Industrial clusters extracted from the trade network between Taiwan and Japan

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Abstract:

In our globalized world today, supply chains are induced by the industrial outputs. In addition, they are cross-boundary. For example, an automobile are assembled in Japan, its intermediate (or engine) is produced in Germany, and its intermediate (or iron ore) is dug out. This supply chain is constructed as the trade network of transactions between industries. Taiwan and Japan frequently trades with each other. In the future, to foster their economic growth, it is important to arrange the environment for innovation with respect to productivity or technical collaboration. This study aims at detecting industrial clusters from industrial trade network among Taiwan and Japan. The concept of an industrial cluster is captured by the relationships between industries which have transactions with each other. Detecting current industrial clusters quantitatively, we consider what kinds of policies are effective toward industrial development or technical collaboration.

1. Introduction

In our globalized world today, supply chains are induced by the industrial outputs. In addition, they are cross-boundary. For example, an automobile are assembled in Japan, its intermediate (or engine) is produced in Germany, and its intermediate (or iron ore) is dug out. This supply chain is constructed as the trade network of transactions between industries. Taiwan and Japan frequently trades with each other. Figure 1 shows the trend of international trade between Taiwan and Japan from 2010 to 2017. From the figure, we can see that international and economic connection is getting stronger. In the future, to foster their economic growth, it is important to arrange the environment for innovation with respect to productivity or technical collaboration. In other words, for our development, it is important to make a good use of our interdependence which is getting deeper.

Among academic areas of economics or management, based on the expectation for innovation or high productivity by industrial accumulation, the concept of industrial cluster is proposed (Feser et al., 2000; Porter, 2000; Kelton et al., 2008; Delgado et al., 2010). In several researches, industrial cluster is quantitatively captured as the economic relationships between industries which have transactions with each other (Kagawa et al., 2013). In these days, supply chain induced by one unit

of production is getting multinational and complicated. By quantitatively extracting sub-groups (or *cluster*) in which industries have relatively large transactions, we can understand which industries are strongly connected with each other.

Therefore, this study aims at analyzing current clusters and consider what is desired for our economic development, using the trade network between Taiwan and Japan.
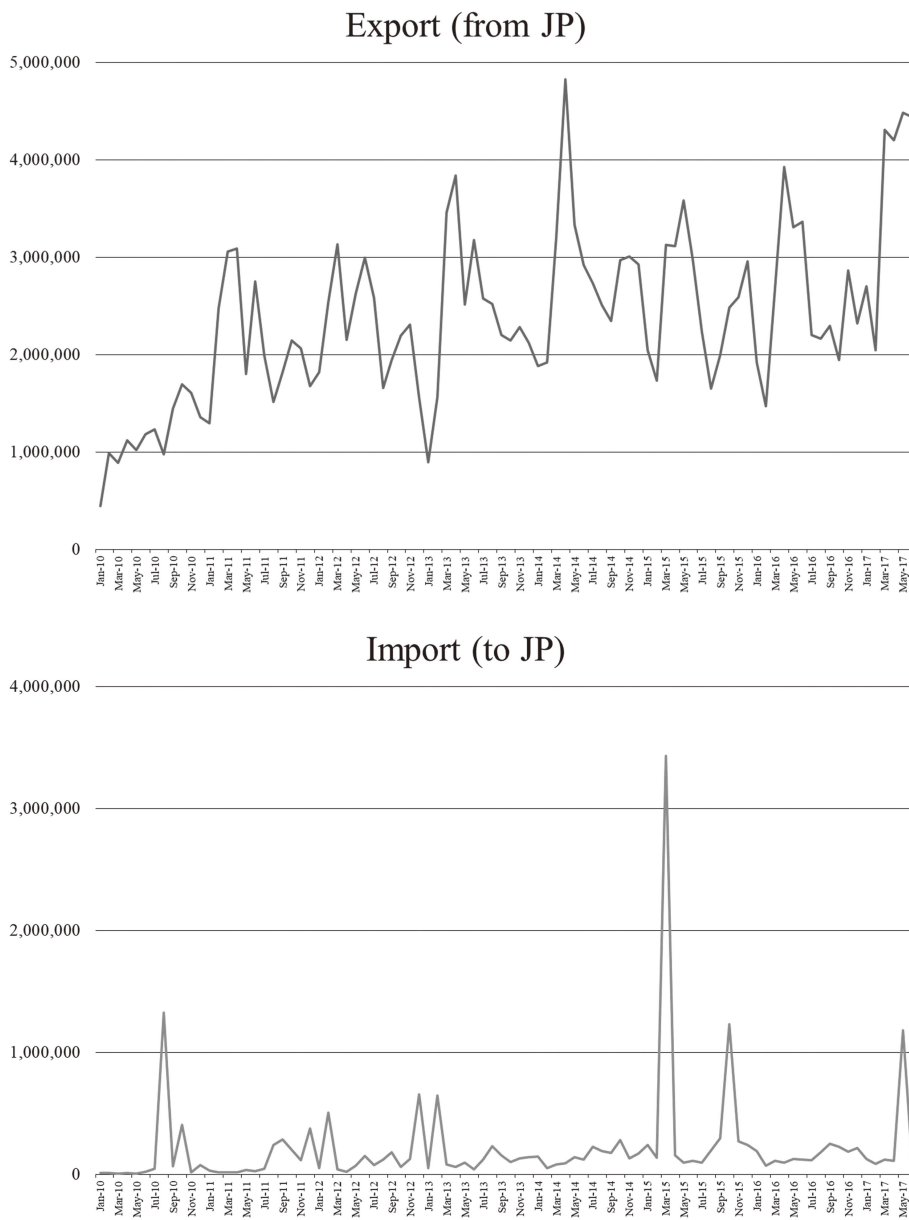
Export (from JP)

Import (to JP)

Figure 1. The trend of international trade between Taiwan and Japan from 2010 to 2017.

(Unit: 1000 JPY)

2. Methodology

2.1 Constructing trade network graph

In this paper, Input-Output table is employed for getting the information about the connection between industries (Miller and Blair, 2009). In this table, the amount of transactions between industries are described in monetary base. The intermediate matrix is described as $\mathbf{Z} = (Z_{ij})$. Here, Z_{ij} is the intermediate inputs from industry i to industry j. The large transactions are considered to be large edges between industries. This information is useful for constructing the transaction network.

