Linkage and Network Changes in Industrial Clusters of Korea

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Ⅰ. Introduction

Since the 1990's an empirical observation has gained popularity that clusters could have a significant impact on the competitiveness of firms operating in a region, which led to escalating academic studies and policy applications regarding clusters. However, it has been pointed out that clusters could slip into a chaotic concept due to a diversity of definitions and a lack of an empirical analysis of clusters such as an identification of clusters in a regional or national economy (Held, 1996; Malizia and Feser, 1999; Feser and Bergman, 2000). Moreover, the formation and evolution processes of clusters show a sharp difference by local circumstances and characteristics of agglomerated industries. This means that an identification of industrial clusters but also knowledge regarding industrial linkages and their changes over time within each industrial cluster are very important in implementing cluster-based industrial policies.

The research of cluster identification has not intensively carried out because of not

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only a multiple of cluster definitions but also the unavailability of micro-level data with diverse information on inter-industrial linkages. In particular, just a few of studies have been carried in Korea. They have not considered fully a variety of inter-industrial linkages and have only identified industrial clusters in a specific time. Moreover, an analysis has not been carried out regarding the characteristics of identified clusters and their changes over time, thus failing to understand clusters in an exact way and having some limitations in terms of the implementation of policies.

This paper analyzes industrial clusters in manufacturing based upon inter-industrial input-output linkages at the national level and examines changes in linkages structure and nodal industries as a key player within identified clusters and their economic performance over time

Ⅱ. Discussions on existing studies

An empirical analysis of identifying clusters is closely associated with the conceptualizations of clusters[2]. Despite the existence of a diversity of cluster definitions, Feser and Bergan (2000) distinguish the case in which input-output or buyer-supplier linkages are emphasized from the one where geographical co-location is highlighted. Furthermore, they name the former as industrial clusters - a group of firms functionally linked - while the latter as regional clusters based upon a specific local agglomeration.

An empirical elaboration has made regarding the identification of industrial clusters, mainly capitalizing upon input-out tables. The following studies are well known:

[2] Bergman and Feser (1999) summarize a diverse body of definitions regarding clusters and several methods of empirically identifying clusters.

Czamanski (1971, 1974); Czamanski and Ablas (1979); Bergman and Feser (1999); Feser and Bergman (2000); and Akgungor et al. (2003). And when identifying regional clusters, it is the case that after an analysis of the degree of industrial concentration through a calculation of location quotients, a typology of regional clusters is carried out with an additional consideration of industrial input-output linkages. This kind of researches includes Braunerhjelm and Carlsson (1999), Department pf Trade and Industry (2001), Porter and Monitor Group (2001) and Min and Kim (2003).

The study of industrial cluster identification is to discover a set of industries having a similar input-output structure as an industrial group by applying principal factor analysis in the national input-output tables. This method attempts to emphasize complementary industrial relationships such as the production of complementary products and the use of joint supplies rather than vertical relationships of inter-industry forward and backward linkages (Latham, 1976). The identification of industrial clusters can be evaluated as a significant work in the complementary relationships among industries may be a source of generating external economies of scale for firms and internal economies of scale for industries (OhUallachain, 1984).

In Korea, this kind of research has recently been implemented by SERI and ITEP (2004) and Choi et al. (2005). The former identified around 40 industrial clusters with help of factor analysis on industrial output coefficients with 347 sectors excluding 57 sectors out of the 404 sectors of the 2000 National Input-Output Tables, while the latter discovered 11 industrial clusters with a focus of 258 manufacturing sectors and investigated the degree of regional specialization of these industrial clusters identified in Busan. Both studies can be highly assessed as the first attempt to comprehend the identification of clusters in Korea. However, SERI and ITEP (2004) identified industrial clusters with an output coefficient to emphasize the market-oriented nature of industrial clusters, whist, in the work of Choi et al. (2005), it was not evident what type of industrial linkages was employed. According to Feser and Bergman (2000), four types of industrial linkages[3] can be produced from a pair of industries; the results of the identification of industrial clusters can be differentiated by the type of industrial linkages employed. In this regard, existing studies in Korea have not considered fully the potentiality of multiple industrial linkages. In particular, SERI and ITEP (2004) ignored the similarity of input structure reflecting technological configuration and similarity between input and output structures. What is more, since both studies lacked the analysis of industrial clusters identified, i.e. the role and significance of an individual industry within the industrial cluster, some limitations are evident in the application of policy.

Ⅲ. The procedure of analysis and methods

In order to identify industrial clusters and analyze changes in linkages and network within identified clusters, the following three steps are taken. In the first stage, the input and output coefficients of an individual industry are obtained by using recently published input-output tables and then the input matrix is produced, composed of a maximum value of the correlation coefficients generated by the analysis of correlation among four types of input-output coefficients. The Second step is to draw common properties by applying factor analysis in the input matrix and then to identify industrial clusters consisting of highly inter-related industries. The final step is to examine

[3] This will be discussed in detail in the following section.

changes not only in linkages structure and nodal industries within identified clusters but also in their economic performance in terms of value-added, exports and imports drawing upon social network analysis (SNA).

1. Generating the input matrix of correlation coefficients using I-O tables

An intermediate input matrix (Z) representing inter-industry links in a national input-output table provides core information in the identification of industrial clusters Each element (z_{ij}) in a detailed inter-industry transaction (Z) matrix provides the value of goods and services sold by row industry *i* to column industry *j*. Given, for each industry, total intermediate goods purchases ($Z_j = \sum_{i=1}^{n} z_{i,j}$) and sales ($Z_i = \sum_{j=1}^{n} z_{i,j}$), purchase and sales coefficients between any two industries, *i* and *j*, respectively representing forward and backward linkages can be derived:

$$a_{ij} = \frac{z_{ij}}{Z_j}, \quad b_{ij} = \frac{z_{ij}}{Z_i}$$

Where a_{ij} specifies intermediate good purchases by *j* from *i* as a share of *j*'s total intermediate good purchases, a large value for a_{ij} suggests that industry *j* depends upon industry *i* as a source for a large share of its total intermediate inputs. On the other hand, b_{ij} indicates intermediate goods sales from *i* to *j* as a proportion of industry *i*'s total intermediate good sales. A large value for b_{ij} shows that industry *i* depends upon industry *j* as a market for a large portion of its total intermediate good sales. Each coefficient is an indicator of dependence between *i* and *j* in terms of relative purchases and sales linkages.

Capitalizing upon these purchasing and sales coefficients across multiple industries, industrial linkages between any two industries, *i* and *j* may be measured through correlation analysis. Four correlations depict the similarities in input-put structure between two industries:

$c(a_{.i}, a_{.j})$: the degree to which *i* and *j* have similar input purchasing patterns.

$c(b_{i.}, b_{j.})$: the degree to which *i* and *j* have similar output sales patterns.

$c(a_{.i}, b_{j.})$: the degree to which the purchasing pattern of *i* is similar to the sales pattern of *j*, i.e. the degree to which *i* purchases inputs from industries where *j* supplies.

$c(b_{i.}, a_{.j})$: the degree to which the sales pattern of *i* is similar to the purchasing pattern of *j*, i.e. the degree to which *j* purchases inputs from industries where *i* supplies

If relating these four types of functional relationships to inter-industry relationships defined by ÓhUallacháin (1984), $c(a_{.i}, a_{.j})$ means the similarity in terms of using inter-industrial joint supplies, $c(b_{i.}, b_{j.})$ of producing basic products, and $c(a_{.i}, b_{j.})$ and $c(b_{i.}, a_{.j})$ of forward and backward vertical relationships.

