Article

Statistical Pattern Analysis for Application

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Summary

The method of Statistical Pattern Analysis is quite useful for an integrated use of various indices or categorical data processing. There are three types of application: firstly, an integrated observation method for cross table; secondly, an analysis method for large scale data in the form of data matrices; and thirdly, a statistical processing method for descriptive data on various individual cases. The procedure of this method can be summarized in three steps: (1) classifying data into simple categories; (2) combining these categories into a set of patterns; (3) comparing/analyzing these patterns. Statistical Pattern Analysis has the following positive characteristics: firstly, it is exceedingly simple, useful and also quite flexible; secondly, in spite of an information loss for each piece of data, a set of combined patterns conveys several kinds of information simultaneously; and thirdly, case study can be conducted in close connection with statistical analysis when using this method.

Key Words:

categorical data, pattern, qualitative data, descriptive data, case study

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1 Purpose

The process of classification is generally applied in many academic fields as a basic task, and the first step in statistical observation is also data classification. Although detailed classification or multiple-cross data analysis is useful when we analyze complicated socio-economic phenomena, it does demand a considerable degree of specialist and technical knowledge to achieve. For example, in the case of Japan, there are no less than 452 industrial sub-classifications, and the overall picture is rather complex. Furthermore, for a cross-data analysis, when there are several items and classifications, the number of combinations becomes too enormous to analyze. For example, in the case of 5 kinds of item and 10 classifications for each item set, the total number of groups combined with these classifications is 10^5.

However, even if an original classification of the statistics is complicated, for general observation a simple classification or a dichotomy of the data can often be useful with particular threshold values. Research into statistical comparison of infant mortality conducted by the late Dr. Hiroshi Maruyama (former professor of Osaka University) could be quoted as an example. His idea for a data analyzing method is characterized by the following three stages: (1) classification of data into simple categories; (2) combining these categories into patterns; and (3) comparing/analyzing the resulting patterns.

Analysis through data-classification is used for statistical data processing such as cluster analysis or categorical data analysis[1]. Nevertheless, characteristic for this method is that: (1) it is exceedingly simple, having no complicated numerical formulae for classifying/combining categories; (2) a set of combined patterns indicates several kinds of information simultaneously; (3) it is flexible, because various approaches can be tried by altering the threshold values and the number/order of items for combination.

With the assistance of a computer system, Prof. Hiroshi Iwai, my fellow researcher, and I attempted to apply this method to research conducted into fluctuations in population, labour force, employment structure and workers' health[2]. The purpose of this paper is to present Dr. Maruyama's original theory and then propound some types of Statistical Pattern Analysis for application. The actual concrete procedure of this method is omitted here because this is explicated in "Statistical Pattern Analysis and its Procedure" (ILO, Bureau of Statistics 1997) [3].

2 Maruyama's Statistical Pattern Analysis

In Dr. Maruyama's research on infant mortality (from 1930s to 1950s), simple classification is used from a comprehensive view point for analyzing quantitative indices (infant mortality rate, neonatal death rate, and stillbirth rate), as well as qualitative indices (α -index: infant mortality rate÷neonatal death rate [this index shows the degree of socio-economic causes of infant mortality]). In other words, firstly, he classified each district according to one of three categories (a , b , c) in relation to infant mortality rate (=R) and α -index (=A). In the same way, regarding stillbirth rate (=S) and neonatal death rate (=N), he classified them into three categories (X, Y, Z). He then combined these three categories into a set of nine pattern groups for easy comparison (see Table 1) [4].

Table 1 Category and pattern classification on infant mortality

R & A / S & N	Type-a: R>10(A−1)	Type-c: R≒10(A−1)	Type-b: R<10(A−1)	Number of cases
Type-X: S>N (Number of cases)	aX (0)	cX (0)	bX (6)	(6)
Type-Z: S≒N (Number of cases)	aZ (0)	cZ (1)	bZ (5)	(6)
Type-Y: S<N (Number of cases)	aY (0)	cY (5)	bY (12)	(17)
Total	(0)	(6)	(23)	(29)

Notes: S=Still birth rate, N=Neonatal death rate, R=Infant mortality rate, A= α index (R÷N), 10(A-1); Scale adjusted to infant mortality rate for comparison, type-a; R>10(A-1), type-b; R<10(A-1), type-c; R≒10 (A-1), type-X; S>N, type-Y; S<N, type-Z; S≒N

Source: Hiroshi Maruyama, *Research in Socio-Medical Science I: Infant Mortality*, 1976, Iryotosho Publisher, p.406

When analyzing statistical data, the integrated use of several kinds of data often facilitates a comprehensive understanding. Nevertheless, it is not easy to analyze several indices simultaneously for an integrated use of them. Dr. Maruyama simplified this method by combining data classified into several categories.

When we go about classifying data, the categorization of indices should be kept as simple as possible. The simplest classification is a dichotomy, such as above-average level and below-average level, or increasing and decreasing tendency[5]. Besides these formal statistical criteria for categorizing data, there are some other ones such as theoretical criteria/threshold values or the criteria based upon deductive information from statistical observation or case study etc..

Classifying data into several categories means transforming the variables into a nominal or an ordinal scale. Each category classified should then be stated in figures such as 1, 2, 3. For example, below-average level can be termed category-1, average level category-2, and above-average level category-3, or decreasing tendency category-1 and increasing tendency category-2.

The second step of this method is combining each category into a set of patterns. For instance, with the first index at average level or over we have category-2, with the second index at below-average level category-1, and when the third index shows a rising tendency we also have category 2, and so the combined pattern of these three categories is 212.

The demotion of variables into a nominal or an ordinal scale seems to involve an information loss for each piece of data. Nevertheless, it widens the scope of the information provided because several kinds of data are being used simultaneously when categories of each item have been combined into patterns. Furthermore, when we use spreadsheet on a computer system such as Lotus-123 or Microsoft-Excel, the original data remain because these categories are linked with them on the worksheet.

