

Development of Indicator with Interactive Visualization System

Masaaki Ida

Research Division, National Institution for Academic Degrees and Quality Enhancement of Higher Education, Tokyo, Japan

ida@niad.ac.jp

Abstract— In this paper we examine financial indicators and related institutional data of higher education institutions. It is desired for sophisticated data analysis and decision making to develop new indicators combining with conventional indicators and related data. Therefore, system development of decision support tools for generating new indicators is expected. As a consideration of the system development, effective and agile functions of user-interaction and visualization are crucial issues. The purpose of this paper is to introduce our decision support system for indicator development which is currently under construction, and show actual operation examples by using our system.

Keywords—financial indicator, correlation, principal component analysis, clustering, visualization, business intelligence

I. INTRODUCTION

Financial Statement data consists of *Balance Sheet (BS)*, *Profit and Loss statement (PL)*, *Cash Flow statement (CF)* and so on. As a basis of corporate management, *Financial Analysis* is a method of obtaining valuable management information on the financial condition of corporation based on reliable *Financial Statement* data. Every kind of *Financial Indicators* are constructed by combining these financial statement data and related basic information of the corporation.

In recent years, financial analysis is performed not limited to corporation or profit organization but also to educational institution. Moreover, non-financial data, which are related to organizational structure, internal or external evaluation, organizational improvement, international and regional contribution are need to be investigated for institutional evaluation and reformation and planning.

So far, we have examined the financial and non-financial information of Japanese universities from the point of information disclosure and university reformation support. Up to now our discussion has focused on reconsidering the existing financial indicators. Concerning this issue, we have developed some data visualization tools with man-machine interaction as a part of decision support system [1],[2].

However, what will be more desired for sophisticated data analysis and decision making is a development of appropriate indicators combining with conventional indicators. Therefore, system development of decision support tools for generating new indicators is expected. As a consideration of system development, developments of effective and agile functions of

user-interaction and visualization are crucial issues. The purpose of this paper is to introduce our decision support system which is currently under construction, and explain actual operation examples by using our system.

II. FINANCIAL DATA ANALYSIS

A. Financial data

In much literature, conventional financial indicators or financial analysis ratio of Japanese universities have been categorized in five financial categories which correspond to general financial indicators of corporations such as “*Financial soundness and stability*”, “*Activity*”, “*Development*”, “*Efficiency*” and “*Profitability*”. Dozens of financial indicators of universities are defined in these categories [1],[2].

B. Basic analysis with BI tools

As a basic financial data analysis, we usually examine basic statistical features of financial statement data and indicators. In recent years *Business Intelligence (BI)* tools have made progress and obtained commercial success. Combining useful user-interaction and visualization functions, BI tools play important and promising role of the basic data analysis. BI tools effectively visualize the data charts, and moreover dynamically change many of them in conjunction with user-interaction functions such as *Filtering* or *Drill-down*. User of the tools can repeatedly operate exploratory examination with filtering and displaying results interactively.

Until now we have developed many BI tools. Adding to these developments, we developed more easily operational web-based BI tools [1],[2]. Figure 1 and 2 show our BI tools for basic financial analysis for the features of education or research indicators of Japanese university by *Box plot* or *Violin plot*. Left side panels in these figures provide selection functions for some ordinal indicators, academic fields or fiscal years. As a basic statistical examination, Figure 2 also provides the result of *Normality Test (Shapiro–Wilk test, Kolmogorov–Smirnov test)* in upper side of the figure. These interactive visualization tools provide the BI functions of such as *filtering* and *drill-down* with agile reaction of user-interface.

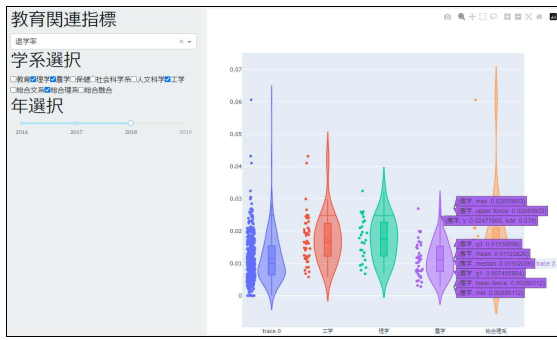


Figure 1. Violin plot of educational indicators with man-machine interaction

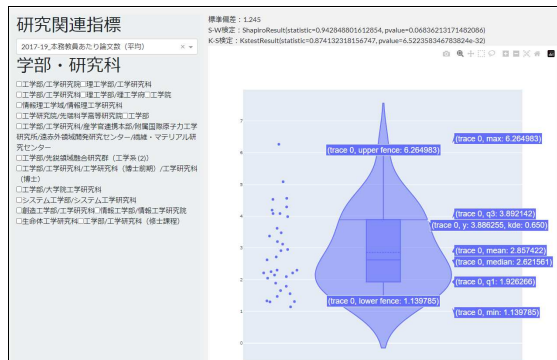


Figure 2. Violin plot of research related indicators with man-machine interaction