The results of analysis on industrial clusters can be differentiated by the choice of input matrix, because different input matrices tend to emphasize different types of inter-industry linkage. In this paper, factor analysis will be performed relying upon a matrix of correlation coefficients which consist of the maximum correlations among the purchases and sales coefficients for each pair of industries in the national input-output table, which have been much used by Czamanski (1971, 1974), Czamanski and Ablas (1979), Bergman and Feser (1999), Feser and Bergman (2000) and so on. The values in the correlation matrix are drawn from so that:

$$c_{ij} = c_{ji} = \max\left[c(a_{.i}, a_{.j}), c(b_{i.}, b_{j.}), c(a_{.i}, b_{j.}), c(b_{i.}, a_{.j})\right]$$

Where the *a* and *b* values are inter-industrial purchases and sales coefficients respectively. This input matrix is a symmetry matrix composed of the strongest linkages among the purchases and sales coefficients for each pair of industries. Using such an input matrix, since all the purchases and sales coefficients for each pair of industries can be taken into accounts at the same time, it may be avoided that only specific aspect of the purchases and sales coefficients for each pair of industries is *ex ante* highlighted. Sometimes, it has, however, a difficulty with interpreting industrial clusters.

2. Implementing factor analysis

The method of factor analysis has been performed to extract potential common factors from multivariate data. Applying this method to the input matrix derived above, the extraction of common factors as a measure on the identification of industrial clusters can be performed. This method provides a means of reducing multiple and complex inter-industrial relationships through the extraction of common factors. In brief, the method consists of solving the following equation for $\mathbf{a}_p$: $(\mathbf{Z'Z} - \lambda_p\mathbf{I})\mathbf{a}_p = 0$, where the λ_p's are the characteristic roots or eigenvalues of $\mathbf{Z'Z}$, the matrix of correlations among the empirical variables, and the $\mathbf{a}_p$'s are the related eigenvectors. The number of eigenvalues is equal to the number of variables, and for each eigenvalue an eigenvector is obtained. Here some decision rules have to be followed in order to identify which subset of factors should form the basis for cluster identification. Typically a large proportion of the variation in these matrices is accounted for by a subset of factors. A number of criteria have been suggested to determine the number of components to retain. These include factors accounting for 90% of the variation, or factors associated with eigenvalues greater than 1.0.

In practice, it has been thought to be useful to scale the matrix of eigenvectors by the square roots of the related eigenvalues. Once the decision regarding the number of factors to extract is obtained, those factors are often rotated to maximize the variation in the factor loadings. The varimax rotation of those eigenvectors with eigenvalues higher than unity is widely accepted and is used in this paper. This can to a great extent help the assignment of industries to individual clusters. Once the factors are extracted and/or rotated, the composition of each cluster is determined. Generally, this is based on the correlations of each industry with each factor, as represented in the factor loadings matrix. Although a number of approaches have been adopted at this stage, this paper accepts Feser and Bergman (2000)'s strategy assuming that an industrial cluster is composed of two types of industries: primary industries with factor loadings above 0.60 and secondary industries that reach factor loadings on the cluster between 0.35 and 0.60.

3. Analyzing linkages and network within the industrial cluster identified

In order to understand linkages and networks within identified clusters, social network analysis has been usually used (Feser and Bergman, 2000). The social network analysis permits the relationships among the elements of a matrix to be quantitatively illustrated based upon a Boolean matrix. The pattern of industrial linkages within the cluster is much more difficult to recapitulate. It would be actually difficult to present the most comprehensive picture within the cluster. For the convenience of analysis, when transforming the pattern of intra-cluster linkages into a Boolean matrix possessing a value of 0 or 1 through the application of a certain rule, it would be much easier to recognize the pattern of linkages within the cluster. Using purchasing and sales coefficients derived from the national input-output table, the value of cut-off could be set. The lower the threshold, the more linkages shown and the more difficult to understand the summary graphic becomes (Feser and Bergman, 2000). Thus, in order to generate the map, a significant proportion of linkages have been defined as one which meets or exceeds the 90^{th} percentile considering intra-cluster mean and median linkages in this paper.

In the graphic pattern of purchasing linkages, the direction of the arrow between industries *i* and *j* describes that industry *j* buys a significant proportion of its inputs (the 90^{th} percentile in this paper) from industry *i*, whilst the direction of the arrow between industries *i* and *j* indicates that industry *i* sells a significant proportion of its outputs to industry *j* in the graphic pattern of sales linkages. Although the cut-off of a significant proportion is possibly somewhat arbitrary, it does mirror the skewed distribution of actual linkages. Also, note that the length of the arrow is not associated with magnitude.

In the social network analysis, calculating the index of degree centrality which means the degree to which an individual sector is located around the center of an intra-cluster, it may be possible to illustrate the role of an industrial sector and to identify a node industry within the cluster. In order to gauge properly the degree to which inter-industrial links are formed with the cluster, the direction of the arrow as well as inter-relationships with the cluster should be considered. Due to this reason, the index of degree centrality has two types of an in-degree and out-degree:

The index of in-degree centrality ($W_{i+,\ k}$) = $\sum_{j=1}^{n} W_{ijk}$

The index of out-degree centrality ($W_{j+,\ k}$) = $\sum_{i=1}^{n} W_{ijk}$

Where W_{ijk} indicates any links between industry i and industry j in the network of links with the number of industries k, the total of links is ${}_kC_2$ = k(k-1). In such a network, the out-degree index shows the number of any links with the direction of the arrow from i towards j (i→), while the in-degree index indicates the number of any links with direction of the arrow to i from j (i←).

These indexes of degree centrality can be interpreted as follows:

1) where both of an in-degree and out-degree index are higher than zero, acting as a mediator in the network in question.

2) where an in-degree index is equal to zero, but an out-degree index more than zero, acting as a messenger in the network in question.

3) where an out-degree index is equal to zero, but an in-degree index more than zero, acting as a receiver in the network in question.

4) where both of an in-degree and out-degree index are equal to zero, resulting in a self-contained island in the network in question.

Relating these cases identified above to the pattern of inter-industrial linkages, the first case as a mediator means an intermediate supplier to other industries through inter-industrial linkages within the industrial cluster, the second as a messenger indicates a supplier providing parts and materials, the third as a receiver shows the role of producing final goods and markets through assembly and processing. The final case as a self-contained island may be thought not to play a significant role in inter-industrial linkages.

Ⅳ. Using Data and results

1. Using Data

The data for analysis are the 1995-2000-2005 linked Input-Output Tables of producer transactions which have been published by the Bank of Korea. Since this linked I-O table has consistency in statistics-makings and industrial classifications over time, it is very useful to compare changes in some characteristics of identified clusters over time.

For the ease of interpretations and convenience of analysis, only the 220 manufacturing sectors have been selected out of 350 basic industrial classification sectors. Specifically, food and beverages have been integrated into a large-sized classification sector. Thus, the 193x193 manufacturing sectors’ intermediate input matrix has been utilized in this paper.

An identification of clusters will be undertaken in terms of I-O table of 2005 and industrial linkages and their characteristics within the individual cluster identified will be compared for two temporal points of 1995 and 2005. In particular, the period 1995-2005 seems to be very special to Korea. In other words, since it contains the event of financial crisis in 1997, conceived as the period of restructuring by external shocks, that period seems to very important for understand how much manufacturing has been restructured.

2. Industrial clusters identified by factor analysis

When carrying out factor analysis on the input matrix whose elements are composed of the maximum values of four correlation coefficients generated by using 2005 input-output tables, as shown in Table 1, twenty-eight industrial clusters have been extracted.

Since this paper focuses upon investigating inter-industry linkages structure and node industries within the industrial clusters identified rather than upon counting the number of industrial clusters, attentions are mainly directed to exploring multi industry clusters which consist of relatively multiple industries instead of excluding single-industry clusters with a few of industries. Multi-industry clusters consist of two types of industries: the first type can be referred as primary industries whose factor loading values are higher than 0.6; while the second type as secondary industries with the values of factor loading ranging from 0.35 to 0.6, as with existing studies (Fesser and Bergman, 2000). Furthermore, we have just selected multi-industry clusters when the number of industries comprising industrial clusters is more than 5, although rather arbitrary. Given these criteria, multi-industry clusters have been identified as twenty-two.

