The number of industries that have non-zero purchases from the two industries mentioned provides an index of the selling market similarity of the two industries. Counting the number of industries that have non-zero transactions with the industries mentioned provides a purchasing similarity index. Roepke et al (1974) suggested a market commonality index which was the sum of these two similarity indexes. Leontief (1965), Streit (1969) and Slater (1977) suggested similarity indexes from the same viewpoint which were defined by using input coefficients instead of transaction value. The main drawback of these indexes is that statistical tests are impossible and that there are no theoretical criteria for significant transactions. Correlation coefficients enable statistical testing as in Czamanski (1971), they have with much difficulty been used for the following analysis like grouping. The original input-output table only gives direct transactions between industries, Leontief's inverse matrix however, provides the total relationship, considering succeeding vertical linkages.The row vector of the inverse matrix shows the total backward influence induced by the industry mentioned, as well as the column vector of its mean total forward influence based on the demand on the industry. Blin et al (1977) proposed using correlation coefficients of the two columns or two laws in order to estimate the similarity of the total influences of the industries mentioned. Anyway, the horizontal linkages derived from these indexes based on the input-output table are those which are based on market structure, not on technological relationship.

Similarity of geographical location may be another index of horizontal linkages. The number of employees is usually used as a measure of industrial location.The geographical employment dispersion pattern was investigated by Roepke et al (1974). Florence (1944) developed one of the earliest measurements of geographical association between industries, which is obtained by adding the absolute values of the difference between the regional employment proportions of any two industries over the sample regions. It was severely criticized because it is only sensitive for large-sized zones and it gives large values even though the geographical patterns differ in the other small-sized zones. Correlation coefficients, which provide the testing procedure, came to be widely used, as well as multiple-coefficients and partial coefficients, by Richter (1969), Streit (1969) and so on. However, using geographical employment data cannot be freed from the problem of zoning or the difficulty of extracting industrial linkage from the general effect of population scale. Nor have geographical analyses succeeded in identifying technological linkages.

Other researchers tried to analyze the technological structure more directly. Isard et al (1959) decomposed the process in chemical industries and picked out the technological relationships in each unit process. This microscopic analysis can consider local conditions or characteristics, but requires much detailed data. It is only applicable to short-run assessment and only to limited industries in limited areas. Patent analysis has become very popular recently. In Japan, a patent owner must categorize his patent to one or two industries which are able to purchase his patent. Though, actual patent transaction data are not available, we can use the patent category data to grasp technological similarity instead. The Invention Association (1985) analyzed technological structure in the field of electronics. A criticism of this method is that all of the technologies used are not registered as patents therefore the method is only applicable to so-called high-technology industries such as electronics or biochemical industries. The increase in overseas transactions of patents makes the analysis more difficult.

As mentioned here, technological linkages have begun to be analyzed recently, but the suggested methods demand a great amount of data and their applicability is limited; more effective methods covering wider range of industries are very much needed for regional technological policy making.

Diversification of Products in Multi-Product Firms

Here, let us consider the behaviour of firms. Every firm chooses profitable products which can be produced with the resources, labour and technology it has available. Many firms produce more than two products, they are called multi-product firms. The production of by-products, such as sulphuric acid when refining steel, is the oldest case of multi-production. However, the concept of multi-production covers a much wider field than that trivial case; many firms consciously develop new products which may yield more profit. This is a firm's diversification, which receives words of caution from researchers in marketing. According to the Japanese Census of Manufactures (JCM), almost half of the manufacturing firms in Japan (43.6%) produce products which were categorized in more than two Standard Industrial Codes (2-digit SIC's) in 1987. Product diversification is one of the effective and important strategies for firms, especially for large-sized ones. Rumelt (1974) surveyed diversification patterns of American manufacturing firms and their relationship with economic results, such as profit. The ratio of the production of main product to the total production of the firm provided a criterion for classifying the firm's strategy as Single, Dominant, and Diversified. Diversified strategy was further subdivided into Vertical, Related and Unrelated. Rumelt found that the Related-Diversification strategy, where products were chosen so that existing market information or technology were applicable to them, was more profitable than the other strategies. Another study by Hakoda (1987) who interviewed 171 major firms in Japan shows an increase of Related-Diversification at the expense of the Single strategy. (See Table 1.) In many firms, diversification is promoted on the basis on horizontal linkages, therefore, diversification patterns may well provide an index of horizontal linkages.

