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Reaffirmation of J. Bertin's Ordinal Matrix for business strategy decision– taking apart of visualized data on map and reconstruction by the Ordinal Matrix

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Abstract: Visualization of statistical data is used for a good communication among involved personals. Taking an example of question on earthquake, it is important to review information where it will be occurred and how strong intensity is. Cartogram types of maps allow to easily see such information at a glance for everyone.

In case of insurance companies who develop their business worldwide, the map let them understand where we see earthquake risks without knowing local location information. This means that a European underwriter can review it even if this personal do not know Japanese earthquake risk at all, for example. So, the map is one of fundamental tools to assess where the company shall take insurance risks more or do not take it. In other word, where they efficiently do marketing to provide insurance? For marketing strategy, it is needed to see and to analyse several issues at once, i.e., how much exposures they are retaining within their portfolio, how much loss they will pay in future and how many expected clients they will have. Analysis for each aspect can be done by using a map to visualize relevant data. This is known as statistical map.

However, a simultaneous observation of different maps is not easy to see and understand how each aspect of alanysis should be considered with others. Now, this paper aim to show a capability of Jacques Bertin's Ordinal Matrix. So, information on maps is taken and integrated by Bertin's Matrix to analyse all information at once. And we will see how the Matrix lead us to make a decision for future strategy.

Keywords: Visual analytics, Decision making support, Ordinal Matrix, Jacques Bertin., Data mining

1. Introduction

In a current situation, a mutual understanding among involved parties is required for any kind of discussions and for every time. The visualization in general is expected to let us understand concerned information among all stakeholders as an intermediate communication tool. Actually, in many cases, visualization or more general illustrations which can easily show the key points are commonly used to describe things better than text. Text/language or letters/words "represent" phenomena or events, meanings of them are used and understood differently based on situations and/or background of involved parties. For example, the word "risk" can be understood as pure negative risk, but also be understood as speculative risk which includes a possible positive impact. Also, verbal communication requires a time spent in communicating, which is an important issue. Therefore, not only text explanation, but illustrations are commonly used to describe things, and further, they allow us to have mutual understanding with different language users.

A brochure of the seismic intensity scale issued by Japan Meteorology Agency (JMA) is an example as shown in Figure.1 By using the illustration, we see how strong a ground shaking is for JMA earthquake intensity scale of "6 Lower" (7 is the maximum) is easily seen. Rather than taking time to read detailed explanations by text, it is easy to understand the circumstances by illustrations. Also, a comparison of this illustrations will give an idea how different between an intensity "6 Lower" and other intensities. The visualizations are used so because of their excellent characteristics of information transmission: instantaneous understanding.

As an example, this paper would like to show how visualization can be used in the insurance industry, especially, how they can manage marketing strategy for earthquake insurance based on leading of the Ordinal Matrix that Jaques Bertin has established.

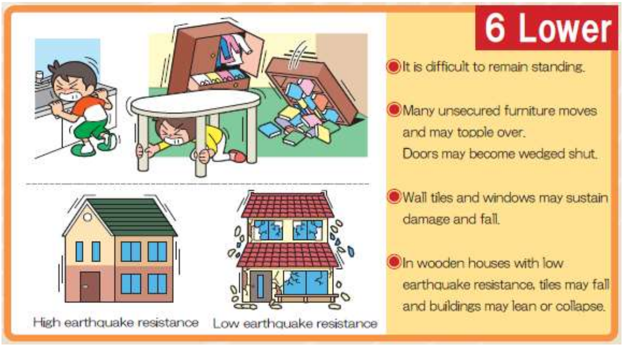

Figure 1. Examples of JMA seismic intensity scale (source: Japan Meteorology Agency)

2. Earthquake risks for insurance company

2.1 Earthquake risk in Japan

Japan is well known as earthquake prone country. The Great East Japan Earthquake in 2011, 11th March. JMA intensity of 7 (magnitude 9.0) was observed as recent large earthquake. We said that this is the 4th largest earthquake in the world.

Currently, National Research Institute for Earth Science and Disaster Resilience (NIED), who conducts research for disaster risk reduction, established Japan Seismic Hazard Information Station (J-SHIS). It was to help peoples to prevent and prepare against the earthquake disaster. And J-SHIS provide a seismic hazard map in their web-site to public.

One of maps showing below explains a probability by percent that each site would be affected by an earthquake of seismic intensity 6 lower or more within 30 years. All we can see how much risk is exposed in each location. This understanding is same regardless who knows or do not know Japanese language or geography of Japan. The map is an essential tool to allow observations of information belonging to location specification. And this is one of visualizations of risks.