C. Correlation analysis

As a next stage of financial analysis, we examine from the points of *Correlation Analysis*. Figure 3 shows our supporting tool for correlation analysis by using visualization and interaction of two financial statement data [2]. The figure is an example of visualization and interaction report of PL statement with comparing two accounting items. In the left side, pointing (or mouse over) the point (university) in scatter plot generates a popup modal window of detailed information, and time series charts of the selected two financial items in right side.

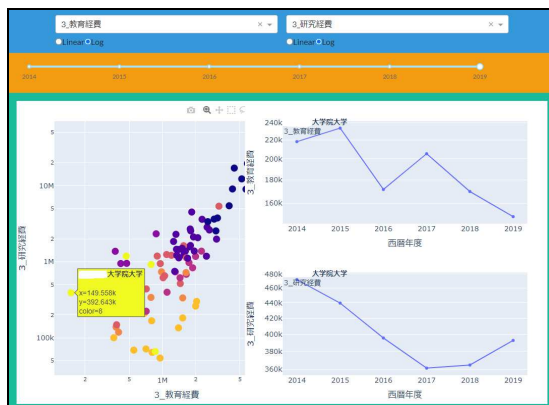


Figure 3. BI report of visualization and interaction for correlatoion of two indicators in reference [2]

We can also consider *Correlation Matrix with Heat Map* and so on. As one of the correlation analysis, Figure 4 shows *Graphical Representation* of indicator correlation which expresses the proximity of financial indicators in terms of correlation or partial-correlation [2]. Moreover, in order to express the proximity for supporting indicator selection, we also applied *Graphical Lasso* method for the covariance matrix of our financial indicators.

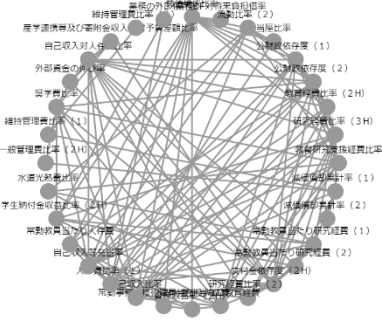


Figure 4. Graphical representation of proximity of financial indicators in reference [2]

D. Dimension reduction

In the case of investigating huge multiple dimensional data of universities and financial indicators, we should consider *Dimension Reduction and Visualization* in lower dimensional space by utilizing *Principal Component Analysis (PCA)* or other dimension reduction methods, i.e., *Manifold Learning* methods (*t-SNE*, *Isomap* and so on). We have so far utilized these dimension reduction methods equipped in our supporting system. Right side of Figure 5 shows the scatter chart of financial indicators in lower dimension by PCA [2].

III. DECISION MAKING WITH SUPPORT SYSTEM

In near future it is expected that the number of indicators to be examined will increase with new data to be considered. The increase of the numbers of data and indicators is a general problem of big data analysis. Therefore, it is needed to develop new methods to re-organize indicators, that is *Indicator Selection* or *Indicator Reduction and Reorganization* methods.

As a supervised learning method, in *Multiple Regression Analysis*, many indicators re-organizing methods have been proposed, and implemented in data analysis tools. However, our situation is a kind of *Unsupervised Learning*, so that it has a problem that there are many kinds of selection criteria. Therefore, it is difficult to evaluate the result of variable or indicator selection or re-organization.

We are developing the financial indicator analysis system that aims to deepen the understanding of data by experts in the financial field, that is a kind of man-machine Interaction System [2]. In this system, as *recommendation* functions, various data science methods are utilized, and are aimed to support the user's understanding of data. In our decision-making situation, since it is necessary to consider the

knowledge of specialized field of university finance, our methodology should be involved with the expert judgment. Therefore, for assisting the expert's judgement process, support system provides some assistant functions or suggestions based on data science methods combined with data visualization system [2].