It appears that automotives, shipbuilding, IT, chemicals, textiles industrial clusters have played a significant role in the Korean manufacturing industries. Besides, components and parts-related industrial clusters have been drawn involving food, beverages and sundries, Petroleum refinery products for construction, iron and steel, wood products, home appliances, automotive parts, machinery of special purpose, electronic machinery equipment and so on. In particular, automotives industrial cluster has been identified as the first one having the highest eigenvalue, and automotive parts industrial cluster including tires and tubes, motor vehicle engines has also been investigated as an independent industrial cluster. Likewise, the shipbuilding cluster has the second highest eigenvalue and iron and steel has been identified as an industrial cluster. Also the IT cluster has the third highest eigenvalue and electronic machinery equipment has been identified as an industrial cluster. In this regard, it is recognized that assembly and processing industries occupy a significant portion in the Korean manufacturing industries.

Table 1. Summary Results: factor analysis

Factor	Interpritation	Initial		Rotation	
		Eigenvalue	% of Variance	Sums of Squared Loadings	% of Variance
1	Automotives	33.91	17.57	18.54	9.61
2	Shipbuilding	22.29	11.55	18.38	9.52
3	IT	17.72	9.18	17.79	9.22
4	Textiles	12.97	6.72	14.22	7.37
5	Chemicals	11.17	5.78	13.16	6.82
6	Food, beverages and sundries	8.59	4.45	8.33	4.31
7	Petroleum refinery products for construction	7.63	3.95	8.15	4.22
8	Iron and steel	5.78	2.99	6.97	3.61
9	Wood products	4.99	2.59	6.36	3.30
10	Home appliances	4.85	2.51	5.91	3.06
11	Automotive parts	4.39	2.28	5.00	2.59
12	Machinery of special purpose	3.87	2.01	4.84	2.51
13	Electronic machinery equipment	3.47	1.80	4.36	2.26
14	Printing and publishing	3.07	1.59	3.99	2.07
15	Paper	2.99	1.55	3.95	2.05
16	Leather and fur	2.90	1.51	3.89	2.02
17	Plastic products	2.39	1.24	3.63	1.88
18	Glass products	2.11	1.10	2.66	1.38
19	Nonferrous metals	2.07	1.07	2.52	1.31
20	Knitted products	1.90	0.98	2.41	1.25
21	Cement and concretes	1.83	0.95	2.33	1.21
22	Nonmetallic minerals	1.72	0.89	2.19	1.13
23	Jewelry and plated ware	1.57	0.82	2.16	1.12
24	Fertilizers	1.45	0.75	2.13	1.10
25	Batteries	1.38	0.71	1.80	0.93
26	Other petroleum refinery products	1.26	0.65	1.74	0.90
27	Cut stone	1.15	0.60	1.58	0.82
28	Paper products	1.07	0.55	1.49	0.77

3. Industrial linkage network analyzed within the most significant industrial clusters identified

Attempts have been made to explore inter-industry linkage networks, mainly focusing upon automotives, shipbuilding and IT industrial clusters which have significant portions in the Korean manufacturing industries as mentioned earlier.

Automotives industrial cluster

Looking at the characteristics of the automotives cluster, it is comprised of nineteen primary and thirteen secondary industries totaling thirty-two industrial sectors. As indicated in Figure 1, the following industries play a central role in purchasing and sales industrial linkage network in the automotives cluster: motor vehicle engines (176), treatment and coating of metals (128), valves (130), industrial plastic products (80), metal molds and industrial patterns (142), filtering or purifying machinery for liquid and gases (135), passenger automobiles (173) and so on.

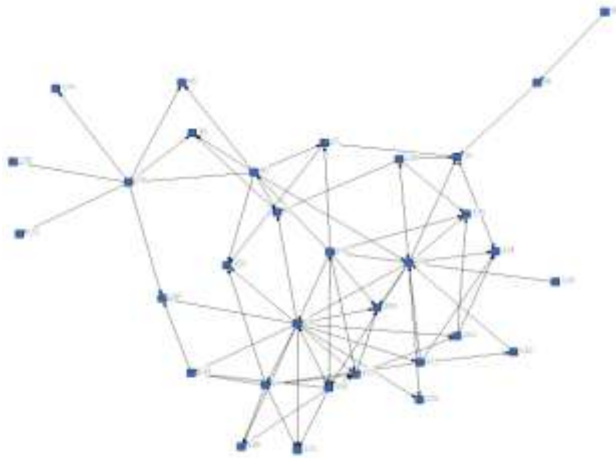
Capitalizing upon the index of degree centrality, let us explore node industries within the automotives industrial cluster. In the case of purchasing linkage network, analytical weights are put on industries acting as suppliers which provide raw materials and components with other industries. If an industry has a high out-degree index but a low in-degree index, this industry can be regarded as a node industry in the purchasing industrial linkage. In this paper, for the convenience of analysis, we has interpreted as a node industry an industry which has an out-degree index higher than its average but an in-degree index lower than its average. Given this criterion, the following industries have been recognized as node industries in the purchasing industrial linkage of the automotives cluster in 1995: motor vehicle engines (176), industrial plastic products

(80), fabricated wire products (126), metal molds and industrial patterns (142), misc. primary iron and steel products (111), motors and generators (144), and in 2005: motor vehicle engines (176), iron foundries and foundry iron pipe and tubes (108), industrial plastic products (80), fabricated wire products (126), metal molds and industrial patterns (142) misc. primary iron and steel products (111).

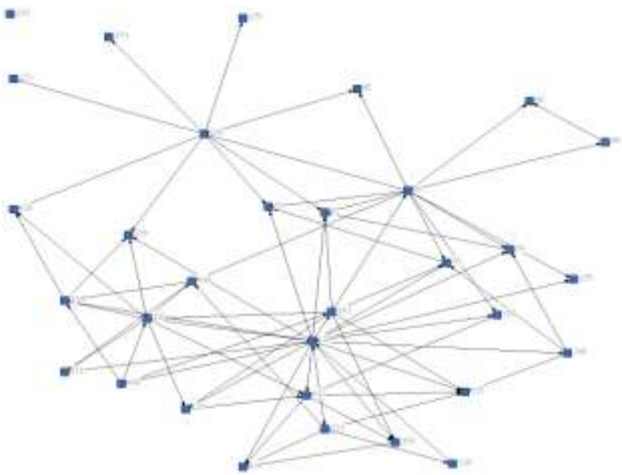
Especially, the out-degrees index of industrial plastic products (80), metal molds and industrial patterns (142) and motor vehicle engines (176) are relatively high and increasing both 1995 and 2005. These are playing a key role as a supplier and their role is becoming stronger than before. On the other hand, in the sales industrial linkage network, an analytical focus is paid to industries responsible for production and sales markets for final goods. Similarly in the purchasing industrial linkage network, a node industry can be recognized if it has an in-degree index higher than its average but an out-degree index lower than its average. Given this rule, the following industries have been identified as node industries in 1995 and 2005, same five industries: passenger automobiles (173), motor vehicle engines (176), construction and mining machinery (139), conveyors and conveying equipment (131), and filtering or purifying machinery for liquid and gases (135). Since the in-degree indexes of motor vehicle engines (176) and passenger automobiles (173) are very high, it can be said that they have played a core role as producers and sales market for final goods. In particular, motor vehicle engines (176) have been evaluated as node industries in both purchasing and sales industrial linkages network, it can be argued that motor vehicle engines (176) plays a pivotal role as producers and sales market for final goods as well as suppliers.

