Abstract
Office workers’ productivity might be affected by their satisfaction with not only their own workplace but also meeting area, break area and accessory spaces in and around the building. This paper investigates the relation between workers’ subjective productivity and satisfaction with those spaces, statistically analyzing the data collected by the SAP that is a subjective productivity assessment system developed in Japan. Applying a statistical causality analysis to the data of 228 offices, it was revealed that, in addition to satisfactions with environmental factors in an office, satisfaction and frequency of use in other spaces considerably affect workers’ easiness of four types of behavior, focusing, relaxing, communicating, and creative activity, which finally influence productivity in a building. This finding supports the significance of extending the questions from office to overall building in the SAP system.

Keywords: office building; productivity; assessment system; structural equation modeling; graphical modeling

1. Introduction
Today enhancement of productivity is one of the main issues in Japan, as the present government is emphasizing it in its revitalization strategy\(^1\). In designing an office environment, productivity is considered to be an essential factor as well as energy saving. There are several systems such as LEED of the USA and CASBEE\(^2\) of Japan to provide certification of sustainable buildings directly assessed from building properties, however, it is quite difficult to assess the productivity of an occupying organization from the physical measurement of its office environment.

Veitch et al.\(^3\) suggested a hypothesis that satisfaction of physical environment may indirectly contribute to a wider organizational outcome. The certification of LEED or CASBEE guarantees the comprehensive quality of building environment, and therefore, it might be used to estimate the productivity of the building. However, Altimonte et al.\(^4\) found that there is no difference of occupants’ satisfaction with their offices between LEED-certified and non-LEED-certified buildings. Thus, as several researches\(^5\)^\(^6\)^\(^7\) claim, a better way to evaluate workplace productivity is to ask building occupants directly about their needs and comfort of a building.

Several factors of indoor environment influence human comfort with different importance on overall satisfaction with indoor environment\(^8\). Although subjective evaluation of office environment and workplace productivity does not provide an absolute assessment of outcomes and earnings, it is useful for organizations to compare their own evaluation results with others, based on a common tool for questionnaire survey. The Center for the Built Environment (CBE) at the University of California, Berkeley has developed a web-based, open to the public, standardized subjective evaluation system for indoor environmental quality in office buildings\(^9\). The users of this system, if they are CBE’s partners, can compare the workers’ productivity and satisfaction of their office environment relatively with the entire database. The CBE also provided several researches\(^10\)^\(^11\)^\(^12\), by analyzing the data accumulated in the system. The CBE system can be used in multi languages; however, it does not include Japanese. In addition, the questionnaire in the system focuses mainly on office environmental factors, with a few additional questions about building features such as cleaning and maintenance services. On the other hand, several researches\(^13\)^\(^14\) studied the effect of satisfaction with other spaces such as meeting,
communicating and break areas, as well as the features of the overall building. They suggest that workers' productivity might be affected by their satisfaction with not only their own workplace but also those other spaces. Thus, in order to clarify the influence of various spaces on productivity in office buildings, this paper investigates the relation between workers' subjective productivity and satisfaction with those spaces, statistically analyzing the data collected by a subjective productivity assessment system developed in Japan.

2. SAP System

In this survey, data on occupants' satisfaction with their office and overall office buildings were collected by the SAP (Subjective Assessment of Productivity) system in Japan. This system was developed and offered for public use by the Japan Sustainable Building Consortium, who are developing the CASBEE system. Similar to the CBE system, the SAP system is a web-based questionnaire tool with which an organization can conduct a workers' subjective assessment of their office environment and productivity, including meeting area, break area and accessory spaces in and around the building. While it is offered in Japanese, questions about office environment are referred to those of the CBE system.

Table 1 shows the questions about office environment and respondent's attributes. Most of the questions are answered based on a 5-point scale. Sources of dissatisfaction of each environmental element are required to be chosen from the list. For comprehensive evaluation, respondents are also required to judge the easiness of four types of behavior, focusing, relaxing, communicating, and creative activity, which are supposed to influence productivity as well as overall satisfaction.