Table 1: Diversification strategies of major Japanese industrial firms

Strategy	1960	(%)	1965	(%)	1970	(%)	1975	(%)	1980	(%)	1983	(%)
Single	73	42.6	60	35.0	50	29.2	40	23.3	41	23.9	39	22.8
Dominant	44	25.7	49	28.6	52	30.4	54	31.5	42	24.5	43	25.1
Diversified	32	18.7	49	28.6	47	27.4	59	34.5	74	43.27	74	43.2
(Vertical)	10	5.8	18	10.5	18	10.5	21	12.2	24	14.0	23	13.4
(Related)	22	12.8	18	10.5	18	10.5	22	12.8	30	17.5	31	18.1
(Unrelated)	22	12.8	13	7.6	11	6.4	16	9.3	20	11.6	20	11.6
TOTAL	171	100	171	100	171	100	171	100	171	100	171	100

Note: Single: Main product gives more than 95% of total production of the firm.
Dominant : Main product gives between 70%-95% of total production.
Diversified : Main product covers less than 70% of total production.
Quoted from Hakoda(1987): *Diversification Strategies and Industrial Structural Change*

Co-production Rate as an Index of Horizontal Linkage

Concentrating the discussion on the manufacturing industry improves the availability of data. The products book in the series published by JCM collects the annual production data classified by category of product. We can obtain the number of firms categorized in a certain industry that produce each kind of product. Because the industry classification is so detailed, each category only contains a small number of works which can be considered homogeneous. Based on this data, each categorized product is checked whether it is produced by a certain industrial category. If two different products are produced in the same industrial group, it is probable that these two products are actually produced in the same workplace. When there is neither direct vertical linkage nor technological relationship between two products, there is no reason to produce them under the same roof. From the opposite viewpoint, products in the same industrial categories must possess vertical or technological linkage. On this basis, the "co-production rate" is proposed as an index of linkages; the definition is as follows:

$$C_{jk} = \frac{\sum_{i=1}^{M} \delta_{ik} N_{ij}}{N_{ij}} \tag{1}$$

where, C_{jk}: Co-production rate of jth product and kth product.
N_{ij}: The number of works in ith industry that produce jth product, and
δ_{ik}: Index variable that has the value 1 when kth product is produced in ith industry (if $N_{ik}<0$), else it has the value 0 (if $N_{ik}=0$).

This index has a non-negative value. It has the value 1, the maximum value, when all of *j*th product is produced with *k*th product, as is the case of perfect by-production. Table 2 shows the distribution of this index calculated for pairs of each 3-digit good (149 categorized). The horizontal axis represents the cumulative occurrence. 1294 of 22052 pairs (149 x 148) have non-zero values. Table 3 shows the overall pattern based on an aggregation to 2-digit industries (23 x 23) pairs. The pattern in this aggregation corresponds to vertical linkages to some extent. For example, metal products (SIC.28) have linkages with other 13 categories. Linkage with pig iron and steel (SIC.26) is strongest, followed by linkages with general machinery (SIC.29), electrical equipment (SIC.30), motor vehicle and transportation equipment (SIC.31), office machines (SIC.32).

