〈経営研究　第2巻　第1号　昭和63年12月〉

The Regional Structure of Japan as Revealed by Multivariate Statistics

K. Nishigaya

I. INTRODUCTION

This paper treats the regionalization of Japan as an exercise in regional analysis. Traditionally, there are two kinds of concepts of regionalization (i. e. formal regionalization and nodal regionalization). The study of regionalization in terms of formal and nodal aspects is very active in both the U. S. A. and Japan (Berry, 1968 and Hayashi, 1974 etc.).

But, Berry (1968) argued that these two concepts of regionalization are not independent of each other, that one is the cause of the other, and he proposed a general field theory.

According to his argument, a difference in attribute is the cause of flow and flow causes the difference in attribute.

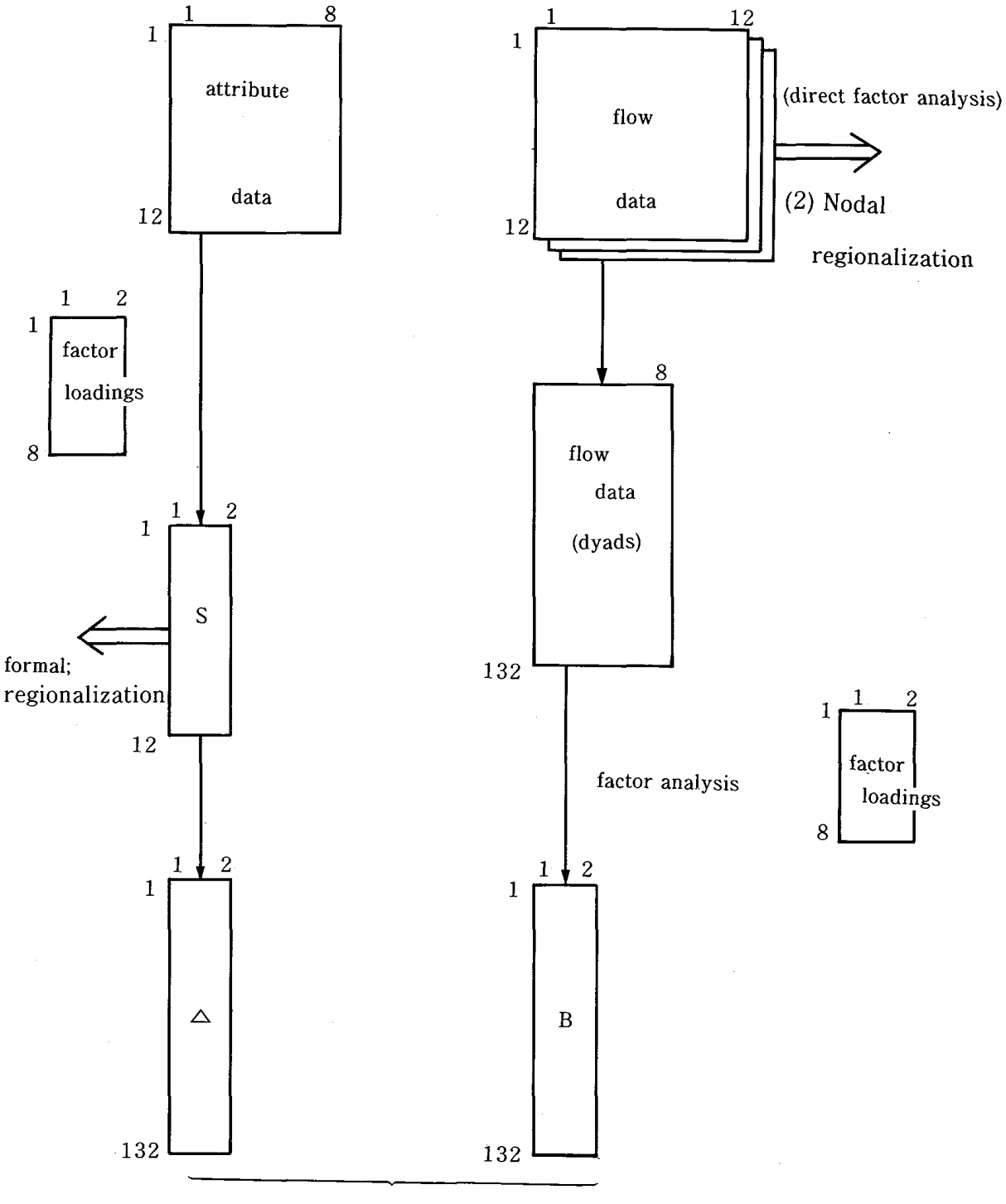
He proposed canonical correlation analysis as a tool to operationalize his general field theory.

Although this paper follows Berry's scheme of general field theory, the data are also applicable to the two traditional types of regionalization. In addition, I also discuss formal and nodal regionalization in order to be able to compare the three types of regionalization.

The basic unit of region in Japan is the prefecture (47) which has its own local government and assembly. Districting above the prefecture level is not unique. It varies from eight to twentythree according to administrative agen-

Exhibit 1. Research Scheme

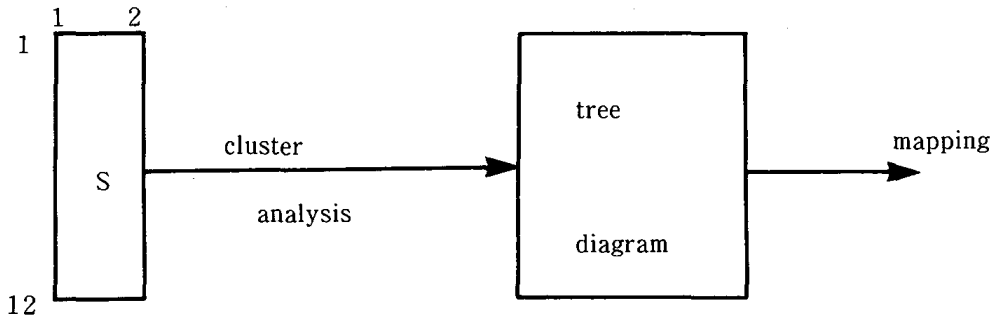
(1) General flow chart of the analysis



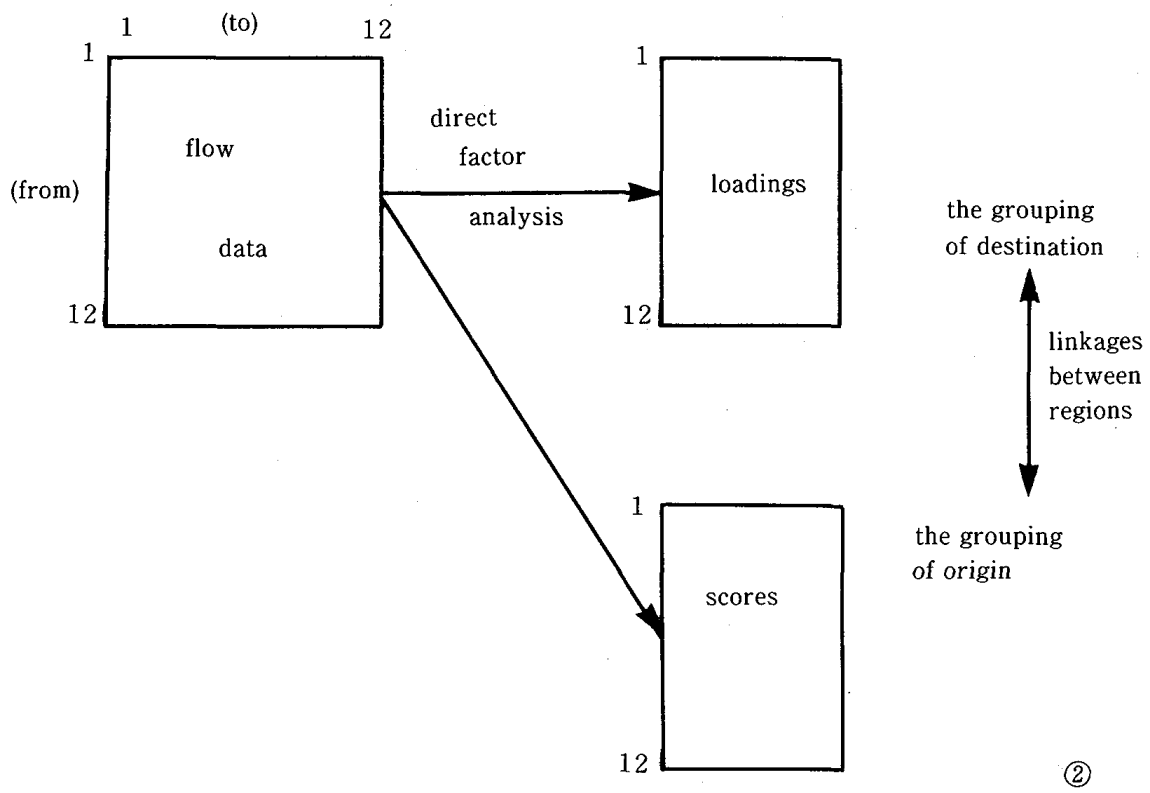
(3) Canonical correlation analysis

Exhibit 1. (continued)

(2) Formal regionalization



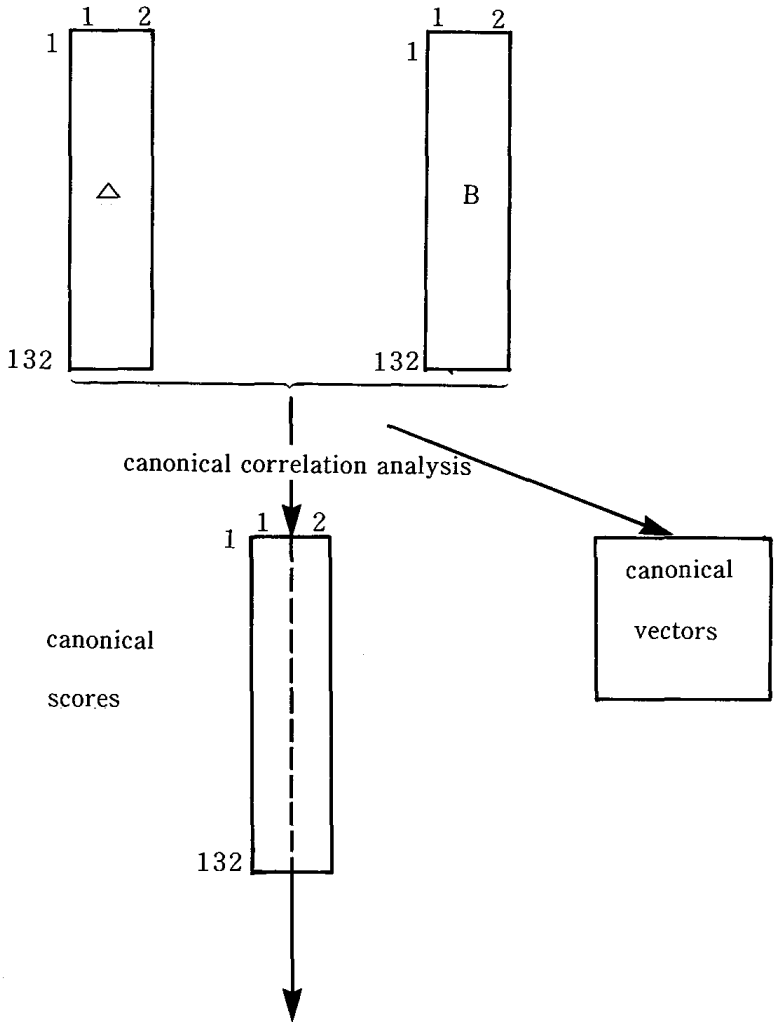
(3) Nodal regionalization



②

Exhibit 1. (continued)

(4) Synthesis (general field theory)



Mapping of distinct dyads ③

cies. This paper adopts 12 divisions and all the flow data are converted into 12 x 12 matrices. When N is the number of regions in the research area, the number of dyads is N^2–N. In Berry's research in India, he adopted 36 regions, and the number of dyads became 1260.

This is the reason why I decided to compromise with12 divisions (dyads = 132). If I had worked with data from the prefecture level, the number of dyads would be 2160. Although there are many studies (Saino and Higashi, 1978 and Ichinami, 1978) which treat the regionalization of Japan in terms of

formal or nodal regionalization, there has been no attempt to employ the dyad concept, nor to synthesize two types of regionalization.

The comprehensive research scheme is shown in Exhibit 1. The factor analysis is used three times. When we employ factor analysis, we have to predetermine the number of factors according to the theory which we are using. But because we do not have clearcut theory, we apply, at first, principal component analysis on the data and extract the major components from our exploratory research. The number of major components is determined by the criteria of eigenvalues over unity or the sharp drop in eigenvalues.

Ⅱ. DATA AND MAJOR FACTORS

The data consist of two categories——attribute data and flow data.

We adopt the following eight variables as the attribute data which refer to regional characteristics in terms of industries, economy, culture and population.

WAGE	Average workers' wage deflated by regional C. P. I. of the year 1977
GROWTH	Average annual growth rate of gross regional products (%) (1965–1975)
JOB	Ratio of job openings to applicants for senior high–school graduates (1977)
PERGRP	per capita gross regional products (¥10^6 ,1977)
MANAGERI	The percentage of managerial and professional labor forces in total workers (1977)
UNI	The ratio (%) of the number of residents with college degrees in region to the total population in region
UGROSS	The ratio (%) of total number of residents with college degrees in region to the total national population with college degrees

USA	Number of American residents (exclude military personnel) (1977)

We adopt the following 8 variables as the flow data which refer to the movement of persons (trip and migration), the movement of goods and interregional commercial transactions.

