Relation Between People’s Evaluations on Living Conditions and Plan Locations of Dwelling Units in MFRHC with Parallel Layout in Beijing

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Abstract
The purpose of this study is to examine and clarify the relation between people’s evaluations on the living conditions and the plan locations of the dwelling units in Multi-Floor Row House Cluster (MFRHC) with the parallel layout. Instead of the on-site survey, four models were used to collect people’s evaluations in the investigation. The evaluation indices included: the Sunlight situations (ES), Views from dwelling units (EV), Privacy (EP), Noise situations (EN), and Comprehensive Evaluation index (CE). The plan locations of the dwelling units were described with four nominal variables indicating the positions in a row house, the relations with the green land, the north-south locations and the east-west locations in MFRHC respectively. The Ordinal Regression models were utilized to make clear the specific relation between the subjective evaluations and the physical variables indicating plan locations. The results were found accordant with the most preferred and the most disliked dwelling units selected by the respondents. The order of the relative contributions of the item indices in CE from high to low is EV, EN, EP and ES.

Keywords: living condition; plan location; Multi-Floor Row House Cluster (MFRHC); parallel layout; Ordinal Regression

1. Introduction
1.1 Background
The sustained economic growth of China has fueled vast housing production throughout the country. Only in a period of four years 1996-2000, about 3.1 billion square meters or about 44.3 million housing units were completed in urban area. The popular building types in the housing market can be classified into Slab-Type and Point-Type, according to the plan patterns. A slab-type building, or row house, is usually composed of 3-6 segments, each of which contains 2-3 dwelling units and a common staircase. And a point-type building is made up of more than four dwelling units surrounding the concentrative traffic core (Fig.1). According to a recent survey, the multi-floor row house was the most popular building type among customers in Beijing, winning 56% customers’ preferences.

In China, the hierarchical structure of residential districts is organized in three layers in accordance with the population or household number, including Residential Districts, Residential Quarters and Housing Clusters. The housing cluster is the basic organizational unit with comparatively pure function as residence. The scope of this study thus focused on the living conditions of the dwelling units in the Multi-Floor Row House Cluster (MFRHC).

The dominant layout type of MFRHC is the parallel layout and its variations (Fig.2), because it can efficiently satisfy the dwelling units with the consistent living conditions in a comparative high density, and suit the demand of industrialized construction. Although the living conditions of the dwelling units in MFRHC with the parallel layout are relatively homogeneous compared with those with other layout types, they do show discrepancies when the dwelling units differ in the locations in the housing cluster. Among the various factors that influence the living conditions of the dwelling units, the locality determines some inborn conditions, which were unchangeable or hard to be

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remedied thoroughly, such as the sunshine and noise situations. We attempted to extract the influences of the plan locations of the dwelling units upon the living conditions by using the established models in the investigation. It was analogous to the common situation in Beijing that customers judged which dwelling units to buy by means of scaled models, illustrated catalogues and model homes. The study was concentrated on the relation between people’s evaluations on several aspects of the living conditions and the plan locations of the dwelling units in MFRHC with the parallel layout. It could be the basic knowledge for developing the parallel layout in terms of improving the living conditions of the dwelling units.

It should be noted that the vertical location factor, storey level, was excluded to make the investigation operable. The further reasons included: 1) in Beijing the row houses were usually 6-storey, the highest limitation for multi-floor residential buildings without elevators, to ensure the density; and 2) it was supposed that the influences of the vertical location factor were in a similar pattern and irrelative with the plan locations. So the dwelling units on the third floor were chosen as the representations of the dwelling units with the same plan locations.

1.2 Purpose

The primary purpose is to clarify the relation between people’s evaluations on the living conditions and the plan locations of the dwelling units in MFRHC with the parallel layout. The other analyses attempt to reveal the structure how people’s evaluations on the item evaluation indices compose the comprehensive evaluation and to verify the result of the Ordinal Regression models. The study questions include:

1. What are the specific relations between people’s evaluations on the living conditions and the plan locations of dwelling units in MFRHC with the parallel layout?
2. What are the relative contributions of the item evaluation indices in the comprehensive index?
3. Where do the most preferred and the most disliked dwelling unit types occur? And does it agree with the result of regression models?