Table 2: Distribution of co-production rate (1985)

Range of co-production rate		Frequency	Cumulative Frequency
0		20758	20758
0	0.001	392	21150
0.001	0.002	255	21405
0.002	0.005	285	21690
0.005	0.01	135	21825
0.01	0.02	86	21911
0.02	0.05	72	21983
0.05	0.1	28	22011
0.1	0.2	23	22034
0.2	0.5	12	22046
0.5	1.0	5	22051
1.0		1	22052

Table 3: Co-production pattern aggregated at 2-digit level

Industry i \ j	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
12 Food	◎	◎					△		○														
13 Beverage and tobacco	◎	●							○														
14 Fiber textile			●	◎	○		○		○		○				○		○	○		○			○
15 Apparel products			◎	●	○	○	△	△	△			○	○										○
16 Wood and wooden product			○	○	●	○	○				○									○			△
17 Furniture and fixture				○	◎	●	○				○					○	○	△	△	△			○
18 Pulp and paper product	◎		○	○	○	○	●	○	◎		○	○		○									○
19 Printing, publishing and allied				○			○	●															
20 Chemical Product	○	○	◎	○			○		●	○	○			○	○	◎		○	○	△		○	○
21 Petroleum and coal product									◎	●													
22 Plastic products			○		○	○	○		○		●	○		○			○		○				○
23 Rubber product			◎	○			○				○	●	○	◎		○							○
24 Leather, leather product and fur			○	◎								◎	●										
25 Earthen and related product					△		○		○		○	◎		●	○	○	○	○	△	○	○		
26 Iron and steel material and product			○						○					○	●	●	●	○		○			
27 Non-ferrous metal material and product						○			◎			○		◎	◎	●	◎	○	○	○	○		○
28 Fabricated metal product			○		△	○					○			○	◎	○	●	○	○	○	△		○
29 Ordinary machinery			△			△			○						○	○	○	●	△	○	△		△
30 Electrical machinery and equipment						○			△		○			△		△	○	△	●	△	○	○	○
31 Transport equipment					△	▽			◎					○	○		○	○	○	●	○	○	○
32 Precision equipment														○		○	○	○	○	○	●		◎
33 Ordnance									●									◎	◎	◎	◎	●	
34 Other manufacturing product			○	○	○	○	○		○		○	○				○	○	○	○	○	○		●

● ◎ ○ △ ▽
Co-Production Rate : 1 - 0.1 - 0.01 - 0.001

The co-production rate is a new measurement index of diversification strength at workshop level, not at firm level. Therefore, it may be expected to reflect technological linkages better than firm level indexes. Unless there is any technological similarity, this co-production rate may have a high value when firms have a Vertically Related Diversification strategy. The introduction of vertically related industries is expected to reduce the cost and uncertainty of transaction. These vertical linkages can be analyzed using input-output data as mentioned above, matching results from these analyses are possible.

Overlapping Clustering to Extracting Factors

The intensity of diversification, as measured by the co-production rate, may be influenced by many factors. Here we consider that the influences of such factors are additive, therefore each co-production rate should be explained as a summation of the effects of factors as follows:

$$C_{jk} = \sum_{\ell=1}^{L} \zeta_{j\ell}\zeta_{k\ell}D_{\ell} \tag{2}$$

where, $\zeta_{j\ell}$: Index variable that has the value 1 when kth product possesses ℓth factor, else it takes value 0, and
D_{ℓ}: Effect of ℓth factor.

When we consider factors that are not as many as the number of non-zero co-productions, residuals are left. Here we consider a non-linear program choosing such a combination of ;$\zeta_{j\ell}$s and D_{ℓ}s as to minimize the squared residuals as follows,

$$\text{Minimize} \sum_{j=1}^{M} \sum_{k=1}^{M} \left(C_{jk} - \sum_{\ell=1}^{L} \zeta_{j\ell}\zeta_{k\ell}D_{\ell} \right)^2 \tag{3}$$

The procedure for solving this problem was developed by Arabie et al (1980) as the "Overlapping Clustering Method", which is available in major statistical packages. This procedure was repeated changing the number of clusters, and the resulting decline of residuals was investigated. From the inflection of squared residuals, the number of clusters was set designed as 75, about half of the number of industries.