This method must be useful and widely applicable for statistical data analysis; however, some attentive consideration is necessary when classifying the data into categories and combining them into patterns. Firstly, regarding classification, the number of categories and the threshold values for classification of each type of data have to be distinct. If the threshold values are more vague, the analysis of pattern groups could prove to be meaningless. Secondly, the kinds and number of items for combination should be carefully checked. If there are many items and categories to be combined, then the number of patterns will be too enormous to analyze. Thirdly, the order in which we combine these categories is also of importance. In cases where the implication of the order for category-combination is not distinct, the combined patterns might be of very little significance.

3 Application of Statistical Pattern Analysis

3-1 Statistical Pattern Analysis for analyzing complicated cross tables

The first type of application of this method: i.e. an integrated observation method for various indices in the form of statistical cross tables, consists of three steps: firstly, classifying each index into categories; secondly, combining these categories into patterns; and thirdly, indicating the patterns selected.

Table 2, indicated on spreadsheet, is a table of cohort fluctuation indices according to sex, age, industry and occupation between 1975 and 1990 in Japan. There are three indices: (1) cohort fluctuation rate from 1975 to 1980; (2) the rate 1980-1985; and (3) the rate 1985-1990. For example, 195.1 at E4 (1975=100) is the rate of productive workers at 20-24 years (male, in 1980) in manufacturing industry (=M20-24, 1980, Manuf-Prod) from 1975-1980, and a formula for this rate is as follows:

[Number of M20-24, 1980, Manuf-Prod]/[Number of M15-19, 1975, Manuf-Prod] ∗100

The rate for 1980-1985 and 1985-1990 according to each cohort group can be calculated in the same way, and only pieces of them are indicated on the table. The purpose of this table-based analysis is to illustrate the characteristics of fluctuations in employment structure in modern Japan, and just a part of the analysis is shown as an example here[6].

The first stage of this statistical pattern analysis involves categorizing the data of the three kinds of indices mentioned above. The threshold values for categorization are the average fluctuation rates of each gender, age-group and period. The rate for below average level can be termed category-1, and that at average level or over category-2. For example, the average rate for males, aged 20-24 (in 1980) from 1975 to 1980 was 325.7 (C3), and then 195.1 (E4): "M20-24, 1980, Manuf-Prod" from 1975 to 1980, is transformed into category-1 (E204). The discriminant for categorizing using the "IF function" on the spreadsheet (e.g. in the case of MS-EXCEL) is as follows:

Table 2 Patterns of Cohort Fluctuation Rate of Workers according to Industry and Occupation (1975-1990, Japan): on Spreadsheet

	A	B	C	D	E	…	AC	AD	AE	…
1	Cohort Fluctuation Rate			1975–1980			1980–1985			
2		15–19	Mal. Tot	Prof.	Prod.	---	Mal. Tot	Prof.	Prod.	---
3	15–19	Ind. Total	325.7	1651.1	235.3	---	375.0	1744.2	278.9	---
4	↓	Manufac.	224.7	2612.5	195.1	---	373.1	4612.0	317.7	---
5	20–24	Service	531.5	1643.8	317.7	---	558.9	1485.6	295.9	---
•	-	***	-	-	-	---	-	-	-	---
•	-	***	-	-	-	---	-	-	-	---
19	20–24	Ind. Total	124.5	230.5	106.4	---	130.4	273.9	102.2	---
20	↓	Manufac.	107.1	250.0	96.1	---	131.2	454.1	108.2	---
21	25–29	Service	162.0	242.7	119.7	---	164.6	243.2	99.7	---
•	-	***	-	-	-	---	-	-	-	---
•	-	***	-	-	-	---	-	-	-	---
202	Fluctuation Categories									
203	15–19	Ind. Total	2	2	1	---	2	2	1	---
204	↓	Manufac.	1	2	1	---	1	2	1	---
205	20–24	Service	2	2	1	---	2	2	1	---
•	-	***	-	-	-	---	-	-	-	---
•	-	***	-	-	-	---	-	-	-	---
402	Fluctuation Patterns						Select Pt.	111	112	
403	15–19	Ind. Total	222	222	111	---			111	---
404	↓	Manufac.	111	222	111	---	111		111	---
405	20–24	Service	222	222	112	---			112	---
•	-	***	-	-	-	---	-	-	-	---
•	-	***	-	-	-	---	-	-	-	---
419	20–24	Ind. Total	222	222	111	---			111	---
420	↓	Manufac.	121	222	111	---			111	---
421	25–29	Service	222	222	111	---			111	---
•	-	***	-	-	-	---	-	-	-	---
•	-	***	-	-	-	---	-	-	-	---
467	35–39	Ind. Total	222	121	211	---				---
468	↓	Manufac.	112	121	111	---	112		111	---
469	40–44	Service	222	121	212	---				---
•	-	***	-	-	-	---	-	-	-	---
•	-	***	-	-	-	---	-	-	-	---
483	40–44	Ind. Total	222	121	212	---				---
484	↓	Manufac.	112	121	111	---	112		111	---
485	45–49	Service	222	121	222	---				---
•	-	***	-	-	-	---	-	-	-	---
•	-	***	-	-	-	---	-	-	-	---

Code: Ind.=Industry, Manufac.=Manufacturing, Mal. Tot=male total workers, Fem. Tot=female total workers, Prof.=Professional and Technical Workers, Prod.=Production workers, Pt.=Pattern