1.3 Past Studies

There have been plenty of the studies on the living conditions of the dwelling units in MFRHC. Some of them focused on the physical indices of the living conditions. Muraoka and Aoki (1998)\(^1\) optimized the layout of Multi-floor houses to maximize the received solar energy. Wang (2002)\(^2\) studied the sunshine situations of the dwelling units in MFRHC with the parallel layout, and concluded that the height of the dwelling units in the middle of the row house should be lower than those at the end for the sake of the improvement in sunlight situations. Another study by Yu (2001)\(^3\) concentrated on the influence of the traffic noise to the dwelling units and provided a programming that could automatically create the noise contour map according to the building layouts. Some other studies focused on the evaluations of the residents. Kfir et al (2002)\(^4\) utilized the multiple regression analysis and image processing of photographs to clarify the relation between residents’ evaluations of the view from the dwelling units and the components in the photographs. The Residential District Planning Research Group (1985)\(^5\) presented their prominent study on the interaction between residents’ outdoor activities and the exterior spaces in housing clusters based on the large-scale investigation. They also established a comprehensive evaluation system for the living environments of residential districts by giving weights to kinds of the evaluation indices based on investigations and opinions from experts.

In this study, the scope and method of past studies were modified in the following ways. First, this study concentrates on the differences in the living conditions of the dwelling units with the different plan locations in MFRHC with the parallel layout, which can provide a basis for developing the parallel layout. Second, people’s evaluations are given to the dwelling units represented by the established models. By using models in the investigation, people’s evaluations are limited in the evaluation indices closely related to the building layout and the other influential factors are filtered, such as the economic factor, applicability of dwelling units and green coverage. Third, the multivariable analysis is applied to examine the relation between people’s evaluations and the plan locations.

2. Method

2.1 Investigation by Using Models

An investigation was conducted to collect people’s evaluations on the living conditions of the dwelling units with the different plan locations in MFRHC. The outline of the investigation is introduced in Table 1. In this investigation, the respondents were requested to imagine and evaluate the living conditions of the dwelling units represented by the established models (Fig. 3), instead of the on-site survey. Therefore, the Architecture students were chosen as the respondents due to their familiarity with the modeling techniques.
A general introduction was given to the respondents at the beginning of the questionnaires, including the layout of dwelling units. But, the detailed technical conditions were not specified, as in the reality they were complemented by the customers. Although these complements might differ in people, as a whole, the result was expected to represent the common situations in Beijing.

In the main section of the investigation, people were requested to evaluate 34 dwelling units in the models. These dwelling units were chosen according to their plan locations in the housing cluster, which were described with four items. The specific categories in each item and the plan locations they represent are shown in Table 2 and Fig.4. Then, these typical dwelling units were composed into four models and evaluated. Because some criteria differed in people, such as where the last unit that could benefit from the Green Land (GL) occurred, or where the last unit influenced by the east boundary occurred, 8 out of 34 dwelling units were located in the models by the respondents before the evaluations.

Five evaluation indices were used in the investigation, which were ES, EV, EP, EN and CE. The item evaluation indices were selected from a variety of evaluation indices on the living conditions of the dwelling units from the view of residents. The criteria were: 1) the evaluations

Table 2. Four Items Indicating Plan Locations

| Item | Category | Category Number |
|------|----------|-----------------|
| 1. Position in a row house | End unit | 1 |
| | West end unit | 2 |
| | Middle unit | 3 |
| 2. Relation with the green land (GL) | Directly facing GL | 1 |
| | Indirectly facing GL | 2 |
| | On the north of GL | 3 |
| | On the south of GL | 4 |
| | 1st unit | 5 |
| | 2nd unit | 6 |
| 3. North-south location in housing cluster | On the north boundary | 1 |
| | Inside (north-south) | 2 |
| | On the south boundary | 3 |
| 4. East-west location in housing cluster | Near the east or west boundary | 1 |
| | 1st unit | 2 |
| | 2nd unit | 3 |
| | Last unit | 4 |
| | Inside (east-west) | 5 |
on these indices should vary obviously with the plan locations of the dwelling units, and 2) they must be easily imagined for the respondents by means of the models. Based on these item indices, the comprehensive evaluation index recorded the general image of the living conditions. It should be emphasized again that in this study people’s evaluations were given to the dwelling units represented by the established models, but not the residents’ evaluation on site.