Because vertical diversifications are accomplished as well as ones based on market similarity, some clusters must be the result of vertical linkage or market similarity. Indexes on input-output data helps us understand each of the derived clusters. In order to test the vertical linkage, the following two indexes are defined; one is Purchase Rate: p_{jk} which means the importance of purchasing from kth goods for the total purchases of jth industry, and the other is Selling Rate: s_{jk} which indicates the proportion of transactions with kth industry in the total sales of jth goods. That is;

$$p_{jk} = \frac{t_{kj}}{t_j},\ s_{jk} \frac{t_{jk}}{t_{jk}} \tag{4}$$

where, t_{jk}: transaction value from jth industry (goods) to kth industry (goods).

If either of these two indexes has a high value, there is vertical linkage between two products. Therefore, it is concluded that a certain cluster is a vertical one when these indexes have a high value among the goods corresponding to the cluster mentioned.

In order to check marketing commonality, two other indexes are defined, one is Co-Purchasing Rate and the other is Co-Selling Rate. Co-Purchasing rate ( ) indicates the applicability of information about the input market of kth industry when inputs for jth goods are purchased, defined as the proportion of input purchases from the industry which also sells goods to kth industry. That is:

$$Cp_{jk} = \frac{\sum_{m=1}^{M} \lambda_{mk} t_{mj}}{t_j} \tag{5}$$

where, λ_{mk} : Index variable that has the value 1 when kth product uses input of mth goods (t_{mk}), else it has the value 0.

This is an index for marketing commonality, though it has significance from the viewpoint of technological linkage. Let us consider two different industries using semi-conductor devices as parts. Heat, electricity and magnetic lays cause damage to semi-conductors. Therefore such physical forces are required to be well controlled in both of the processing routines for these two products. There is much commonality of processing skills for such two products.

The Co-Selling Rate (Cs_{jk}) is defined similarly, as the proportion of sales to such industries that purchase kth product to the total sales of jth goods. It represents the applicability of the selling market information of kth goods when jth good is sold, defined as follows:

$$Cs_{jk} = \frac{\sum_{m=1}^{M} \lambda_{mk} t_{jm}}{t_j} \tag{6}$$

It is also true that this Co-Selling Rate has technological meaning as well as market linkage. We can imagine two different mechanical goods used as inputs for a small video machine, for example. To enable the down-sizing of video machine, both of these two parts must be compact; fine and careful processing is indispensable for these two goods.

When both of these two indexes have high values, technological linkage between the two is to be expected. As expressed here, the values of the Co-Purchasing Rate and Co-Selling Rate among the goods in a certain cluster help us to understand the meaning of the cluster. Table 4 shows the list of diversification clusters which are classified in five groups, that is (1) vertical, (2) co-purchasing, (3) co-selling, (4) co-purchasing and co-selling, and (5) without a market relationship.

Table 4: Clusters derived by the overlapping clustering method

Type	Name of Cluster	Products (SIC)
(1)Vertical	7	128,135
	16	123,131
	29	142,144,146,204
	36	162,173
	54	183,185
	59	149,159
	60	129,135
(2)Co-Purchasing	2	261,265
	3	212,215
	19	183,185,189
	23	265,287
	24	233,239
	25	126,128,135
	37	203,204,213
	40	271,272,279
	42	201,213
	55	185,189
	58	261,265,287,288
	65	202,203,213
	67	201,202,272
	75	233,259
(3)Co-Selling	5	209,331
	10	293,302,331
	13	144,149,159
	18	258,259
	21	293,297,299,306, 315,319,331
	22	294,296,305,314, 321,322,331
	26	311,312
	27	129,181
	28	297,302,305,331
	30	294,315,319,331
	31	296,299,331
	32	293,321,331
	35	304,305,306,331
	43	284,312,315
	46	201,294,302,331
	47	124,181,182
	49	203,296,297, 312,331
	51	205,209,306, 315,331
(3)Co-Selling	52	302,319,331
	53	293,315,331
	57	201,203.206,215, 219,305,319
	62	302,306,331
	63	201,293,331
	68	201,203,321,331
	70	306,307,315,322
	74	203,294,295,331
(4)Co-Purchasing and Co-Selling	4	241,248
	6	261,287
	8	202,271
	9	154,248
	11	151,242
	14	223,229
	15	191,192
	20	201,202,203,205, 209,213,331
	33	203,205,209, 302,331
	39	151,152
	41	142,149,159,204
	44	232,243
	45	221,222
	48	308,309
	50	202,262,273,279
	56	294,297,299,331
	61	301,304,306,312
	64	205,297,321,331
	66	205,299,305,331
	69	293,296,331
	71	145,155,245
	72	259,261,262, 266,271
(5)Without Market Relation-ships	1	345,349
	12	247,249
	17	212,219
	34	321,322
	38	143,147
	73	203,219