Recently, Multi-Regional Input-Output tables (: MRIO) have been developed (Timmer et al., 2015). Figure 2 shows the structure of MRIO. Here, Z^{rs}_{ij} shows intermediate inputs from industry i in region r to industry j in region s, f^{rs}_i shows final demands of region s toward industry i in region r, e^r_i shows exports from industry i in region r, m^s_j shows imports to industry j in region s, v^s_j shows value added in industry j in region s, x^r_i and x^s_j shows total outputs of industry i in region r and industry j in region s respectively, n shows the number of industries, and k shows the number of regions.

Although MRIO also include national industrial transactions, they are ignored in this study to capture the trade network $\left(Z^{rs}_{ij} = 0(r = s)\right)$. Then, the trade network matrix in this study is described as follows;

$$\mathbf{G} = \left(g^{rs}_{ij}\right) = \frac{\mathbf{T}+\mathbf{T}\prime}{2}.$$

The concept of the network is as figure 3. The broken lines are excluded. Using this trade network matrix, we could quantitatively extract industrial clusters.

	Intermediate inputs					Final demands			Export	Total outputs
z^{11}_{11}	z^{11}_{1n}			z^{1k}_{11}	z^{1k}_{1n}	f^{11}_1			f^{1k}_1 e^1_1	x^1_1
z^{11}_{n1}	z^{11}_{nn}			z^{1k}_{n1}	z^{1k}_{nn}	f^{11}_n			f^{1k}_n e^1_n	x^1_n
		z^{rs}_{ij}					f^{rs}_i		e^r_i	x^r_i
z^{k1}_{11}	z^{k1}_{11}			z^{kk}_{11}	z^{kk}_{11}	f^{k1}_1			f^{kk}_1 e^k_1	x^k_1
z^{k1}_{n1}	z^{k1}_{nn}			z^{kk}_{n1}	z^{kk}_{nn}	f^{k1}_n			f^{kk}_n e^k_n	x^k_n

Left labels: **Intermediate inputs** (rows above); **Inports**; **Value added**; **Total outputs**.

Inports	m^1_1	m^1_n	m^s_j	m^k_1 m^k_n
Value added	v^1_1	v^1_n	v^s_j	v^k_1 v^k_n
Total outputs	x^1_1	x^1_n	x^s_j	x^k_1 x^k_n

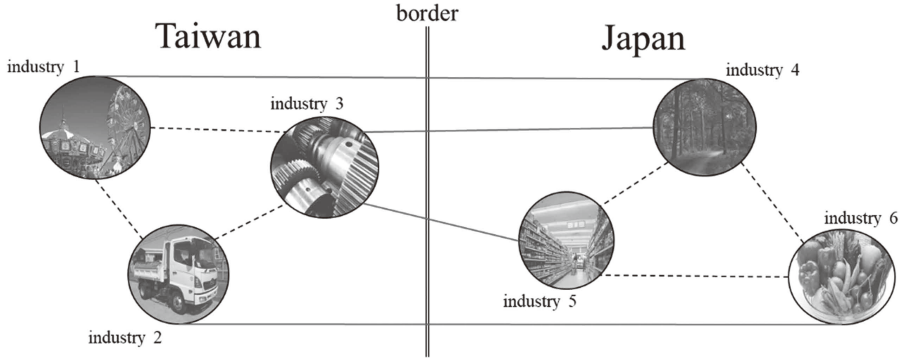**Figure 2.** The structure of MRIO framework.

Figure 3. The concept of trade network in this study.

2.2 Extracting using spectral clustering method

From the trade network, it is difficult to intuitively define the clusters, because there are many patterns of allocation of industries. The clustering method is to extract the dense parts from network information and it has been especially developed in the area of image segmentation (Lee and Seung (1999); Shi and Malik (2000); Lee and Seung (2001)). The basic one is to reiterate dividing network into 2 parts solving eigenvalue problem (Shi and Malik (2000)). However, this method lacks the clear criterion about the number of times implemented and it tends to result in arbitrary analysis to some extent. Therefore, as overcoming method, this research employ the multiway normalized cut of spectral clustering (Ng et al. (2001); Azran and Ghahramani (2006)). Using this method, it is possible to simultaneously assign nodes to plural clusters with objective index under given number of division.

Throughout the analysis, industries and amounts of transactions are regarded as nodes and edges respectively on the context of networks. It is difficult to test all combination patterns about which industry should belong to a cluster from the network information (Bolla (2011)). Spectral clustering method tries to extract the information about to which cluster each node should belong from the resulting eigenvectors, after solving eigenvalue problem which contains network information. Eigenvectors for smaller eigenvalues could make better clustering assignment.

Ncut is defined as equation (1) and the index shows how densely the nodes are collected within each cluster or how far each cluster are apart from each other (Shi and Malik (2000); von Luxburg, 2007; von Luxburg *et al.*, 2008). The smaller the value of *Ncut* is, the better the clustering assignment would be.

$$Ncut = \sum_{y=1}^{Y} \frac{\sum_{i \in V_y, j \in V} g_{ij} - \sum_{i \in V_y, j \in V_y} g_{ij}}{\sum_{i \in V_y} d_i} = \sum_{y=1}^{Y} \frac{\mathbf{h}_y^T(\mathbf{D} - \mathbf{G})\mathbf{h}_y}{\mathbf{h}_y^T \mathbf{D} \mathbf{h}_y} = \sum_{y=1}^{Y} \frac{\mathbf{h}_y^T \mathbf{D}^{\frac{1}{2}} \mathbf{D}^{-\frac{1}{2}}(\mathbf{D} - \mathbf{G})\mathbf{D}^{-\frac{1}{2}} \mathbf{D}^{\frac{1}{2}} \mathbf{h}_y}{\mathbf{h}_y^T \mathbf{D}^{\frac{1}{2}} \mathbf{D}^{\frac{1}{2}} \mathbf{h}_y} \qquad (1)$$

$$\mathbf{h}_y = \left(h_{iy} \right) = \begin{cases} 1 & \left(i \in V_y \right) \\ 0 & \left(i \notin V_y \right) \end{cases} \qquad (2)$$

Here, Y is the number of clusters, V is a universal set of nodes, V_y is y^{th} cluster which consists of nodes, $d_i = \sum_{j=1}^{n} g_{ij}$ is degree of node i, and $\mathbf{D} = (d_i)$. $\mathbf{h}_y$ is vector and its factor is 1 if node i belongs to V_y, otherwise 0. The role of $\mathbf{h}_y$ is to assign nodes to clusters and it is available by solving the eigenvalue problem of . $\mathbf{D}^{-\frac{1}{2}}(\mathbf{D} - \mathbf{G})\mathbf{D}^{-\frac{1}{2}}$. (D-G) is so-called Laplacian matrix. In this study, Y is set to 70, expecting that each cluster has around 10 industries. The algorithm of spectral clustering is as follows.