GOOD	the interregional movement of goods (1976)
TRIP	the interregional person trips (1976)
COMMERCE	the interregional commercial transactions (1976)
REGULAR	the interregional workers migration (except for new school graduates and temporary workers) (1976)
TEMPORAL	the interregional temporary worker movement (1976)
S.HIGH	interregional movement of graduates who joined labor force (senior high school) (1977)
JU.HIGH	interregional movement of graduates who joined labor force (junior high school) (1977)
COLLEGE	interregional movement of senior high school graduates who went to college (1977)

Factor analysis summarized the information which is carried by these variables. The varimax rotation of factors clarifies the interpretation of factors. Factors analysis on the attribute data extracts two factors which account for 91% of the variance in attribute data (Exhibit 2).

(1) The first factor, which accouuts for 77% of variance refers to the urban factor and economic activities. The two (east and west) core regions in Japan show high scores in the first factor.

(2) The second factor, which is orthogonal to first one, refers to economic growth and cultural factor. Two cores in Japan show opposite scores with respect to this second factor. This factor differenciates two cores, east and west, in Japan.

Exhibit 2. Factor Analysis of Attribute Data

(1) Factor loadings (after varimax rotation)

SIMULTANEOUS VARIMAX ON 2 FACTORS WITH NORMALIZED LOADINGS

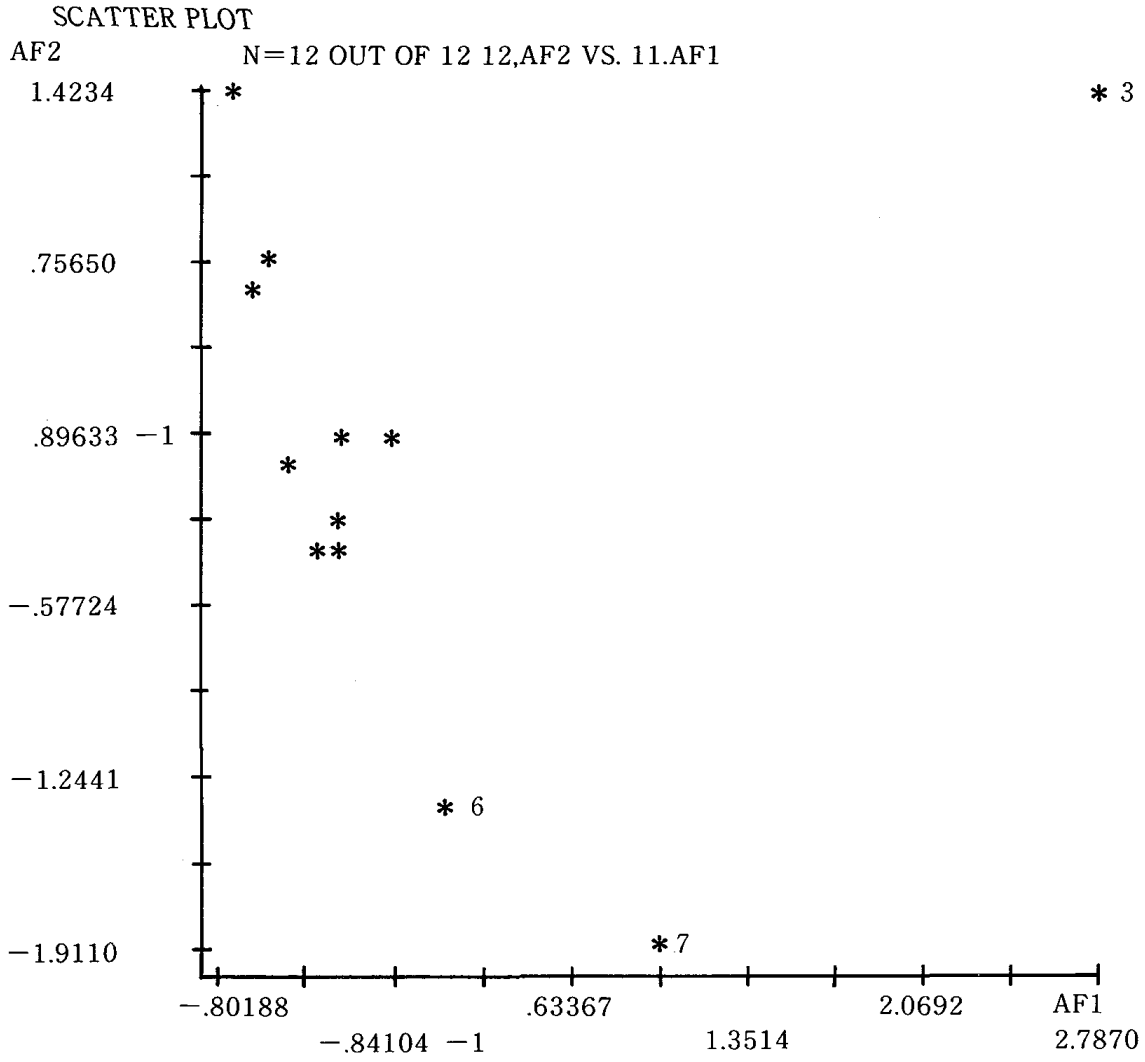
VARIABLE	COMMUNALITY	(1)	(2)
1. WAGE	.88352	.83060	−.44003
2. GROWTH	.93733	−.66496	.70367
3. JOB	.9.1824	.90805	−.30609
4. PERGRP	.91378	.92055	−.25761
5. MANAGERI	.65322	.80209	−.99339 −1
6. UNI	.97776	.98805	.39021 −1
7. UGROSS	.97243	.96240	.21500
8. USA	.99973	.90727	.42022
	SUM SQRS	6.1730	1.0830
	% VARIANCE	77.2	90.7

(2) Factor scores

CASE	AF1	AF2
1	−.32483	−.24682
2	−.68358	.66130
3	2.7870	1.4234
4	−.29485	.37062 −1
5	−.36340	−.38666
6	.13179	−1.3471
7	1.0234	−1.9110
8	−.30818	−.37647
9	−.49409 −1	.45666 −1
10	−.49448	−.62766 −1
11	−.62153	.76440
12	−.80118	1.3990

Exhibit 2. (continued)

(3) Scatter diagram of factor scores



Factor analysis on flow data extracts two factors (Exhibit3).

(1) The first factor refers to permanent residential change (migration).

(2) Second factor refers to temporary movement (movement of goods and person trips).

(3) Commercial transaction and college selection show intermediate position in factor loadings.

As we will see later in Chapter V, canonical correlation analysis shows that attribute factor I corresponds to flow factor I and attribute factor II corresponds to flow factor II.

This suggests that migration is related to attribute difference with respect to

urban and economic aspects.

Exhibit 3. Factor Analysis of Flow Data

(1) Factor loadings (after varimax rotation)

SIMULTANEOUS VARIMAX ON 2 FACTORS WITH NORMALIZED LOADINGS

VARIABLE	COMMUNALITY	(1)	(2)
1. GOOD	.86096	−.27940 −1	.92746
2. TRIP	.85814	−.65063 −1	.92407
3. COMMERCE	.39443	.36601	.51036
4. REGULAR	.81386	.88104	.19397
5. TEMPORAL	.66474	.81083	.85422 −1
6. S. HIGH	.96810	.89510	.40853
7. JU. HIGH	.49701	.69585	.11316
8. COLLAGE	.69398	.52164	.64951
	SUM SQRS	3.1302	2.6210
	% VARIANCE	39.1	71.9

Ⅲ. FORMAL REGIONALIZATION

Formal regionalization is based on the homogeneity among regions. Factor analysis on the attribute data gives factor scores. Cluster analysis (Ward method) is applied on the factor scores weighed by eigenvalues. Five groups are identified from the tree diagram (The criteria is the sharp change in distances).

We named these groups as follows according to the knowledge we have (Exhibit 5):

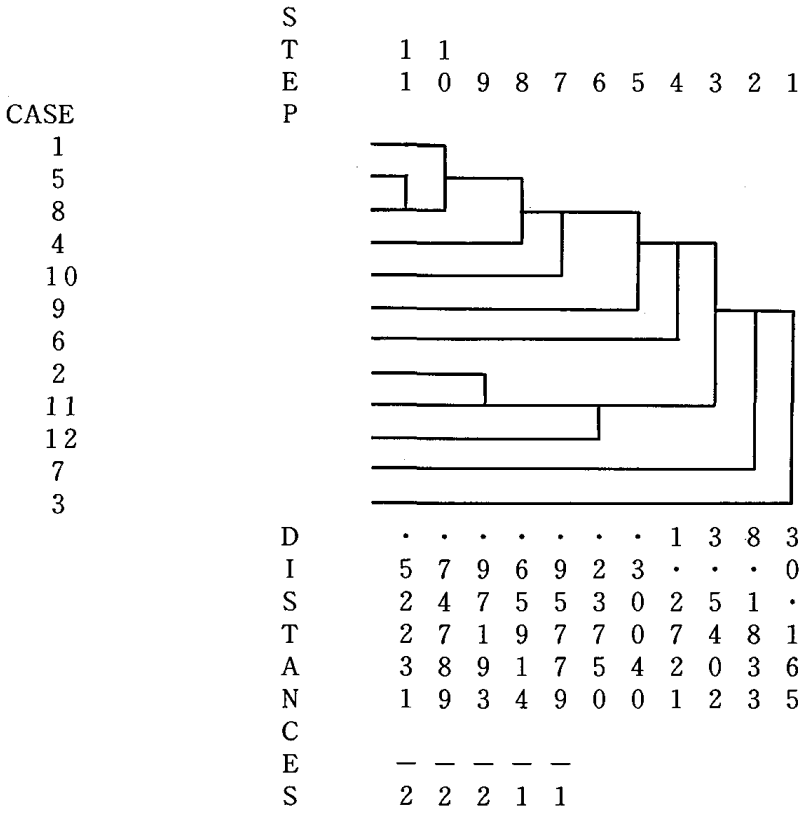
the principal core	region 3
the secondary core	region 7
the tertiary core	region 6
the intermediate regions	region 1, 4, 5, 8, 9, 10
the backward regions	region 2, 11, 12

(1) The principal core does not merge with any regions (Exhibit 4). This

Exhibit 4. The Cluster Analysis of Attribute Factor Scores

CLUSTER ANALYSIS
CASEWISE N=12 ALGORITHM=MINVAR DISTANCE=EUCLIDEAN

USING: 11.AF1, 12.AF2



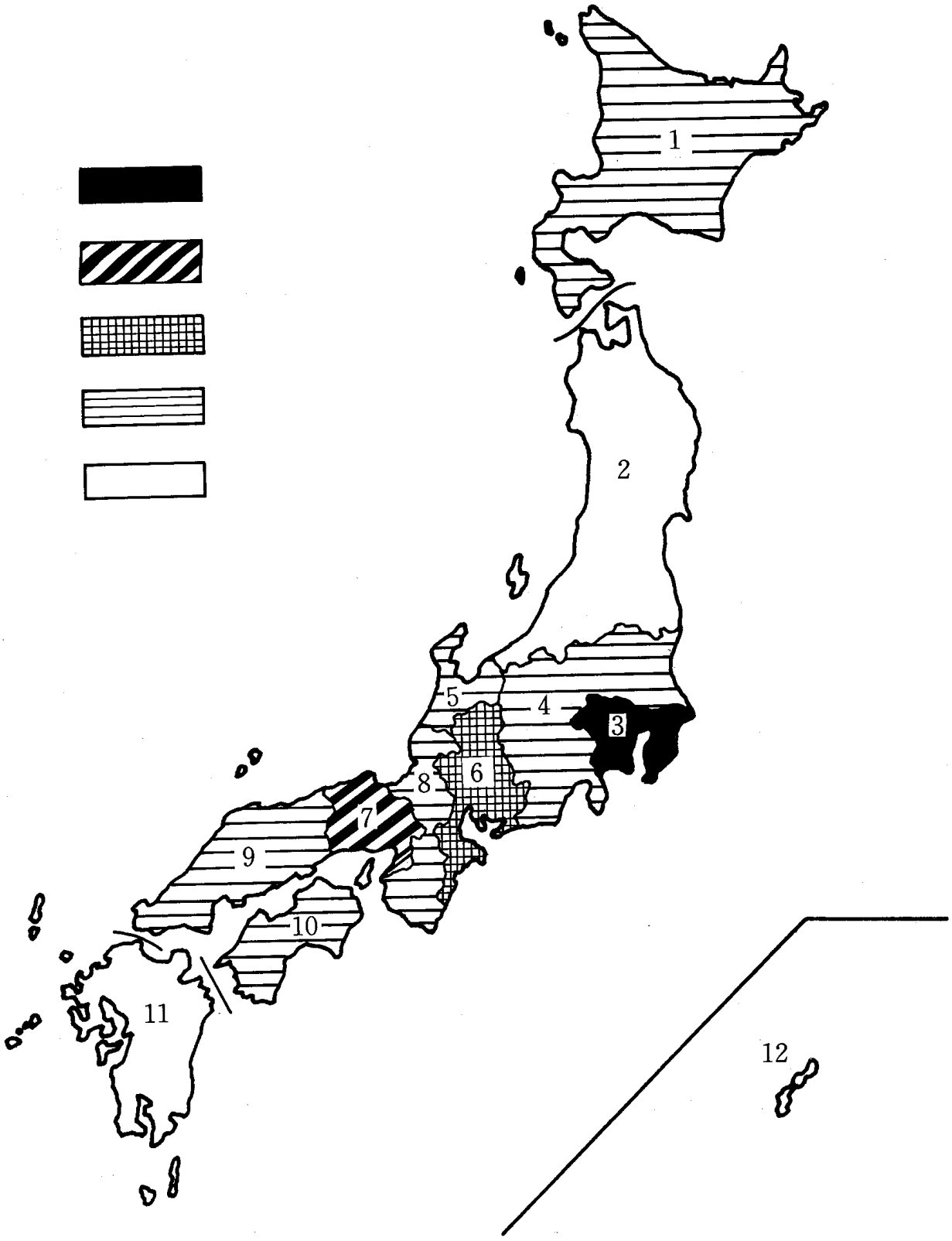
COPHENETIC CORRELATION= .9590

implies that region 3 has distinct attributes which the other eleven regions do not have.