Table 1. Questions about Office Environment and Respondent's Attributes

| Questions | Way to answer |
|-----------|---------------|
| Brightness of desk | 5 pt. scale |
| Brightness of room | 5 pt. scale |
| Source of dissatisfaction: reflection of PC screen, glare of window, glare of light fixtures, visual privacy, view of window, lack of natural light, confined feeling | Multi answers |
| Thermal sensation | 5 pt. scale |
| Source of dissatisfaction: draft against body, radiation from surroundings, temperature gap between upper and lower body, temperature fluctuation, no air-conditioning during overtime hours | Multi answers |
| Air quality satisfaction with air quality | 5 pt. scale |
| Source of dissatisfaction: air pollution, stuffiness, unpleasant odors, dustiness | Multi answers |
| Spatial environment satisfaction with work area layout | 5 pt. scale |
| Satisfaction with furniture | Multi answers |
| Source of dissatisfaction: size of personal space, office decor, size of desk and surroundings, usability of chair, adjustability of chair, desk and chair layout, wiring and phone layout, storage space, cleaning services, narrow pathways | Multi answers |
| IT environment satisfaction with IT environment | 5 pt. scale |
| Source of dissatisfaction: PC performance, display, LAN environment, software, printer, peripheral devices | Multi answers |
| Ease of behavior: focusing, relaxing, communicating with others, creative activity | 5 pt. scale |
| Satisfaction with overall office environment | Multi answers |
| Impact of work environment on productivity | 5 pt. scale |
| Level of interference/enhancement of productivity | 17 pt. scale |
| Increase level of productivity in the case of improvement of the environment | 10 pt. scale |
| Lost hours of productivity in the last month | 7 pt. scale |
| Absence days in the last month | 8 pt. scale |
| Free description of dissatisfaction with the office environment | Free |

Table 2. Questions about Meeting and Break Areas

| Questions | Way to answer | Meeting | Break |
|-----------|---------------|---------|-------|
| Frequency of use | Frequency | 5 point | 5 point |
| Reason not to use | Free description | 5 point | 5 point |
| Pros and cons factor | Positive & appealing | Multi-choice answers | 5 point |
| Flaws & unfavorable | Informal conversation | Multi-choice answers | 5 point |
| Sourse of dissatisfaction: informal conversation | Discussion to resolve | Multi-choice answers | 5 point |
| Activities and easiness for the activity | Creative discussion | Multi-choice answers | 5 point |
| Refreshing | 5 point | 5 point |
| Exchange of ideas | Easy of use | 5 point | 5 point |
| Work-related talking | Work-related simple activities | 5 point | 5 point |
| Work-related simple activities | Creative thinking | 5 point | 5 point |
| Comprehensive evaluation | Satisfaction | Multi-choice answers | 5 point |
| Impact of building environment on productivity | Level of interference/enhancement of productivity | 17 point | 17 point |

Table 3. Questions about Overall Building

| Questions | Way to answer |
|-----------|---------------|
| Accessory Space | Entrance hall, staircase, elevator hall, atrium, outside area, smoking area, washroom/kitchen |
| Other space (respondent description) | Indication of where and what type of activity | Benefits of use (as above) |
| Satisfaction | Multi-choice answers | 5 point scale |
| Building exterior | Building interior | Maintenance |
| Duration of behavior: concentrating, relaxing, communicating with others, creative activity | Satisfaction with overall building environment | Multi-choice answers | 5 point scale |
| Impact of work environment on productivity | Level of interference/enhancement of productivity | 17 point scale | 17 point scale |
The SAP system provides three sets of optional questionnaires for meeting area, break area and accessory spaces of buildings. The questionnaires for meeting and break areas consist of similar questions as shown in Table 2. The questions about those spaces were selected in order to find enhancing or interfering factors for subjective productivity, rather than to evaluate the environmental factors of an office. Respondents choose positive/apppealing and negative/unfavorable ones from a list of several factors, which varies from environmental elements to facilities of the space. Respondents are also required to evaluate easiness of productivity-related behaviors.

Accessory spaces of an office building such as elevator hall or washroom are generally considered as nonproductive spaces, however, it can be expected that interaction among workers or changing behavior outside of workplace have some influence on workers' productivity. Thus, respondents are required to answer the questions about the frequency of use and productivity-related behaviors in accessory places of their building such as elevator hall, staircase and washroom. Besides, respondents are required to indicate other places in addition to the list of locations where they can conduct productivity-related behaviors. Satisfactions with several features of a building and comprehensive evaluation of a building are also evaluated. Table 3. shows questions about other places in a building.