	BA	BB	BC	BD	BE	···	BP	BQ	BR	···
1			1985-1990							
2		15-19	Mal. Tot	Prof.	Prod.	---	Fem. Tot	Prof.	Prod.	---
3	15-19	Ind. Total	406.1	1477.6	299.3	---	441.6	972.6	237.5	---
4	↓	Manufac.	323.0	1259.2	272.7	---	311.0	1685.6	201.6	---
5	20-24	Service	684.3	1571.7	441.0	---	644.4	917.8	731.3	---
•	-	***	-	-	-	---	-	-	-	---
•	-	***	-	-	-	---	-	-	-	---
19	20-24	Ind. Total	129.8	218.3	101.6	---	83.2	97.4	90.3	---
20	↓	Manufac.	123.8	248.2	99.8	---	74.0	110.9	79.0	---
21	25-29	Service	159.7	206.1	112.0	---	96.1	95.9	135.2	---
•	-	***	-	-	-	---	-	-	-	---
•	-	***	-	-	-	---	-	-	-	---
202										
203	15-19	Ind. Total	2	2	1	---	2	2	1	---
204	↓	Manufac.	1	2	1	---	1	2	1	---
205	20-24	Service	2	2	2	---	2	2	2	---
•	-	***	-	-	-	---	-	-	-	---
•	-	***	-	-	-	---	-	-	-	---
402			Select Pt.	222	221					
403	15-19	Ind. Total	222	222		---	222	222		---
404	↓	Manufac.		222		---		222		---
405	20-24	Service	222	222		---	222	222	222	---
•	-	***	-	-	-	---	-	-	-	---
•	-	***	-	-	-	---	-	-	-	---
419	20-24	Ind. Total	222	222		---	222	222	222	---
420	↓	Manufac.		222		---		222	221	---
421	25-29	Service	222	222		---	222	222	222	---
•	-	***	-	-	-	---	-	-	-	---
•	-	***	-	-	-	---	-	-	-	---
467	35-39	Ind. Total	222			---	222		222	---
468	↓	Manufac.				---	221		221	---
469	40-44	Service	222			---	222		222	---
•	-	***	-	-	-	---	-	-	-	---
•	-	***	-	-	-	---	-	-	-	---
483	40-44	Ind. Total	222			---	222	221	222	---
484	↓	Manufac.				---	221		221	---
485	45-49	Service	222		222	---	222	221	222	---
•	-	***	-	-	-	---	-	-	-	---
•	-	***	-	-	-	---	-	-	-	---

Indices: cohort fluctuation rates between 1975-1980 (1975=100), 1980-1985 (1980=100), 1985-1990 (1985=100)
e.g. [Number of M20-24, 1980, Manuf-Prod]/[Number of M15-19, 1975, Manuf-Prod]*100

Category: 1=below average cohort fluctuation rate of each gender, age-group and period, 2=average level or over

Source: Population Census

[at E204] =IF (E4< $ C $ 3,1,2)

In the same way, the rate of the same gender and age-group of "Manuf-Prod" from 1980 -1985 (317.7, AE4) can be transformed into category-1 (AE204), because the average level of this group is 375.0 (AC3); correspondingly, 272.7 (BE4) for 1985-1990 is transformed into category-1 (BE204).

In the second stage of this method we combine each of the categories into a set of patterns. For example, when combining the above-mentioned three categories: 1 (E204), 1 (AE204), and 1 (BE204) into patterns, a three-digit figure will be indicated as pattern 111 (E404). In the same way, other categories can be combined into various patterns using and copying the following formula:

[at C403] =(C203*100)+(AC203*10)+BC203

The third step involves indicating the selected patterns on the table for easy analysis. For example, pattern-111, in which the three categories are all at below average level, is indicated at AE404, AE420, AE468 and AE484 on the worksheet. The way to show selected patterns is to use the following formula and transfer it to other cells:

[at AC403] =IF (OR (C403= $ AD $ 402, C403= $ AE $ 402), C403,"")

This pattern, 111, meant that the suction power of the labour market had been at a relatively low level during the three periods among male production workers in manufacturing industry in the age-group 20-24 years. In contrast, pattern 222 and 221 are indicated for female production workers in manufacturing industry (BR420, BR468, and BR484). It showed that there were two opposing trends in labour-market fluctuations among productive workers in manufacturing industry. One is less cohort increase rates among young male workers and another is a relatively high level of such increase rates among female workers at both young and middle age. What was happened was that, young male production workers had been replaced by their female counterparts, whose labour costs were at a comparatively low level. Moreover, pattern 222, a continuous high level of increase rate, is indicated for young male professional and technical workers in both manufacturing and service industries (BD404, BD405, BD420, BD421).

Here it has been demonstrated how a complicated analyzing process can be transformed into an easy and efficient one through aforementioned procedure, i.e. (1) categorizing data, (2) combining them into patterns, and (3) indicating selected patterns.

For further analysis, various indices can be categorized and combined into patterns, although only 3 indices have been used here. Therefore, this type of analysis method would be exceedingly effective when various indices have to be analyzed simultaneously, or when applied to a large scale cross table, which might include several hundred rows and columns.

Furthermore, although categorizing data seems to involve an information loss, summarized information of data has in fact been supplemented to the original data. Each pattern is namely linked with categories, the categories are linked with original data through formulae, and the original data remain on the worksheet. In addition, the combined patterns include various summarized information from several kinds of indices, and then the whole information, which is given by the pattern-figures indicated in just a few digits instead of the considerable volume that would otherwise be necessary.

3-2 Data analysis method for large scale data file

The second type of application, i.e. a data analysis method in the form of data matrices, aims at analyzing a large scale data file with fields and records, such as population indices (=fields) according to municipalities (=records). This method has wide applicability for data analysis, because some multi-dimensional cross data can be transformed into a data format of two dimensions with fields and records. Although this method is also useful for analyzing individual case records, analysts should proceed with caution in order to safeguard privacy. It consists of three steps: (1) classifying each index into a certain category; (2) combining the categories into patterns; and (3) counting the number of records (=cases) belonging to each pattern group.