a) Purchasing industrial linkage network

<1995>

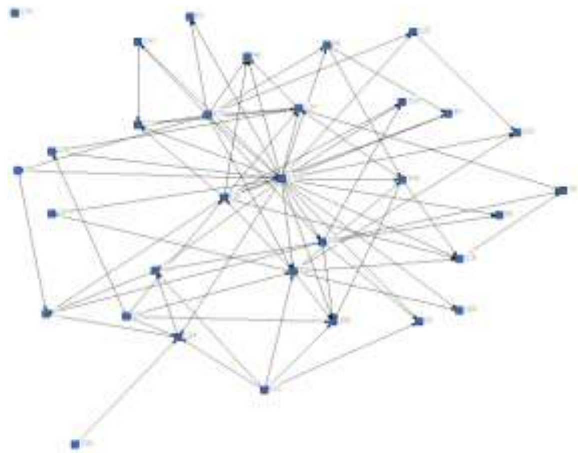


<2005>



b) Sales industrial linkage network

<1995>



<2005>

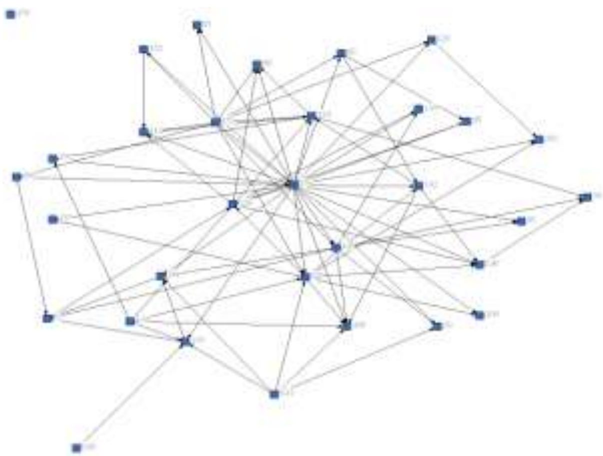


Figure 1. Automovites industrial cluster’s inter-industry linkage network

We analyzed the economic position of the automotives cluster and its changes for 1995-2005 comprised of a total of 32 industries and 11 nodal industries. The level of import dependency of intermediate goods increased from 16.9% in 1995 to 12.3% in 2005 as a whole, the ratio of export to output increased from 18.4% to 21.9% during the same period and the portion of value added in manufacturing expanded from 22.3% in 1995 and 23.4% in 2005. Particularly, the level of import dependency of intermediate goods for nodal industries decreased from 16.4% to 9.4% during the same period, the ratio of export to output increased from 19.8% to 29.3% and the portion of value added in manufacturing increased from 14.1% in 1995 and 15.1% in 2005. The level of import dependency of intermediate goods and the ratio of export to output are higher than the average of manufacturing: 28.7% for the latter; 28.6% for the former in 2005. Given these fact, industrial linkages structure has been upgraded in the last decade, its economic impact has also gradually increased. However, some major parts such as aluminum products have still very high level of import dependency.

Table 2. Automotives industrial cluster's degree centrality and its status quo in the total manufacturing

industry	Purchasing linkages				Sales linkages				Dependency of intermediate imports(%)		Export / Gross output(%)		Value-added Share in Manufactring(%)	
	1995		2005		1995		2005							
	Out-deg.	In-deg.	Out-deg.	In-deg.	Out-deg.	In-deg.	Out-deg.	In-deg.	1995	2005	1995	2005	1995	2005
Buses and vans(174)	0	1	0	1	0	0	0	0	12.5	11.8	22.1	31.6	0.4	0.2
Trucks(175)	0	1	0	1	1	2	1	1	16.1	10.3	11.1	26.7	0.8	0.3
Passenger automobiles(173)	**0**	**1**	**0**	**1**	**0**	**11**	**0**	**10**	**16.7**	**12.6**	**32.1**	**30.9**	**4.7**	**3.6**
Industrial rubber products(83)	2	4	2	5	2	0	3	1	23.4	14.4	14.3	25.6	0.4	0.6
Bolts, nuts, screws, rivets, and washers(125)	0	4	0	5	2	1	3	1	5.5	6.8	1.6	1.1	0.3	0.3
Misc. electric equipment and supplies(150)	1	5	2	3	3	2	3	1	15.2	17.9	50.9	29.5	0.3	0.4
Motor vehicle engines(176)	**7**	**2**	**9**	**2**	**3**	**24**	**2**	**26**	**12.4**	**10.1**	**33.3**	**43.0**	**3.4**	**4.5**
Asbestos and mineral wool products(95)	2	1	2	2	3	1	3	1	17.8	21.3	3.2	7.4	0.0	0.0
Iron foundries and foundry iron pipe and tubes(108)	**7**	**4**	**4**	**3**	**6**	**0**	**6**	**0**	**11.1**	**7.7**	**16.4**	**31.7**	**0.3**	**0.2**
Agricultural implements and machinery(138)	1	4	1	4	1	2	1	2	21.7	16.0	4.7	15.8	0.3	0.1
Forgings(109)	1	4	1	3	2	0	2	0	3.5	13.4	24.4	26.5	0.2	0.2
Industrial plastic products(80)	**8**	**2**	**12**	**2**	**3**	**3**	**3**	**3**	**16.2**	**13.8**	**9.9**	**15.5**	**1.6**	**2.7**
Knitted clothing accessories(20)	1	4	1	5	3	0	4	1	21.6	9.1	79.1	61.0	0.1	0.1
Valves(130)	14	6	8	4	5	8	5	8	14.0	13.3	10.4	7.1	0.7	0.7
Industrial pottery products(87)	2	4	0	5	6	1	2	0	11.7	6.1	36.8	55.2	0.4	0.1
Primary aluminium products(118)	2	1	1	1	4	1	4	1	65.1	66.5	32.2	3.9	0.4	0.3
Steel rods and bars(102)	3	2	3	4	3	0	4	0	9.4	2.5	0.3	0.3	0.5	0.6
Pumps and compressors(134)	2	4	3	5	5	3	5	3	27.7	11.9	18.8	23.3	0.3	0.4
Handtools(124)	1	4	0	4	5	3	4	3	19.4	22.2	6.0	7.2	0.2	0.2
Treatment and coating of metals(128)	10	6	20	4	4	8	4	11	12.3	5.1	8.1	4.5	1.2	2.3
Abrasives(96)	2	2	1	3	5	1	5	1	13.1	12.5	0.0	0.0	0.0	0.0
Construction and mining machinery(139)	**1**	**3**	**1**	**5**	**1**	**6**	**1**	**4**	**34.0**	**15.4**	**20.7**	**35.2**	**0.6**	**0.5**
Coated steel plates(110)	3	2	3	2	3	2	5	2	12.4	10.6	17.9	18.9	0.5	0.7
Fabricated wire products(126)	**5**	**2**	**5**	**2**	**5**	**2**	**3**	**2**	**15.6**	**5.8**	**17.5**	**20.1**	**0.4**	**0.6**
Metal molds and industrial patterns(142)	**8**	**3**	**9**	**3**	**4**	**4**	**4**	**5**	**6.7**	**3.1**	**14.7**	**24.5**	**0.5**	**0.9**
Misc. primary iron and steel products(111)	**5**	**3**	**5**	**2**	**5**	**0**	**4**	**1**	**0.7**	**0.4**	**19.5**	**25.3**	**0.5**	**0.4**
Newspapers(45)	1	3	1	3	4	1	4	1	13.4	3.9	6.5	6.2	0.8	0.2
Metal forming machine tools(137)	3	5	2	4	3	1	3	1	14.2	9.1	9.7	24.1	0.2	0.2
Motors and generators(144)	**6**	**3**	**3**	**4**	**5**	**2**	**5**	**1**	**27.1**	**14.7**	**25.9**	**56.6**	**0.4**	**0.4**
Conveyors and conveying equipment(131)	**1**	**4**	**1**	**4**	**1**	**6**	**1**	**5**	**27.1**	**10.1**	**16.7**	**15.9**	**0.9**	**0.7**
Wooden containers(34)	3	5	2	4	3	0	6	0	9.7	5.4	12.9	3.2	0.2	0.2
Filtering or purifying machinery for liquid and gases(135)	**1**	**4**	**1**	**3**	**3**	**8**	**3**	**7**	**12.8**	**9.2**	**10.9**	**24.0**	**0.8**	**0.8**
Average(or Total)	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	16.9	12.3	18.4	21.9	(22.3)	(23.4)
Node industries(#), average(or(Total)	6 (176, 80, 126, 142, 111, 144)		6 (176, 108, 80, 126, 142, 111)		5 (173, 176, 139, 131, 135)		5 (173, 176, 139, 131, 135)		16.4	9.4	19.8	29.3	(14.1)	(15.1)

Shipbuilding industrial cluster

The shipbuilding industrial cluster consists of a total of thirty-eight industries including eighteen primary and twenty secondary industries. Figure 3 shows a hierarchical industrial linkage structure typically representing the nature of shipbuilding industries. In the automotive cluster, the following industries form an important industrial linkage structure: steel ships (178), metal products for structure (121), steel pipe and tubes, except foundry iron pipe and tubes (106), misc. primary iron and steel products (111), conveyors and conveying equipment (131), metal molds and industrial patterns (142), construction and mining machinery (139), printing machinery (143), air-conditioning equipment and industrial refrigeration equipment (132) and so on.