Note: The name of cluster is assigned in the sequence of effect, D_i.

Table.4 shows the list of diversification clusters which are classified into five groups, that is, (1) vertical, (2) co-purchasing, (3) co-selling, (4) co-purchasing and co-selling, and (5) without market relationship.

EMPIRICAL STUDY OF LOCAL INDUSTRIAL CHARACTERISTICS

In this section, the political implication of horizontal linkage indexes and derived clusters for regional industrial development is discussed. An empirical study has been conducted in the Kohoku Region in the Shiga-Prefecture (780) near Kyoto, where 1005 manufacturing workshops had 22,423 employees in 1985. Sixty 3-digit SIC categorized products are made in the region, they are about half of the total number of categories (149).

The industrial clusters derived in the last section are helpful for evaluating the technological characteristics of the region. When at least one of the products in a certain cluster is produced in the region, another product in the same cluster is easily produced in the region on the basis of technological linkage or market commonality. Therefore the number of clusters indicates the variety of regional industries from the viewpoint of horizontal linkages. The power to breed new industry in a certain cluster may be clearly indicated by the number of employees who are engaged in the industries included in the cluster. Table 5 shows the existence of clusters in the Kohoku Region. Twelve clusters were found and one cluster diminished between 1983 and 1988, which shows that the variety of regional technologies was increased in the period, though the number of total employees was almost constant. The clusters which have a large number of employees have considerable ability to act as "seeds", because much of the manpower can easily adapt to the new industries which are included in the cluster.

As concerns the vertical linkages between industries that existed in 1983 and 1988, many of them had diminished and the industrial structure had gained considerable endurance to structural slump. These figures also implies a shift from vertical linkages to horizontal linkages.

In the case of the Kohoku region, cluster 43 and cluster 41 have a large number of employees and include non-existent industries. If we consider these clusters as seeds, we can select the candidate industries to be located in the region. Railway vehicles (SIC.312), aircraft and their accessories (SIC.315), spinning (SIC.142), and chemical fibres and textiles (SIC.204) are selected on the basis of horizontal linkages.

CONCLUSION

A retrospective consideration of industrial policies revealed the fragility of industrial structure based on vertical linkages. The globalization of industrial market competition and an emphasis on Research and Development strengthen the importance of horizontal linkages in manufacturing industries. Horizontal linkages are very important for finding the regional technological characteristics and selecting such industries as can utilize and strengthen these characteristics. This paper has discussed these horizontal linkages and their political implications for industrial development in medium-sized cities. New indexes measuring horizontal linkages were proposed and technologies were well understood by using the Overlapping Clustering Method. Candidate industries which can utilize and strengthen the existing technology were also selected on the basis of the previous analysis.