Table 3-1, indicated on the worksheet, is a table of population fluctuation from 1980 to

Table 3-1 Population fluctuation in the smallest municipalities (1980-1990, Japan)

	A	B	••	E	F	G	H	I	J	K	L	M	N	O
1	Municip.	Municip.	-	Pop		Inc.Rt	Inc.Rt	Cp		CgA	CgB	CgC	CgD	Ptn
2	Code	Name	-	1990		80-85	90-95	65-						
3	11002	Sapporo	-	1671742		10.07	8.35	9.10		3	3	1	1	3311
4	12025	Hakodate	-	307249		-0.30	-3.74	13.01		3	2	1	2	3212
5	12033	Otaru	-	163211		-4.56	-5.38	15.81		3	2	1	2	3212
6	12041	Asahikawa	-	359071		3.12	-1.25	11.59		3	2	1	1	3211
7	12050	Muroran	-	117855		-9.31	-13.47	13.23		3	1	1	2	3112
8	12068	Kushiro	-	205639		-0.07	-4.15	9.78		3	2	1	1	3211
9	12076	Obihiro	-	167384		5.90	2.73	9.51		3	3	1	1	3311
10	12084	Kitami	-	107247		4.24	-0.03	10.37		3	2	1	1	3211
11	12092	Yubari	-	20969		-24.09	-33.78	18.37		2	1	1	2	2112
12	12106	Iwamizawa	-	80417		4.28	-1.53	12.86		2	2	1	2	2212
13	12114	Abashiri	-	44416		-1.10	0.30	11.03		2	3	2	1	2321
.	-	-	-	-		-	-	-		-	-	-	-	-
.	-	-	-	-		-	-	-		-	-	-	-	-
.	-	-	-	-		-	-	-		-	-	-	-	-
3267	473758	Tarama	-	1463		-2.10	-10.36	18.93		1	1	1	2	1112
3268	473812	Taketomi	-	3468		2.70	0.03	20.21		1	3	1	2	1312
3269	473821	Yonaguni	-	1833		-3.07	-10.76	13.69		1	1	1	2	1112

Codes: Municip.=municipalities, Pop=population, Inc.Rt80-85=population increase rate from 1980 to 1985, Inc.Rt85-90=population increase rate 1985-1990, Cp65-=65 years proportion of overall population in 1990, CgA=categories of Item-A, CgB=categories of item-B, CgC=categories of item-C, CgD=categories of item-D

Categories: item-A (CgA); 1=below 10,000, 2=10,000~99,999, 3=100,000 or over
item-B (CgB); 1= below −10%, 2=−10%~−0.01%; 3=0%~9.99%, 4=10% or over
item-C (CgC); 1 for Inc.Rt85-90<Inc.Rt80-85, 2 for Inc.Rt85-90≧Inc.Rt80-85
item-D (CgD); 1=below 12.07% (average level of whole of Japan), 2=12.07 or over

Source: Population Census

Table 3-2 A summary table of population fluctuation patterns

	A	..	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	Municp.		Inc.Rt.	Cp		CgA	CgB	CgC	CgD	Ptn	Cnt	No		No	Ptn	No	Comp.
2	Code		85-90	65-													ratio
3	423033		-78.8	29.4		1	1	1	2	1112	1			>0	1112	140	4.3
4	214078		-61.2	24.2		1	1	1	2	1112	2				1121	1	0.0
5	14257		-31.9	22.5		1	1	1	2	1112	3				1122	27	0.8
6	183423		-29.0	20.4		1	1	1	2	1112	4				1211	10	0.3
7	204293		-27.5	18.0		1	1	1	2	1112	5				1212	838	25.7
8	336033		-24.0	27.8		1	1	1	2	1112	6				1221	3	0.1
9	294471		-23.7	21.9		1	1	1	2	1112	7				1222	260	8.0
10	14702		-23.4	13.0		1	1	1	2	1112	8				1311	7	0.2
11	423157		-20.2	16.2		1	1	1	2	1112	9				1312	115	3.5
12	13323		-20.2	16.8		1	1	1	2	1112	10				1321	3	0.1
13	473537		-20.0	24.8		1	1	1	2	1112	11				1322	99	3.0
14	216241		-18.9	24.0		1	1	1	2	1112	12				1411	4	0.1
15	23035		-18.4	20.0		1	1	1	2	1112	13				1412	3	0.1
16	403652		-18.2	21.7		1	1	1	2	1112	14				1421	7	0.2
17	384259		-18.2	27.4		1	1	1	2	1112	15				1422	10	0.3
18	344281		-17.9	24.2		1	1	1	2	1112	16				2112	17	0.5
19	364673		-17.8	28.3		1	1	1	2	1112	17				2211	31	0.9
20	343145		-17.7	29.7		1	1	1	2	1112	18				2212	630	19.3
•			-	-		-	-	-	-	-	-				-	-	-
•			-	-		-	-	-	-	-	-				-	-	-
35	15806		-15.1	17.0		1	1	1	2	1112	33				3222	3	0.1
36	454036		-14.8	23.0		1	1	1	2	1112	34				3311	88	2.7
37	344290		-14.6	29.5		1	1	1	2	1112	35				3312	21	0.6
38	193640		-14.4	33.5		1	1	1	2	1112	36				3321	35	1.1
39	344257		-14.3	29.2		1	1	1	2	1112	37				3322	1	0.0
40	383821		-14.2	27.3		1	1	1	2	1112	38				3411	9	0.3
41	383511		-14.0	19.2		1	1	1	2	1112	39				3421	9	0.3
42	23256		-13.9	22.9		1	1	1	2	1112	40				Total	3267	100.0
•			-	-		-	-	-	-	-	-						
•			-	-		-	-	-	-	-	-						
140	15547		-10.1	18.1		1	1	1	2	1112	138						
141	63223		-10.1	21.9		1	1	1	2	1112	139						
142	14311		-10.1	20.0		1	1	1	2	1112	140	140					
143	473588		-11.1	11.2		1	1	2	1	1121	1	1					
144	23060		-27.2	19.7		1	1	2	2	1122	1						
•			-	-		-	-	-	-	-	-						
•			-	-		-	-	-	-	-	-						
3267	112259		16.0	7.0		3	4	2	1	3421	7						
3268	112372		18.9	5.2		3	4	2	1	3421	8						
3269	272167		19.1	9.7		3	4	2	1	3421	9	9					

1990 for the smallest municipalities in Japan. There are 3267 records (=municipalities), and some fields for each record. In the fields, four kinds of data are indicated, i.e. original data, indices, categorized data, and combined patterns. The original data includes the total population in 1980, 1985 and 1990, as well as the number of senior citizens aged 65 years and over in 1990. The indices consist of: (1) population increase rates 1980-1985, (2) the rate 1985-1990, and (3) the proportion of those aged 65 years and over to the overall population in 1990. Names of municipalities, and their code-numbers are shown from A3 to B3269. The three kinds of indices are found at G2～G3269, H3～H3269, and I 3～I 3269 on the worksheet respectively. The purpose of an analysis using this table is to classify the municipalities according to population size, population movements and the rate of ageing, and then to establish statistical trends or regularities in their population fluctuation.