[Man-machine interaction system]

- (i) Data Science Stage: Calculating the result concerning financial indicator based on data science methods (e.g., Correlation Analysis, Dimension Reduction, Clustering, and so on), and visualizing the result with interaction.
- (ii) Expert Judgement Stage: Financial judgement with expert knowledge of the specialized field (e.g., balance of conventional indicator classification) by using the support tools of Data Science Stage.
- (iii) Repeat the process until expert reaches the final decision.

IV. DEVELOPMENT OF DECISION SUPPORT SYSTEM

We are developing effective and agile web-based financial analysis system (Work in progress) to mixed with various data science methods. The system is utilized with convenient user-interaction and visualization functions [2].

In this section, we introduce the development of our system as described in reference [2] as follows.

Implementing the functions of agile user-interaction and effective visualization is crucial for the rapid man-machine interaction with various advanced data science methods. However, practically there exist various limitations to realize advanced data science technique, e.g., limitation concerning system load, response speed, visual and user interface implementation. it is preferable that many users can easily use it by web browser without installing any special applications.

For practically realizing the decision-making procedure, we are developing the decision support system on high-speed application server with data analysis Python packages [3]. We have implemented some interactive tools on the server. The system can rapidly response to the request and provide enough interaction and visualization functions.

Figure 5 shows an example of our dashboard of decision support for indicator selection [2]. Left side of the figure is the indicator selection panel of financial indicators for comparison of two situations of indicator selection. Top side of the figure is the selection panel of fiscal year. Right side consists of several data analysis reports. We explain from top to bottom [2]: Correlation analysis with *Heat maps*, correlation analysis by *Connecting Graphs*, dimension reduction for indicators by *Principal Component Analysis (PCA)*, dimension reduction for universities by PCA with similarity degree. These analysis reports show more detailed information by mouse-hover operation. All these reports are connected to indicator selection and year selection. Change of the result are responded instantly.

Two analysis results (Left and Right in the figure) are provided as comparison to the user or experts of this field while repeating trial and error (exploratory way). Consequently, they can reach the final decision of financial indicator selection.

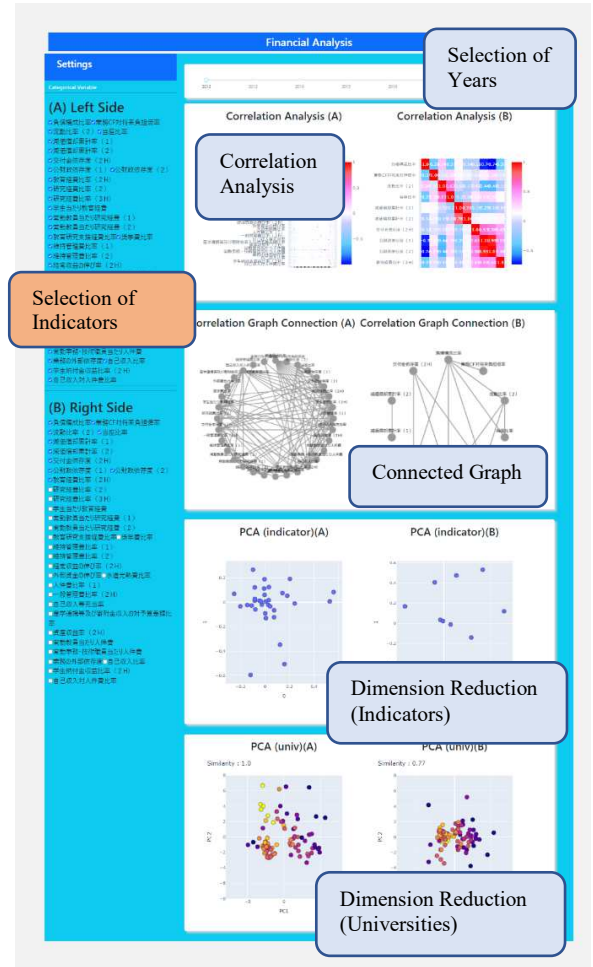


Figure 5. Dashboard of decision support system for financial indicator selection described in reference [2]

V. DECISION SUPPORT FOR GENERATION OF NEW INDICATORS

In this section, as a continuation from the system development described in previous section, we examined decision support system for the *Generation of New Indicators*. As mentioned in previous section, we have developed some support system for *exploratory* selection of financial indicators. However, indicator selection cannot adequately comprehend various characteristics of university clusters or groups. In the near future it will be necessary to create new indicators in addition to the existing financial indicators. Therefore, it is desired to construct a support system for searching and generating new indicators.