Looking in detail at the industrial linkage network, the following industries have been identified as node industries for the purchasing industrial linkage network in 1995: steel pipe and tubes, except foundry iron pipe and tubes (106), cold rolled steel sheet, strip, and bars (107), misc. primary iron and steel products (111), internal combustion engines and turbines (129), industrial automatic regulators (170), metal molds and industrial patterns(142), fabricated wire products (126), paints, varnishes, and allied products (73); and in 2005: steel pipe and tubes, except foundry iron pipe and tubes(106), misc. primary iron and steel products (111), industrial automatic regulators (170), metal molds and industrial patterns (142), valves (130), coated steel plates(110). For purchase linkage network, in particular steel related products have continued to play a key role as supplier such as steel pipe and tubes, except foundry iron pipe and tubes (106), misc. primary iron and steel products (111).

While for the sales industrial linkage structure in 1995, steel ships (178), metal products for structure (121), boiler (133), conveyors and conveying equipment (131), metal cutting type machine tools (136), construction and mining machinery (139), printing machinery (143), air-conditioning equipment and industrial refrigeration equipment (132) are identified as node industries, and in 2005 steel ships (178), metal products for structure (121), other ships (179), conveyors and conveying equipment(131), construction and mining machinery (139), printing machinery (143), air-conditioning equipment and industrial refrigeration equipment (132). For sales industrial linkage structure, steel ships (178), metal products for structure (121) have played a pivotal role as the production of final goods and market.

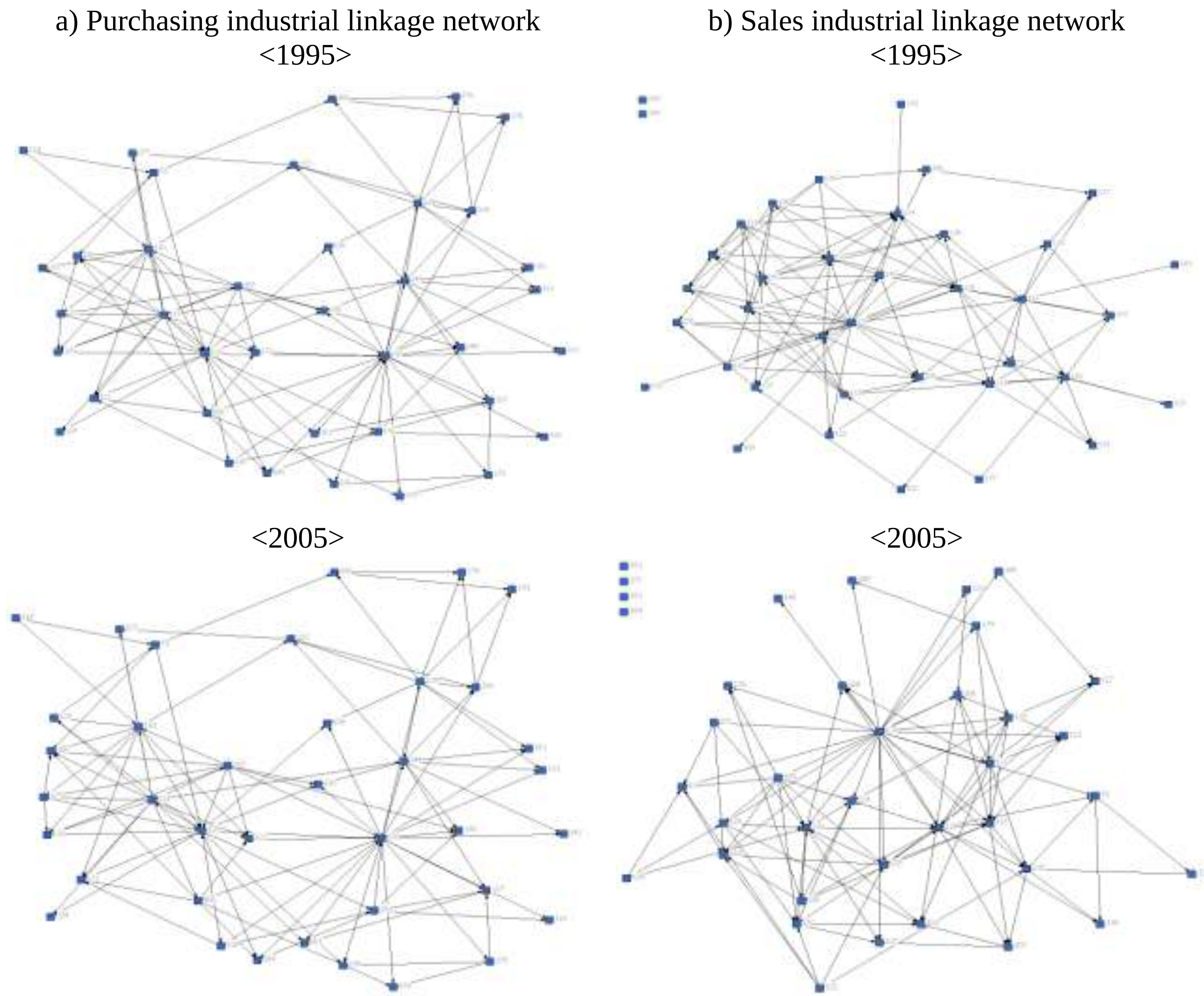


Figure 2. Shipbuilding industrial cluster's inter-industry linkage network

In the case of shipbuilding cluster, nodal industries are relatively more than that of auto cluster in both purchase and sales linkages network, while these have decreased over time and substituted for other industries. In 1995 and 2005 a total of nodal industries was identified in purchase and sales linkages network. For purchase linkages network, four industries identified as a nodal industry in 1995 dropped out from nodal industries in 2005 involving cold rolled steel sheet, strip, and bars (107), internal combustion engines and turbines (129), fabricated wire products (126), paints, varnishes, and allied products (73) and two new industries valves (130), coated steel plates (110) were identified as a nodal industry. On the other hand, in the case of sales linkage network, boiler (133) and metal cutting type machine tools (136) identified as a nodal industry in 1995 dropped out in 2005. Instead, other ships (179) was identified as a new nodal industry. Such changes in these linkages networks reflect the modularization of production system in shipbuilding industry, while sales has recently been diversified into a variety of products.

During the period 1995-2005, the level of import dependency of intermediate goods has decreased from 20.1%, 20.7% to 16.4%, 16.1% respectively for the average of the cluster and nodal industries, while the ratio of export to total output sharply increased from 17.7%, 14.7% to 25.7%, 21.2% respectively for the average of the cluster and nodal industries. In addition, the ratio of value-added in manufacturing increased from 18.9%, 12.7% to 20.7%, 13.6% respectively for the average of the cluster and nodal industries. The shipbuilding cluster has gained higher economic impact and upgraded in terms of linkage effects in the last decade. However, the level of import dependency is still higher than expected in major nodal industries with high portion of exports involving cold rolled steel sheet, strip, and bars (107), steel ships (178), other ships

(179), paints, varnishes, and allied products (73), internal combustion engines and turbines (129), industrial automatic regulators (170). This implies that its relatively less economic impacts have had on economy as whole and other industries. Thus, for sustainable growth in this industry, it is important to enhance the ratio of local contents.