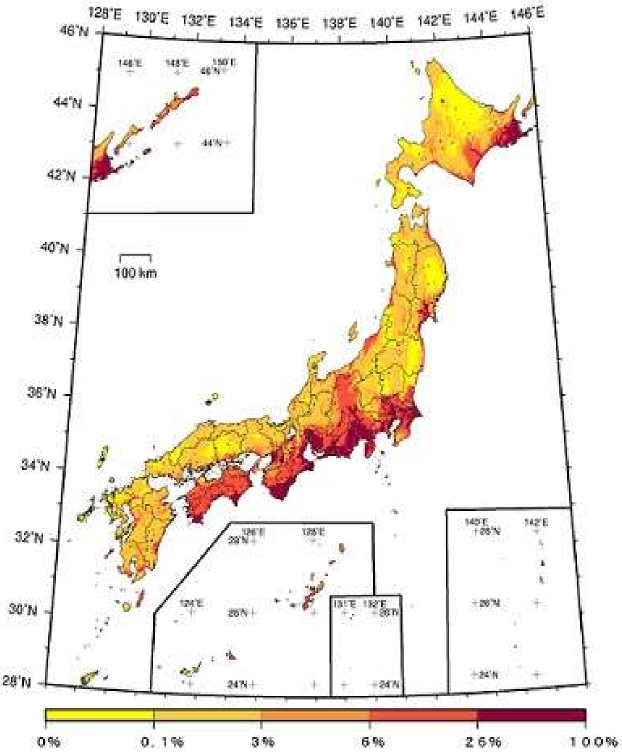

Figure 2. J-SHIS map (source: NIED)

2.2 Case study for insurance company

Insurance companies sell insurance products to cover client risks: damages and/or loss from sudden and unforeseeable events. Risks related earthquake activities are also able to be covered by relevant insurance products. As a commercial corporation and on a going concern basis, insurance companies are required by shareholders to manage a better financial result than breaking even basis business maintenance. And to be managed their business strategy in a better way according to shareholder's expectation, they review continuously their portfolio taking consideration of three major index: Exposure as to see current status of their portfolio, AAL as an expected loss and number of Office as potential number of client, which are generally explained as below.

- Exposure

  This is to see how much the insurance company provide capacity to existing clients and which let them know an accumulation issue which areas are largely exposed against earthquake risk. High accumulation means a concentration of earthquake risk for the company. As portfolio management perspective, it is better to have a good geographical spread of exposures.

- Annual Average Loss: AAL

  This is an estimated loss based on simulation. An estimated losses shall be generated differently depend on occurrence probability of earthquakes, geology characteristics, building specifications, etc. For such complex computation, a probabilistic simulation is used for loss estimation which is defined as Annual Average Loss: AAL. (See also 6.1. Simulated loss as expected loss)

- Number of Office

  In this paper, Number of Office in a prefecture is used as an index how possibly expected clients are to be found in respect to the company's marketing. A prefecture with a large Number of Office, they can expect to get business chances.

2.3 Relevant maps

This paper takes a case study how an insurance company make a decision for marketing strategy to provide earthquake related insurances in Japan. As an example, three major indices are taken for this study: Exposure, AAL and Number of Office for each of 47 prefectures in Japan. The original data lists are shown in appendix (6.2. Original data).

The data is shown by maps as follows. Each of map give us an idea which prefecture is important for each index, much better than the original numerical data lists (6.2. Original data). However, to establish a strategy where the company shall focus on for future marketing, it is difficult to see what relationships are able to be observed from three separated maps.

Therefore, in this paper, all maps are decomposed as the original numerical data gain, and then, this data is going to be analysed by using Jaques Bertin's Ordinal Matrix.

Proceedings of the International Cartographic Association, 2, 2019.
29th International Cartographic Conference (ICC 2019), 15–20 July 2019, Tokyo, Japan. This contribution underwent
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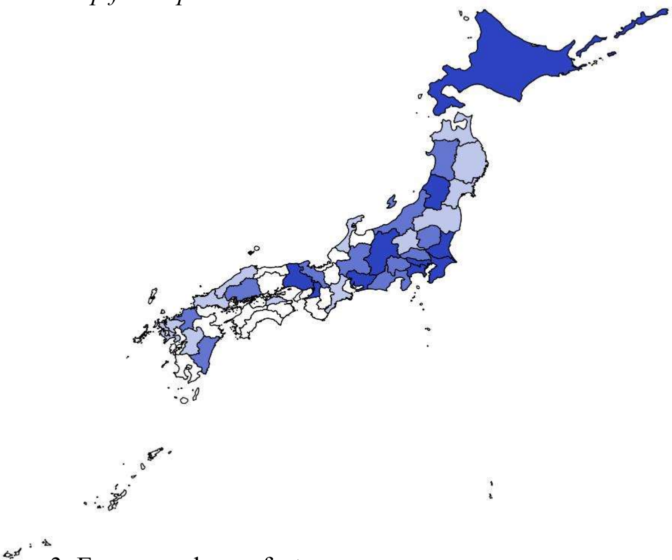
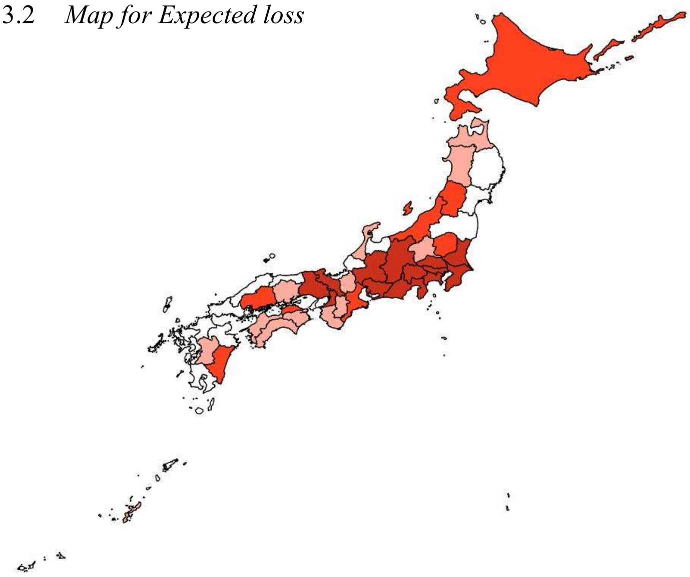
2.3.1 *Map for Exposure*