After some preliminary tests and modifications, the whole system of SAP was released in 2012. The data of 5912 respondents from 283 offices had been accumulated in the database by the end of October 2014. In the survey below, this data is used.

3. Analysis

3.1 Data and Variables

In this paper, structural equation modeling analysis (SEM) is conducted with average data for the respondents of each office. Since data from an office with a too little number of respondents is unreliable, data of 228 offices that have more than three respondents are used. Then three problems arise as below. (1) In 120 out of the 228 offices, respondents evaluated office environment only, whereas those of 108 respondents additionally evaluated other spaces. (2) Even in some offices out of the 108, respondents did not evaluate meeting or break areas. (3) As respondents who do not use meeting or break areas are not required to evaluate those spaces, some questions about those spaces might have a too small number of respondents. Thus, if the number of respondents for a question is less than four for each space, the average data is treated as a missing value. In order to deal with data including missing values, the Full Information Maximum Likelihood (FIML) is adopted as the solution procedure of SEM.

| Table 4. | Variables and Abbreviations in SEM |
|----------|-----------------------------------|
| (1) Variables on satisfaction and frequency of use | Space | Original question | Name of variables |
| Office | Satisfaction with lighting environment | Office_Lighting_satisfaction |
| | Satisfaction with thermal environment | Office_Thermal_satisfaction |
| | Satisfaction with air quality | Office_Air_satisfaction |
| | Satisfaction with sound environment | Office_Sound_satisfaction |
| | Satisfaction with spatial environment | Office_Spatial_satisfaction |
| Meeting | Satisfaction with building interior | Bldg_Interior_satisfaction |
| | Satisfaction with maintenance | Bldg_Maintenance_satisfaction |
| Break | Frequency of use | Meeting_frequency |
| | Satisfaction | Meeting_satisfaction |
| Building | Satisfaction with outside area | Bldg_Outside_satisfaction |

(2) Variables on easiness of behavior in office

| Space | Original question | Name of variables |
|-------|------------------|-------------------|
| Office | Easiness of relaxing | Office_Relaxing |
| | Easiness of communicating with others | Office_Communication |
| | Easiness of focusing | Office_Focusing |
| | Easiness of creative activity | Office_Creative_activity |

(3) Variables on impact for productivity by office environment

| Space | Original question | Name of variables |
|-------|------------------|-------------------|
| Office | Impact of work environment on productivity | Office_Productivity |

(4) Variables on easiness of behavior in overall building

| Space | Original question | Name of variables |
|-------|------------------|-------------------|
| Building | Easiness of relaxing | Bldg_Relaxing |
| | Easiness of communicating with others | Bldg_Communication |
| | Easiness of focusing | Bldg_Focusing |
| | Easiness of creative activity | Bldg_Creative_activity |

(5) Variables on impact for productivity by building environment

| Space | Original question | Name of variables |
|-------|------------------|-------------------|
| Building | Impact of building environment on productivity | Bldg_Productivity |

In this analysis, 24 variables of five categories are used: (1) 14 variables in satisfaction and frequency of use. (2) 4 variables in easiness of behaviors in office. (3) 1 variable in impact of office environment on productivity. (4) 4 variables in easiness of behaviors in overall building. (5) 1 variable in impact of building environment on productivity.

Some causal relationships can be expected to exist in those categories, however, the relationship between (3) and (4) is not clear. Therefore, levels of causal relationship are assumed as follows: Level 1 for (1), Level 2 for (2), Level 3 for (3) and (4), and Level 4 for (5), where the level of a smaller number means the cause of the level of a larger number. Table 4. shows the variables and their abbreviations in the analysis below.

3.2 Procedure of SEM

The procedure of the analysis consists of five steps. The first step is an advance procedure. From all variables of the data, outliers are excluded and some variables are combined, if needed.

In the second step, a full model is estimated, where paths are added among all variables of different levels. Each path means a causal relationship between the two connected variables, and those of the lower and higher levels correspond to the cause and result, respectively. Between two variables of the same level, a correlation coefficient is calculated for each pair in Level 1, and an error correlation is calculated for each pair in Levels 2 and 3.
In the third step, non-significant paths were deleted by the Wald test, unless the goodness of fit becomes worse. Thus, a model with statistically significant paths is acquired.