The first step of this method is once again the classification of data into categories. Here we use four items for data categorizing: (1) population size (item-A); (2) population increase rate 1985-1990 (item-B); (3) comparison-index between the increase rate 1980-1985 and 1985-1990 (item-C); and (4) 65-years plus proportion (item-D). The indices of item-A are classified into 3 categories: 1=below 10,000, 2=10,000～99,999, 3=100,000 or over; item-B is split into 4 categories: 1=below−10%, 2=−10%～−0.01%; 3=0%～9.99%, 4=10% or over; item-C has 2 categories: they are 1 for Inc.Rt85-90<Inc.Rt80-85, and 2 for Inc.Rt85-90≧Inc.Rt80-85; and item-D also has 2 categories: 1=below 12.07% (average level for the whole of Japan), 2=12.07 or over. These categorized data are indicated at K3～N3269.

The second step is combining each category of these four items into pattern-indicating 4 digit figures (O3～O3269).

The third step is re-arranging the records, and counting the number of cases according to pattern group. For this procedure a sorting and retrieving／extracting function can be used on the spreadsheet. Finally, a summary table of the case counting is indicated at T1～V42 in table 3-2.

Procedural details for these three steps are omitted here also because they have been presented in the aforementioned paper (Fujioka, Iwai, 1997, ILO).

The end result is that we now have access to summarized information concerning population size, population fluctuation and rates of ageing for 3,267 municipalities in Japan. It transpires that patterns 1112, 1212 and 1222 are the main ones among smaller size municipalities (below 10,000 people), and pattern 1212 showing 838 cases is a typical pattern, accounting for 25.7% of the 3,267 municipalities overall and 54.9% of generally smaller size municipalities (1,527 cases). This means the majority of smaller municipalities in Japan have seen a decline in their population within the limit of −10%∼−0.01%, there has been an acceleration in this decreasing tendency, and the rate of ageing is higher than 12.07%. Furthermore, 140 cases, 9.2% of smaller sized municipalities, have witnessed a relentless and drastic decline in their populations. Since the 1980s, a large scale migration out of rural area into urban ones has been observed, the reverse side of rapid economic development in Japan. As a result of this migration, i.e. a net outflow of young people after graduation, rates of ageing among the population have risen sharply in rural areas. For instance, when calculating the 65 years and over proportion of each pattern on this work sheet, we end up with 19.7% among pattern group 1212 and 21.7 % among 1112.

Statistical trends or regularities can be readily observed using this type of statistical pattern analysis. Moreover, the statistical characteristics of each individual pattern group can also be observed because all the patterns and categories are linked with original data on the worksheet.

Furthermore, the codes/names of all the cases (municipalities) belonging to each pattern group can be listed on the worksheet (each case is to be found among partial aggregation, using multi-cross classification with some items). Multiple cross classification has been used in order to select cases for particular survey[7], which is rather effective compared with regular sampling survey methods. If we were to apply this method to the Statistical Pattern Analysis, we would be able to use a considerable number of items for selecting cases.

This case selecting method was applied to our survey for the purpose of analyzing causes of recent population decline in rural areas in Japan. In 1992, a survey entitled "Young Persons Settlement Survey"[8] was carried out in Shimane prefecture (the most depopulated area in Japan) and in 6 municipalities belonging to aforementioned pattern

1212. Incidentally, when selecting these 6 cases, some other indices had been used for multi-classification. This survey covered the age-group 15-44 among citizens living in the rural areas as well as persons temporarily resident in rural areas at the time of the survey, and the number of available respondents was 4,551.

Table 4 is a case counting table according to migration-pattern group among these

Table 4 Patterns of Migration/Settlement (Rural Areas, Shimane Prefecture)

	Residents in rural areas						Persons temporarily resident in rural areas					
	Male			Female			Male			Female		
Order	Pattern	Cases	Comp. (%)	Pattern	Cases	Comp. (%)	Pattern	Cases	Comp. (%)	Pattern	Cases	Comp. (%)
1	11103	239	14.0	11103	155	11.1	11103	83	14.5	11103	42	14.9
2	11101	181	10.6	33303	103	7.4	11133	56	9.8	11133	27	9.6
3	11003	83	4.9	11101	86	6.2	11203	39	6.8	11100	21	7.4
4	11203	78	4.6	22202	78	5.6	11233	32	5.6	11130	18	6.4
5	11111	72	4.2	11133	76	5.4	11130	28	4.9	11202	9	3.2
6	11133	69	4.0	22203	69	4.9	11100	26	4.5	11203	9	3.2
7	11100	68	4.0	33333	54	3.9	11102	20	3.5	11233	8	2.8
8	11201	56	3.3	11131	51	3.7	11202	19	3.3	31100	7	2.5
9	11131	52	3.1	11000	42	3.0	11303	19	3.3	33333	7	2.5
10	11000	47	2.8	11100	40	2.9	11101	15	2.6	11102	6	2.1
11	11001	46	2.7	11003	38	2.7	11000	14	2.4	11122	6	2.1
12	11002	46	2.7	11303	35	2.5	11003	12	2.1	11230	6	2.1
13	11102	42	2.5	22222	35	2.5	11200	11	1.9	22203	6	2.1
14	11202	37	2.2	11102	32	2.3	11122	10	1.7	22222	6	2.1
15	11303	34	2.0	22232	28	2.0	11132	9	1.6	33303	6	2.1
16	11333	33	1.9	11111	26	1.9	11222	9	1.6	11000	5	1.8
17	22202	30	1.8	22233	26	1.9	11333	8	1.4	21130	5	1.8
18	22203	29	1.7	11203	25	1.8	33333	8	1.4	11003	4	1.4
19	33303	23	1.3	22003	23	1.6	11223	7	1.2	11120	4	1.4
20	33333	23	1.3	11202	18	1.3	11230	7	1.2	11200	4	1.4
	Others	416	24.4	Others	355	25.4	Others	140	24.5	Others	76	27.0
	Total	1704	100.0	Total	1395	100.0	Total	572	100.0	Total	282	100.0