This map shows Exposure volume by prefecture. Depth of colour explains importance of Exposure. Deeper blue shows higher accumulation of Exposure compare to lighter blues or whites.
There are 4 different grades of blue[1].

Figure 3. Exposures by prefecture

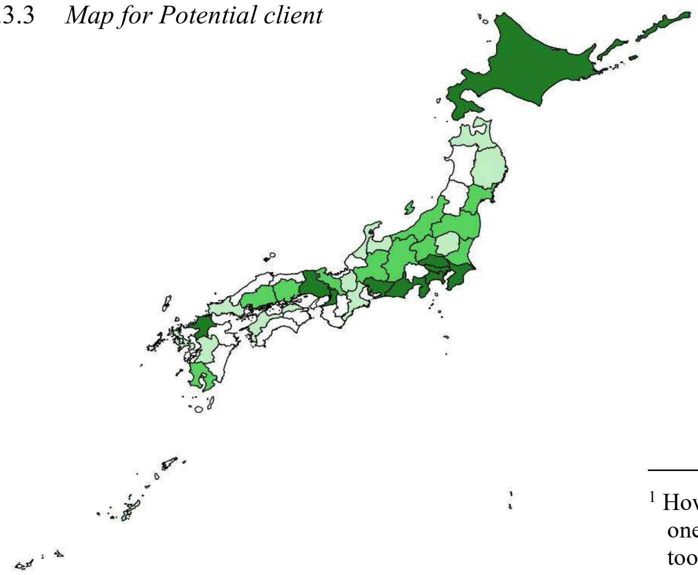
2.3.2 *Map for Expected loss*



AAL as expected losses are calculated by a probabilistic approach[1]. AAL are generated firstly based on location which is directory referred to seismic catalogue where are affected and referred to geological conditions. Also, simulation calculations take considerations of building specifications which lead damageability how much severe damage is occurred. Prefectural office addresses are selected to represent a location of risk. Building specifications are assumed as steel structure basis building with 7 floors. Prefectures which is represented by deep red represent severe damage as large AAL amount.

Figure 4. AAL by prefecture

2.3.3 *Map for Potential client*



Map for Number of Office is made based on how many offices are in each prefecture. We assume that there is more chance in prefecture where we see many offices to provide earthquake insurance compare to prefectures where there is less offices.

Figure 5. Number of Office in each prefecture

[1] How many different depths of blue should be used? This is one of question for visualization. It is not recommended to use too many. Abuse of gradation will not give selectivity of one with others, i.e., it is almost impossible to identify 100% depth of blue and 99% depth of this blue.

3. Production of Bertin’s Ordinal Matrix

In the Semiology of graphics, Jaques Bertin shows a replacement of value in statistic table to numerical values by visual variables[2] and reordering rows and columns of visualized matrix table to improve the readability of concerned information data set. Reordering of matrix provides actually a possibility to discover more insights of the information, rather than non-reordered Matrix. In summary, the idea is to highlight relevant elements in concerned information.

3.1 Approach of the Ordinal Matrix

J. Bertin’s Ordinal Matrix is a visualization of data which is a replacement of numeric data table by visual variables. And another characteristic is re-ordering of rows and columns in matrix. A matrix with permutations of rows and columns improves visibility of the table and makes it more readable, in view of the concerned data set. Then, the Ordinal Matrix lets observers grasp insights of the data as a whole. An example is in Figure 6., example data comes from a survey with respect to urban equipment for several areas where people live. And this tried to discover a categorization: city, suburban or country, depending on different equipment in each place in question. An Ordinal Matrix, just after replacing numerical figures to visual element, is shown at (1) in Figure 6.; and (2) is after re-ordering of columns and rows. By looking at the Ordinal Matrix of (2), the observer can easily and quickly see the categories of area: city, suburban or country by identification of which equipment makes such categorization (highlighted by red frame). Areas categorized as city are C, H and K where we see properties: “high school”, “station” and “police station”. On the other hand, the county is represented by “only 1 class in school”, “no medicine” and “no water conveyance”. So, this example of Ordinal Matrix makes observers relatively easily to see correspondences between township categories and urban equipment.