<u>Algorithm</u>

Input: The network information (: matrix **(D-G)**)

Output: V_y $(y = 1, \cdots Y)$

1: Calculate **(D-G)** and solve the eigenvalue problem of $\mathbf{D}^{-\frac{1}{2}}(\mathbf{D} - \mathbf{G})\mathbf{D}^{-\frac{1}{2}}$.

2: Set the eigenvalue $\lambda_y (\lambda_{y-1} < \lambda_y)$ and corresponding eigenvectors $\mathbf{v}_y$.

3: Prepare $\mathbf{V}_Y = [\mathbf{v}_2, \cdots \mathbf{v}_Y]$ and get $\mathbf{H}_Y = [\mathbf{h}_2, \cdots \mathbf{h}_Y]$ after applying k-means method to $\mathbf{V}_Y^{1,2}$.

4: Get V_y $(y = 1, \cdots Y)$ following $\mathbf{H}_Y$.

3. Data

In this study, EORA MRIO table is employed (Lenzen et al., 2012; Lenzen et al., 2013). This table covers 187 countries and totally 15909 sectors. Taiwan has 162 industrial sectors and Japan has 401 industrial sectors. In this study, the table at 2013 is employed. The industry list is shown in Appendix.

4. Results

The set of industries/areas are assigned to clusters following spectral clustering method. The number of clusters is 70. Figure 4 shows top 10 clusters according to the trade volume in clusters. Clustering list is also shown in Appendix. Red nodes are industries in Japan and blue ones are Taiwan. The thickness of lines are relevant to the transactions between industries/countries.

Figure 5 shows the cluster which is relevant to making cell phone. From this figure, it is found that semiconductor from Taiwan is essential for the production of cell phone in Japan. In addition, these transactions are also relatively large compared with the entire trade network. Figure 6 shows the cluster which is relevant to making computer components. Semiconductor' in Taiwan also links

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1 In case that nodes are normalized to 1, the smallest eigenvalue of Laplacian matrix is 0 and corresponding eigenvector is **1**. The fact that all elements of vector are 1 is equal to the fact that all nodes belong to a single cluster, In other words, they are not divided at all. Therefore, 2nd smallest eigenvalue and corresponding eigenvector are employed for k-means method. (Meila and Shi (2001)).

2 k-means method is reiteration of adjustment from initial random assignment. Therefore, the final might depend on the initial assignment to some extent. In this study, k-means method is reiterated by 100 times. The final assignment is employed following the smallest *Ncut* from 100 results.

with other Japanese industries in other cluster. 'Semiconductor' in Taiwan also links with other Japanese industries in this cluster. We can see that although these 4 industries frequently trade their goods with each other, Japanese industries are considerably supported by 'Semiconductor' industry in Taiwan. Figure 7 shows the cluster which is relevant to making electronic precision instruments. From this figure, we could see that several industries from both countries are fully connected with each other and expect the potential for innovation or industrial accumulation for high productivity. But, for instance, 'Research and development' industries are excluded from the cluster. For mutual innovation, such an industries should be involved in the cluster.
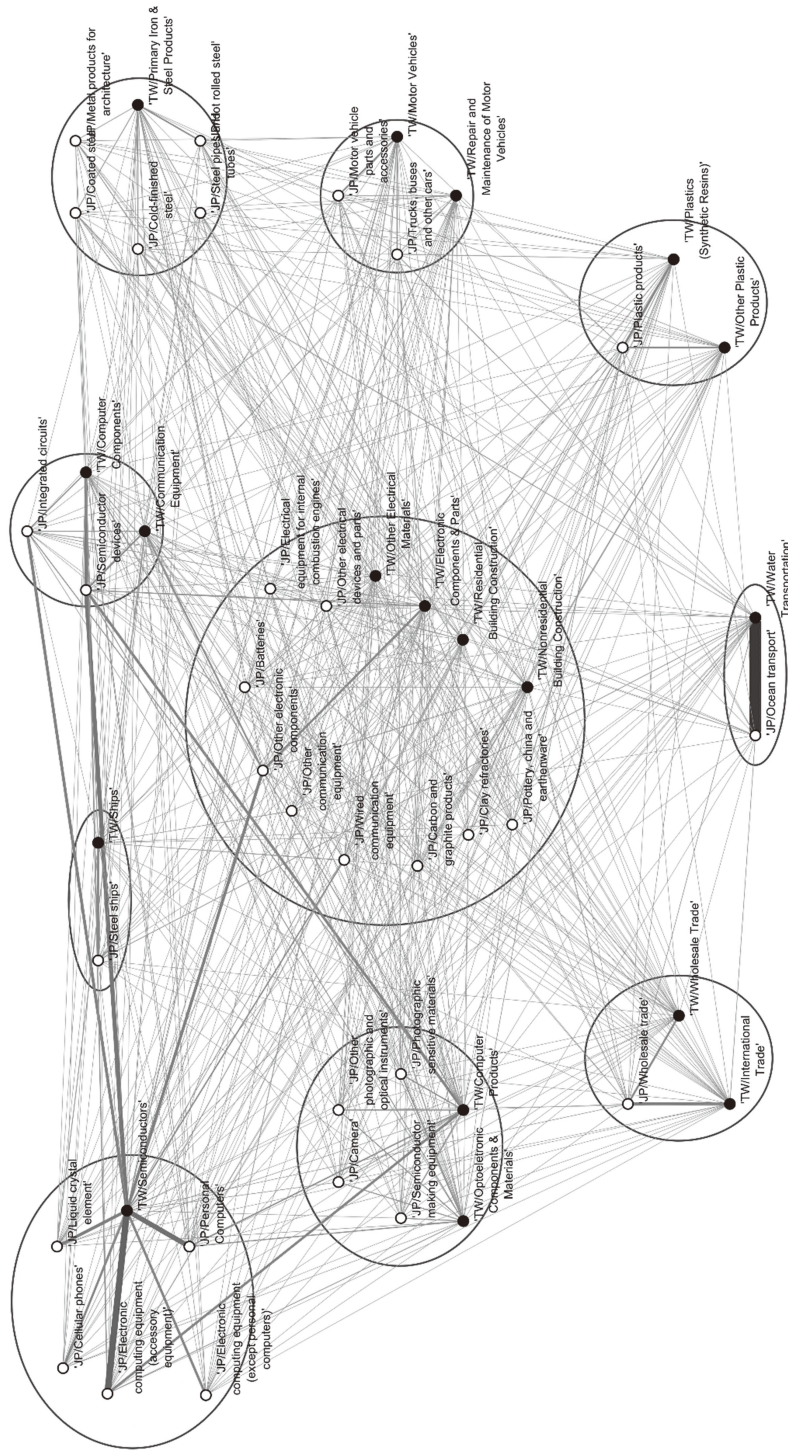
Figure 4. Relatively large clusters from the industrial trade network between Taiwan and Japan3.