Notes: meaning of patterns (a number of five digit figures)
items; 1st = birth place, 2nd = domicile just before graduation from junior high school, 3rd = the same for senior high school, 4th = the same for college or university, 5th = domicile at the time of having job after graduation
categories; 1 = domicile place at the time of this survey (rural area),
2 = elsewhere with close range,
3 = elsewhere (metropolitan area or other distant place),
0 = others or no answer (incl. no experiences)

Source: Hiroshi Iwai, Mitsuo Fujioka, ***Statistical Study on the Employment Structure and the Stratum Structure of Labour Force in Modern Japan***, The Institute of Economic and Political Studies, Osaka, Japan, 1993, p.349.

rerespondents using the second type of Statistical Pattern Analysis. There are five items to classify into patterns, i.e. (1) birth place, (2) domicile at the time of graduation from junior high school, (3) the same for senior high school, (4) the same for college or university, and (5) the location of the first job after graduation. Each item has three categories, i.e. 1=one's rural native place, 2=elsewhere within close range, 3=metropolitan area or other distant place.

In the table, various migration patterns are indicated, and most common pattern among male residents in rural areas is 11103. This means the typical male of this pattern was born and raised in a rural area until graduation from senior high school, and then had a job in a metropolitan area or other distant place before returning to his rural native place. The second most common pattern is 11101, i.e. "lived whole life in rural area". When comparing these two patterns as an example, we have found the following differences: referring to the main reasons for difficulties in settling down in one's rural native place, the percentage of respondents choosing "Lack of desirable employment" was 72.0% among pattern 11103 and 59.7% among pattern 11101. Other reasons were selected as follows: "Low levels of income" 68.2% (11103) and 57.5% (11101); for "Worries about living conditions (incl. access to good medical treatment or educational facilities etc.)" 20.9% (11103) and 14.9% (11101); and "Meddlesome atmosphere, no privacy" 24.3% (11103) and 16.6% (11101) respectively. The results indicate that the percentages are higher among the residents experienced in living in metropolitan areas, and this tendency is especially marked among female and more highly qualified people. In spite of the improvement in job opportunities and starting salary levels in rural areas since the 1980s, such employment has tended to involve unqualified manual tasks in manufacturing or construction industries, and salary levels for middle-aged people and those in mid-career remain very low, especially among women. Under these difficult circumstances, the main reasons for people returning to their rural native places are "To be ready to help parents in their old age", and a "Strong desire of their parents for them to return home". Additionally, case study of females in pattern 33303 (i.e. the second most common female-pattern and the probable pattern among wives for the typical male of the most common male-pattern 11103) highlighted the self-sacrificial lifestyle of rural middle-aged women (i.e. hard work, little spending money and no free-time etc.), and not only the young people themselves but also their mothers have had a generally negative attitude toward young people's return home[9].

In this survey we have seen how case study is closely related to statistical observation/analysis, and this method would no doubt enhance the standard of case study considerably.

3-3 Pattern analysis for descriptive data on individual cases

The third method of pattern analysis involves dealing with the descriptive data relating to individual cases. This method could be useful for processing various kinds of administrative data which have not always been processed by statistical methods. Incidentally, it would be rewarding for case studies in the fields of epidemiology, sociology, biology etc. Furthermore, it could be utilized for a study of judicial precedents.

For descriptive data processing, different interpretations by different analysts cause difficulties for persuasive analysis. The same descriptive data may result in opposite conclusions. It is also quite difficult to categorize the descriptive data because of the various viewpoints relating to numbers and standards for classifying them. If the standards are unclear or unfounded, then classifying data into categories is meaningless. Different classification may result in different analyses. Furthermore, an interview or a survey itself has difficulty in getting the same kinds of descriptive data when the questionnaire is not standardized. A well-thought-out and standardized set of questions and answers is indispensable for a high quality of data.

Therefore it is necessary to process descriptive data before classifying it into categories. It is namely the transfer of descriptive data into codes, that constitutes so-called coding[10]. Titles, items and sub-items have to be clear for coding the data. When they are well-thought-out and comprehensive, descriptive data are valuable for statistical analysis. The codes are also useful for data gathering. After coding, categorizing the codes has to be conducted especially carefully in the case of qualitative data. When classifying qualitative data, classificatory criteria should be theoretically well-grounded.

Then the process of pattern analysis for descriptive data consists of four steps: (1)

coding descriptive data into a standardized title and items; (2) classifying each code into categories; (3) combining the categories into patterns; and (4) counting the number of cases in each pattern group and interpreting the pattern.

Table 5 is a list of individual case records of Karoshi, i.e. death from overwork. However, the data in the table is limited to only 8 cases, and so the tables for coding and categorizing illustrated are not perfect but should only be regarded as an example. Therefore nothing but the general idea of this method is indicated here (This topic may be analyzed in greater depth in a forthcoming paper of mine, in which the actual mechanism of death from overwork could be examined more closely).

The first step of this method is coding descriptive data. Although, in advance of coding data, comprehensive coding tables have to be prepared, the simple coding table (6) is used here as an example. When descriptive data are not standardized, i.e. in the case of judicial precedents, coding work is complicated and needs specialist knowledge about the data. Conversely, when standardized individual case records such as death certificates are accumulated, the work takes on a simple and fixed form. In this case, for easy processing, it is quite effective to input the data into a computer-database.

The second step of this method is classifying the codes into categories. Table 7 is also an example list for categorizing the codes. A result of conversion from codes to categories is indicated in table 8. When using standardized descriptive individual case records in the computer data-base system, the conversion could be processed automatically.