Table 5: Clusters existing in the Kohoku region

Cluster Name (Type)	Number of Employees in 1983	Number of Employees in 1988	Existing Industries in 1988	Candidate Industries
12 (5)	39	2544	247,249	-
21 (3)	341	1418	293,297,299,319	306,315,(331)
41 (4)	1047	1323	149,159	142,204
10 (3)	266	1095	293,302	(331)
32 (3)	0	886	293	321,(331)
53 (3)	0	886	293	315,(331)
63 (3)	0	886	293	201,(331)
69 (4)	0	886	293	296,(331)
48 (4)	671	830	308,309	-
43 (3)	619	686	284	312,315
45 (4)	167	596	221,222	-
56 (4)	377	554	294,297,299	(331)
39 (4)	651	471	151,152	-
13 (3)	2706	417	144,149,159	-
11 (4)	500	416	151	242
31 (3)	341	397	296,299	(331)
66 (4)	341	397	299	205,305,(331)
71 (4)	366	373	145,155	245
28 (3)	266	344	297,302	305,(331)
26 (3)	122	304	311	312
61 (4)	68	259	301,304	306,312
45 (4)	302	231	221,222	-
18 (3)	0	229	258,259	-
33 (4)	266	209	302	203,205,209,(331)
52 (3)	266	209	302,319	(331)
62 (3)	266	209	302	306,(331)
19 (2)	135	162	185	183,189
55 (2)	135	162	185	189
49 (3)	0	135	296,297	203,312,(331)
64 (4)	0	135	297	205,321,(331)
27 (3)	105	126	129	181
72 (4)	0	69	259	261,262,266,271
75 (2)	0	69	233,259	-
70 (3)	0	65	307	306,315,322
38 (5)	70	52	143	147
35 (3)	0	50	304	305,306,(331)
57 (3)	0	45	206,319	201,203,215,219,305
14 (4)	321	31	223	229
22 (3)	36	22	294,296	305,314,321,322,(331)
30 (3)	36	22	294,319	315,(331)
74 (3)	36	22	294	203,295,(331)

Technological innovations are continually taking place, especially, in so-called high-tech industries, such as semi-conductors, electronics, biotechnology, and new materials. Profitability may high in such technology-oriented industries, but market competition is also more severe. For medium-sized cities, it is too risky to bet their future on such severe competition. They should look for other less competitive markets based on their characteristics even if this is less profitable. This is what is meant by "niche". This paper shows how medium-sized cities may find promising niches.

We would like to conclude the paper by summarizing the future tasks;

(1) Local technological information was treated as ill-formulated skills which could be standardized or documented in this discussion. However, introducing intellectual machines may compensate for such technologies. The development of soft-engineering also narrows the area for such technologies or skills. A large part of the market information can be also gathered and analyzed by consulting companies which have no direct transactions. Therefore, the area for ill-formulated skills must be carefully assessed by more detailed case studies.

(2) The Co-Production Rate is based on the diversification behaviour of firms. That behaviour is, needless to say, much influenced by market profitability. Therefore, the Co-Production Rate is function of market price or the demand for goods. Microscopic analyses of a firm's diversification behaviour are needed for the theoretical base for this index.

(3) The aim of this paper is to find a way of applying existing technology along the horizontal linkages. The birth of new technology is beyond our scope. When we discuss the industrial policy for metropolitan areas, such points become more important. Metropolises very much need the ability to develop new technology in order to maintain their comparative superiority.

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Appendix Japanese Standard Industrial Classification (SIC)

Appendix Japanese Standard Industrial Classification (SIC) Continued.

Appendix Japanese Standard Industrial Classification (SIC)