3 Black rounds are industries in Taiwan.
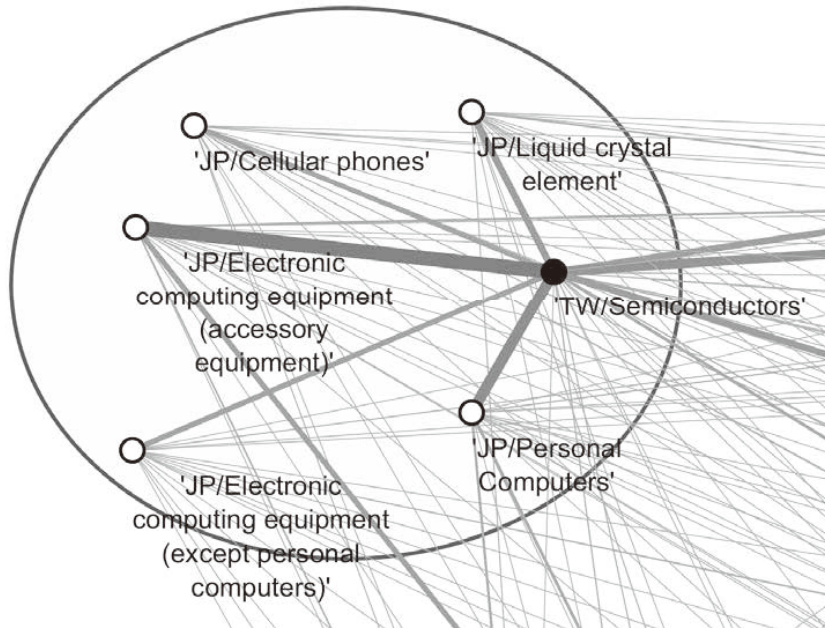   White rounds are industries in Japan.

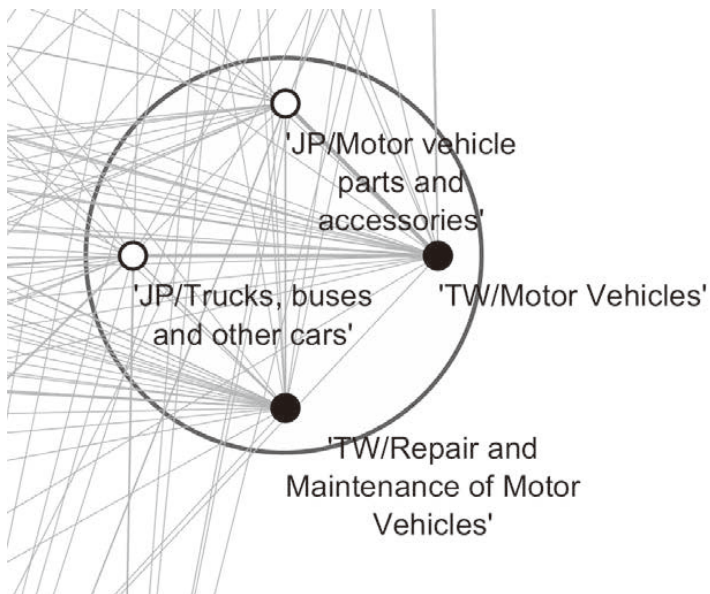**Figure 5.** The cluster which is relevant to making cell phone.

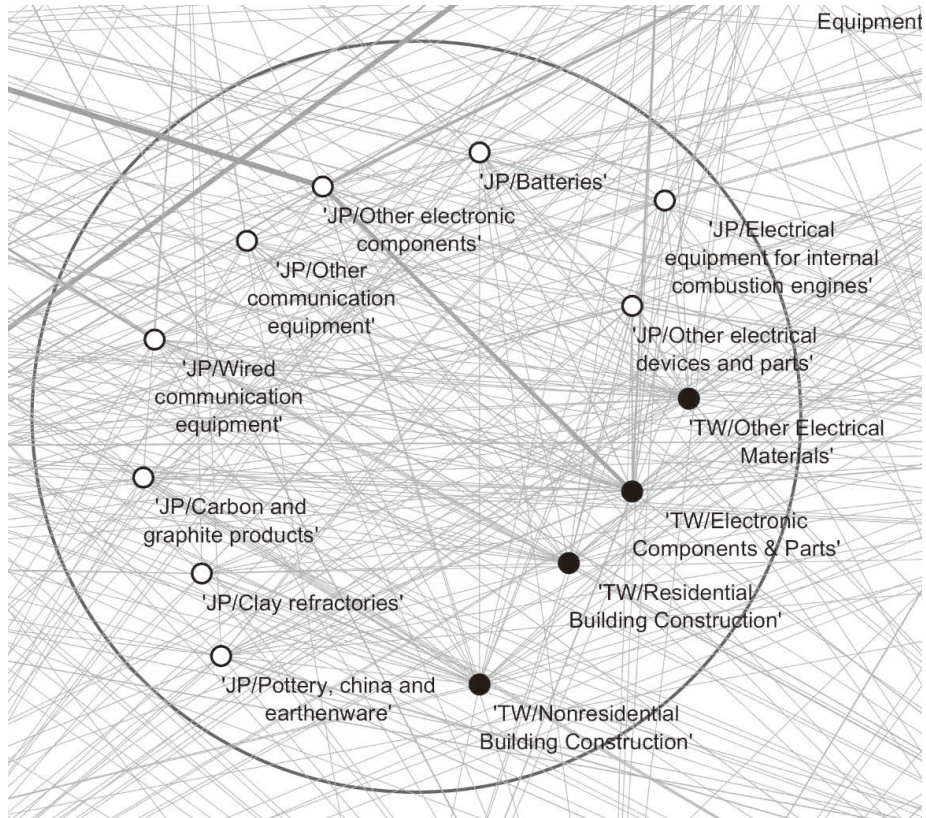**Figure 6.** The cluster which is relevant to making computer components.

Figure 7. The cluster which is relevant to making electronic precision instruments.