2.2 Data Analysis Method

The Ordinal Regression method, a multivariable statistical technique, was utilized in this study to examine the relation between people’s evaluations and the plan locations of the dwelling units. Ordinal Regression is one of the extensions of the logistic regression technique that allows the response (dependent variable) to be polytomous ordinal data. Unlike the ordinary least square in the regressions with continuous variables, Maximum Likelihood Estimation (MLE) is used in logistic regressions to calculate the logit coefficients. MLE seeks to maximize the log likelihood, which reflects how likely the odds are that the observed values of the response may be predicted from the observed values of the predictors (independent variables).

The procedure of the Ordinal Regression analysis includes three steps. First, whether the response is independent of the predictors is checked by Chi-square test. Second, Ordinal Regression is applied with all the predictors that show significant associations with the response in the first step. At last, the regression model is refined by combining the insignificant categories with the neighboring ones until each category of the predictor has significant logit coefficient. That is why in the following text the valid predictors are not exactly the same in the regression models.

To interpret the regression result, the logit coefficients of predictors were converted to the odds ratio of the response. It means that when a predictor is true in a case, the odds that the response occupies the highest category increased by a factor of the value of the corresponding odds ratio, when the other predictors are controlled. Furthermore, the ratio of odds ratios corresponding to the predictors is the ratio of the relative importance of them in term of the effect on increasing the odds of the highest-scored response.

3. Relation Between People’s Evaluations and Plan Locations

This section introduces five regression models, which examine the relations between people’s evaluations on the five evaluation indices and the plan locations of the dwelling units respectively (Fig.5). Because the methods and procedures were the same in each model, only the one between CE and the plan locations was reported in detail, which was also the most important. For the other models concerning the item evaluation indices only the regression results and the special points are briefly introduced.

In the following text, the relations between people’s evaluations and each of the four physical variables indicating plan locations are extracted and introduced separately. That is to say when the relation concerning to one of these physical variables was explained, the others were deemed unchanged. It should be underlined that as regression models our results also could be used to predict the living conditions dwelling units by inputting the plan locations, or to compare the living conditions of two dwelling units even with completely different plan locations.

3.1 Relation Between People’s Comprehensive Evaluations and Plan Locations

In the first step, CE was found associated with each of the four independent variables indicating plan locations by means of Chi-square test. So all of them entered the initial regression model with all categories. As the result, three categories were found with insignificant logit coefficients (P>0.05). In the order of the P value of the insignificant categories, the regression model was refined step by step. At last, except one category with P=0.06, all the other predictors in the model were statistically significant. This category remained in the model because the overall measures of model fitting would fall obviously if it was combined with the others. The Model Chi-Square equaled 1374.94 (df=11, P=0), and the Pseudo R-Square value was 0.46 (Nagelkerke), both indicating that the plan locations, as a set, were reliably distinguished between people’s evaluations on CE. The valid predictors and their logit coefficients were listed in Table 3. The last category in each nominal variable was the reference category, with logit coefficient=0 and odds ratio of CE=1. In order to interpret the regression result, the logit coefficients were converted into the odds ratios of the CE, as shown in the last column of Table 3. Fig.6 shows the specific relation between the odds ratio of CE and the plan locations of the dwelling units.

For the different positions in the row house, the positions at the east end and in the middle are more likely to relate to the high assessments in CE than the west end position.