(2) Three cores are isolated from each other. Although these three cores differ from the backward and intermediate regions with respect to their attributes, they have little similarity with each other, as the scatter diagram of factor cores shows (Exhibit 2,3).

(3) The most underdeveloped areas in Japan are regions 2, 11, and 12. They consistently suffer from low income and unemployment.

Exhibit 5. Formal Regionalization



Ⅳ. NODAL REGIONALIZATION

Direct factor analysis is applied to seven (12x12) flow matrices. Among eight flow matrices, one (junior high school graduate migration) is a singular matrix, hense factor analysis on it is not applicable. In direct factor analysis, the origins are assumed to be observations and the destinations are assumed to be variables. Factor loadings give the groupings of destinations. Factor scores give the groupings of origins. Each factor brings up one nodal region (the combination of origins and destinations).

As an example, let us examine the direct factor analysis of commercial transaction (Exhibit 6). As the number of eigenvalues which exceed unity is two and as there are sharp drops after socond factor. the number of factors to be extracted is determined to be two. The number of nodal regions to be defined is two likewise.The results of direct factor analysis of commercial transaction may be interpreted as follows:

(1) The first factor shows high loadings in variables 3, 5, 8, 9, 10 and 11 (destinations) and shows high scores in case 7 (origin). This factor defines the the west Japan nodel region which centers in region 7 (Osaka).

(2) The second factor has high loadings in variables 1, 2, 4, 7 and 12 (destinations) and has high score in case 3 (origin). This factor defines the east Japan nodal region which centers in region 3 (Tokyo).

(3) The varimax rotation redestributes eigenvalues.
The new first eigenvalue is 5. 58 and the new second one is 5. 52.
Two nodal regions have almost equal weight. Thus, with respect to commercial transaction, Japan can be divided into two (west and east) regions which are equal to each other with respect to the amount of transaction.

(4) While region 12 (Ryukyu) locates in the southwest, it is classified an au eastern group.

(5) Region 7 belongs to the east group and region 3 belongs to the west

group. This implies that there exist another flow which connect two regional centers in addition to the flow within nodal regions.

Direct factor analyss on the other flow matrices give 3 to 6 nodal regions to each flow matrix. The number of total nodal regions reaches to 28. As there are many duplications in those nodal regions, we classify these regions according to two types of flow, which are mentioned in Chapter II, i. e., temporary flow and migration flow.

——Temporary flow——(Exhibit 7)

(1) The major nodal regions in temporary flow are two (west and east). There exists a third flow which connects two centers (There is no flow which connects two cores in migration flow).

(2) East Japan nodal region covers all of east Japan and Ryukyu.

(3) Only one west Japan nodal region covers all west Japan. Region 5, 7, 8 and 10 appear to be core regions in the western group. The western region extends in a northeast/southwest direction. Region 6 hinders the eastward expansion of the west nodal region.

(4) Region 9 and 11 are the center of two local flows.
The southwest was Japan's historical core and has been well–developed due to its location nearest to the the Asian continent. They have developed their own nodal regions and have many natural sea ports which facilitate interaction between regions.

(5) Thare is no major core except region 3 in east Japan.

(6) Region 6 (tertiary core) does not belong to other nodal regions, nor does not have surrounding hinterlands. It seems to be self–suffcient.

(7) Ryukyu maintains a strong connection to region 3 and 11.

——Migration flow——(Exhibit 8)

(1) Two main labor supply flows (east and west) originate from two backward regions (2 and 11). These two regions are labor supply cores.

(2) Three long distance migration flows concentrate into region 3.

(3) There exists west Japan (Inland sea) local flow.

In summary:

1. There are two major (west and east) nodal regions in Japan.
2. There are local nodal regions in southwest Japan.
3. Region 6 is self–sufficient.
4. Flows connects core and hinterland, that is, flow reflects the difference in attributes in general.

Exhibit 6. Nodal Regionalization by Commertial Transaction

(1) Eigenvalues

	1	2	3
1	8.0992	67.4938	67.4938
2	2.6040	21.7001	89,1939
3	0.4618	3.8483	93.0422
4	0.3329	2.7744	95.8166
5	0.2135	1.7794	97.5960
6	0.1480	1.2337	98.8298
7	0.1007	0.8395	99.6692
8	0.0238	0.1980	99.8672
9	0.0098	0.0813	99.9485
10	0.0051	0.0425	99.9910
11	0.0011	0.0090	100.0000
12	0.0000	0.0000	100.0000

COLUMN 1=EIGENVALUES, COLUMN 2=PERCENT OF TRACE
COLUMN 3=CUMULATIVE PERCENT OF TRACE

Exhibit 6. (continued) (2) Factor loadings

(the groupings of destinations)

	1	2
1	0.6016	−0.7037
2	0.3689	−0.8856
3	0.7838	0.3719
4	0.4514	−0.8820
5	0.9182	−0.3433
6	0.6197	−0.6864
7	−0.0747	−0.9268
8	0.9471	−0.2499
9	0.8696	−0.2289
10	0.9277	−0.3131
11	0.7132	−0.5414
12	0.0990	−0.9861

ROTATED FACTOR MATRIX–COLUMN

(2) Factor scores

(the groupings of origins)

	1	2
1	−0.4349	0.3576
2	0.1106	0.4299
3	0.1669	−3.1369
4	−0.0565	0.4620
5	−0.6156	0.2853
6	0.1187	−0.0263
7	3.0025	0.4860
8	−0.6653	0.2557
9	−0.3530	0.0830
10	−0.5647	0.2686
11	−0.0210	0.1437
12	−0.6878	0.3909

VARIMAX FACTOR SCORES–COLUMN

Exhibit 6. (continued)

(4) West Japan

(region 7–oriented)

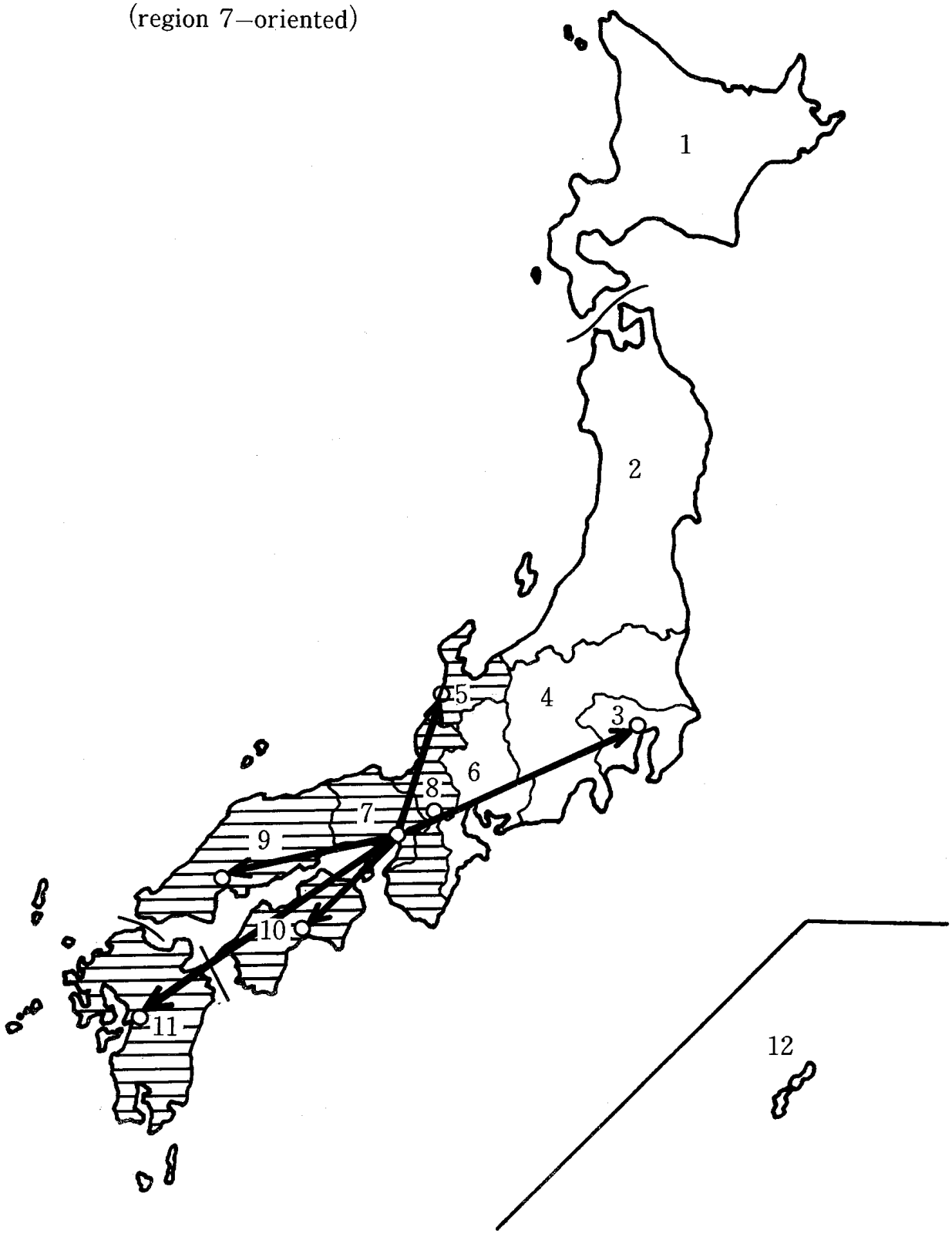


Exhibit 6. (continued)

(5) East Japan

(region 3–oriented)