5. Conclusions

This paper constructed the industrial trade network from regional input-output table, or EORA MRIO table, and quantitatively extracted the industrial clusters using spectral clustering method. Relatively large 10 clusters are found like figure 4 from the trade network which consists of 563 industries/prefectures, 401 in Japan and 162 in Taiwan respectively. The findings are as follows;

1) Several industrial clusters are found, including electronic precision instruments cluster, cell phone cluster, end so on.

2) For mutual innovation or economic development, promoting industries should be involved in the cluster, such as 'Research and development' industries, for instance.

It is expected that policy implementation like supporting industrial development could be effective when administrators from each country cooperate with each other. Applying research framework of the paper to the international technical cooperation for our future could contribute to production innovation or activating their economy after expansion of industrial infrastructure.

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Appendix

Table 1 is the industry list. Table 2 shows the clustering result.

Table 1. The industry list.

1 Japan	Rice	61 Japan	School lunch (private)*
2 Japan	Wheat, barley and the like	62 Japan	Other foods
3 Japan	Potatoes and sweet potatoes	63 Japan	Refined sake
4 Japan	Pulses	64 Japan	Beer
5 Japan	Vegetables	65 Japan	Whiskey and brandy
6 Japan	Fruits	66 Japan	Other liquors
7 Japan	Sugar crops	67 Japan	Tea and roasted coffee
8 Japan	Crops for beverages	68 Japan	Soft drinks
9 Japan	Other edible crops	69 Japan	Manufactured ice
10 Japan	Crops for feed and forage	70 Japan	Feeds
11 Japan	Seeds and seedlings	71 Japan	Organic fertilizers, n.e.c.
12 Japan	Flowers and plants	72 Japan	Tobacco
13 Japan	Other inedible crops	73 Japan	Fiber yarns
14 Japan	Dairy cattle farming	74 Japan	Cotton and staple fiber fabrics (inc. fabrics of synthetic spun fibers)
15 Japan	Hen eggs	75 Japan	Silk and artificial silk fabrics (inc. fabrics of synthetic filament fibers)
16 Japan	Fowls and broilers	76 Japan	Woolen fabrics, hemp fabrics and other fabrics
17 Japan	Hogs	77 Japan	Knitting fabrics
18 Japan	Beef cattle	78 Japan	Yarn and fabric dyeing and finishing (processing on commission only)
19 Japan	Other livestock	79 Japan	Ropes and nets
20 Japan	Veterinary service	80 Japan	Carpets and floor mats
21 Japan	Agricultural services (except veterinary service)	81 Japan	Fabricated textiles for medical use
22 Japan	Silviculture	82 Japan	Other fabricated textile products
23 Japan	Logs	83 Japan	Woven fabric apparel
24 Japan	Special forest products (inc. hunting)	84 Japan	Knitted apparel
25 Japan	Marine fisheries	85 Japan	Other wearing apparel and clothing accessories
26 Japan	Marine culture	86 Japan	Bedding
27 Japan	Inland water fisheries and culture	87 Japan	Other ready-made textile products
28 Japan	Metallic ores	88 Japan	Timber
29 Japan	Materials for ceramics	89 Japan	Plywood
30 Japan	Gravel and quarrying	90 Japan	Wooden chips
31 Japan	Crushed stones	91 Japan	Other wooden products
32 Japan	Other non-metallic ores	92 Japan	Wooden furniture and fixtures
33 Japan	Coal mining	93 Japan	Wooden fixtures
34 Japan	Crude petroleum and natural gas	94 Japan	Metallic furniture and fixture
35 Japan	Slaughtering and meat processing	95 Japan	Pulp
36 Japan	Processed meat products	96 Japan	Paper
37 Japan	Bottled or canned meat products	97 Japan	Paperboard
38 Japan	Daily farm products	98 Japan	Corrugated cardboard
39 Japan	Frozen fish and shellfish	99 Japan	Coated paper and building (construction) paper
40 Japan	Salted, dried or smoked seafood	100 Japan	Corrugated card board boxes
41 Japan	Bottled or canned seafood	101 Japan	Other paper containers
42 Japan	Fish paste	102 Japan	paper textile for medical use
43 Japan	Other processed seafood	103 Japan	Other pulp, paper and processed paper products
44 Japan	Grain milling	104 Japan	Newspapers
45 Japan	Flour and other grain milled products	105 Japan	Printing, plate making and book binding
46 Japan	Noodles	106 Japan	Publishing
47 Japan	Bread	107 Japan	Chemical fertilizer
48 Japan	Confectionary	108 Japan	Industrial soda chemicals
49 Japan	Bottled or canned vegetables and fruits	109 Japan	Inorganic pigment
50 Japan	Preserved agricultural foodstuffs (other than bottled or canned)	110 Japan	Compressed gas and liquefied gas
51 Japan	Sugar	111 Japan	Salt
52 Japan	Starch	112 Japan	Other industrial inorganic chemicals
53 Japan	Dextrose, syrup and isomerized sugar	113 Japan	Petrochemical basic products
54 Japan	Vegetable oils and meal	114 Japan	Petrochemical aromatic products (except synthetic resin)
55 Japan	Animal oils and fats	115 Japan	Aliphatic intermediates
56 Japan	Condiments and seasonings	116 Japan	Cyclic intermediates
57 Japan	Prepared frozen foods	117 Japan	Synthetic rubber
58 Japan	Retort foods	118 Japan	Methane derivatives
59 Japan	Dishes, sushi and lunch boxes	119 Japan	Oil and fat industrial chemicals
60 Japan	School lunch (public)**	120 Japan	Plasticizers

Table 1. The industry list (continued).