Table 3. Shipbuilding industrial cluster's degree centrality and its status quo in the total manufacturing

industry	Purchasing linkages				Sales linkages				Dependency of intermediate imports(%)		Export / Gross output(%)		Value-added Share in Manufactring(%)	
	1995		2005		1995		2005							
	Out-deg.	In-deg.	Out-deg.	In-deg.	Out-deg.	In-deg.	Out-deg.	In-deg.	1995	2005	1995	2005	1995	2005
Metal tanks and reservoirs for equipment(122)	1	6	1	5	3	2	4	3	7.1	7.5	16.5	32.6	0.1	0.2
Steel ships(178)	**0**	**3**	**0**	**4**	**0**	**21**	**0**	**23**	**35.1**	**37.9**	**31.4**	**63.0**	**1.6**	**2.3**
Ship repairing and ship parts(180)	3	3	3	4	2	1	3	1	14.4	11.8	16.0	40.4	0.2	0.2
Metal products for structure(121)	**1**	**6**	**3**	**4**	**3**	**11**	**3**	**10**	**10.1**	**10.0**	**16.3**	**12.8**	**1.6**	**1.2**
Other ships(179)	**0**	**3**	**0**	**4**	**1**	**0**	**2**	**4**	**3.0**	**34.3**	**11.6**	**18.8**	**0.1**	**0.1**
Steel pipe and tubes, except foundry iron pipe and tubes(106)	**6**	**3**	**8**	**2**	**7**	**2**	**6**	**3**	**12.4**	**11.9**	**1.2**	**0.6**	**0.4**	**0.4**
Boiler(133)	**1**	**4**	**1**	**5**	**2**	**5**	**2**	**2**	**10.9**	**7.6**	**20.1**	**7.8**	**0.7**	**0.3**
Trailers and containers(177)	1	4	1	4	1	3	1	1	25.4	10.5	84.9	54.3	0.2	0.0
Cold rolled steel sheet, strip, and bars(107)	**10**	**1**	**6**	**5**	**5**	**1**	**3**	**2**	**37.8**	**38.9**	**5.0**	**11.6**	**0.7**	**0.7**
Metal products for construction(120)	0	5	0	5	3	3	4	5	6.7	5.9	61.4	47.3	0.3	0.4
Misc. primary iron and steel products(111)	**14**	**2**	**14**	**2**	**6**	**3**	**7**	**3**	**0.7**	**0.4**	**19.5**	**25.3**	**0.5**	**0.4**
Internal combustion engines and turbines(129)	**10**	**3**	**4**	**4**	**6**	**3**	**4**	**4**	**39.8**	**19.4**	**27.0**	**57.8**	**0.3**	**0.4**
Filtering or purifying machinery for liquid and gases(135)	1	5	2	4	5	9	4	6	12.8	9.2	10.9	24.0	0.8	0.8
Fastening metal products(127)	2	4	3	6	3	0	5	1	7.1	5.6	8.7	14.8	0.2	0.2
Steel ingots and semifinished products(101)	2	4	2	4	2	2	7	1	25.3	30.8	26.3	59.3	1.2	1.1
Metal furniture(186)	0	6	1	7	3	2	2	2	4.2	2.7	10.1	6.2	0.1	0.1
Metal forming machine tools(137)	2	5	2	5	5	2	5	1	14.2	9.1	9.7	24.1	0.2	0.2
Treatment and coating of metals(128)	13	6	29	6	8	7	8	11	12.3	5.1	8.1	4.5	1.2	2.3
Conveyors and conveying equipment(131)	**1**	**4**	**1**	**4**	**2**	**7**	**2**	**4**	**27.1**	**10.1**	**16.7**	**15.9**	**0.9**	**0.7**
Textile machinery(141)	1	3	1	4	1	2	1	1	21.0	25.9	14.0	23.0	0.4	0.1
Motors and generators(144)	9	4	5	4	8	1	8	1	27.1	14.7	25.9	56.6	0.4	0.4
Industrial automatic regulators(170)	**4**	**2**	**6**	**2**	**6**	**1**	**4**	**1**	**17.2**	**18.6**	**21.3**	**36.9**	**0.5**	**0.6**
Handtools(124)	1	3	1	3	9	0	8	1	19.4	22.2	6.0	7.2	0.2	0.2
Metal cutting type machine tools(136)	**2**	**4**	**1**	**4**	**3**	**5**	**4**	**5**	**24.9**	**7.3**	**16.9**	**18.5**	**0.5**	**0.5**
Metal molds and industrial patterns(142)	**6**	**3**	**6**	**3**	**6**	**5**	**6**	**5**	**6.7**	**3.1**	**14.7**	**24.5**	**0.5**	**0.9**
Valves(130)	**19**	**6**	**15**	**3**	**7**	**7**	**8**	**8**	**14.0**	**13.3**	**10.4**	**7.1**	**0.7**	**0.7**
Pumps and compressors(134)	5	4	3	4	6	3	6	2	27.7	11.9	18.8	23.3	0.3	0.4
Railroad vehicles and parts(181)	1	4	1	2	1	2	1	1	38.8	32.1	4.0	14.7	0.2	0.1
Bicycles and parts and misc. transportation equipment(184)	1	5	1	5	1	1	1	1	16.1	24.7	45.0	93.5	0.0	0.0
Construction and mining machinery(139)	**1**	**4**	**1**	**5**	**1**	**6**	**1**	**4**	**34.0**	**15.4**	**20.7**	**35.2**	**0.6**	**0.5**
Fabricated wire products(126)	**5**	**2**	**3**	**2**	**6**	**1**	**5**	**1**	**15.6**	**5.8**	**17.5**	**20.1**	**0.4**	**0.6**
Food processing machinery(140)	1	5	1	6	1	1	2	1	7.6	3.4	10.3	15.0	0.1	0.0
Printing machinery(143)	**1**	**3**	**1**	**3**	**3**	**8**	**1**	**11**	**24.0**	**16.1**	**1.7**	**14.2**	**0.7**	**1.6**
Metal cans, barrels, and drums(123)	1	3	1	3	2	2	1	1	28.6	9.8	13.4	31.4	0.2	0.2
Coated steel plates(110)	**10**	**4**	**10**	**2**	**6**	**4**	**7**	**4**	**12.4**	**10.6**	**17.9**	**18.9**	**0.5**	**0.7**
Paints, varnishes, and allied products(73)	**4**	**3**	**3**	**3**	**5**	**3**	**4**	**3**	**43.5**	**29.5**	**1.7**	**4.7**	**0.4**	**0.3**
Air-conditioning equipment and industrial refrigeration equipment(132)	**2**	**5**	**2**	**2**	**2**	**8**	**1**	**6**	**23.6**	**15.2**	**8.2**	**9.1**	**1.2**	**0.8**
Lead and zinc ingots(114)	3	1	2	1	4	1	4	1	54.3	76.1	2.9	1.5	0.1	0.1
Average(or Total)	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	20.1	16.4	17.7	25.7	(18.9)	(20.7)
Node industries(#), average(or(Total)	8 (106, 107, 111, 129, 170, 142, 126, 73)		6 (106, 111, 170, 142, 130, 110)		8 (178, 121, 133, 131, 136, 139, 143, 132)		7 (178, 121, 179, 131, 139, 143, 132)		20.7	16.1	14.7	21.2	(12.7)	(13.6)

IT industrial cluster

Looking at the characteristics of the IT cluster, it is comprised of nineteen primary and eighteen secondary industries totaling thirty-seven industrial sectors. The industrial linkage structure of the chemical industrial cluster, as indicated in Figure 3, exhibits a star type in which the following industries play a central role in the industrial linkage network: integrated circuits (154), capacitors and rectifiers (146), computer and peripheral equipment (164), electric lamps and electric lighting fixtures (149), industrial glass products (85), insulated wires and cables (147), line telecommunication apparatuses (162), misc. chemical products (78), primary copper products (117), printed circuit boards (157), wireless telecommunication apparatuses (163) and so on.