In the fourth step, Graphical Modelling (GM)\(^{9,15}\) is applied to the model, using estimated correlation coefficients between error variables of Levels 2 and 3. The GM is used to deduce and identify causal relationships among variables in the same level, based on analysis of conditional independence.

In the last step, the SEM is conducted on the data with new paths between Levels 2 and 3 obtained in the fourth step. After deleting non-significant paths using the Wald test, the final model of causal relationships among variables is extracted.

### 4. Results

In the first step of the analysis, correlations among variables were checked. In Level 1, the correlation coefficient between "Bldg_Exterior_satisfaction" and "Bldg_Interior_satisfaction" is quite high (\(r=0.843\)), while others are less than 0.75. Since high correlations among causal variables are unsuitable for the analysis, and the meanings of the two variables are close, a latent variable of "Bldg_in/exterior_satisfaction" is introduced as one of the structural variables in the following procedure.

Secondly, the SEM was conducted with a model having 159 paths among structural variables. This model is fully saturated with structural variables, however, the degree of freedom is 21 because of the use of the above latent variable. The result of the test of goodness of fit is tolerable (\(\chi^2 = 25.6, df = 21, p = 0.220\)), which supports the adequacy of the measured model with the latent variable.

In the third step, from the 159 paths among structural variables, 106 non-significant paths were deleted through the Wald test, which leads to a model with 53 paths. In this process, all paths from "Bldg_Exterior_satisfaction" were deleted, and thus this variable was also deleted from the model. The result of the test of goodness of fit is tolerable (\(\chi^2 = 115.13, df = 116, p = 0.505\)), which means the model is acceptable, judging by p-value.

In the fourth step, Table 5. shows estimated correlation and partial correlation coefficients among the error variables of Levels 2 and 3 in the model of the third step.

The GM was conducted for the variables of Level 2, regarding that Table 5.(a) is the matrix of correlation coefficients for the data of \(N = 200\) in consideration of missing values. Here, a model was adopted in which three partial correlation coefficients are assumed to be zero (\(\chi^2 = 1.09, df = 3, p = 0.780\)). The independent graph is shown as Fig.1.(a). This suggests four causal relationships with the conditions of DAG (Directed acyclic graph)\(^{16}\) as below.

(A) Focusing → Relaxing → Creative Activity → Communication
(B) Focusing ← Relaxing → Creative Activity → Communication
(C) Focusing ← Relaxing ← Creative Activity → Communication
(D) Focusing ← Relaxing ← Creative Activity ← Communication

Conducting the SEM on the model in the third step where the relations of variables of Level 2 were rearranged according to the above four causal models, the model (D) was the best (\(\chi^2=116.9, df=119, p=0.537\)), while \(\chi^2\) of other models were about 125. Thus the model (D) is adopted as the causal relationships in Level 2.
In a similar way, the GM was conducted for Level 3, regarding Table 1.(b) for the data of N = 103. Again, a model was adopted in which five partial correlation coefficients are assumed to be zero ($\chi^2 = 6.45$, df = 5, $p = 0.265$). The independent graph is shown as Fig.1.(b), where the correlations and partial correlation coefficients between "Office_Productivity" and each easiness of four behaviors in overall building, "Bldg_Focusing", "Bldg_Communication", "Bldg_Relaxing", and "Bldg_Creative Activity", are assumed to be zero. Although the order of causal relationships of "Office_Productivity" and the four building behaviors was not clear, this result suggests that there is no need to assume direct causal relationships among them for developing the final model.

If there exist two paths from "Bldg_Creative Activity" to "Bldg_Relaxing", and from "Bldg_Relaxing" to "Bldg_Focusing" among the four building behaviors in the same way as the office behaviors, it suggests a path from "Bldg_Relaxing" to "Bldg_Communication", based on Fig.1.(b). Then there remains a question on what relations exist between "Bldg_Communication" and "Bldg_Focusing", and between "Bldg_Focusing" and "Bldg_Creative Activity". For this question, the SEM was conducted with several models, changing the directions of paths and the settings of correlations of error among those variables, and it was found that the causal relation model in Fig.2. is the most adequate one ($\chi^2 = 120.4$, df = 124, $p = 0.574$). Thus the model was adopted as the causal model in Level 3.