121 Japan	Synthetic dyes		181 Japan	Optical fiber cables
122 Japan	Other industrial organic chemicals		182 Japan	Rolled and drawn copper and copper alloys
123 Japan	Thermo-setting resins		183 Japan	Rolled and drawn aluminum
124 Japan	Thermoplastics resins		184 Japan	Non-ferrous metal castings and forgings
125 Japan	High function resins		185 Japan	Nuclear fuels
126 Japan	Other resins		186 Japan	Other non-ferrous metal products
127 Japan	Rayon and acetate		187 Japan	Metal products for construction
128 Japan	Synthetic fibers		188 Japan	Metal products for architecture
129 Japan	Medicaments		189 Japan	Gas and oil appliances and heating and cooking apparatus
130 Japan	Soap, synthetic detergents and surface active agents		190 Japan	Bolts, nuts, rivets and springs
131 Japan	Cosmetics, toilet preparations and dentifrices		191 Japan	Metal containers, fabricated plate and sheet metal
132 Japan	Paint and varnishes		192 Japan	Plumber's supplies, powder metallurgy products and tools
133 Japan	Printing ink		193 Japan	Other metal products
134 Japan	Photographic sensitive materials		194 Japan	Boilers
135 Japan	Agricultural chemicals		195 Japan	Turbines
136 Japan	Gelatin and adhesives		196 Japan	Engines
137 Japan	Other final chemical products		197 Japan	Conveyors
138 Japan	Petroleum refinery products (inc. greases)		198 Japan	Refrigerators and air conditioning apparatus
139 Japan	Coal products		199 Japan	Pumps and compressors
140 Japan	Paving materials		200 Japan	Machinists' precision tools
141 Japan	Plastic products		201 Japan	Other general industrial machinery and equipment
142 Japan	Tires and inner tubes		202 Japan	Machinery and equipment for construction and mining
143 Japan	Rubber footwear		203 Japan	Chemical machinery
144 Japan	Plastic footwear		204 Japan	Industrial robots
145 Japan	Other rubber products		205 Japan	Metal machine tools
146 Japan	Leather footwear		206 Japan	Metal processing machinery
147 Japan	Leather and fur skins		207 Japan	Machinery for agricultural use
148 Japan	Miscellaneous leather products		208 Japan	Textile machinery
149 Japan	Sheet glass and safety glass		209 Japan	Food processing machinery
150 Japan	Glass fiber and glass fiber products, n.e.c.		210 Japan	Semiconductor making equipment
151 Japan	Other glass products		211 Japan	Other special machinery for industrial use
152 Japan	Cement		212 Japan	Metal molds
153 Japan	Ready mixed concrete		213 Japan	Bearings
154 Japan	Cement products		214 Japan	Other general machines and parts
155 Japan	Pottery, china and earthenware		215 Japan	Copy machine
156 Japan	Clay refractories		216 Japan	Other office machines
157 Japan	Other structural clay products		217 Japan	Machinery for service industry
158 Japan	Carbon and graphite products		218 Japan	Electric audio equipment
159 Japan	Abrasive		219 Japan	Radio and television sets
160 Japan	Miscellaneous ceramic, stone and clay products		220 Japan	Video recording and playback equipment
161 Japan	Pig iron		221 Japan	Household air-conditioners
162 Japan	Ferro alloys		222 Japan	Household electric appliances (except air-conditioners)
163 Japan	Crude steel (converters)		223 Japan	Personal Computers
164 Japan	Crude steel (electric furnaces)		224 Japan	Electronic computing equipment (except personal computers)
165 Japan	Steel scrap		225 Japan	Electronic computing equipment (accessory equipment)
166 Japan	Hot rolled steel		226 Japan	Wired communication equipment
167 Japan	Steel pipes and tubes		227 Japan	Cellular phones
168 Japan	Cold-finished steel		228 Japan	Radio communication equipment (except cellular phones)
169 Japan	Coated steel		229 Japan	Other communication equipment
170 Japan	Cast and forged steel		230 Japan	Applied electronic equipment
171 Japan	Cast iron pipes and tubes		231 Japan	Electric measuring instruments
172 Japan	Cast and forged materials (iron)		232 Japan	Semiconductor devices
173 Japan	Iron and steel shearing and slitting		233 Japan	Integrated circuits
174 Japan	Other iron or steel products		234 Japan	Electron tubes
175 Japan	Copper		235 Japan	Liquid crystal element
176 Japan	Lead and zinc (inc. regenerated lead)		236 Japan	Magnetic tapes and discs
177 Japan	Aluminum (inc. regenerated aluminum)		237 Japan	Other electronic components
178 Japan	Other non-ferrous metals		238 Japan	Rotating electrical equipment
179 Japan	Non-ferrous metal scrap		239 Japan	Relay switches and switchboards
180 Japan	Electric wires and cables		240 Japan	Transformers and reactors

Table 1. The industry list (continued).

241 Japan	Other industrial heavy electrical equipment		301 Japan	Wholesale trade
242 Japan	Electric lighting fixtures and apparatus		302 Japan	Retail trade
243 Japan	Batteries		303 Japan	Financial service
244 Japan	Electric bulbs		304 Japan	Life insurance
245 Japan	Wiring devices and supplies		305 Japan	Non-life insurance
246 Japan	Electrical equipment for internal combustion engines		306 Japan	Real estate agencies and managers
247 Japan	Other electrical devices and parts		307 Japan	Real estate rental service
248 Japan	Passenger motor cars		308 Japan	House rent
249 Japan	Trucks, buses and other cars		309 Japan	House rent (imputed house rent)
250 Japan	Two-wheel motor vehicles		310 Japan	Railway transport (passengers)
251 Japan	Motor vehicle bodies		311 Japan	Railway transport (freight)
252 Japan	Internal combustion engines for motor vehicles and parts		312 Japan	Bus transport service
253 Japan	Motor vehicle parts and accessories		313 Japan	Hired car and taxi transport
254 Japan	Steel ships		314 Japan	Road freight transport
255 Japan	Ships (except steel ships)		315 Japan	Self-transport by private cars (passengers)
256 Japan	Internal combustion engines for vessels		316 Japan	Self-transport by private cars (freight)
257 Japan	Repair of ships		317 Japan	Ocean transport
258 Japan	Rolling stock		318 Japan	Coastal and inland water transport
259 Japan	Repair of rolling stock		319 Japan	Harbor transport service
260 Japan	Aircrafts		320 Japan	Air transport
261 Japan	Repair of aircrafts		321 Japan	Freight forwarding
262 Japan	Bicycles		322 Japan	Storage facility service
263 Japan	Other transport equipment		323 Japan	Packing service
264 Japan	Camera		324 Japan	Facility service for road transport
265 Japan	Other photographic and optical instruments		325 Japan	Port and water traffic control**
266 Japan	Watches and clocks		326 Japan	Services relating to water transport
267 Japan	Professional and scientific instruments		327 Japan	Airport and air traffic control (public)**
268 Japan	Analytical instruments, testing machine, measuring instruments		328 Japan	Airport and air traffic control (industrial)
269 Japan	Medical instruments		329 Japan	Services relating to air transport
270 Japan	Toys and games		330 Japan	Travel agency and other services relating to transport
271 Japan	Sporting and athletic goods		331 Japan	Postal service
272 Japan	Musical instruments		332 Japan	Fixed telecommunication
273 Japan	Audio and video records, other information recording media		333 Japan	Mobile telecommunication
274 Japan	Stationary		334 Japan	Other telecommunication
275 Japan	Jewelry and adornments		335 Japan	Other services relating to communication
276 Japan	Tatami (straw matting) and straw products		336 Japan	Public broadcasting
277 Japan	Ordnance		337 Japan	Private broadcasting
278 Japan	Miscellaneous manufacturing products		338 Japan	Cable broadcasting
279 Japan	Reuse and recycling		339 Japan	Public administration (central)**
280 Japan	Residential construction (wooden)		340 Japan	Public administration (local)**
281 Japan	Residential construction (non-wooden)		341 Japan	School education (public)**
282 Japan	Non-residential construction (wooden)		342 Japan	School education (private)**
283 Japan	Non-residential construction (non-wooden)		343 Japan	Social education (public)**
284 Japan	Repair of construction		344 Japan	Social education (private, non-profit)*
285 Japan	Public construction of roads		345 Japan	Other educational and training institutions (public)**
286 Japan	Public construction of rivers, drainages and others		346 Japan	Other educational and training institutions (profit-making)
287 Japan	Agricultural public construction		347 Japan	Research institutes for natural science (public)**
288 Japan	Railway construction		348 Japan	Research institutes for cultural and social science (public)**
289 Japan	Electric power facilities construction		349 Japan	Research institutes for natural sciences (private, non-profit)*
290 Japan	Telecommunication facilities construction		350 Japan	Research institutes for cultural and social science (private, non-profit)*
291 Japan	Other civil engineering and construction		351 Japan	Research institutes for natural sciences (profit-making)
292 Japan	Electric power for enterprise use		352 Japan	Research institutes for cultural and social science (profit-making)
293 Japan	On-site power generation		353 Japan	Research and development (intra-enterprise)
294 Japan	Gas supply		354 Japan	Medical service (public)
295 Japan	Steam and hot water supply		355 Japan	Medical service (non-profit foundations, etc.)
296 Japan	Water supply		356 Japan	Medical service (medical corporations, etc.)
297 Japan	Industrial water supply		357 Japan	Health and hygiene (public)**
298 Japan	Sewage disposal**		358 Japan	Health and hygiene (profit-making)
299 Japan	Waste management services (public)**		359 Japan	Social insurance (public)**
300 Japan	Waste management services (private)		360 Japan	Social insurance (private, non-profit)*