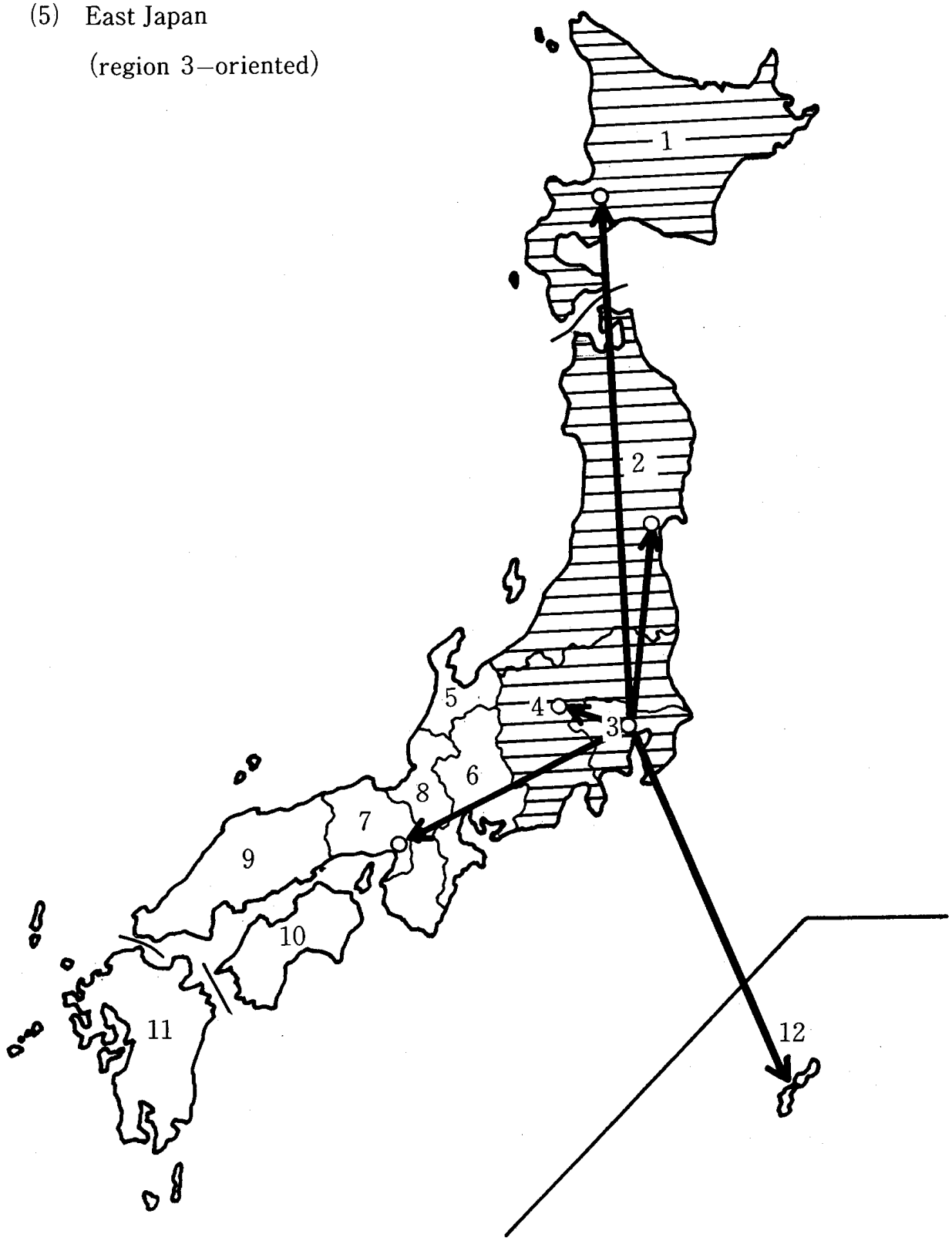


Exhibit 7. Nodal Regionalization

Movement I –Temporary–

(1) East Japan main flow

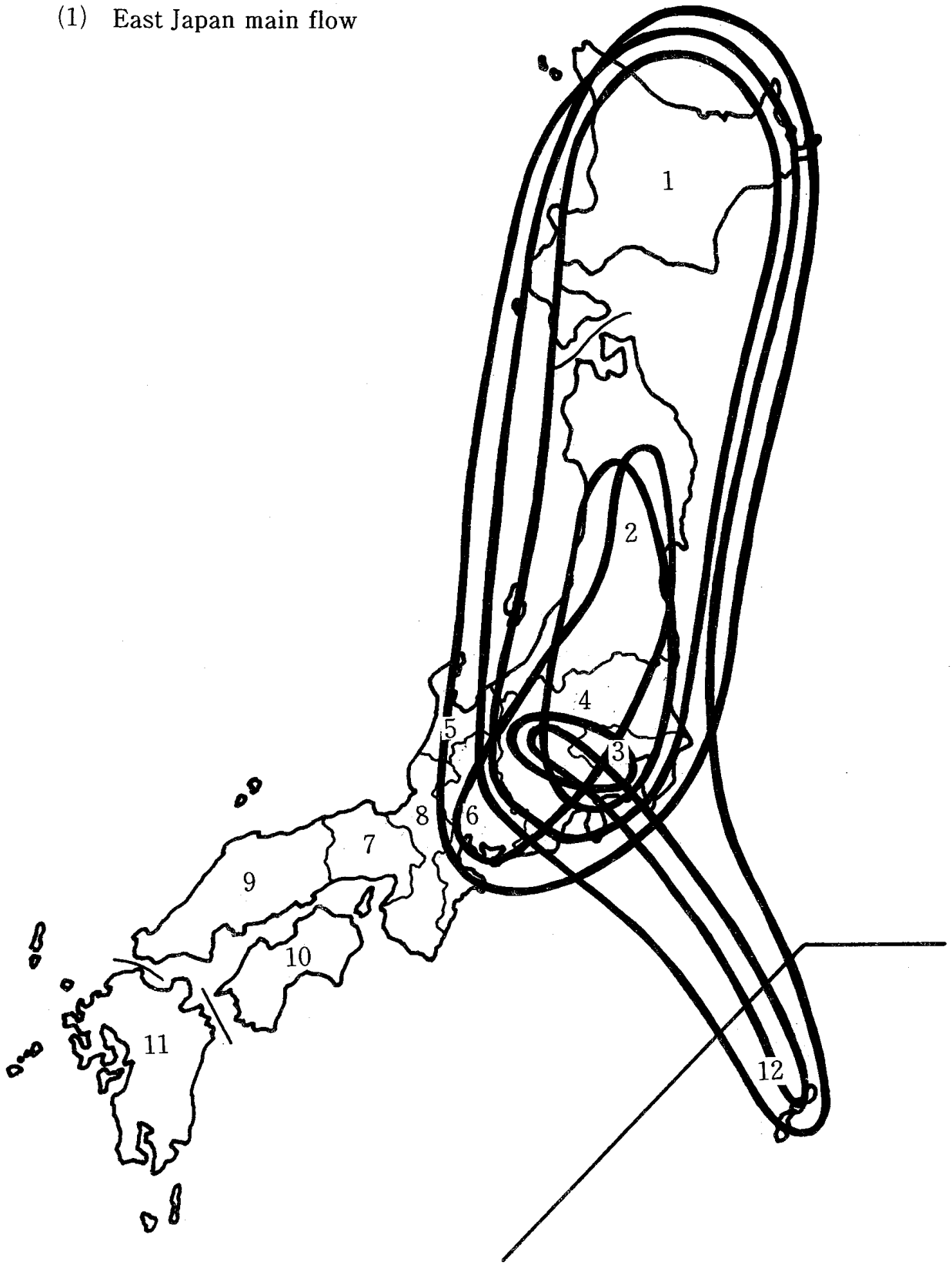


Exhibit 7. **(continued)**

(2) West Japan main flow

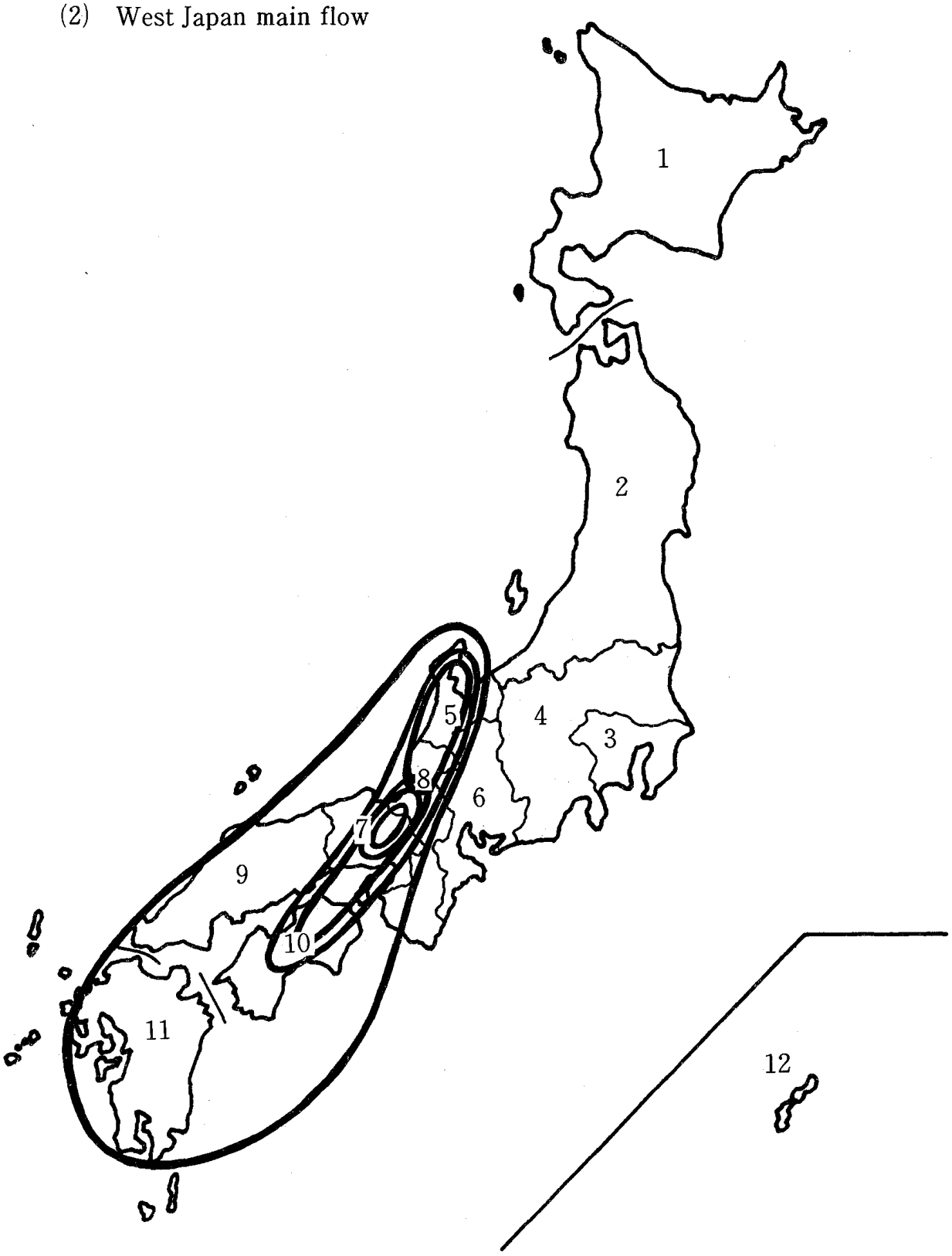


Exhibit 7. (continued)

(3) East–west main flow

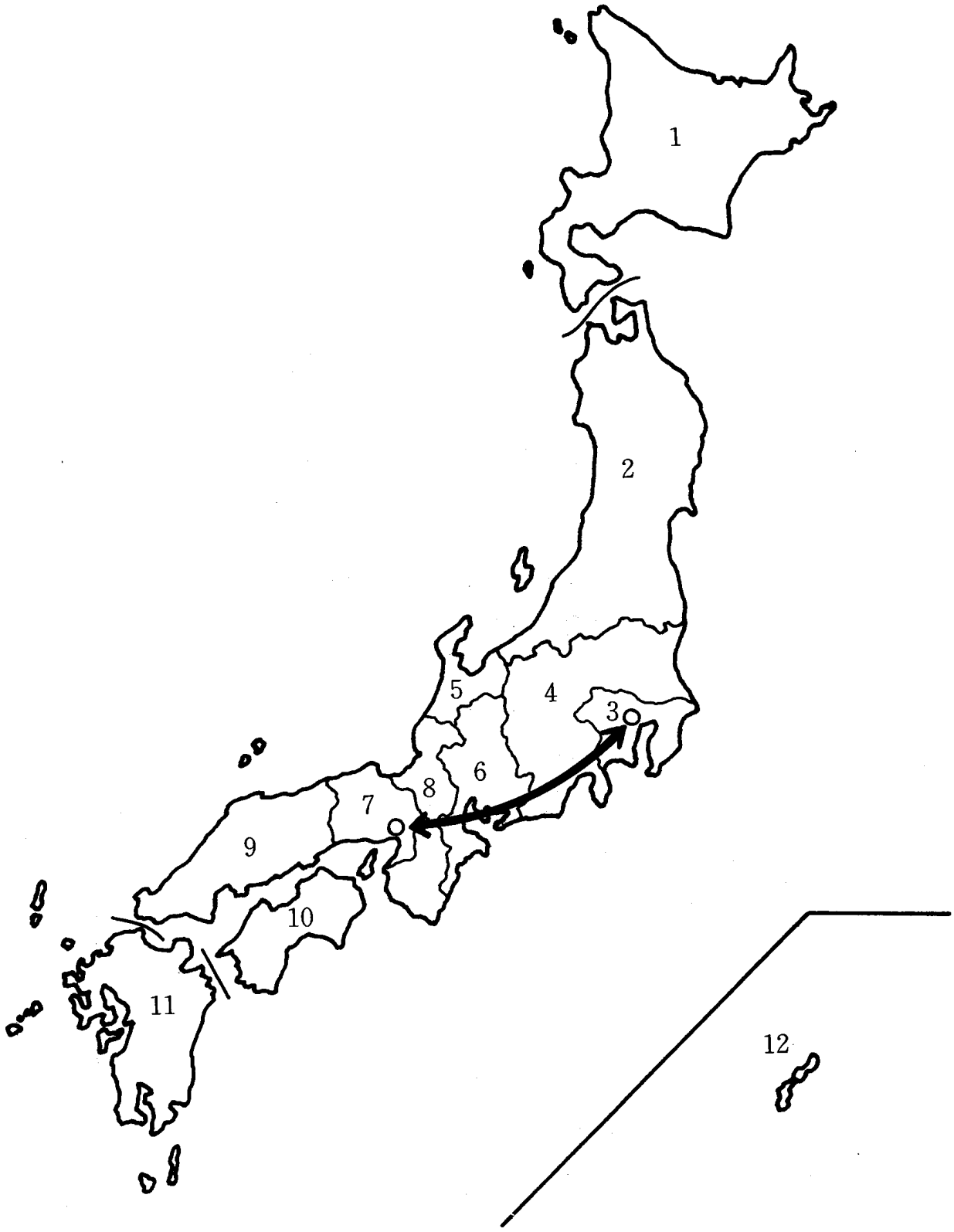


Exhibit 7. (continued)

(4) Local flow

(Inland Sea and North Japan)

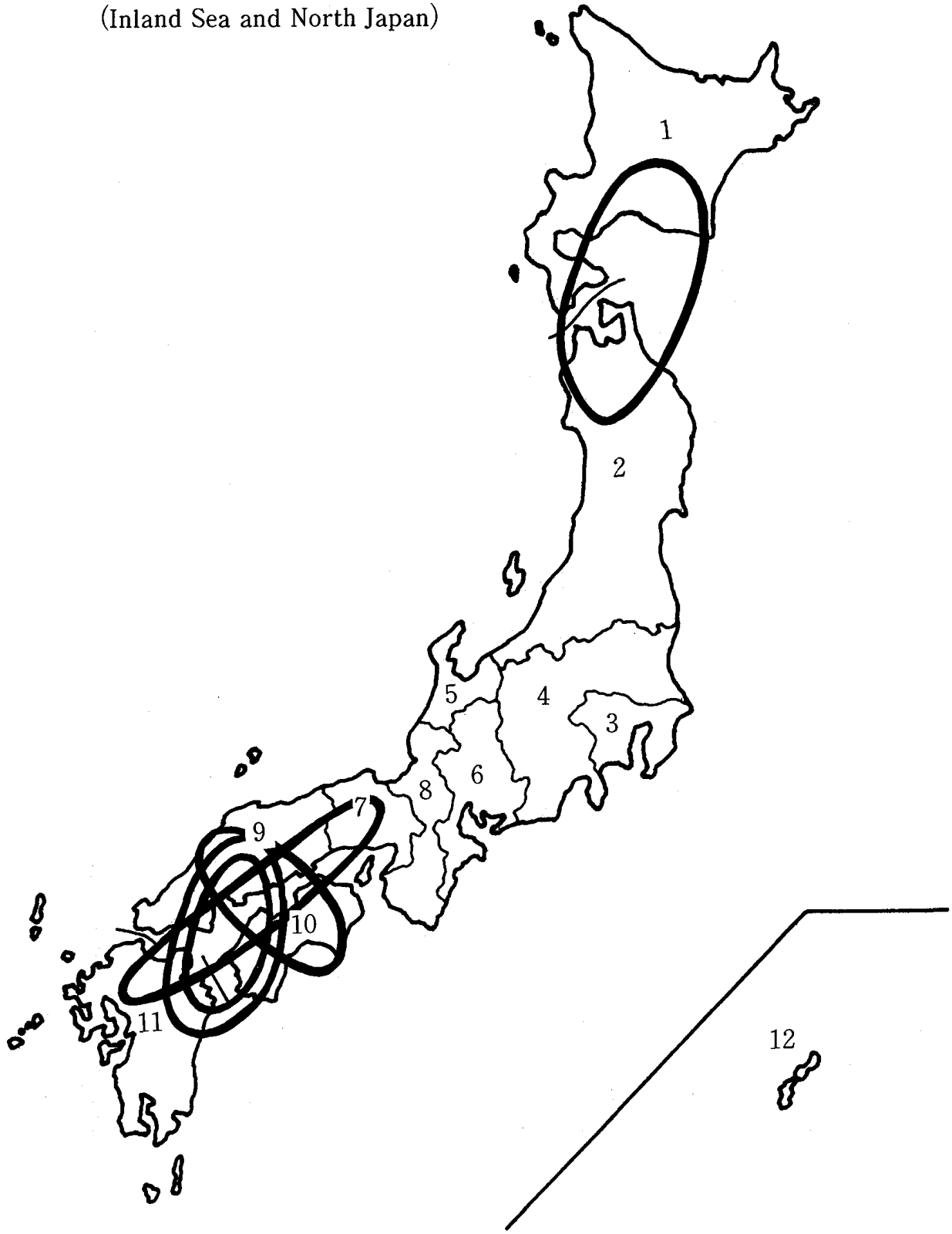


Exhibit 7. (continued)