In the last step, the SEM was conducted based on the causal relations in Levels 2 and 3, where several paths became non-significant, thus being deleted. The final model is shown in Fig.3. Standardized path coefficients are added at arrows, and coefficients of determination are added at the upper right of endogenous variables. With $\chi^2 = 126.5$, df = 132, $p = 0.618$, this result is acceptable, judging by $p$-value. There are 52 paths among structural variables. Four of them are slightly non-significant (0.05 < $p$ < 0.12), and 48 paths are significant ($p < 0.05$).

5. Discussion

5.1 Interpretation of the Causal Relationship Model

As the final model is very complicated, the total effect matrix is additionally shown in Table 6. in order to discuss the results as below.
1) As expected beforehand, an overall structure of the model is obtained in which causal relationships start from the satisfactions with environmental factors and the frequencies of use of spaces, to the productivity of office and building, by way of the easiness of behaviors in office and building.
2) In addition, there are many paths that start from the satisfaction with each factor and the frequency of use of each space, connecting directly to the productivity of office and building not via the easiness of behaviors.
3) The coefficients of determination for the easiness of behaviors are generally high (0.6 to 0.8), although that of "Office_Communication" is relatively low (0.52).
Productivity" are quite high (0.85 and 0.88), thus it can be concluded that the cause variables in the model explain them sufficiently.

4) Between the easiness of behaviors in office and building, direct paths connect only between the same behavior in office and building.

5) The patterns of causal relationships among the four behaviors in office and building are not the same, however, both include common causal relationships as shown in Fig.4. In the superposed pattern, the causality among "Communication", "Creative Activity" and "Relaxing" circulates in this order, and "Focusing" is directly affected by "Communication" and "Relaxing".

6) The satisfactions with office environments of lighting, thermal, air quality, sound and space enhance the productivity of both office and building directly or by way of the easiness of behaviors.

7) Satisfaction with the IT environment in an office enhances the easiness of focusing in both office and building, however, there is a negative path to "Bldg_Communication". The total effect of IT on "Bldg_Productivity" is positive, thus the above negative path means a negative effect, which might be a concern for the introduction of IT.

8) The results for meeting space are intriguing. The frequency of use of meeting space enhances "Office_Communication", but spoils other behaviors and the productivity of office and building. On the other hand, the satisfaction with meeting space enhances the productivity of office and building, with the largest total effects among the variables of satisfaction and frequency of use.

9) As for break space, the frequency of use and the satisfaction enhance the productivity of an office and building. However, a negative path is found from "Break_satisfaction" to "Office_Focusing". Moreover, their total effects suggest that a good break space promotes communication, relaxing and creative activity more than focusing.

10) "Bldg_in/exterior_satisfaction" has positive paths to "Office_Relaxing", "Bldg_Relaxing" and "Office_Creative Activity", and enhances the productivity of office and building. Its total effects on productivity are the second largest following satisfaction with meeting space.

5.2 Significance of Evaluating Overall Building

In order to clarify the significance of extending the questions from office to overall building for productivity assessment, a simplified path diagram was reconstructed as shown in Fig.5. In the model represented by this graph, the effect of cause variables for office and other spaces, and the easiness of behaviors in office and building are integrated, and standardized path coefficients are given from the composite variables to the productivity of office and building. Note that the two models of Fig.3 and Fig.5.
represent the same causal relationship, and these are "equivalent models" with the same values of $\chi^2$, df and P-value.

In the model of Fig.5., the productivity of building is considerably different from that of office, and the path coefficients from other spaces to the productivity are not negligibly small. Thus, it can be stated that the extension of the SAP system to overall building has a certain degree of significance. Moreover, the path coefficient from office is larger than that from other spaces to the productivity of office, whereas the relation to the productivity of building is the opposite. This is consistent with the difference of the productivity of office and building.

Regarding the paths from the easiness of behaviors in office and building, the coefficients are about 0.5 and 0.3, respectively, and both of which are considerably large. This suggests that the easiness of the four behaviors can be intermediate variables from the cause variables to the productivity. However, for the direct paths not via the easiness of behaviors, there is a possibility that other intermediate variables are added, which is to be further investigated. Furthermore, in the SAP system for evaluating the productivity of overall building, there is room for consideration of which questions, such as the easiness of behaviors in office, can be omitted to reduce the burden of answering.