Processes from steps 3 to 4 are here omitted because they are the same as for the second type of our pattern analysis. Each type of descriptive data will change into a simple line of digital data such as 1122 on the right-hand verge of table 8. Finally, a summarizing table of the case-counting according to pattern group, and the case-code list belonging to each set of patterns will be illustrated as shown in table 9.

We have thus demonstrated that enumerating descriptive case data can be analyzed by our method of Statistical Pattern Analysis. If we were to integrate this method into the aforementioned second type of application, more comprehensive information could be collected for detailed analysis, which is impossible when using only statistical data.

Table 5 Cases of Karoshi (death from overwork) for middle-aged male workers in Japan

Case number & Occupation, Age	Working conditions		Living conditions & Life styles	Fundamental diseases & Death causes
	Regular	Immediately preceding		
No. 1 Driver of sightseeing bus, 37	● 5 M bD: ・av. Distance covered (skiing season); 1.5 × of an av. driver	● 2 M bD: ・av. Distance covered; 2.3 × of an av. driver ・continuous Wg without days off: 21 Dec.-8 Jan. (19 D) 12 Jan.-24 Jan. (13 D) ・total days off bD: 5 D in a M	・inverting daily life of day and night ・irregular & unsatisfactory sleeping	・nothing ・Sub-arachnoid hemorrhage
No. 2 Administrator, 45 (research institute in chemical company)	● Regular Wk: ・leading and directing research for staff, & management, sales etc. ・stressful situation; big expectation of company, complex human relationships, heavy responsibilities	● a W just bD: ・change of staff composition in his group, increase in number of staff from 19 to 30 ・Wk preparing term-end meeting; report on results & plans ・a lot of stress	・smoking: 17-18 per D ・drinking: 1 bottle of whisky per W ・sports: stopped playing tennis	・Hyper-tension ・Cerebral hemorrhage
No. 3 Factory worker, 35	● 5 M bD: ・overtime Wk: 50 H per M (av. 2 H per D) ・preparing Wk at home: 40-50 minutes per D ・11.5 Wg H per D ・2 commuting H per D ・days off: Sunday & public holidays	・almost the same as usual Wg cond.	・usual daily life: 6 a.m. got up; 7:30 a.m. left for work; 11 p.m. home to bed	・Heart disease & Hyper-tension ・Cerebral hemorrhage
No. 4 Engineer of electrical construction, 34	● a few M bD: ・excessive overwork, overtime Wk; until 12 p.m. for 2 W ・returning home at midnight ・holiday Wk ・long-distance driving	● during the W bD: ・same as usual Wg cond ・sometimes, night Wk & overnight stay at construction site ● just bD: returning to hometown to attend a wedding ceremony	・unsatisfactory sleeping due to night Wk ・overweight ・drinking & smoking habits	・Diabetes & Hyper-tension ・Sub-arachnoid hemorrhage

Case number & Occupation, Age	Working conditions: Regular	Working conditions: Immediately preceding	Living conditions & Life styles	Fundamental diseases & Death causes
No. 5 Section chief (sales promotion in big publishing company), 45	● 6 M bD: ·transferred to a newly-organized section ·alone in charge of sales promotion ·frequent business travel: 41 D in 4 M ·long distance driving: 150 km in a D (av.)	● 2 M bD: ·desperate efforts to achieve sales targets ·a great many business trips ·long-distance driving ·hard sales activity ·continuous heavy strain	·drinking: 1 bottle of beer a D ·smoking: 20 a D ·sports: playing golf ·confidence in his health	·nothing at medical examination (1 Y bD) ·Myocardial infarction
No. 6 Chief director of TV station, 49	● 3 Y bD: ·promotion to chief director ·accumulated fatigue ● 8 M bD: ·business travel to U.S.A.; collecting news for 2 M ·terrible Wg stress	● several W bD: ·carrying out work for his superior during absence ·overwork & overtime Wk ·big responsibilities & heavy stress ·continuous severe strain for 2 W	·lack of & restless sleep	·Hyper-tension ·Sub-arachnoid hemorrhage
No. 7 Truck driver, 49	● usual Wg cond.: ·driving & loading Wk ·night or early morning Wk (sometimes) ·long Wg H ·irregular & extra Wk ·average distance covered per M: 4,000-6,000 km	● 2 W bD: ·continuous Wg: 14 D ·night Wk: 10 times ·14 H away from home ● just bD: ·long distance driving ·driving H per D: 12 H ·5 H continuous night driving	·drinking: a little ·tobacco: 30 per D	·Hyper-tension ·Cerebral hemorrhage
No. 8 Foreman of boiler installation	● 5 M bD: ·5 days off per M ·overtime Wk: 4.6 H per D ·holiday Wk: 2 - 3 times ·heavy responsibility as a foreman	● just bD: ·continuous Wg: 9 D	attending a hospital: 2 or 3 times a M	·severe heart muscle disease ·Cardiac insuffi-ciency

Notes: M; month(s), W; week(s), D; day(s), H; hour(s),
Wk; work, Wg; working, av.; average, cond.; condition(s), bD; before his death

Source: Mitsuo Fujioka, "Workers' health and Working Conditions in Japan, the United States and Europe: A Trial of Statistical Comparison", *Journal of Economics*, No.20, Shimane University, 1994, Japan, pp.4-9.

Table 6 Codes on work-related cardiovascular diseases (CVDs)

A	**Work-related factors**
1	Long working hours
2	Night and shift work
3	Driving work
4	Career development
5	Change of workplace
6	Over-ambitious targets
7	Excessive business trips
8	Excessive receptions for customers
9	Heavy physical work
10	Others
B	**Change of life habits**
1	Smoking
2	Alcohol abuse
3	Loss of physical activities
4	Imbalance in dietary habits
5	Lack of sleep
6	Fewer chances for medical examination
7	Others
C	**Fundamental diseases**
1	Hypertension
2	Heart diseases
3	Diabetes
4	Asthma
5	Others
D	**Death causes**
1	Cerebral bleeding
2	Subarachnoidal bleeding
3	Aortic aneurysm
4	Myocardial infarction
5	Angina pectoris
6	Cerebral infarction
7	Acute cardiac failure
8	Others

Notes: These categories have been classified using the following research: Tetsunojo Uehata, "Long working hours and occupational stress-related cardiovascular attacks among middle-aged workers in Japan", *Journal of Human Ergol.*, No 20, Center for Academic Publication Japan, 1991, P.151.