3.2 Application of Ordinal Matrix

As shown in the example of the Ordinal Matrix, this provides readability of insights about concerned data. In other words, the Ordinal Matrix allow us to provide un aspect of analysis to discover what a data tell us, and which might give opportunity what we should do for next based on a clear understanding of data. This is a reason why this paper concentrates an application of the Ordinal Matrix to data which is to be used for a business strategy in case of insurance company.

The involved data: Exposure, AAL and Number of Office that this paper is going to work here is different with the example data shown in Figure 6. The data was shown by 1 or 0 in that example. These 2 numbers were transformed by black or white blocks in cells of Ordainable Matrix to visualize existence of equipment in cities. However, now, it is required to see a set of data with different numbers, not only 1 and 0. To show differences of numbers visually regarding involved data, 4 different grey scales are introduced. Larger numbers in data are shown by black block and smaller numbers are shown by white block. And 2 different intensity of grey are applied for numbers in between larges and smalls[3]. So, each of captured data is transformed by black, dark grey, light grey and white cell. The larger numbers in each category of data; Exposure, AAL and Number of Office are shown in black, and smaller figures are gradually whiten.

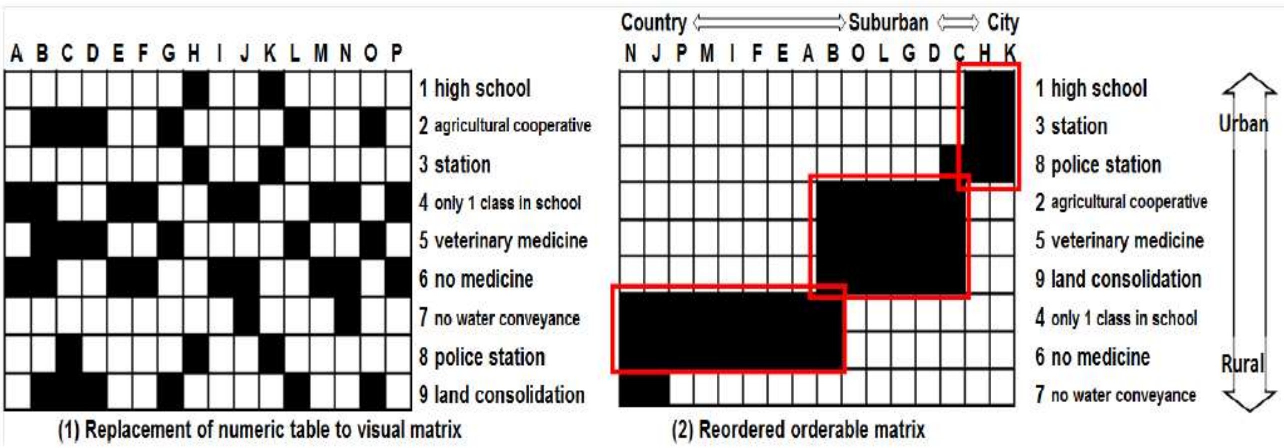


Figure 6. Procedure of Bertin’s Ordinal Matrix

[2] Variable is used by J. Bertin’s work which established graphic semiology to provide a good graphical communication. He developed a notion of visual variables based on perception effects. There are 6 visual variables on 2 dimensions: Size, Value, Texture, Color, Orientation and Shape.

[3] Refer to note 2 in above mentioned.
Also, it shall be noted that 4 different scales of grey does not mean different color, but it is different “Value” that J. Bertin introduced as visual variable. It should be understood as different intensity of black.

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3.3 Ordinal Matrix

Figure 7 shows an Ordinal Matrix after transformation of figures to visual cells by different scale of greys. And Figure 8 is a matrix after re-ordering of columns and rows. Figure 8 is more visible to identify some visual groupings than Figure7. These groups are objects to analyse.