Fig.5. Simplified Path Diagram (Values: Standardized Path Coefficients Estimated by the Model with Composite Variables)

6. Conclusion

This paper studied the factors for productivity, applying a statistical causality analysis with the data of subjective evaluation for 228 offices, gathered by the SAP system that enables office organizations to assess their office and overall building in the Japanese language. The main findings are as follows.

Firstly, a causal relationship model was obtained from individual satisfactions and frequencies of use in offices and other spaces, which influence workers' easiness of behavior, and productivity in the end. This model is consistent with the structure of the questionnaire in the SAP system, thus confirming the validity. Secondly, it was also found that productivity in a building is influenced not only by the environmental factors of an office, but also by other factors of break area, meeting area and overall building. This finding supports the significance of providing questions about those areas in addition to office environment in the SAP system. Finally, the obtained model suggests a future possibility of improving the composition of the questionnaire.

Acknowledgement

This study was conducted as part of the activity of a research committee of the Japan Sustainable Building Consortium. The authors would like to express their special thanks to the organization.

References

1) http://www.kantei.go.jp/jp/singi/keizaisaisei/pdf/daiien.pdf (2015.9.14)
2) Murakami, S., Iwamura, K., Cole, R.J. (2014) CASBEE, A decade of Development and Application of an Environmental Assessment System for the Built Environment. Tokyo. IBEC.
3) Veitch, J. A., Charles, K. E., Farley, K. M. J. and Newsham, G. R. (2007) A model of satisfaction with open-plan office conditions: COPE field findings. Journal of Environmental Psychology, 27, pp.177-189.
4) Altomonte, S. and Schiavon, S. (2013) Occupant satisfaction in LEED and non-LEED certified buildings. Building and Environment, 68, pp.66-76.
5) Frontczak, M., Schiabon, S., Goins, J., Arens, E., Zhang, H. and Wargocki, P. (2011) Quantitative relationships between occupant satisfaction and satisfaction aspects of indoor environmental quality and building design. Proceedings of Indoor Air 2012, 22, pp.119-131.
6) Zagreus, L., Huizenga, C., Arens, E. and Lehre D. (2004) Listening to the occupants: a Web-based indoor environmental quality survey, Proceedings of Indoor Air 2004, 14, pp.63-74.
7) Frontczak, M. and Wargocki, P. (2011) Literature survey on how different factors influence human comfort in indoor environments. Building and Environment, 46, pp.922-937.
8) Abbassadeh Fard, L., Zagreus, L., Lehrer, D. and Huizenga, C. (2006) Occupant Satisfaction with Indoor Environmental Quality in Green Buildings. Proceedings of Healthy Buildings 2006, Vol. III, pp.365-370.
9) Kojima, T., Wakabayashi, N. and Hirate, K. (2000) A study on the hierarchical structure of evaluation using 'graphical modelling': Causality analysis on environmental evaluation part I-. Journal of Architecture, Planning and Environmental Engineering, 535, pp.47-52 (Japanese).
10) Munakata, J. and Tanaka, T. (2014) Effects of office environment on workers’ motivation: Comparison with evaluations such as comprehensive satisfaction and refreshment. Journal of Environmental Engineering, 695, pp.19-25 (Japanese).
11) Akiyama, K., Hirayama, T., Nakamura, Y. and Inui, M. (1996) Privacy and communication in office environment evaluation. Journal of Architecture, Planning and Environmental Engineering, 484, pp.97-104 (Japanese).
12) Oyama, Y., Morikawa, Y. and Nakamura, Y. (2003) Actual situation of refreshment in office. All Journal of Technology and Design, 17, pp.269-274 (Japanese).
13) http://www.jsbc.or.jp/sap/notes.html (2015.10.7).
14) Munakata, J., Kawase, T., Kojima, T., Sakuma, T., Takahashi, M., Hashimoto, S., Harada, M. and Yoshii, T. (2015) Development of a comprehensive assessment system of office workplace productivity in an office building. All Journal of Technology and Design, 49, pp.1087-1092 (Japanese).
15) Kojima, T., Wakabayashi, N. and Hirate, K. (2002) Exploratory modeling for causality in hierarchical structure of evaluation: Causality analysis on environmental evaluation part 2-. Journal of Architecture, Planning and Environmental Engineering, 556, pp.77-82 (Japanese).
16) Pearl, J. (2009) Causality -Models, Reasoning and Inference- (Translated by Kuroki, M.) Tokyo: Kyoritsu shuppan. (Japanese)