(5) Local flow

(far west Japan)

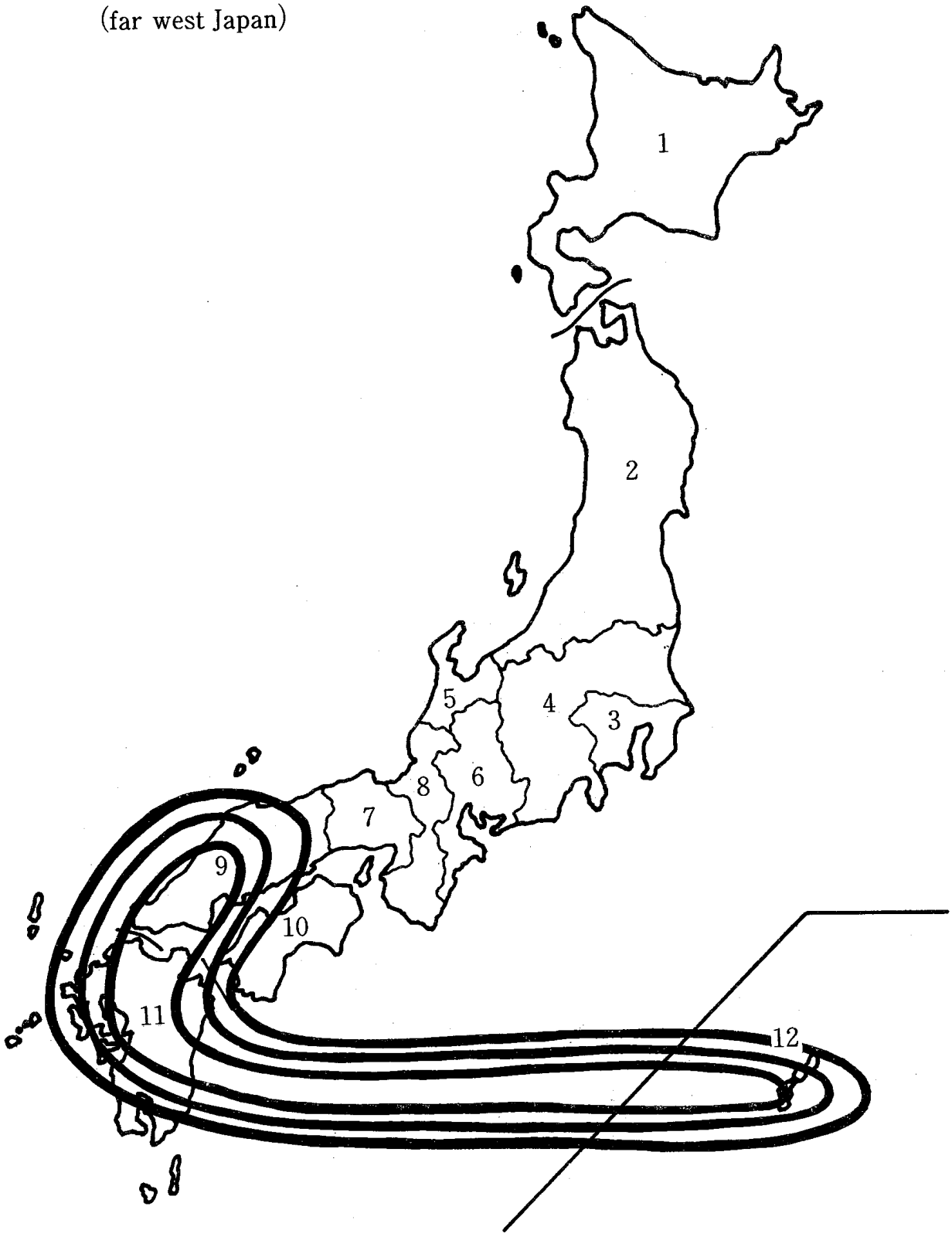


Exhibit 8. Nodal Regionalization

Movement II —Migration—

(1) East Japan labor supply flow

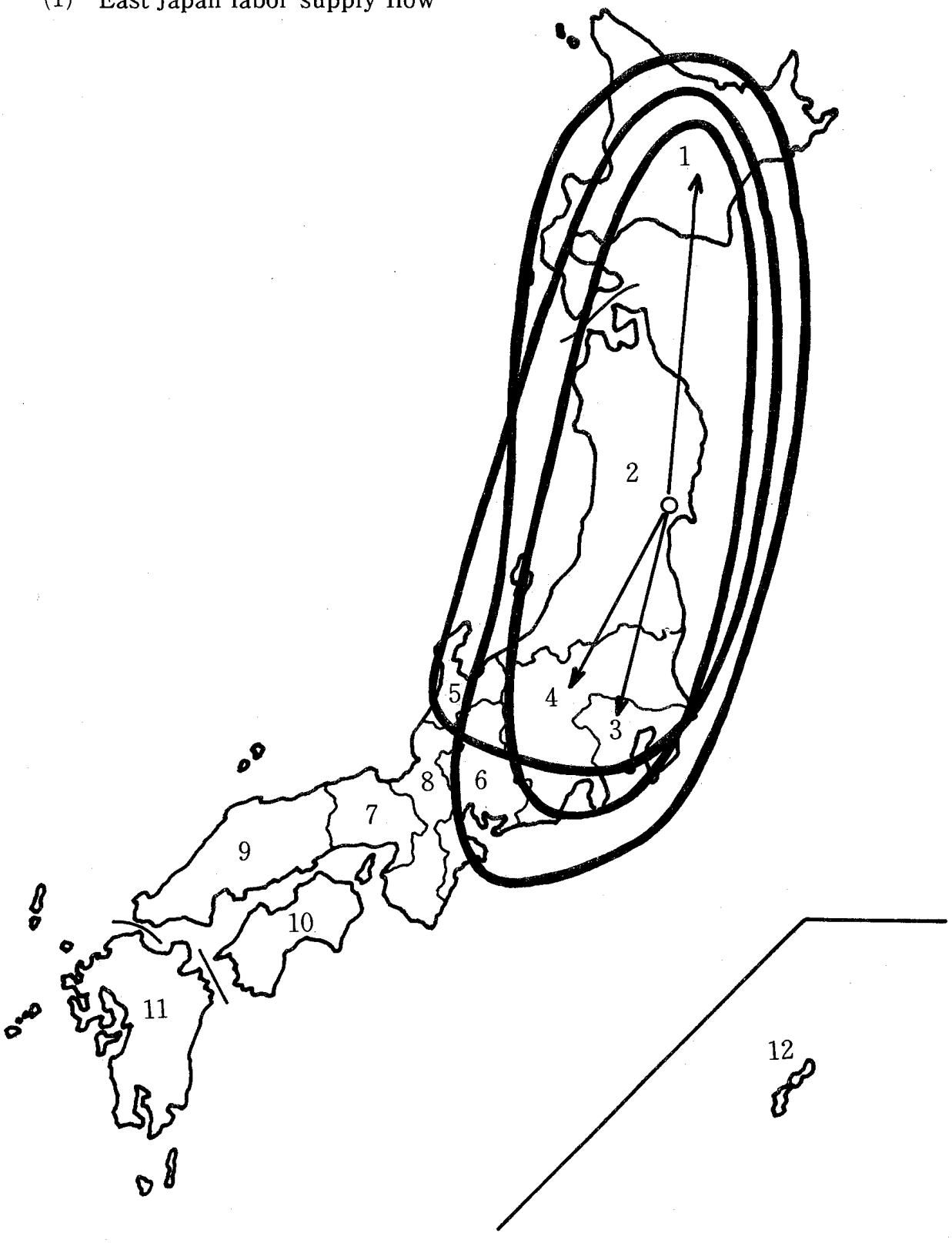


Exhibit 8. (continued)

(2) West Japan labor supply flow

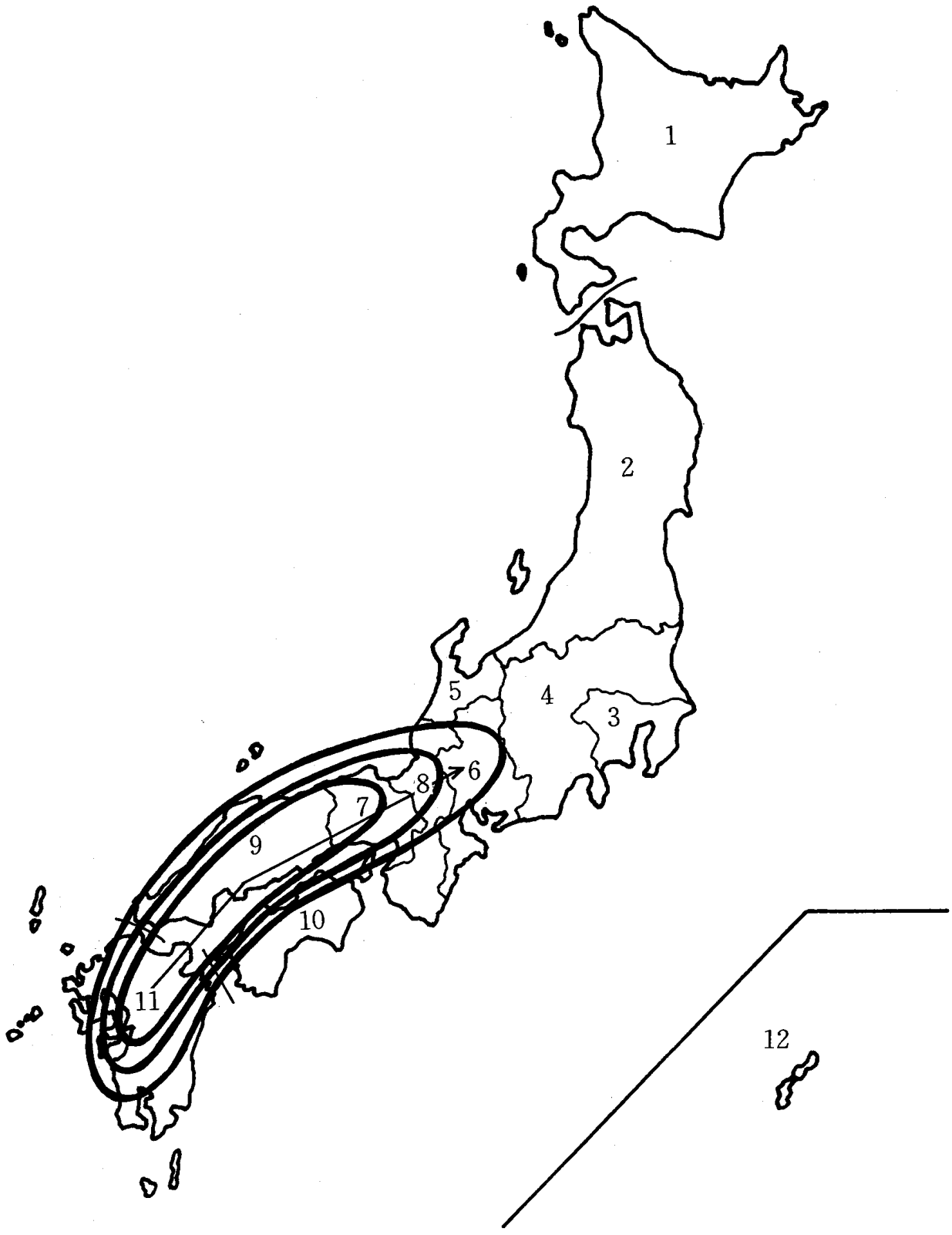


Exhibit 8. (continued)