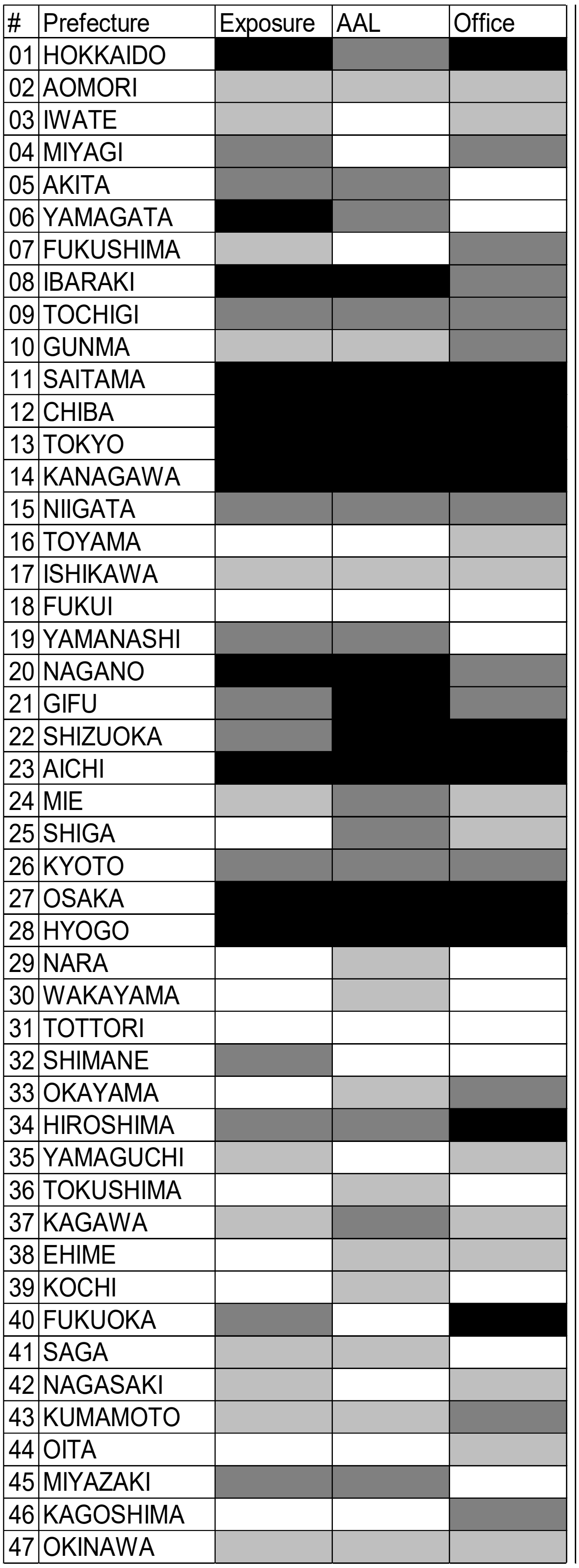

Figure 7. Initial Ordinal Matrix

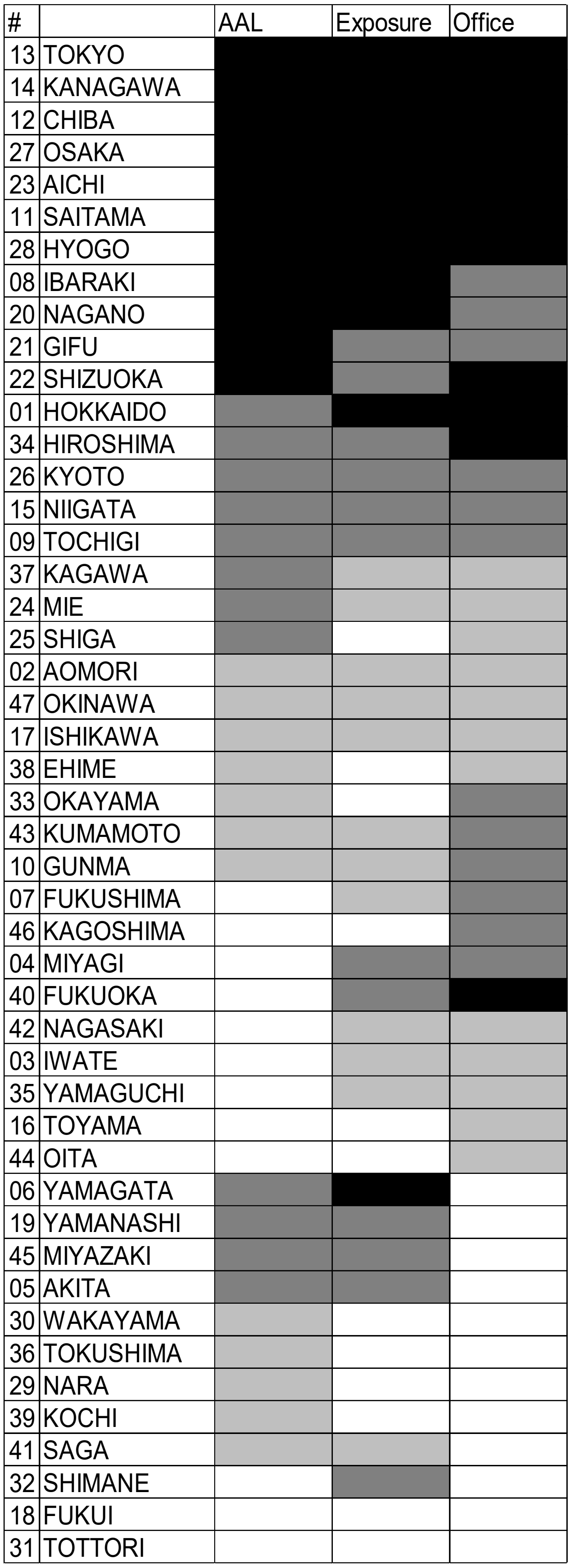

Figure 8. Re-ordered Matrix

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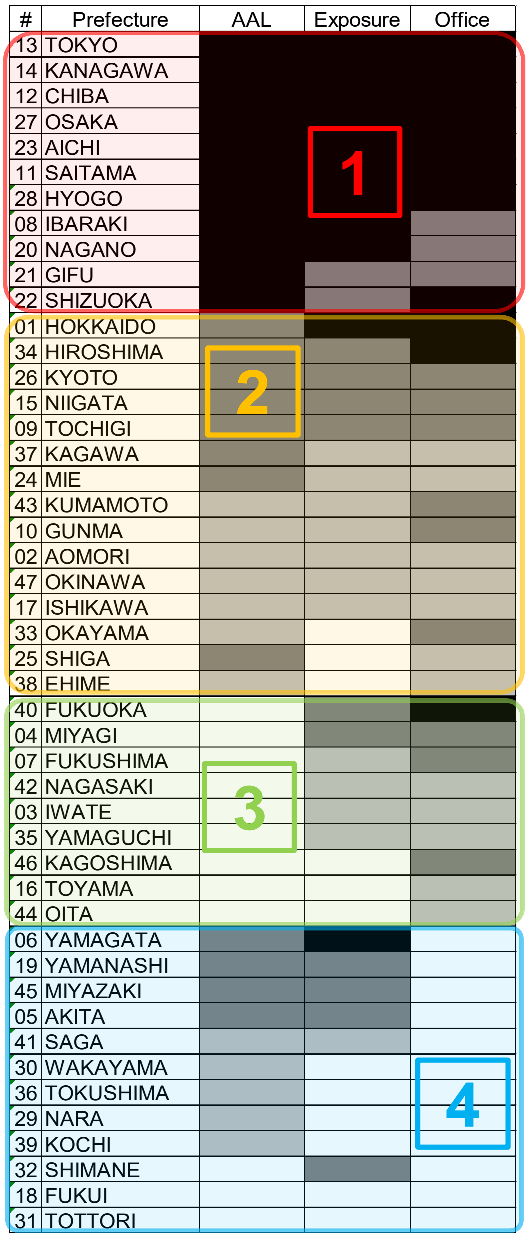

Figure 9. Interpretation of Ordinal Matrix

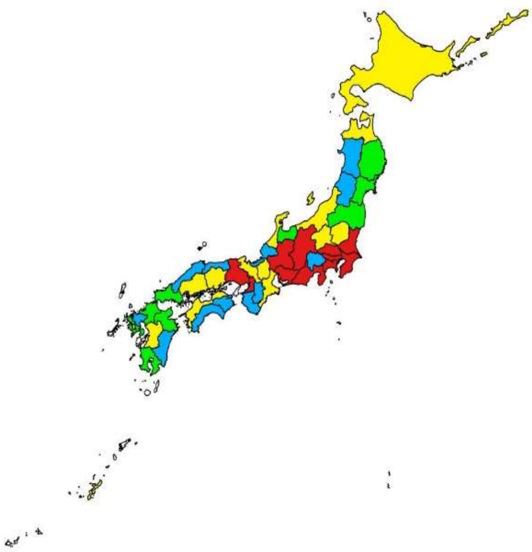

Figure 10. Integrated data by Ordinal Matrix on mapping

3.4 Interpretation

This part is for observations of the Ordainable Matrix. Four major groups are identified (number 1 to 4 in the matrix).

<u>GROUP 1 (framed in red)</u>: no business appetite area

Most of black cells are in this category. From a column of the AAL, we see that relevant prefectures can be categorised as high hazardous areas and also, that there are accumulations of the Exposure in these prefectures more than other prefectures. For example, for Tokyo (#13, top of the figure), many expected clients can be seen from Number of Office. But the Exposure is very much accumulated. And AAL as estimated loss is severe in these prefectures. So, the company should understand that enough earthquake insurance coverage has been already provided to this group, even if we can see large Numbers of Offices which permitted them to have business opportunity to sell insurance. A business development in these prefectures may not be a good strategic decision.

<u>GROUP 2 (framed in yellow)</u>: carefully business expanding area