The variance tendency of odds ratio of CE in X1 indicates that the closer the relationship between the dwelling unit and GL is, the more likely it is to get a high evaluation. As expected, the category directly facing GL corresponds to the highest odds ratio of CE, which
Table 3. Valid Predictors for CE and Corresponding Logit Coefficients

| Predictor | Corresponding plan location | Logit coefficient | Sig. | Odds ratio of CE |
|-----------|-----------------------------|-------------------|------|-----------------|
| X₁        | W: West end in the building; E&M: East end & Middle unit in the building. | -0.68 | 0.00 | 0.51 |
|           | DF: Directly Facing Green Land (GL); | 3.07 | 0.00 | 21.45 |
|           | IN-1: The 1st unit Indirectly facing and on the North of GL; | 1.61 | 0.00 | 5.00 |
|           | IN-L: The last unit Indirectly facing and on the North of GL; | 1.30 | 0.00 | 3.69 |
|           | IS-1: The 1st unit Indirectly facing and on the Side of GL; | 0.79 | 0.00 | 2.21 |
|           | IS-2: The 2nd unit Indirectly facing and on the Side of GL; | 0.52 | 0.03 | 1.69 |
|           | * Other: The Other relations with GL. | 0.00 | 0.00 | 1.00 |
| X₂        | SB: On South Boundary; | -1.62 | 0.00 | 0.20 |
|           | NB: On North Boundary; | -1.01 | 0.00 | 0.37 |
|           | INS: Inside (north-south direction). | 0.00 | 0.00 | 1.00 |
| X₃        | EB: On the East (or west) Boundary; | -1.95 | 0.00 | 0.14 |
|           | NEB-1: The 1st unit Near the East (or west) Boundary; | -0.67 | 0.00 | 0.51 |
|           | NEB-O: The other units Near the East (or west) Boundary; | -0.22 | 0.06 | 0.80 |
|           | * IEW: Inside (east-west direction). | 0.00 | 0.00 | 1.00 |

Reference category in the variable, with logit coefficient=0 and odds ratio=1

Table 4. Overall Measures of the Regression Models Concerning the Item Evaluation Indices

| Model Chi-square | ES | EV | EP | EN |
|------------------|----|----|----|----|
| df               | 7.00 | 10.00 | 7.00 | 1112.32 |
| sig.             | 0.00 | 0.00 | 0.00 | 0.00 |
| Pseudo R-Square  | 0.26 | 0.63 | 0.20 | 0.39 |

is about 22 times more efficient than the reference category in terms of increasing the odds that CE gets the highest evaluation.

As for the north-south locations in the housing cluster, the locations either on the south boundary or on the north boundary are likely to relate to the decrease of the odds of a highest evaluation. The locations on the south boundary are even worse than those on the north boundary in terms of having high evaluations in CE.

In the east-west direction, the farther from the east or west boundary the location is, the more efficient it is to increase the odds of the highest evaluation in CE. The inside locations are most likely to get the high evaluations.

3.2 Relation Between People's Evaluations on the Item Evaluation Indices and Plan Locations

Following the same procedure, the relation between people's evaluations on each item evaluation index and the plan locations was examined. The overall measures of model fitting indicate that the people's evaluations on EV can be predicted by the plan locations best, while the models concerning EP and ES perform not so well (Table 4). The reason for the worst performance in predicting EP lies on that the respondents’ evaluations on it were influenced by two opposing factors. One was the visual disturbance from the opposite dwelling units, which tended to become serious when the dwelling unit located in the middle of a row house and with a normal building interval in front. The other factor was the disturbance caused by people's activities in the exterior spaces, such as GL and road, which tended to become better in the above situation. Therefore, this index was too intricate to be predicted efficiently by the plan locations. The bad performance in the regression model concerning ES might be because people’s evaluations on it were too concentrative compared with the other indices. Table 5 shows the specific relations between the odds ratios of the item indices and the plan locations.