(3) Long distance labor supply flow

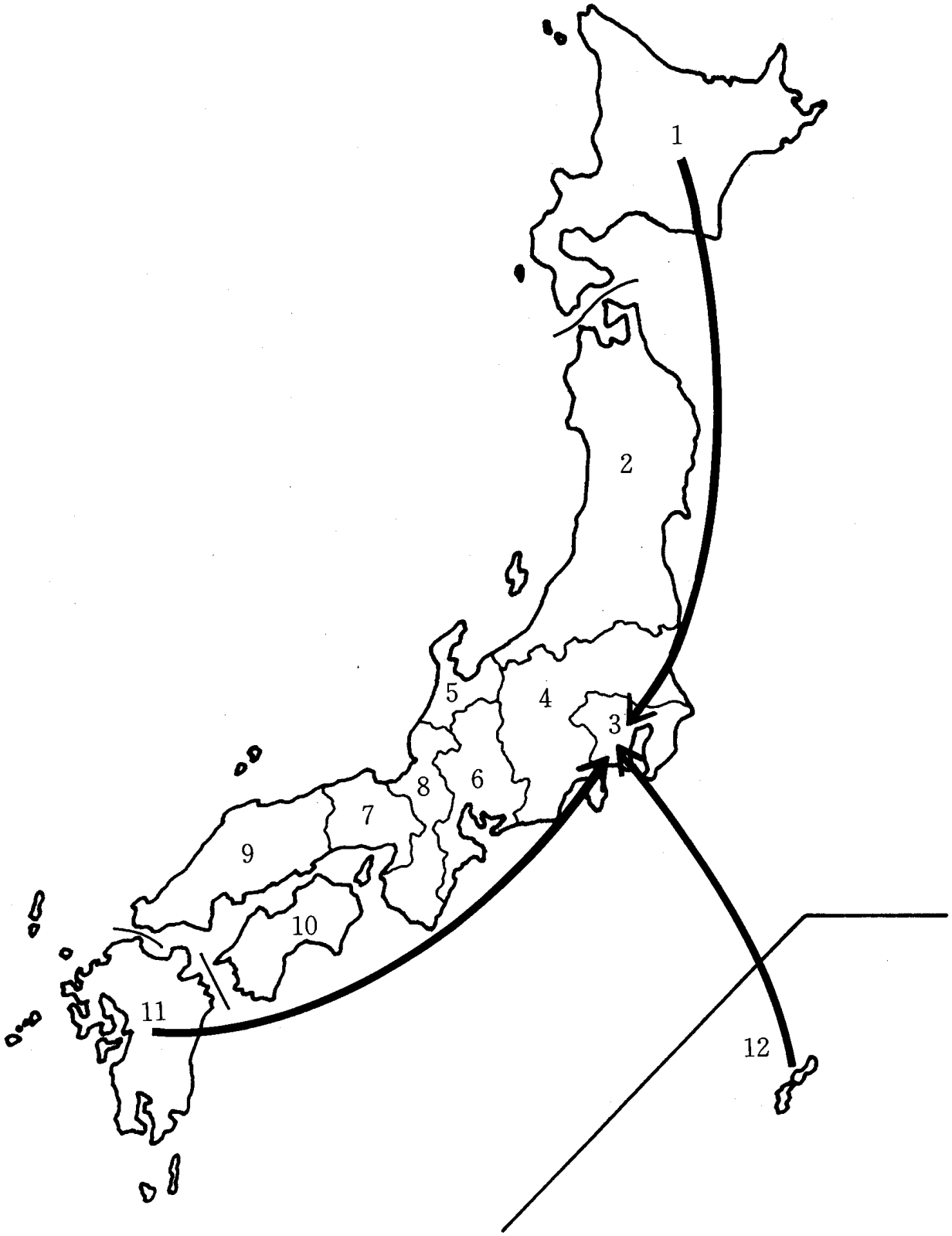
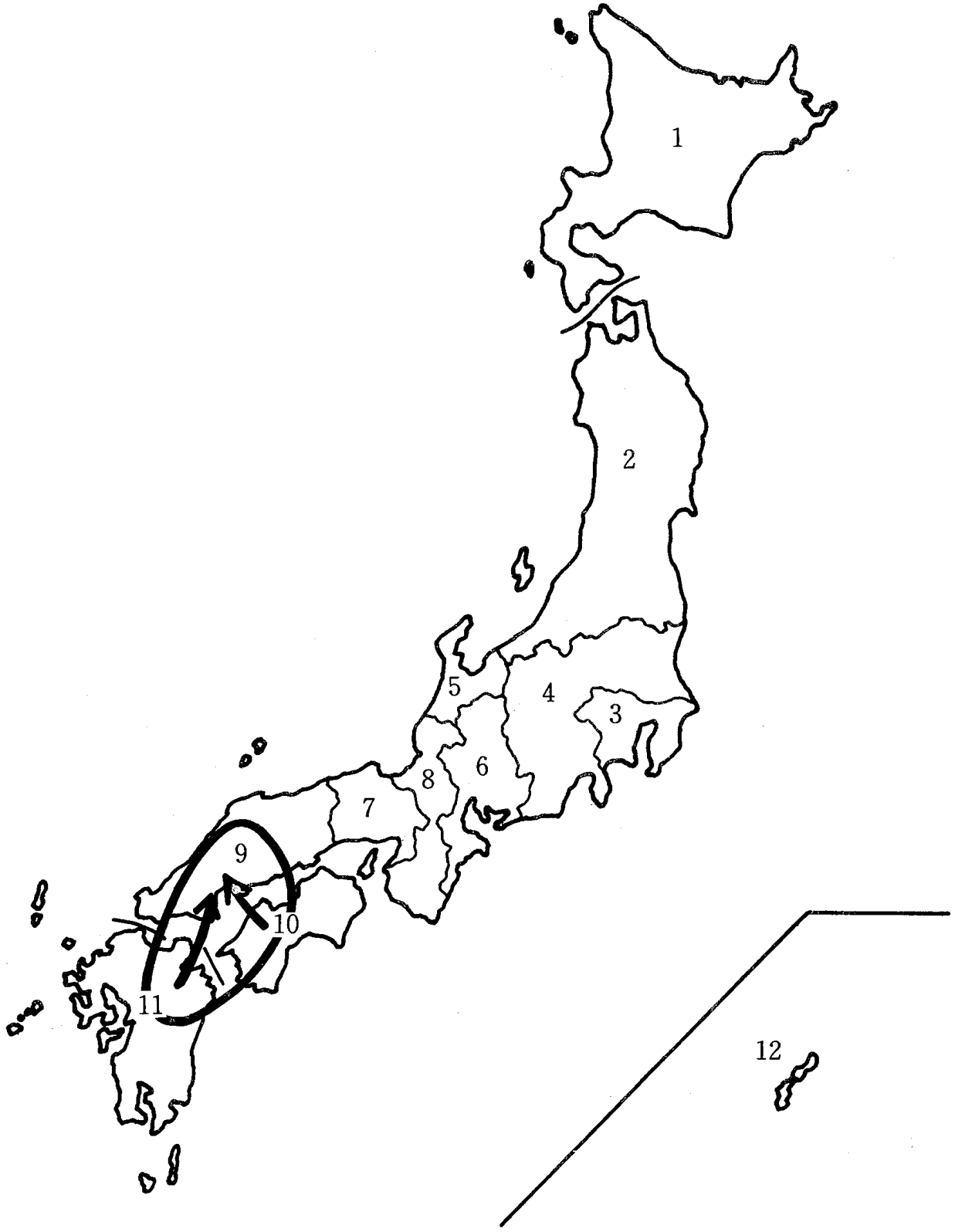


Exhibit 8. (continued)

(4) Inland Sea local labor supply flow



V. Synthesis

Canonical correlation analysis is applied to two data sets (△ matrix and B matrix). Two canonical vectors and corresponding canonical scores are produced (Exhibit 9 and Exhibit 12).

According to canonical vectors, the first attribute factor (urban–economic) corresponds to the first flow factor (migration) negatively. The second attribute factor (growth–culture) corresponds to the second flow factor (tamporary flow). The correlation in the second combination is very low. This implies that some portion of temporary flow corresponds to the first attribute factor (urban & economic). Although the individual correlations between factors are low, the overall correspondence between the two data sets is very significant.

Canonical scores are obtained for each dyad. The maps of major dyads are produced.

(1) As for the first canonical vectors,12major dyads are selected for mapping. 12 arrows compose 3 nodal–type regions (Exhibit10). The following strong ties are maintained between backward regions and three cores in spite of long distance.

region 2 → region 3 and 6
region 11 → region 3, 6 and 7
region 12 → region 3 and 7

Thus, the first vector produced two major regions and one minor region.

(2) 20 dyads are selected from the second canonical scores according to the values (Exhibit 11). The distribution of 20 arrows is as follows.

	major 10	second major 10
region 3	8	2

region	7	2	7
region	6	0	1

While both region 3 and 7 cover the whole country, 80 % of major 10 arrows start from region 3. Seventy per cent of the second 10 major dyads from region 7. This implies that region 7 has something to offer which region 3 does not have. The second canonical scores are related to the second attribute factor which discriminates region 3 (principal core) from regions 6 and 7 (secondary and tertiary cores). Regarding these factors (i. e., growth and culture), region 3 dominates whole country. Thus, Japan can be regionalized into one or two regions depending on the aspects by which we classify.

In summary,

(1) The mapping of the first canonical scores gives two or three nodal-type regions.

(2) The mapping of the second canonical scores gives two stratified regions which are identical with respect to coverages.

Exhibit 9. Canonical Vectors

CANONICAL CORRELATIONS

TESTS OF INDEPENDENCE	STATISTIC	DF	SIGNIF
LIKELIHOOD RATIO	25.257	4	.0000
LARGEST ROOT	.1765	−5,63.0	.0000

COEFFICIENTS FOR CANONICAL VARIABLES N=132 OUT OF 132

VARIABLE	(1)	(2)
CORRELATION	.4201	.0490
11. BF1	−.98895	.15213
12. BF2	−.11831	−.99356
15. AF1	.95955	.28181
16. AF2	−.29404	.95588

Exhibit 10. The Mapping of First Canonical Scores

(12 major dyads)

(1) Region 3–oriented (6 dyads)

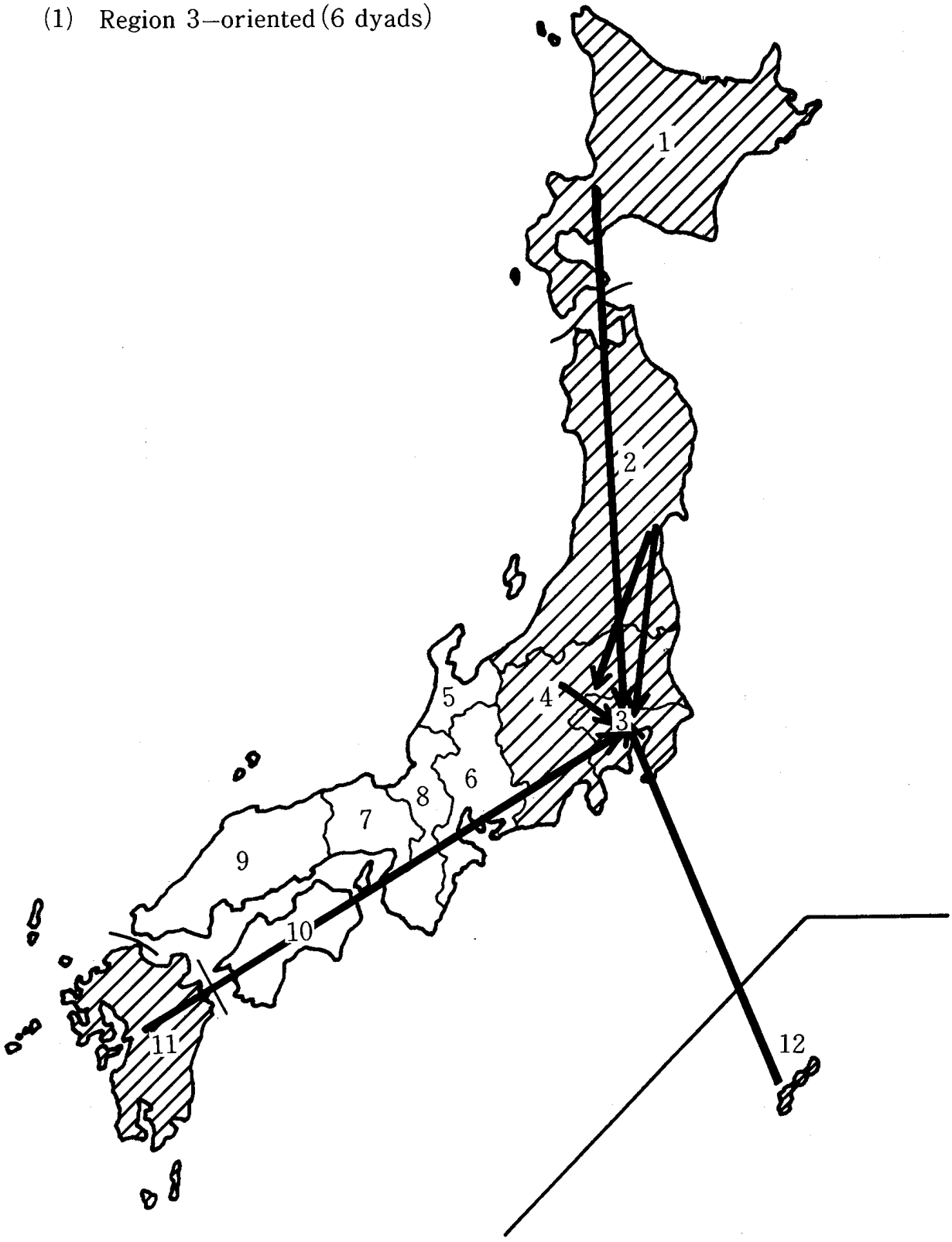


Exhibit 10. **(continued)**

(2) Region 7–oriented (4 dyads)