This area is dominated by grey cells. From all 3 aspects: AAL, Exposure and Number of Office, certain importance is observed. Compare to the GROUP 1, we see smaller AAL, less accumulation of Exposure. Then, the company can offer earthquake relating insurance to expected client. However, at the same time, the company need to watch carefully AAL and Exposure data not to be categorized as GROUP 1. For a case of Hokkaido (#01), if AAL is more important than now, this prefecture will be categorized as GROUP 1, and will stop business growth in this prefecture.

<u>GROUP 3 (framed in green)</u>: high priority area

According to smaller AAL which is shown as white cell, we observe relevant prefectures as low risk area. Exposure-wise, there is not much accumulation of Exposure compare to GROUP 1. Further, there can be found relatively much Number of Offices in this group. In case of Fukuoka (#40) as for example, low AAL and less accumulation of Exposure are observed. This permits the company to provide more earthquake insurance to new clients. The company can have more opportunity to materialized new business in this group based on understanding as mentioned above. This would be a grope that the company should focus on marketing.

<u>GROUP 4 (framed in blue)</u>: inactive area

Regardless of importance of AAL or Exposure, there is less economic activity because of no importance of Number of Office shown with white cells in the matrix. There is less chance to see expected clients in this group. However, we observe a particular case as Yamagata (#06). A black cell in Exposure represents that the company has already provided earthquake insurance to certain important client. If there will be a chance to develop the business in prefectures in this group, the company should lean to find a client efficiently from this exceptional case.