Table 1. The industry list (continued).

361	Japan	Social welfare (public)**	421	Taiwan	Rice
362	Japan	Social welfare (private, non-profit)*	422	Taiwan	Sugar
363	Japan	Nursing care (In-home)	423	Taiwan	Animal Feeds
364	Japan	Nursing care (In-facility)	424	Taiwan	Canned Foods
365	Japan	Private non-profit institutions serving enterprises	425	Taiwan	Frozen Foods
366	Japan	Private non-profit institutions serving households, n.e.c.*	426	Taiwan	Monosodium Glutamate
367	Japan	Advertising services	427	Taiwan	Other Seasonings
368	Japan	Information services	428	Taiwan	Dairy Products
369	Japan	News syndicates and private detective agencies	429	Taiwan	Sugar Confectionery & Bakery Products
370	Japan	Goods rental and leasing (except car rental)	430	Taiwan	Other Foods
371	Japan	Car rental and leasing	431	Taiwan	Non-Alcoholic Beverages
372	Japan	Repair of motor vehicles	432	Taiwan	Alcoholic Beverages
373	Japan	Repair of machine	433	Taiwan	Tobacco
374	Japan	Building maintenance services	434	Taiwan	Cotton & Cotton Fabrics
375	Japan	Judicial, financial and accounting services	435	Taiwan	Wool & Worsted Fabrics
376	Japan	Civil engineering and construction services	436	Taiwan	Artificial Fabrics
377	Japan	Worker dispatching services	437	Taiwan	Knitted Fabrics
378	Japan	Other business services	438	Taiwan	Other Fabrics
379	Japan	Motion picture and video production, and distribution	439	Taiwan	Printing, Dyeing & Finishing
380	Japan	Movie theaters	440	Taiwan	Tatted Garments
381	Japan	Theater and entertainment facilities	441	Taiwan	Knitted Garments
382	Japan	Amusement and recreation facilities	442	Taiwan	Fabric Products, Wearing Apparel & Accessories
383	Japan	Stadiums and companies of bicycle, horse, motorcar and motorboat races	443	Taiwan	Leather
384	Japan	Sport facility service, public gardens and amusement parks	444	Taiwan	Leather Footwear
385	Japan	Theatrical companies	445	Taiwan	Other Leather Products
386	Japan	Other amusement and recreation services	446	Taiwan	Lumber
387	Japan	General eating and drinking places (except coffee shops)	447	Taiwan	Plywood
388	Japan	Coffee shops	448	Taiwan	Wood,Bamboo & Rattan Products
389	Japan	Eating and drinking places for pleasures	449	Taiwan	Non-Metallic Furniture
390	Japan	Hotel and other lodging places	450	Taiwan	Pulp & Paper
391	Japan	Cleaning, laundry and dyeing services	451	Taiwan	Paper Products
392	Japan	Barber shops	452	Taiwan	Newspapers, Books & Magazines
393	Japan	Beauty shops	453	Taiwan	Other Printed Matters & Bookbinding
394	Japan	Public baths	454	Taiwan	Basic Industrial Chemicals
395	Japan	Photographic studios	455	Taiwan	Petrochemical Raw Materials
396	Japan	Ceremonial occasions	456	Taiwan	Chemical Fertilizers
397	Japan	Miscellaneous repairs, n.e.c.	457	Taiwan	Synthetic Fibers
398	Japan	Places for private lessons	458	Taiwan	Other Artificial Fibers
399	Japan	Other personal services	459	Taiwan	Plastics (Synthetic Resins)
400	Japan	Office supplies	460	Taiwan	Other Chemical Materials
401	Japan	Activities not elsewhere classified	461	Taiwan	Coatings
402	Taiwan	Paddy Rice	462	Taiwan	Medicines
403	Taiwan	Coarse Grain Crops	463	Taiwan	Pesticides and Herbicides
404	Taiwan	Sugarcane	464	Taiwan	Cleaning Preparations and Cosmetics
405	Taiwan	Other Special Crops	465	Taiwan	Other Chemical products
406	Taiwan	Fruits	466	Taiwan	Petroleum Refining Products
407	Taiwan	Vegetables	467	Taiwan	Coal Products
408	Taiwan	Other Horticultural Crops	468	Taiwan	Rubber Products
409	Taiwan	Hogs	469	Taiwan	Plastic & Rubber Footwear
410	Taiwan	Other Poultry & Livestock	470	Taiwan	Other Plastic Products
411	Taiwan	Agricultural Services	471	Taiwan	Ceramic Products
412	Taiwan	Forestry	472	Taiwan	Glass & Glass Products
413	Taiwan	Fishery Products	473	Taiwan	Cement
414	Taiwan	Energy Minerals	474	Taiwan	Cement Products
415	Taiwan	Metallic Minerals	475	Taiwan	Other Non-Metallic Mineral Products
416	Taiwan	Salt	476	Taiwan	Pig Iron & Crude Steel
417	Taiwan	Other Non-Metallic Minerals	477	Taiwan	Primary Iron & Steel Products
418	Taiwan	Slaughtering & By-Products	478	Taiwan	Aluminum
419	Taiwan	Edible Oil & Fat By-Products	479	Taiwan	Other Metals
420	Taiwan	Flour	480	Taiwan	Metal Forging & Powder Metallurgy