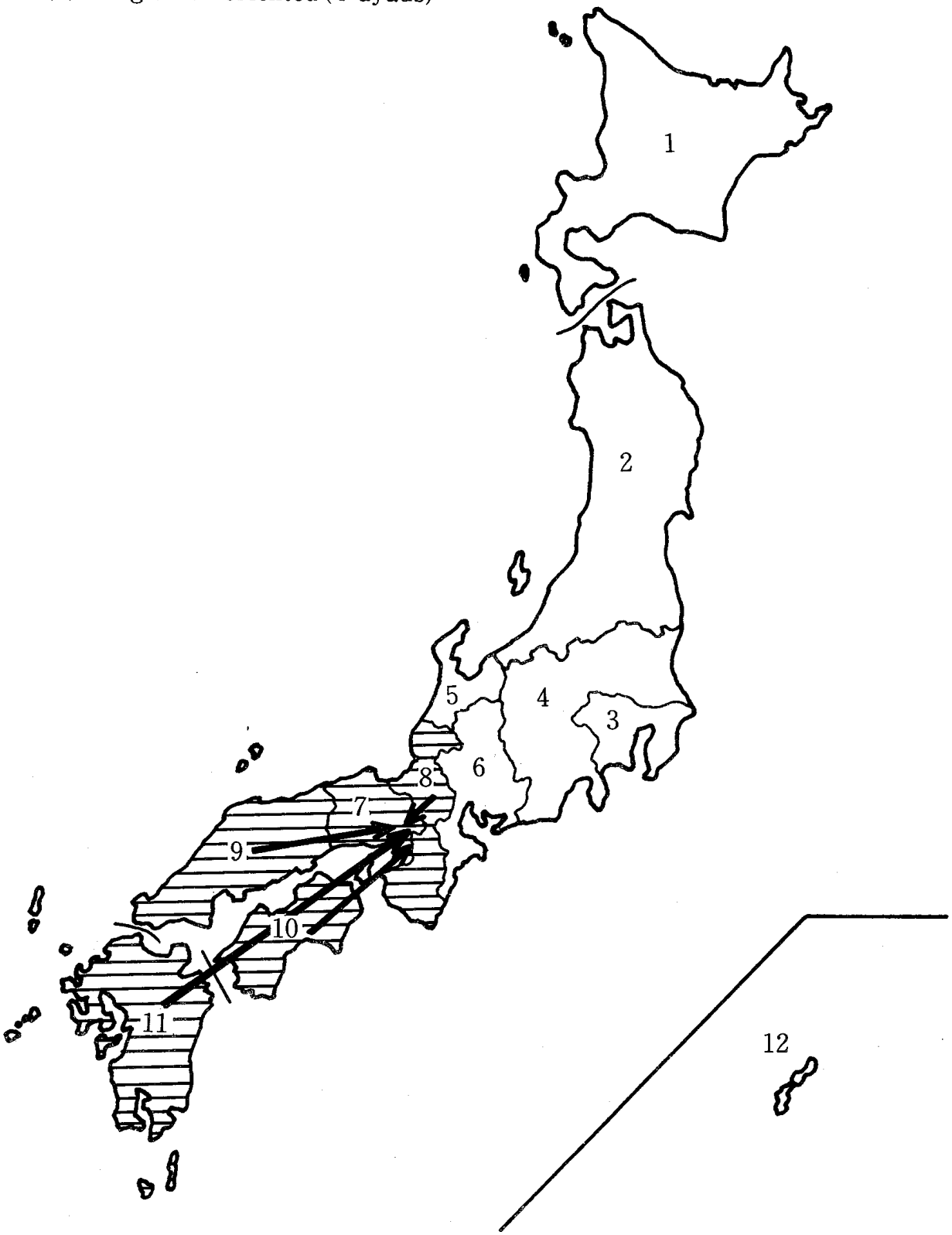


Exhibit 10. **(continued)**

(3) Region 6–oriented (2 dyads)

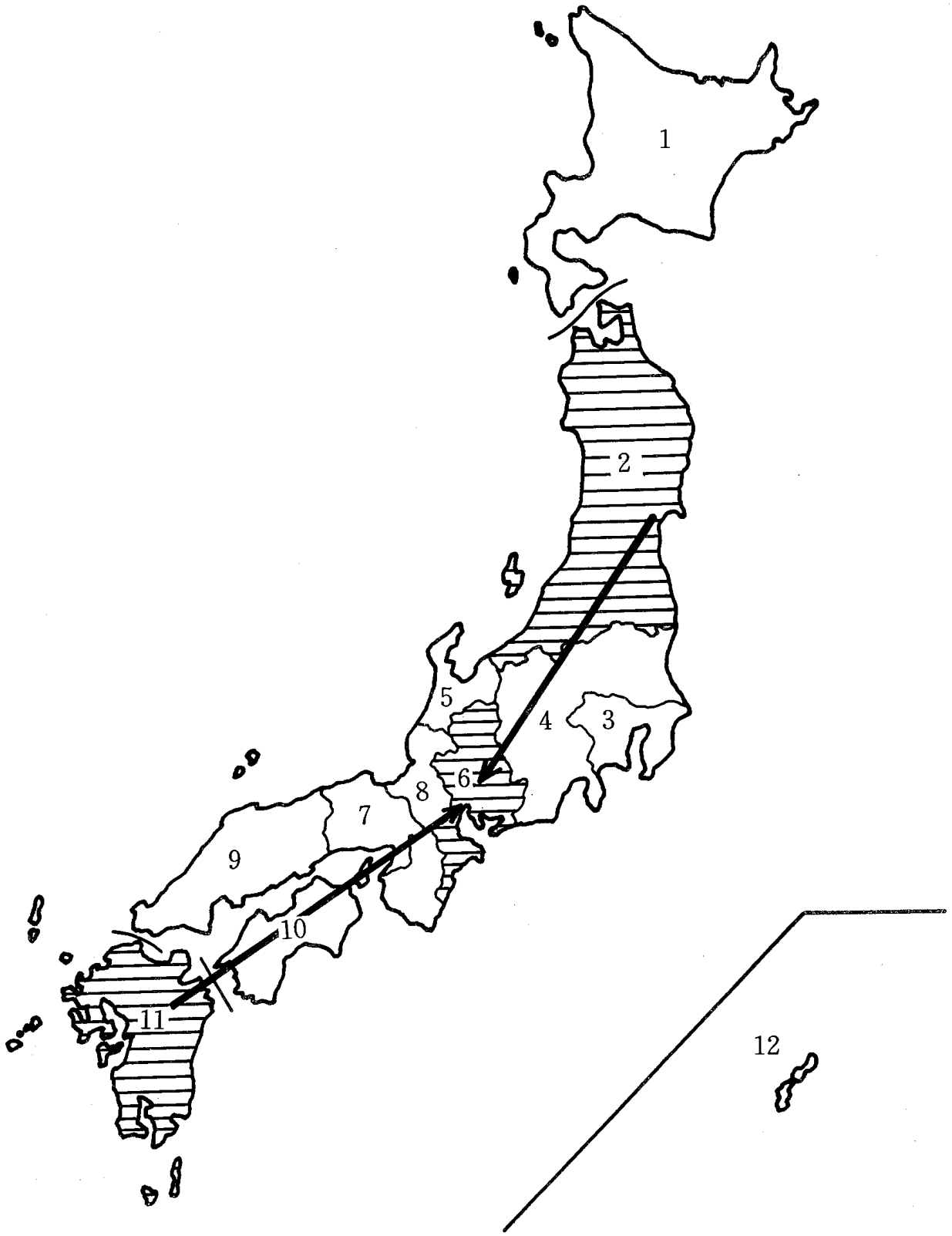


Exhibit 11. The Mapping of Second Canonical Scores

(20 major dyads)

(1) Region 3–oriented

➡ Major ten dyads

⇢ Second major ten dyads

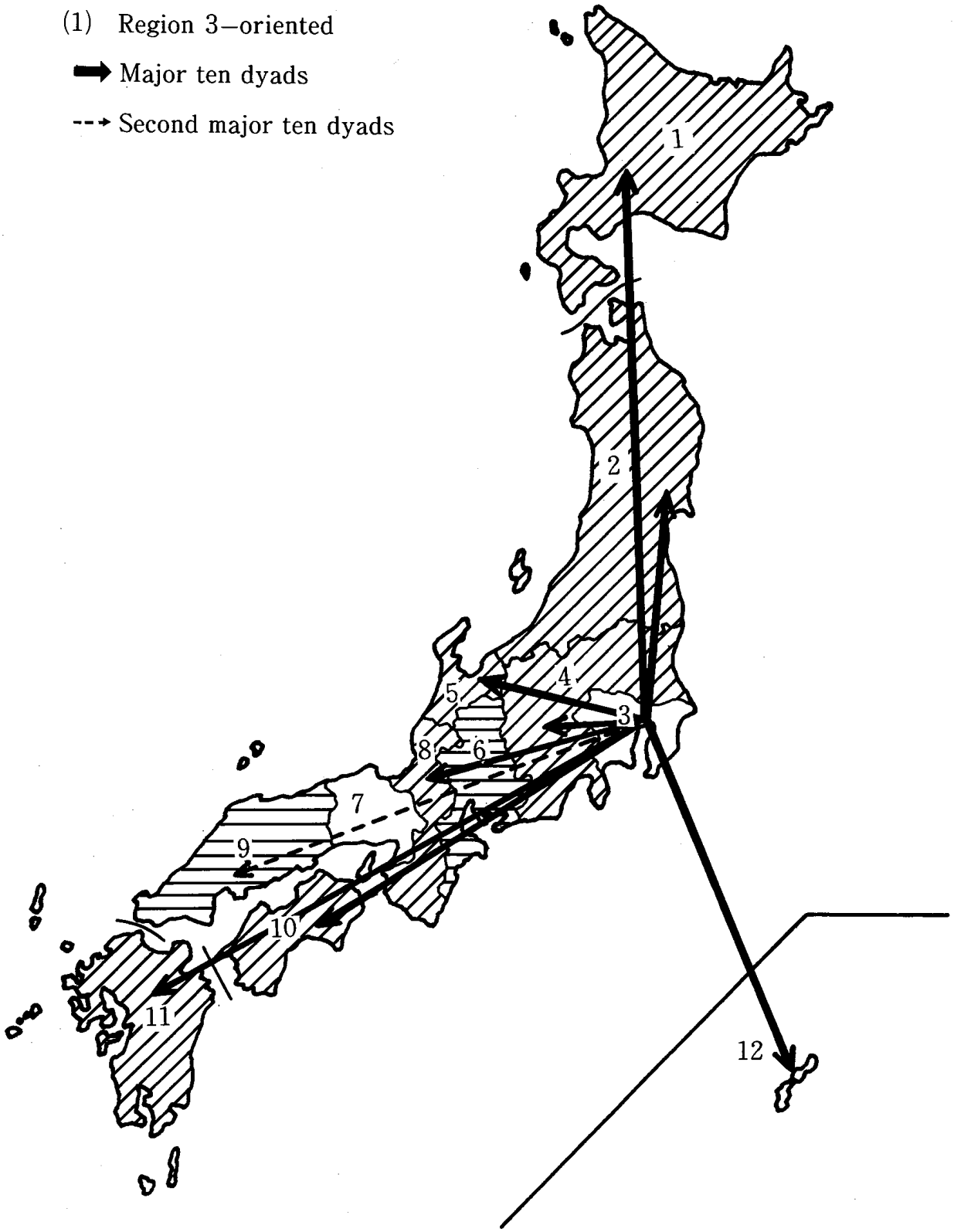


Exhibit 11. (continued)

(2) Region 7—oriented

➡ Major ten dyads

⇢ Second major ten dyads

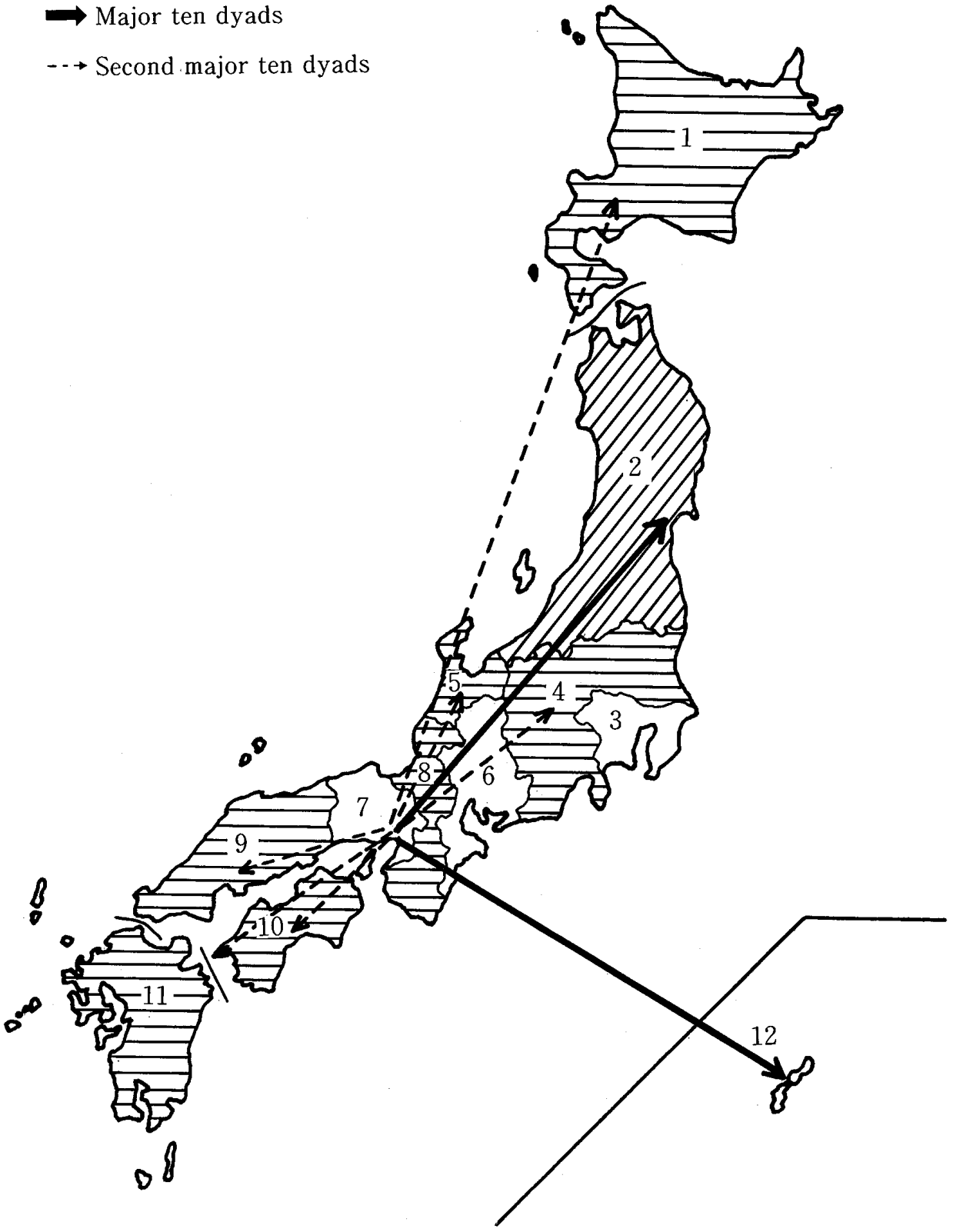


Exhibit 11. (continued)