<u>Recapture on mapping</u>: According to a categorization as figured out above, the three aspects of analysis for business expansion: AAL, Exposure and Number of Office, are integrated into one mapping as Figure 10. Same colors are used for 4 groups: red for no business appetite area, yellow for carefully business expansion area, green for high priority area and blue for inactive area. Compare to checking carefully each map of Figure 3, 4 and 5, this mapping is more visible which areas are important for marketing. Naturally, the company should focus on green areas to provide earthquake insurance covers.

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4. Conclusion

4.1 Strategy to be taken

According to descriptions in above mentioned, preferable area to promote earthquake related insurance product is for prefectures in GROUP 3, less accumulation of risk and more opportunities to see expected client. In case of prefectures in GROUP 4, it is not recommended to take much effort to find expected clients. For prefectures in GROUP 1, it should be to stop providing earthquake insurance since occasional one large earthquake will cause a large amount of loss, which damages a capital of the company, to be indemnified by the company. Only one solution is to invest more capital to provide more capacity. Acceptance of risk for prefectures in GROUP 2 shall be reviewed carefully how one additional client will change the company's portfolio with respect to ALL and Exposure. A change would create a prefecture to be categorized as GROUP 1, and which create different view of the Ordinal Matrix.

4.2 Reaffirmation of J. Bertin's Ordinal Matrix

Bertin's Ordinal Matrix would be a centre of communication process for all involved parties with same level of understanding of observed information. The steps that we see the Ordinal Matrix can permit us to analyse concerned data interactively for causes and future effects. Also, this interactivity can be seen between all involved observers of the Ordinal Matrix to discover same specific findings regarding concerned data. It shall be noted also that an integration of data by the Ordinal Matrix permit to recognize same level of understanding without using long phase of explanation what matter the languages. This is main issue of cartography.

4.3 Future development

There are many possibilities to apply the methodology of the Ordinal Matrix to different type of data: economic statistics, social questionnaire, etc which required more larger data than the example used here in this paper, so can be applied to a big data that we are talking recently.

In this paper, grey scale is used in the Ordinal Matrix. However, to maximize visibility of the matrix, other variables that J. Bertin has established can be used, i.e., Size, Value, Texture, Color, Orientation and Shape. A interpretation of Ordinal Matrix do not change according to different variable usage. However, since data visualization is used to better communicate between observers, and to better analyse of data, the presentation method must be well examined. It will therefore be necessary to further develop the technique of presentation of the Ordinal Matrix by support of different variables.

5. Acknowledgements

I have greatly benefited from Zurich Insurance company to work with colleagues. Without the company's persistent support this paper would not have been possible. The author should take all responsibility of content, data and analyses of this paper, independently from the company's policy.

6. Appendix

6.1 Simulated loss as expected loss

The probabilistic loss estimation is calculated by some steps, methodologically. Firstly, the earthquake hazard is identified as potential earthquakes based on active faults, subduction zones and area sources of activity rates of earthquakes. This gives a statistical distribution of ground motion how probable certain intensity of earthquake would be occurred, as a graph shown on top of Figure 11. Secondary, specifications of asset, i.e., buildings are issue such as construction type, figure, age of construction, etc. Damageability shall be different depend the specifications how resistible against earthquake shock, as a graph shown in the middle of Figure11. Based on these 2 functions, an assumed earthquake and damageability are associated to generate an estimated loss in a simulation computation. And all simulated loss amounts for every possible earthquake event are probabilistically aggregated, as a graph shown in the bottom of Figure11. Annual Average Loss: AAL is finally defined as overall annual basis expected loss.

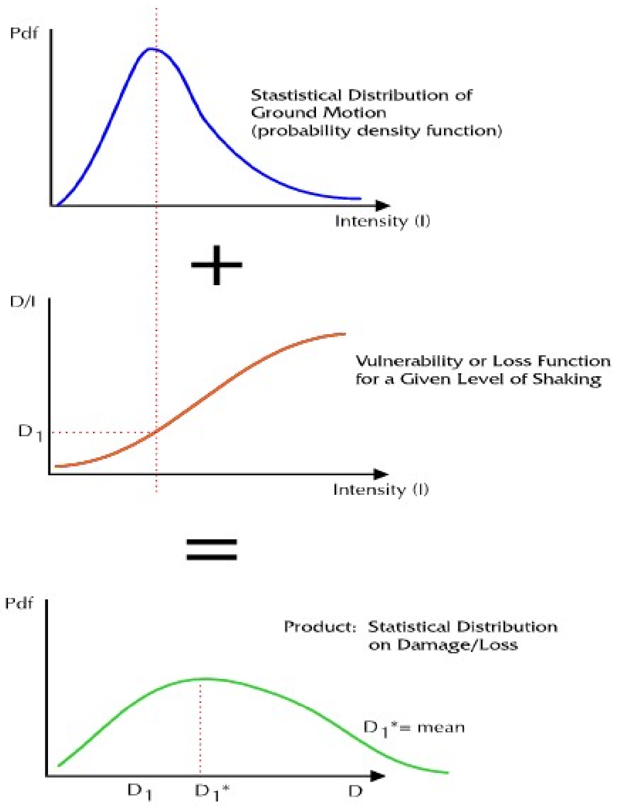

Figure 11. Shema of vulnerability of loss integrating the full statistical variables with uncertainty

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6.2 Original data

The original data is listed as below. It is apparently difficult to see a whole of data at a glance.