In predicting people's evaluations on ES, dwelling units' east-west locations in the housing cluster were found insignificant and excluded. In $X_4$, the dwelling units at the end of the row house tend to get higher evaluations than the middle units. The east end position is the most efficient in terms of increasing the odds of a highest evaluation, which is two times that of the west end. This proves that people prefer the sunlight from southeast. In $X_5$, the situation that can directly face GL is most likely to get the highest evaluation. The situations indirectly facing and on the north of GL are also more efficient than the other categories. It is interesting to find the dwelling units on the south boundary are more likely to have high evaluations on ES than those on the north boundary and inside, because people have thought the interval space were larger on the south boundary, although all the intervals are the same in the models. In addition, people’s evaluations on ES were found not
correlated with the Sunlight Hours of the dwelling units', the usual physical index for sunlight situations, with Person’s R=-0.10. This reveals that the respondents tended to take the conditions of the surrounding exterior spaces into consideration rather than Sunlight Hours, when they evaluated the sunlight situations of the dwelling units in the models. This answers for why the dwelling units with GL and road to the south tend to get high evaluations in ES.

As for the item index EV, the dwelling units at the end of the row house relate to the high odds of a highest evaluation, compared with the middle units. The reason was the respondents thought that the end unit had a wider view with one more window on the sidewall. All the categories of X2 are valid predictors for EV, and the variance range of the odds ratio of EV in them was the largest. The regression result implies an explicit relation that the more GL can be viewed from the dwelling units, the higher the odds that EV has the highest evaluation are. The situations that can directly face GL are about 232 times more likely to have the highest evaluation than the reference situations, not facing GL. In X3 and X4, it can be found that the locations with close relations with the boundaries are against the odds of the highest evaluation in EV.

Although the regression model concerning EP performs worst, the regression result is also reported here. The end positions in a row house are likely to get the lower evaluations on EP than the middle positions. The situations on the north of GL show associations with the increases of the odds that EP occupies the highest category, especially those directly facing GL. All the boundaries relate to the decreases in the odds of a highest evaluation on EP.

The special point in the model concerning EN is that X1 was found insignificant and excluded. In X2, the end positions in the building were more likely to have low evaluations on EN than the middle positions, because the end units were thought usually beside the road and to have more exterior walls. Having a closer relation to any of the boundaries tends to decrease the odds that EN has the highest evaluation. The locations on the south boundary are the most serious, since the living room and the main bedroom usually locate in the south side.

4. Relative Contributions of Item Evaluation Indices in Comprehensive Evolution Index

The comprehensive evaluation index was found strongly correlated with the item evaluation indices respectively, which was represented by the statistic Gamma8 (Table 6).

The other Ordinal Regression model was applied to examine the relative contributions of the item indices in CE when they interlaced together (Fig.7). Unlike the above regression models, the predictors were treated as the scale variables in this model to compare their relative importance, which was widely done when ordinal predictors had no less than five categories. The overall measures of model fitting showed that the association was very strong, with the Model Chi-square=3215.77

Table 6. Correlation between CE and Item Evaluation Indices

| Dependent variable: people’s evaluations on the comprehensive index | Independent variable: people’s evaluations on the item indices |
|---------------|------------------|
| Sunlight | View | Privacy | Noise |
| CE | 0.46 | 0.79 | 0.73 | 0.69 |

Fig.7. Model between People’s Evaluations on CE and Those on the Item Indices
(df=4, and P=0) and the Pseudo R-square=0.78.

The logit coefficients of the predictors were converted into odds ratio of CE to interpret their relations with CE (Fig.8). In terms of the effect on the odds that CE occupies the highest category, the order of relative importance of the item evaluation indices from high to low is EV, EN, EP and ES. The highest-linked item index, EV, is over three times more efficient than the lowest-linked one, ES.

5. The Most Preferred and Most Disliked Dwelling Unit Types

In the last part of the investigation, the respondents were requested to choose their most preferred and most disliked dwelling units in the models, both of which could be multiple selection, and give the brief reasons. There were altogether 25 most preferred types and 18 most disliked types of dwelling units selected by the respondents. The dwelling unit types that were most frequently selected as the most preferred and most disliked dwelling units were listed in Table 7. The common points in the top four most preferred types were: directly facing GL, not on the south boundary and far from the east or west boundary. And the top four most disliked types all occurred in the locations not facing GL and on the corner of the housing cluster. These agree with the result of the regression model between CE and the plan locations.