Table 1. The industry list (continued).

481 Taiwan	Metallic Products for Household Use	
482 Taiwan	Metallic Hand Tools	
483 Taiwan	Metal Structure & Architectural Components	
484 Taiwan	Metal Containers	
485 Taiwan	Other Metal Products	
486 Taiwan	Surface Treating of Metal Products	
487 Taiwan	General-Purpose Industrial Machinery	
488 Taiwan	Metal Processing Machinery	
489 Taiwan	Industrial Machinery	
490 Taiwan	Other Machinery	
491 Taiwan	Machinery Parts,Repair & Maintenance	
492 Taiwan	Household Electrical Appliances	
493 Taiwan	Electric lamps & Lighting Equipment	
494 Taiwan	Power Generation, Transmission and Distribution Machinery	
495 Taiwan	Wires & Cables	
496 Taiwan	Other Electrical Materials	
497 Taiwan	Computer Products	
498 Taiwan	Computer Peripheral Equipment	
499 Taiwan	Data Storage Media	
500 Taiwan	Computer Components	
501 Taiwan	Video and Radio Electronic Products	
502 Taiwan	Communication Equipment	
503 Taiwan	Electronic Tubes	
504 Taiwan	Semiconductors	
505 Taiwan	Optoeletronic Components & Materials	
506 Taiwan	Electronic Components & Parts	
507 Taiwan	Ships	
508 Taiwan	Motor Vehicles	
509 Taiwan	Motorcycles	
510 Taiwan	Bicycles	
511 Taiwan	Other Transport Equitment	
512 Taiwan	Precision Instruments & Apparatus	
513 Taiwan	Education & Entertainment Articles	
514 Taiwan	Other Manufactures	
515 Taiwan	Electricity	
516 Taiwan	Gas	
517 Taiwan	City Water, Steam & Hot Water	
518 Taiwan	Residential Building Construction	
519 Taiwan	Nonresidential Building Construction	
520 Taiwan	Public Works	
521 Taiwan	Other Construction	
522 Taiwan	Wholesale Trade	
523 Taiwan	Retail Trade	
524 Taiwan	International Trade	
525 Taiwan	Commodity Brokerage	
526 Taiwan	Hotel Services	
527 Taiwan	Restaurant Services	
528 Taiwan	Railroad Vehicle Transportation	
529 Taiwan	Other Land Transportation	
530 Taiwan	Water Transportation	
531 Taiwan	Air Transportation	
532 Taiwan	Services Incidental to Transport	
533 Taiwan	Travel Agency Services	
534 Taiwan	Warehousing	
535 Taiwan	Postal Services	
536 Taiwan	Telecommunication Services	
537 Taiwan	Finance	
538 Taiwan	Securities & Futures	
539 Taiwan	Insurance	
540 Taiwan	House Services	

541 Taiwan	Real Estate Services
542 Taiwan	Renting & Leasing Services
543 Taiwan	Legal and Accounting Services
544 Taiwan	Consulting Services
545 Taiwan	Information Services
546 Taiwan	Research & Development Services
547 Taiwan	Advertising Services
548 Taiwan	Other Specialized and Technologic Services
549 Taiwan	Educational Training Services
550 Taiwan	Medical & Health Services
551 Taiwan	Social Welfare Services
552 Taiwan	Radio, Television & Movies Services
553 Taiwan	Recreational & Cultural Services
554 Taiwan	Support Services
555 Taiwan	Environmental Sanitary Services
556 Taiwan	Services of Civil Association
557 Taiwan	Other Social Services
558 Taiwan	Repair and Maintenance of Motor Vehicles
559 Taiwan	Other Repair Services
560 Taiwan	Household Services
561 Taiwan	Other Personal Services
562 Taiwan	Public Administration Services
563 Taiwan	Undistributed

Table 2. The clustering list.

country	industry	country	industry
Japan	Wholesale trade	Japan	Pottery, china and earthenware
Taiwan	Wholesale Trade	Japan	Clay refractories
Taiwan	International Trade	Japan	Carbon and graphite products
Japan	Photographic sensitive materials	Japan	Wired communication equipment
Japan	Semiconductor making equipment	Japan	Other communication equipment
Japan	Camera	Japan	Other electronic components
Japan	Other photographic and optical instruments	Japan	Batteries
Taiwan	Computer Products	Japan	Electrical equipment for internal combustion engines
Taiwan	Optoeletronic Components & Materials	Japan	Other electrical devices and parts
Japan	Steel ships	Taiwan	Other Electrical Materials
Taiwan	Ships	Taiwan	Electronic Components & Parts
Japan	Semiconductor devices	Taiwan	Residential Building Construction
Japan	Integrated circuits	Taiwan	Nonresidential Building Construction
Taiwan	Computer Components	Japan	Trucks, buses and other cars
Taiwan	Communication Equipment	Japan	Motor vehicle parts and accessories
Japan	Plastic products	Taiwan	Motor Vehicles
Taiwan	Plastics (Synthetic Resins)	Taiwan	Repair and Maintenance of Motor Vehicles
Taiwan	Other Plastic Products	Japan	Ocean transport
Japan	Personal Computers	Taiwan	Water Transportation
Japan	Electronic computing equipment (except personal computers)	Japan	Hot rolled steel
Japan	Electronic computing equipment (accessory equipment)	Japan	Steel pipes and tubes
Japan	Cellular phones	Japan	Cold-finished steel
Japan	Liquid crystal element	Japan	Coated steel
Taiwan	Semiconductors	Japan	Metal products for architecture
		Taiwan	Primary Iron & Steel Products