(3) Region 6–oriented

➡ Major ten dyads

⇢ Second major ten dyads

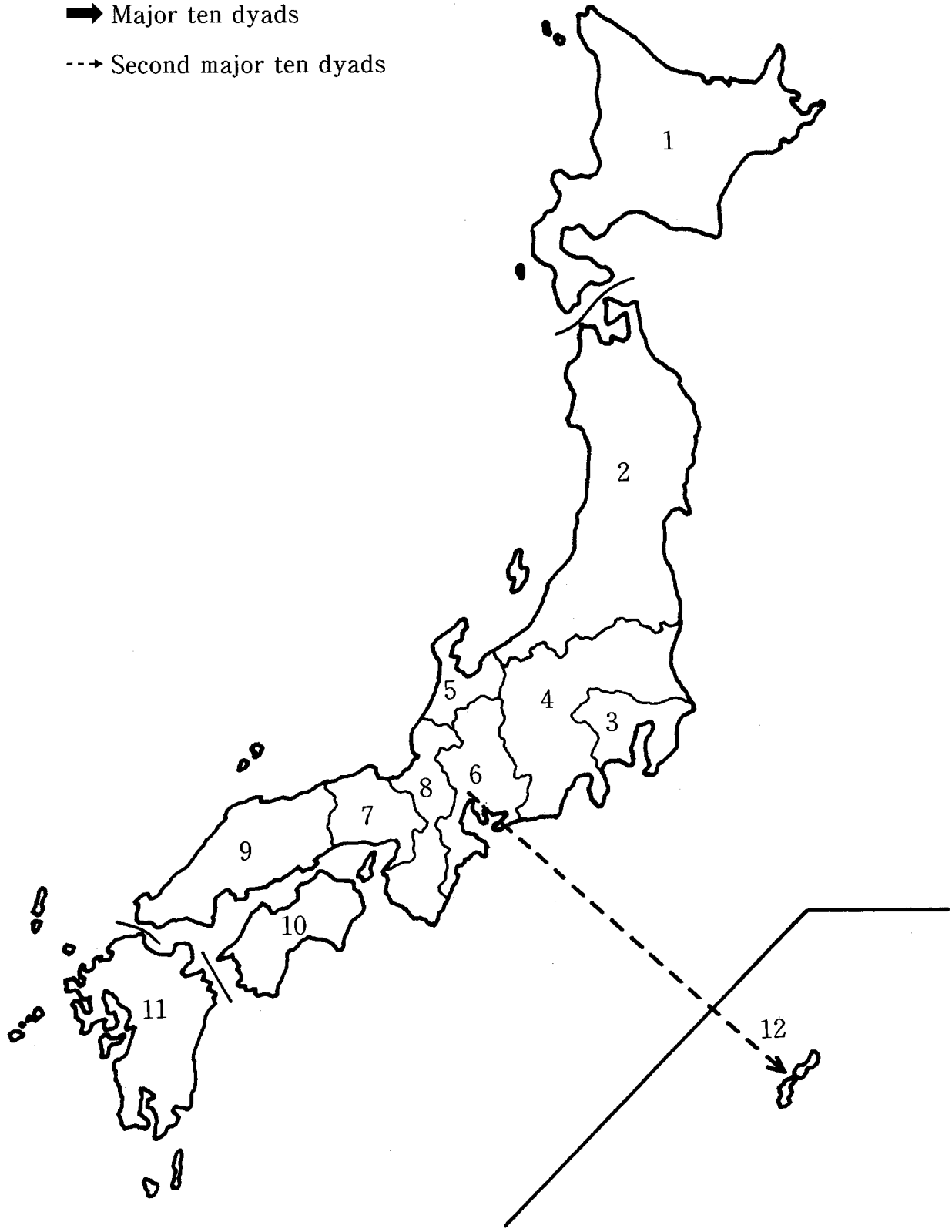
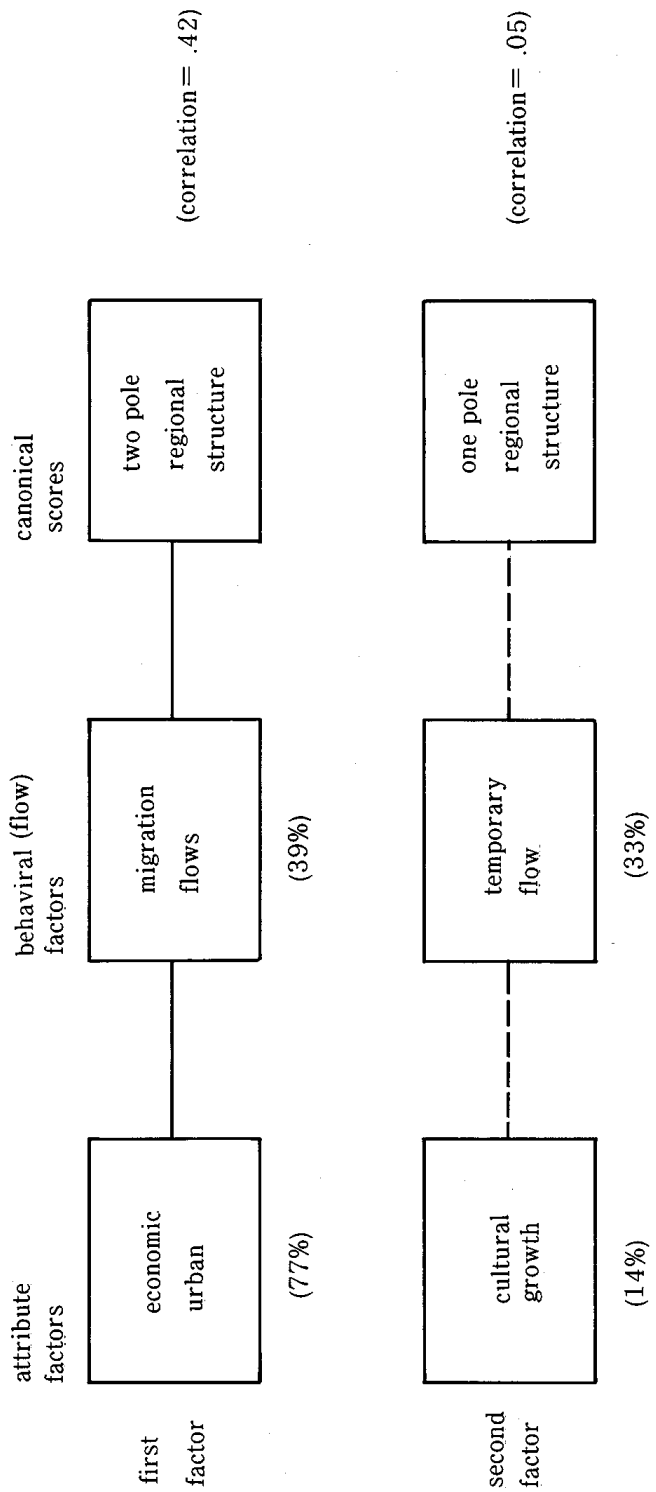


Exhibit 12. The Summary of the Analysis



Ⅵ. CONCLUSION

(1) We can divide Japan into two major regions, i. e. east Japan and west Japan, especially with respect to economic activities. The core region of the first major region is region 3 (Tokyo) and the core region of the second is region 7 (Osaka) respectively. the eastern region covers eastern Japan entirely and region 11 (Ryukyu). While the western region covers western Japan entirely, there exist minor local regions in southwest Japan (historical core) concurrently.

(2) In terms of culture and growth aspects, the influence from Tokyo covers all national territory. This shows that Japan is a well–integrated country. In these same aspects, Osaka exerts a minor influence on all national territory too. This implies that Osaka has something to offer which Tokyo does not have. Two regions are identical with respect to their coverages and are differentiated with respect to their strength.

(3) The significance of third core region (region 6–Nagoya) is questionable. Even if it exists, its influence is probably very minor.

(4) In spite of long physical distances. three backward regions (2, 11 and 12) maintain strong connections to core regions.

(5) Berry's assertion that difference in attribute causes interaction (flow), and vice versa, is well supported. Every major flow connects cores with the peripheries. These flows obviously develop the attribute difference.

REFERENCE

1. Statistical methods

Abler, Ronald, Adams, John S. and Gould, Peter. *Spatial Organization.* Englewood Cliffs, NJ: Prentice–Hall, 1971.

Clark, D. *Understanding Canonical Correlation Analysis.* Norwich, England: Geo Abstracts, 1976.

Daultrey, S. *Principal Components Analysis.* Norwich, England: Geo Abstracts, 1976.

Davis, John C. *Statistics and Data Analysis in Geology.* New York: John Wiley & Sons, 1973.

Fox, Daniel J. and Guire, Kenneth E. *Documentation of MIDAS.* (Michigan Interactive Data Analysis System), Ann Arbor, MI: University of Michigan, 1976.

Goddard, J. and Kirby, A. *An Introduction to Factor Analysis.* Norwich, England: Geo Abstracts, 1976.

Johnston, R. J. *CIassification in Geography.* Norwich, England: Geo Abstracts, 1976.

Johnston, R. J. *Multivariate Statistical Analysis in Geography.* London: Longman, 1978.

2. Researches in regionalization

Berry, B. J. L. 'A Synthesis of Formal and Functional Regions Using a General Field Theory of Spatial Behavior, '*Spatial Analysis,* (1968), pp. 419–428.

Hayashi, Noboru. 'Functional Region Based on Interregional Automobile Flows in the Nagoya Metropolitan Area, '*Geographical Review of Japan,* (1974), pp. 287–298.

Ichinami, F. 'The Spatial Structure of Metropolitan Nagoya with respect to Socio–Economic Regional Charcteristics and Commuter Flows,' *Geographical Review of Japan,* (1978), pp. 545–563.

Saino, Tadero and Higashi. Kenji. 'Structure and its Change of Inter–Prefectural Migration in Japan, '*Geographical Review of Japan,* (1978), pp. 864–875.

Sei, S. 'The Urban System of Korea,' *Geographical Review of Japan,* (1977), pp. 381–401.

(愛知学泉大学経営学部　教授)

昭和63年10月25日受理

〔抄訳〕

多変量解析による地域構造の研究

地域区分のやり方については，伝統的に等質地域をとりあげるものと結節地域をとりあげるものとがある。しかし，Berry は，この両者はそれぞれ互に他方の原因であり結果であるので，この２つの地域概念を１本にまとめることができると提案した。

この論文では，日本について12地域のデータをもとに，多変量解析を用いて体系的に３つの地域構造概念を明らかにすることにした。

等質地域としては，８種のデータについて因子分析を行い，第１因子（経済的，都会的要因）及び第２因子（文化性，成長性）の２つの因子を抽出し，因子得点にもとづいてクラスター分析を行った。その結果，関東臨海（東京）は，他の地域とは，かけはなれた特性をもった地域であることが明らかになった。第１因子は，強い説明力をもった因子であるが第２因子の解釈はかなり不明である。

結節地域としては，12地域間の流動に関する８種のデータを用い，これらの正方行列に，「直接因子分析法」を適用して情報の集約を行い抽出された因子ごとに対応する結節地域を図示するものとした。

また，８種の流動データについて，因子分析を適用し，２大フロー群があることを発見した。ひとつは，労働力の移動のフロー群であり，もうひとつは，物資や短期旅行のフロー群である。商業取引や大学進学は，この２つのフロー群の中間の性格をもっている。

結節地域としては，東日本と西日本の２群があるほか，東西を結ぶ大きなフローでこの２群が結ばれており，又，西南日本や，東北日本にローカルな結びつきが認められた。遠隔地と中心地を結ぶ労働移動フローも認められた。

最後に，Berry の方法論にならい正準相関分析により，等質地域の研究で抽出した２因子と結節地域の研究に使用したフローデータから抽出した２因子間との関連を調べた。

その結果，全体として，２個の因子群の間には高い相関があり，Berry の主張が裏付けられた。また２個ずつの因子の間にもそれぞれ１対１の相関が認められたが，相関係数は高くなかった。これは等質地域を区分するのに第１因子が圧倒的な説明力をもち，第２因子の存在があいまいになっていることにも由来するとみられる。

正準相関分析の結果を図示すると，第１正準得点からは，東西２ブロックと東海地方と遠隔地との結びつきが認められ，第２正準得点からは，東京と京阪神から全国への影響力が認められた。従って日本の地域構造としては，東京，京阪神を中心とする東西の２ブロックの存在とともに，東京，京阪神がそれぞれ，全国的中心機能をもっている重層構造をなしていること，各遠隔地は，中心地域に強い結びつきをもっていること等が判った。

また，主に労働力の移動が，東西２ブロック構造と共に遠隔地流動に対応していることも認められた。