-Exposure: total exposure by prefecture (USD million)

-AAL: Simulated loss amount by asset value (%)

-Office: Total number of offices in a prefecture

#	Prefecture	Exposure	AAL	Office
01	HOKKAIDO	202	0.653%	25,498
02	AOMORI	43	0.334%	5,627
03	IWATE	48	0.055%	6,300
04	MIYAGI	50	0.075%	10,587
05	AKITA	79	0.428%	4,705
06	YAMAGATA	624	1.257%	5,247
07	FUKUSHIMA	32	0.041%	8,133
08	IBARAKI	399	4.027%	10,834
09	TOCHIGI	183	0.656%	7,922
10	GUNMA	32	0.262%	8,555
11	SAITAMA	189	4.535%	25,410
12	CHIBA	401	10.772%	19,676
13	TOKYO	1,334	22.503%	116,304
14	KANAGAWA	377	15.967%	36,589
15	NIIGATA	87	1.040%	11,528
16	TOYAMA	22	0.129%	5,702
17	ISHIKAWA	26	0.138%	6,159
18	FUKUI	7	0.078%	4,271
19	YAMANASHI	82	2.637%	3,528
20	NAGANO	791	2.689%	10,740
21	GIFU	95	3.515%	10,555
22	SHIZUOKA	182	6.429%	18,419
23	AICHI	280	5.384%	40,894
24	MIE	33	0.545%	7,376
25	SHIGA	24	0.462%	5,693
26	KYOTO	127	1.462%	13,037
27	OSAKA	453	6.031%	58,073
28	HYOGO	358	2.657%	24,898
29	NARA	18	0.222%	4,508
30	WAKAYAMA	7	0.364%	4,002
31	TOTTORI	7	0.035%	2,845
32	SHIMANE	49	0.070%	3,795
33	OKAYAMA	21	0.376%	9,117
34	HIROSHIMA	50	0.805%	15,017
35	YAMAGUCHI	29	0.015%	6,817
36	TOKUSHIMA	8	0.283%	3,487
37	KAGAWA	29	0.646%	5,268
38	EHIME	13	0.231%	6,175
39	KOCHI	6	0.180%	3,280
40	FUKUOKA	156	0.121%	25,925
41	SAGA	29	0.132%	3,658
42	NAGASAKI	38	0.100%	6,613
43	KUMAMOTO	30	0.189%	7,851
44	OITA	12	0.107%	5,258
45	MIYAZAKI	54	1.061%	5,053
46	KAGOSHIMA	15	0.126%	7,947
47	OKINAWA	25	0.176%	5,897

Table 1. Original data list

7. References

Fukazawa, N. (2005). Risk perception and human behaviors. Kobundo-shuppansha, 223p.

Fekete, JD., Dragicevic, P. and Perin, C. (2014) Revisiting Bertin Matrices: New Interactions for Crafting Tabular Visualizations. IEEE. p2082-2091.

Hirota, S., Masuda, S. and Sakagami, T. (2002). Physiologically described world of risk. Keikodaigaku-shuppankai, 253p.

National Institute of Building Sciences (1997). Hazus Earthquake Loss Estimation Methodology. Technical Manual Volume III

Neisser, U (1978) [translation by Kozaki, T]. Cognition and reality. Sceince-sha, 246p.

Bertin, J (1977). La graphique et le traitement graphique de l'information. Flammarion. p11, 252p.

Bertin, J (1966). Sémiologie graphique. Paris : Mouton, 432p.

Kamei. K (2001). Management strategies of French company and risk management. Horitsubunka-sha, p512, 544p.

Morita, T. (1982). Zu no Kigougaku. Heibonsha, 277p.

Omi, M., Yosizawa, T., Takao, A., Amari, K. and Kubo, E. Elements of risk and insurance. P82, 320p.

de Saussure, F. (1992) Cours de linguistique générale. Paris : Payot, 520p.

Research Group for Active Faults in Japan. Active faults in Japan (1991). Sheet Maps and Inventories (Revised Edition). Tokyo, Univ. Tokyo Press, 437p.

Steinbourg Karl V. (1982) Earthquakes, Volcanoes, and Tsunami; An Anatomy of Hazards. New York: Skandia america group, 392p

Web-site

Japan Meteorological Agency. http://www.jma.go.jp/jma/indexe.html

National Research Institute for Earth Science and Disaster Resilience http://www.j-shis.bosai.go.jp/en/about

PML simulation software providers: AIR Worldwide, CoreLogic and RMS are commonly used.
AIR Worldwide. http://www.air-worldwide.com/
CoreLogic. http://www.corelogic.com/default.aspx
RMS. http://www.rms.com/

Headquarters for earthquake research promotion. http://www.jishin.go.jp/main/