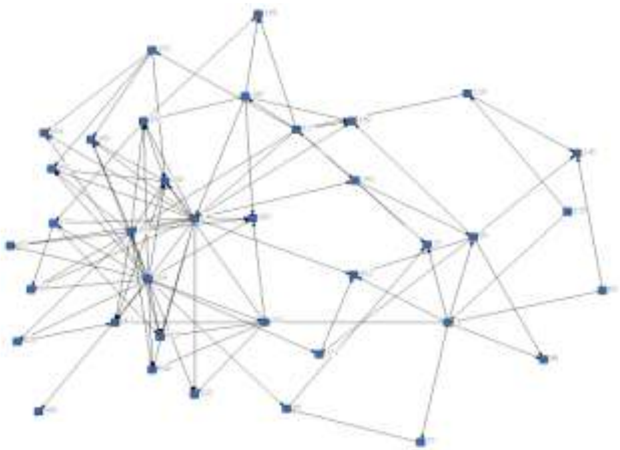
Based on the criterion of identifying node industry, the following industries have been recognized as node industries in the purchasing industrial linkage of the IT cluster in 1995: integrated circuits (154), printed circuit boards (157), semiconductor devices (153), capacitors and rectifiers (146), industrial glass products (85), insulated wires and cables (147), misc. chemical products (78), printing machinery (143), primary copper products (117), and in 2005: printed circuit boards (157), capacitors and rectifiers (146), industrial glass products (85), insulated wires and cables (147), misc. chemical products (78), other nonferrous metal casting and forgings, and primary nonferrous metals (119), primary copper products (117). Especially, since the out-degree index of integrated circuits (154) records the highest value in both 1995 and 2005, it can be said that integrated circuits have played a core role as a supplier.

On the other hand, the following industries have been identified as node industries in 1995: wireless telecommunication apparatuses (163), integrated circuits (154), other audio and visual equipment (161), computer and peripheral equipment (164), line telecommunication apparatuses (162), television (159), capacitors and rectifiers (146), electric lamps and electric lighting fixtures (149), household electric cooking and heating equipment (168); and in 2005: wireless telecommunication apparatuses(163), computer and peripheral equipment (164), line telecommunication apparatuses (162), television (159), printing machinery (143), electric lamps and electric lighting fixtures (149). In particular, the in-degree indexes of wireless telecommunication apparatuses (163) and computer and peripheral equipment (164) are very high.

What is more, since three industries, integrated circuits (154), digital display (152) and capacitors and rectifiers (146), have been evaluated as node industries in both purchasing and sales industrial linkages network, it can be argued that they play a pivotal role as producers and sales market for final goods as well as suppliers.

a) Purchasing industrial linkage network

<1995>



b) Sales industrial linkage network

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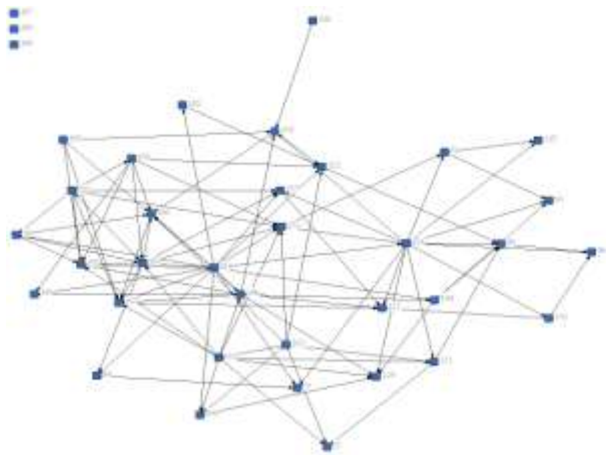

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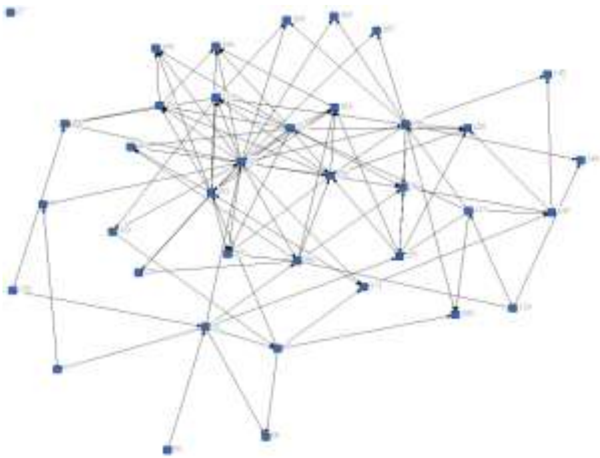

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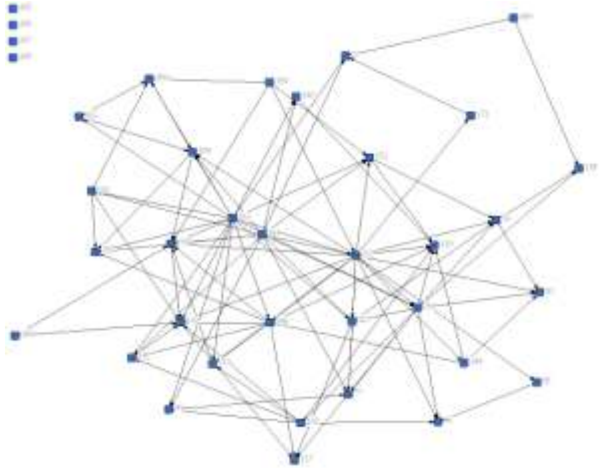

Figure 3. IT industrial cluster's inter-industry linkage network

During the period 1995-2005, the level of import dependency of intermediate goods has increased from 29.2%, 35.1% to 30.6%, 35.6% respectively for the average of the cluster and nodal industries. The ratio of export to total output increased from 27.6%, 28.6% to 25.7%, 38.3% respectively for the average of the cluster and nodal industries. In addition, the ratio of value-added in manufacturing increased from 21.0%, 15.6% to 23.8%, 16.5% respectively for the average of the cluster and nodal industries. It is worthwhile to note five nodal industries decreased including two in the purchase linkages network and three in sales linkages network, the level of import dependency of intermediate goods increased for both the average of the cluster and nodal industries. This means that linkage effects within the IT cluster have been lowered in quantitative and qualitative terms. In particular, some nodal industries with the level of import dependency of intermediate goods such as integrated circuits (154), computer and peripheral equipment (164), other audio and visual equipment (161) still increased from 63.8%, 49.1%, 28.9% to 67.8%, 68.0%, 44.6% respectively. If this could be continued, the sustainable development of IT industry would not be secured. Rather than expanding exports, an effort should be made to capture real competiveness by lowering the level of import dependency.

Table 4. IT industrial cluster's degree centrality and its status quo in the total manufacturing