We utilize the decision support system for addition of generated new indicator. We summarize the sequence of exploratory decision support as follows:

1. Understanding the features and relationships of existing indicators.
2. Understanding the group or cluster of indicators and the relationship of the groups and selection of the groups.
3. Understanding the development of new indicators, and the influence to the existing group of indicators.

In our initial system development stage, as a new financial indicator structure, we assume simple financial ratio. For example, we set a certain financial statement item of BS as *numerator*, and set a certain basic item (e.g., number of students, number of teachers, number of staff, etc.) as *denominator*.

Figure 6 show the whole screen structure of our developing decision support system for new indicator development. We explain the detail of each panel of our system as follows. Left side panel shows the selection panel of ordinal indicators.

Figure 7 shows (multiple) indicator setting panels of numerators and denominators for multiple new indicators. As an example, upper part of this figure shows the ratio of the number of female students to the number of whole students of universities.

Figure 8(a) shows an initial scatter plot of indicators and newly generated two indicators. Figure 8(b) shows the indicator generation (still in progress) as a result of PCA with the combination of the existing indicators and the newly generated two indicators. In the figure, each color represents the conventional five categories of financial indicators.

Figure 9 is a scatter plot of universities of the result of PCA. In the figure, each color represents the conventional class of universities. The tendency of the allocation of points is similar by other dimension reduction methods such as Isomap. We execute some kinds of clustering methods (k-means and so on) on the dimension reduction space and visualize the clustering results. Figure 10 shows the results of clustering (k-means) for the university scatter plot of Figure 9. Different colors in the figure represent different clusters. The number of clusters can be varied depending on the situation.

Figure 11 shows correlation matrix of conventional indicators with new indicator.

The results will change depending on (1) selection of existing indicators, (2) fiscal year, (3) university scale, (4) area (district) selection. By using the information of plots and the variation of scattering, user of this supporting system can understand the influence of adding the new indicators.

Our developing system will contribute to deepen the user's understanding with *Man-machine interaction*. In addition to this we can utilize our decision support system as follows.

1. In case of adding multiple new indicators to the set of conventional indicators such as "S/T (student to teacher) ratio", we can observe the influence by adding new indicators.
2. After the exploratory process or continuous process of trial and error of selection of existing indicators and generating new indicators, if we discover some characteristics in the scatter plots, then reversely we also find characteristic relationships of selected indicators and newly generated indicators.

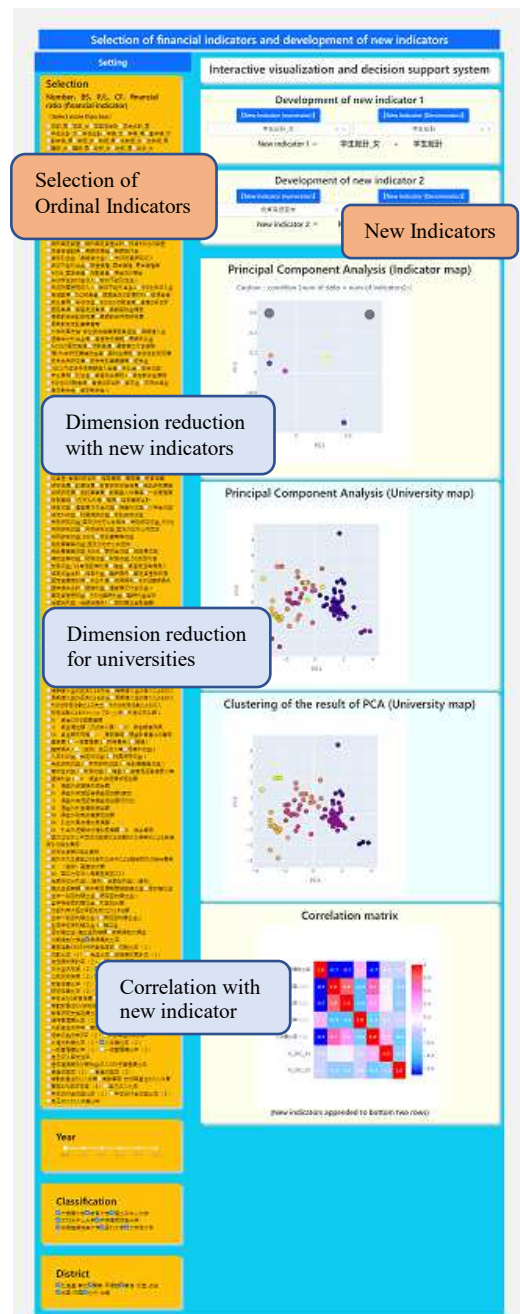


Figure 6. Decision support system for generating new indicator



Figure 7. Generating new multiple indicators with interactive visualization (setting *numerators* and *denominators*)