12 Food
121 Stock-firm food product
122 Fishery food product
123 Agricultural food product
124 Salt and condiments
125 Sugar and saccharoid
126 Cereal products and milling
127 Bread and cakes
128 Fats and oil
129 Other food products
13 Beverage and tobacco
131 Soft drinks
132 Liquor
133 Tea and coffee
134 Ice
135 Fodder and organic manure
14 Fiber textile
141 Filature
142 Spinning
143 Yearning
144 Weaving
146 Dying
147 Net and Rope
148 Lase and products
149 Other fibers
15 Apparel products
151 Outer dresses
152 Inner dresses
153 Hat and headgear
154 Furred dresses
155 Other dresses and accessories
159 Other apparel products
16 Wood and wooden product
161 Logging
162 Plywood and architectural materials
163 Wooden box and container
164 Wooden shoes
164 Other wood products
17 Furniture and fixture
171 Furniture
172 Religious ornaments
173 Fixture
179 Other interior accessories
18 Pulp and paper product
181 Pulpmills
182 Paper mills
183 Special paper
184 Paper product
185 Paper box and container
189 Other paper product
19 Printing, publishing and allied
191 Newspaper
192 Publishing
193 Printing
194 Print engraving
20 Chemical Product
201 Chemical manure
202 Inorganic chemical industry
203 Organic chemical industry
204 Chemical fiber and textile
205 Petrochemical products
206 Pharmacy
209 Other chemical products
21 Petroleum and coal product
211 Petroleum refining
212 Lubricant and grease
213 Coke
214 Briquette and solid fuel
215 Pavement material
219 Other petro or coal product
22 Plastic products
221 Plastic board, bar and pipe
222 Plastic film and sheet
223 Industrial plastics
224 Foamed plastics
229 Other Plastic product
23 Rubber product
231 Tires and tubes
232 Rubber shoes and footwear
233 Industrial rubber products
234 Other rubber product
24 Leather, leather product and fur
241 Leather
242 Industrial leather product
243 Leather shoes material
244 Leather shoes and footwear
245 Leather grove
246 Leather bag
247 Non-leather bag
248 Fur
249 Other leather product
25 Earthen and related product
251 Glass and glass product
252 Cement products
253 Earthen construction material
254 Ceramics and pottery
255 Fireproof clay product
256 Charcoal and carbon
257 Grind stone
258 Stone products
259 Other clay product
26 Iron and steel material and product
261 Iron by blast furnace
262 Crude steel
265 Surface-processed steel
266 Tempered steel
267 Pig iron
269 Other iron and steel

Appendix Japanese Standard Industrial Classification (SIC) Continued.

27 Non-ferrous metal material and product
271 Non-ferrous metal elemental refinement
272 Non-ferrous metal further refinement
273 Non-ferrous alloy
274 Non-ferrous casting
275 Electric wire and cable
279 Other Non-ferrous metal
28 Fabricated metal product
281 Metal can
282 Metal houseware
283 Heating equipments
284 Metal construction material
285 Pressed metal product
286 Metallurgic powder
287 Metal strings
288 Bolt, nut and metal screw
289 Other metallic products
29 Ordinary machinery
291 Boiler and engine
292 Agricultural machinery
293 Construction and mining machinery
294 Fabrication machinery
295 Textile machinery
296 Other industrial machinery
297 General parts for machinery
298 Office and service industrial machinery
299 Other machine and accessories
30 Electrical machinery and equipment
301 Electricity transmission,distribution apparatus
302 Household electric equipment
303 Electric lights and illumination
304 Communication equipment
305 Computer and accessories
306 Electronic equipment, semi-conductor device, IC
307 Electric measuring equipment
308 Weak electrical equipment, parts and accessories
309 Other electric machinery
31 Transport equipment
311 Motor vehicles, parts and accessories
312 Railway ore, parts and accessories
313 Bicycle and other light vehicles
314 Ships, parts and accessories
315 Aerospace
319 Other transport equipment
32 Precision equipment
321 Measures and analyzer
322 Land measurement equipment
323 Medical equipment and tools
324 Equipments for physical chemistry
325 Optical equipments and lens
326 Glasses
327 Clock and watch
33 Ordnance
331 Ordnance
34 Other manufacturing product
341 Precious metals ornament
342 Musical instruments and records
343 Toy, sporting and athletic goods
344 Pen and other stationery
345 Button and other accessories
346 Lacquer ware
348 Other manufacturing product