The brief reasons cited by the respondents were classified into five clusters: reasons related with sunlight, view, privacy, noise, and others (Fig.9). When people chose the most preferred dwelling units, the most frequently cited reasons were those related with the view from the dwelling units. The reasons related with sunlight, privacy and noise were cited in similar frequencies. Other reasons mainly included the ventilation situation, security, and traffic convenience.

For the most disliked dwelling units, people cited the reasons related with the noise situation most frequently. The dissatisfaction with the view also played an important role as the second reason cluster mentioned frequently. Other reasons here were mainly composed of people’s feeling of being on the corner and traffic inconvenience.

6. Conclusions

This study revealed the relation between people’s evaluations on the living conditions and the plan locations of the dwelling units in multi-floor row house cluster with the parallel layout, based on the investigation with the established models. Five Ordinal Regression models were established respectively between people’s evaluations on the five indices and the variables indicating the plan locations of the dwelling units. The order of the associations with the plan locations from strong to weak was people’s evaluations on the “view,” comprehensive index, “noise,” “sunlight,” and “privacy.”

The relations between the positions in a row house and people’s evaluations differ in the evaluation indices. In the comprehensive index, the west end units tend to have low evaluations than the east end and middle units. In the item indices, the end positions are more likely to relate to an increase in the evaluations on the “sunlight” and “view,” but a decrease in those on the “privacy” and ‘noise.’

Generally, the closer the dwelling units’ relations with the green land are, the higher the odds that they might get the highest evaluations are. The exception is in the regression model concerning the “noise,” where this predictor indicating the relations with the green land is insignificant and excludes. Furthermore, the variance range of the odds ratios of the comprehensive evaluation is the widest in this predictor, which implies that the

| Rank | Location in the building | Relation with GL | North-south location in housing cluster | East-west location in housing cluster | Percent in respondents (%) |
|------|--------------------------|------------------|----------------------------------------|--------------------------------------|-----------------------------|
| Most | 1 | In the middle | Not facing GL | Inner | Outer | 51.4 |
|      | 2 | In the middle | Not facing GL | Inner | Outer | 40.3 |
|      | 3 | At the east end | Not facing GL | Inner | Outer | 27.8 |
|      | 4 | At the east end | Not facing GL | Inner | Outer | 25.0 |
| Preferred | 1 | In the middle | Not facing GL | Inner | Outer | 75.0 |
|         | 2 | In the middle | Not facing GL | Inner | Outer | 23.6 |
|         | 3 | In the middle | Not facing GL | Inner | Outer | 22.2 |
|         | 4 | At the east end | Not facing GL | Inner | Outer | 19.4 |

Table 7. The Most Preferred and the Most Disliked Dwelling Unit Types
most efficient way to improve people’s comprehensive evaluations is to relate the dwelling units to the green land more closely.

The locations with close relations to the boundaries are likely to decrease the odds of the highest evaluations, except that in the model concerning the “sunlight” the locations on the south boundary are more likely to have higher evaluations than the inside ones and the predictor indicating the east-west locations are excluded for its insignificance.

The other Ordinal Regression model was used to examine the relative contributions of the item evaluation indices in the comprehensive index. It revealed that the rises of the evaluations on the “view” are the most efficient to increase the odds of the highest comprehensive evaluations, while those on the “sunlight” are the most inefficient.

As the verification, the locations of the most preferred and the most disliked dwelling unit types were found accurately consistent with the results of the Ordinal Regression models.

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Notes

1 The Ministry of Construction and the Ministry of Foreign Affairs of China (2001) Report of the People’s Republic of China on the Development of Human Settlements 1996-2000, China Architecture & Building Press, pp.2.
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6 Zhang, W.T. (2002) Tutorial of Statistic Software SPSS 11.0, First Edition, Beijing Hope Publish House, pp.91.
7 The approximation of sunlight hours of the dwelling units referred to reference 2) p.142.
8 The statistic “Gamma” is used to describe the correlation between 2 ordinal variables. Its value is based on the proportion of the samples that vary simultaneously in the 2 variables and the samples that vary differently.

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