industry	Purchasing linkages				Sales linkages				Dependency of intermediate imports(%)		Export / Gross output(%)		Value-added Share in Manufactring(%)	
	1995		2005		1995		2005							
	Out-deg.	In-deg.	Out-deg.	In-deg.	Out-deg.	In-deg.	Out-deg.	In-deg.	1995	2005	1995	2005	1995	2005
Wireless telecommunication apparatuses(163)	**1**	**4**	**1**	**5**	**1**	**8**	**1**	**18**	**44.2**	**40.8**	**51.7**	**51.1**	**0.5**	**2.7**
Integrated circuits(154)	**20**	**1**	**20**	**4**	**2**	**14**	**4**	**10**	**63.8**	**67.8**	**14.5**	**15.4**	**7.3**	**5.1**
Printed circuit boards(157)	**5**	**2**	**13**	**2**	**5**	**2**	**5**	**4**	**17.3**	**27.3**	**61.9**	**69.7**	**0.4**	**1.0**
Other audio and visual equipment(161)	**1**	**7**	**2**	**7**	**3**	**8**	**3**	**3**	**28.9**	**44.6**	**3.1**	**16.4**	**0.6**	**0.2**
Computer and peripheral equipment(164)	**1**	**4**	**4**	**5**	**1**	**17**	**1**	**14**	**49.1**	**68.0**	**50.6**	**36.4**	**0.8**	**0.7**
Misc. electronic components(158)	5	7	6	6	4	4	6	3	35.6	39.0	81.0	44.1	0.4	0.3
Line telecommunication apparatuses(162)	**1**	**6**	**1**	**7**	**2**	**10**	**3**	**4**	**33.2**	**29.7**	**18.8**	**18.8**	**0.8**	**0.3**
Semiconductor devices(153)	**7**	**3**	**7**	**4**	**8**	**2**	**5**	**3**	**60.4**	**44.2**	**42.0**	**37.6**	**0.2**	**0.2**
Digital display(152)	0	4	10	5	5	1	4	17	47.1	36.6	16.2	15.8	0.0	3.1
Recording media for electronic equipments(77)	2	2	2	2	4	2	6	1	37.0	46.4	25.9	33.5	0.3	0.1
Television(159)	**2**	**3**	**1**	**4**	**2**	**8**	**1**	**5**	**30.3**	**41.2**	**88.6**	**93.3**	**0.6**	**0.4**
Electric resistors and storage batteries(155)	12	4	5	4	9	1	6	1	35.5	39.4	20.1	25.4	0.3	0.2
Reproduction of recorded media(44)	2	3	0	2	4	2	3	1	22.1	12.9	0.9	0.7	0.1	0.0
Electric coils, transformers(156)	3	5	1	6	8	1	8	1	11.5	8.1	43.3	73.7	0.1	0.1
Office machines and devices(165)	1	2	1	5	2	2	1	1	24.4	33.3	51.4	19.6	0.1	0.1
Batteries(148)	1	4	1	3	4	2	3	2	24.6	22.5	22.6	23.3	0.2	0.3
Cinematograph cameras and projectors(171)	2	3	3	4	4	3	2	2	12.9	26.3	20.0	39.9	0.4	0.4
Electric household audio equipment(160)	0	5	0	5	6	9	5	3	34.8	43.2	29.0	37.0	0.4	0.1
Capacitors and rectifiers(146)	**18**	**3**	**12**	**3**	**3**	**9**	**4**	**8**	**18.8**	**15.3**	**43.9**	**95.9**	**1.2**	**1.5**
Medical instruments and supplies(169)	1	6	1	5	1	1	1	3	12.5	24.4	43.8	39.9	0.1	0.3
Industrial glass products(85)	**6**	**3**	**5**	**3**	**5**	**2**	**2**	**2**	**33.5**	**40.8**	**6.3**	**6.4**	**0.8**	**1.0**
Toys and games(188)	1	6	1	6	1	1	1	1	6.6	11.7	24.8	36.7	0.2	0.1
Industrial automatic regulators(170)	3	4	4	6	5	3	5	2	17.2	18.6	21.3	36.9	0.5	0.6
Insulated wires and cables(147)	6	2	4	3	7	1	9	2	45.6	34.7	11.2	15.8	0.7	0.6
Misc. chemical products(78)	**7**	**3**	**7**	**3**	**3**	**3**	**5**	**3**	**43.5**	**43.5**	**6.4**	**9.9**	**0.3**	**0.4**
Other nonferrous metal casting and forgings, and primary nonferrous metals(119)	**3**	**2**	**4**	**1**	**6**	**1**	**8**	**1**	**40.7**	**35.3**	**12.0**	**36.9**	**0.1**	**0.2**
Electric transformers(145)	1	4	1	3	4	1	5	2	23.4	13.6	7.1	14.5	0.2	0.1
Luggage and handbags(27)	1	5	1	1	4	1	5	1	9.1	10.0	43.2	8.7	0.3	0.1
Abrasives(96)	1	3	1	3	4	1	5	1	13.1	12.5	0.0	0.0	0.0	0.0
Household laundry equipment(167)	1	4	1	3	1	1	1	1	17.0	17.7	19.9	24.2	0.3	0.2
Household refrigerators and freezers(166)	1	5	1	4	1	2	1	1	15.8	12.4	45.6	61.3	0.4	0.3
Printing machinery(143)	**4**	**3**	**3**	**2**	**2**	**3**	**2**	**7**	**24.0**	**16.1**	**1.7**	**14.2**	**0.7**	**1.6**
Industrial gases(60)	3	1	2	1	4	1	5	1	14.1	17.5	9.7	33.7	0.2	0.2
Electric lamps and electric lighting fixtures(149)	**1**	**5**	**1**	**4**	**3**	**4**	**2**	**4**	**12.5**	**10.2**	**13.4**	**21.7**	**0.3**	**0.4**
Primary copper products(117)	**9**	**3**	**6**	**2**	**5**	**0**	**4**	**0**	**44.8**	**28.6**	**3.5**	**19.8**	**0.5**	**0.5**
Gold and silver ingots(115)	3	1	3	1	3	1	4	1	58.5	81.6	28.7	34.2	0.1	0.1
Household electric cooking and heating equipment(168)	**1**	**5**	**1**	**3**	**1**	**5**	**1**	**3**	**16.6**	**16.9**	**38.9**	**70.0**	**0.6**	**0.4**
Average(or Total)	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	29.2	30.6	27.6	33.3	(21.0)	(23.8)
Node industries(#), average(or(Total)	9 (154, 157, 153, 146, 85, 147, 78, 143, 117)		7 (157, 146, 85, 147, 78, 119, 117)		9 (163, 154, 161, 164, 162, 159, 146, 149, 168)		6 (163, 164, 162, 159, 143, 149)		35.1	35.6	28.6	38.3	(15.6)	(16.5)

Ⅴ. Summary and conclusions

This paper identified industrial clusters in manufacturing at the national level through a factor analysis based upon I-O linkages and examined industrial linkages structure and nodal industries and their economic performance in two temporal points of 1995 and 2005 drawing upon social network analysis.

According to the factor analysis using the I-O table of 2005, a total of 28 industrial clusters has been identified in manufacturing including automotives, shipbuilding, IT, chemicals, textiles and so on. For three clusters identified such as automotives, shipbuilding, IT, changes in some characteristics over time have been found regarding linkages structure and economic performance as follows:

1) The automotives cluster consists of 32 industries. For purchase linkage network, industries such as industrial plastic products (80), metal molds and industrial patterns (142) and motor vehicle engines (176) and so on play a key role as a supplier; while for sales linkage network, motor vehicle engines (176) and passenger automobiles (173) and so on play pivotal role as a producer and sales market. In particular, motor vehicle engines (176) have played a pivotal role as producers and sales market for final goods as well as suppliers. During the period 1995-2005, the level of import dependency of intermediate goods has decreased, the ratio of export to total output increased, and the portion of valued-added also increased. Given these facts, industrial linkages structure has been upgraded in the last decade, its economic impact has also gradually increased. However, some major parts such as aluminum products have very high level of import dependency.

2) The shipbuilding industrial cluster consists of a total of thirty-eight industries. For purchase linkages network, in particular steel-related products have been continually responsible for a key supplier including steel pipe and tubes, except foundry iron pipe and tubes (106), misc. primary iron and steel products (111). However, sales industrial linkage structure, steel ships (178), metal products for structure (121) have played a pivotal role as production for final goods and sales market. In terms of purchase and sales network, the shipbuilding cluster has more nodal industries than those of the auto cluster. However, the number of these industries has decreased and substituted for other industries. During the period 1995-2005, the level of import dependency of intermediate goods has decreased, the ratio of export to total output sharply increased and the ratio of value-added in manufacturing increased as well. The shipbuilding cluster has gained higher economic impact and upgraded in terms of linkage effects in the last decade. However, the level of import dependency is still higher than expected in major nodal industries with high portion of exports.

3) IT industrial cluster is comprised of thirty-seven industrial sectors. Three industries, integrated circuits (154), digital display (152) and capacitors and rectifiers (146) play a pivotal role as producers and sales market for final goods as well as suppliers. During the period 1995 and 2005 the number of nodal industries has decreased and the level of import dependency of intermediate goods for both the cluster as whole and nodal industries within the cluster has increased. This means that linkage effects within the IT cluster have been lowered in quantitative and qualitative terms. If this could be continued, the sustainable development of IT industry would not be secured. Rather than expanding exports, an effort should be made to capture real competiveness by lowering the level of import dependency.

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