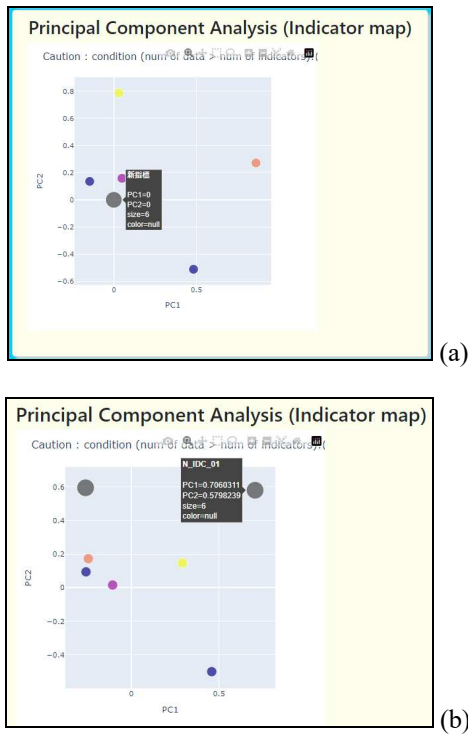


Figure 8. PCA for the set of conventional indicators and multiple new indicators

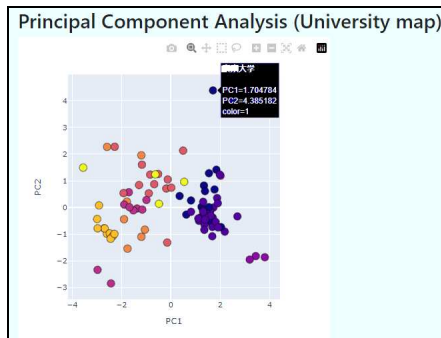


Figure 9. Scatter plot for universities of PCA result by the effect of multiple new indicators

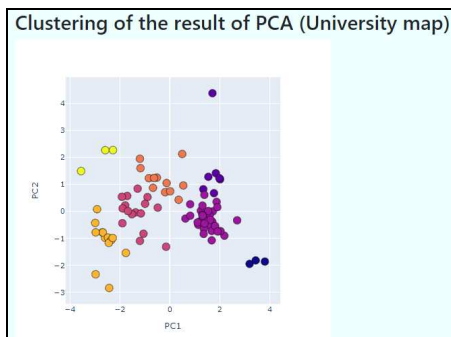


Figure 10. New clustering (by k-means method) on PCA result

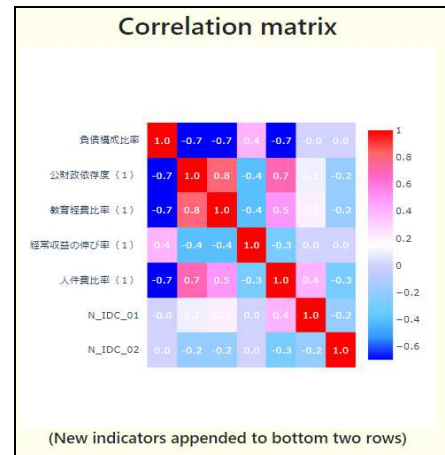


Figure 11. Correlation matrix of conventional indicators with multiple new indicators

VI. CONCLUSION

We have been developing decision support system to reorganize indicators (indicator selection or indicator reduction and reorganization) in [2]. As a continuation from the system development, in this paper, we examined decision support system for generating new financial indicators of higher education institutions, and describe the development of the decision support system with interactive visualization system, which is equipped with the methods of various data science methods of correlation analysis, dimensionality reduction, clustering and various visualization and so on.

In order to expand to more comprehensive data analysis with comprehensive information of education and research activities of universities or non-profit organization, it will become more important that the decision support system should be equipped with various functions of considering various viewpoints.

REFERENCES

- [1] M. Ida, "Data Providing and Analysis System of Japanese Higher Education Institutions", *Proc. of The Thirteenth Higher Education International Conference on teaching and learning quality assurance in the post-pandemic era*, Macao Polytechnic University, pp.65-76, 2022.
- [2] M. Ida, "Decision Support System for the Classification of Financial Indicators", *Proc. of SCIS&ISIS2022*, F-1-E-5, 4 pages, 2022.
- [3] Scikit-learn website. [Online]. Available: [scikit-learn, https://scikit-learn.org/stable/](https://scikit-learn.org/stable/)