Table 7 Categories on work-related CVDs

Factor	Categories		Codes
A	1	Accumulation of physical fatigue	1, 2, 3
	2	Emotional stress	4, 5, 6, 7, 8
	3	Both category 1 and 2	
	4	Others	9, 10
B	1	Change to unhealthy lifestyles	1-6, & 7(case by case)
	2	Regular lifestyles	
C	1	Having some fundamental disease	1-5
	2	Nothing	
D	1	Heart diseases	1, 2, 3, 6
	2	Cerebrovascular diseases	4, 5, 7
	3	Others	8

Table 8 Categorized individual case records

Case No.	Factor A	Factor B	Factor C	Factor D	Pattern
1	1	1	2	2	1122
2	2	1	1	2	2112
3	1	2	1	2	1212
4	1	1	1	2	1112
5	2	2	2	1	2221
6	3	1	1	2	3112
7	1	2	1	2	1212
8	1	2	1	1	1211

Table 9 Summary table of case-counting

Pattern	Number of cases	Component ratio	Case Code
1111	-	-	-,-,—
1112	-	-	4,-,—
1113	-	-	-,-,—
1121	-	-	-,-,—
1122	-	-	1,-,—
1123	-	-	-,-,—
1211	-	-	8,-,—
1212	-	-	3,7,—
1213	-	-	-,-,—
1221	-	-	-,-,—
-	-	-	-,-,—
-	-	-	-,-,—
-	-	-	-,-,—
Total		100.0%	

4 Conclusions

The basic implication of Statistical Pattern Analysis and its application have been presented in this paper. The three types of Statistical Pattern Analysis propounded here involved using a PC spread-sheet to exemplify the following methods: firstly, an integrated observation method for mixed data in the form of a cross-table; secondly, an analysis method for large scale data with fields and records in the form of data matrices; and thirdly, a statistical processing method for descriptive individual case records.

All three methods are characterized by the following points:

(1) they are exceedingly simple, having no complicated numerical formulae for classifying／combining the data,

(2) they are quite flexible, because they enable various approaches through changing threshold values and the number／order of items for combination,

(3) multi-dimensional data can transformed into simple digits,

(4) both qualitative and quantitative data, and even descriptive data, can be transformed into the same kind of categorized and patterned data,

(5) in spite of an information loss for each piece of data, a set of combined patterns conveys several kinds of information simultaneously,

(6) original data remains intact after pattern analysis because the patterned data merely supplements the original data,

(7) case study and statistical analysis become closely connected.

When we use pattern analysis, the following three points should be given careful consideration: firstly, the criteria／threshold values and number of categories for classification; secondly, the number and kinds of items for combining these categories into a set of patterns; thirdly, the order in which the categorized data are combined.

Regarding the criteria／threshold values for classification, these could be determined by the following prior information: ① formal statistical criteria such as average, median, quartile, increase or decrease tendencies, etc.; ② theoretical criteria such as 1.0 of NRR (net reproduction rate, i.e. the average number of live daughters that would be born to a hypothetical female birth cohort) for population replacement; ③ deductive information through statistical observation such as natal sex ratio (male=105 and female=100);

④ international criteria, e.g. criteria based upon high, medium or low level of infant or under-5 mortality recorded by UNICEF; ⑤ information from case study or fact-finding etc.

Although statistical pattern analysis might be perhaps one of the simplest and most useful methods for an integrated observation of mixed or categorical data, only the general idea and some examples for application have been presented here, while theoretical examination of this method has not been sufficient. This method may well have some other useful applications, but at the same time also some limitations not mentioned in this paper. It remains a future task to draw precise comparisons with other multivariate analysis methods, and to examine the prior criteria for categorizing data.

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(5) Hiroshi Maruyama, "My Fifty Years' Research on Population Statistics", (in Japanese), *Statistics*, No.58, The Society of Economic Statistics, Tokyo, 1993, pp.11-12.

(6) see *Statistical Study of the Employment Structure and Stratum Structure of the Labour Force in Modern Japan*, (op.cit.).

(7) For example: Ritta-Sisko Koskela, "Cardiovascular diseases among foundry workers exposed to carbon monoxide", *Scandinavian Journal of Work Environment & Health*, August, 1994.

(8) *Young Persons' Settlement Survey*, The Shimane Ministry of Agriculture, Forestry, and Fisheries (Shimane Prefecture, Japan), 1993.

(9) M. Fujioka, "Causes of Recent Migration from Rural Japan and the Significance of the Gender Aspect", (in English), *Journal of Economics*, No.22, Faculty of Law and Literature, Shimane University, Japan, 1996.

(10) Concerning coding and categorizing qualitative (=descriptive) data, the idea and method have been shown in the following literature, Udo Kelle ed., *Computer-Aided Qualitative Data Analysis: Theory, Methods and Practice*, Sage Publication, London, 1995, and Matthew B. Miles, A Michael Huberman, *Qualitative Data Analysis*, Sage Publication, London, 1994.

Furthermore, they showed an example of combining categories and counting the cases belonging to each set in Table 13.2 in p.185 (Udo Kelle, 1995). Although these ideas are interesting and are similar to our method, our research has been different and independent as Dr. Maruyama had already put forward the original idea of this method in his paper in 1954: i.e. "Psychological and Statistical Regularities on<Tategaki and Yokogaki>", *Journal of the Japanese Statistical Society*, 22 (1954), 23 (1955), 24 (1956), and Fujioka has also used the case-counting method for each set of pattern groups in two aforementioned papers (Fujioka, 1988).

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