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The influence of environmental factors on housing transaction price in local cities in Japan

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Abstract. Generally, it is considered that individual housing quality and the convenience of location are main factors when people purchase their houses. Local governments in Japan that promote housing transaction also place importance on the convenience of location, and they do not necessarily make effective policies which consider importance on other factors such as the environmental aspect of houses and housing area. This study investigated the factors that influence housing transaction prices in local cities in Japan, and the results will be expected to contribute for making local housing policy considering environmental aspects. The study analyzed recent housing transactions of some local cities located about 100 km north of the centre of Tokyo with a population from about two hundred thousand to five hundred thousand, e.g. Utsunomiya City, using open data that contains transaction prices and various attribute of residential. We estimated hedonic prices and reveal characteristics of each region considering individual housing quality, the convenience of location and the environmental factors. In addition, we conducted a questionnaire survey in multiple detached house areas in Utsunomiya City to clarify the factor of housing choice on the consumer side. The result showed that proximity from the station did not always boost house prices. Moreover, there may be an optimal building density for the city. From the results of the questionnaire, environmental factors have affected to a certain extent on consumer's choice of housing. This study suggested that environmental factors may influence housing selection and price formation. However, information on environmental factors in residential areas is not sufficiently prepared and it is difficult for consumers and residents to obtain it. It will be necessary to prepare it and to create a framework for housing evaluation that considers not only convenience and economy but also environmental factors.

1. Introduction

1.1. Background and purpose of the research

The Local cities in Japan are faced with a population decline problem. Especially suppressing population outflow from local cities to the metropolitan area is one of the biggest challenges. Since housing transactions often result in population movements, analyzing what factors determine housing prices is meaningful for the housing policy of local cities in Japan. Generally, it is considered that individual housing quality and the convenience of location are main factors when people purchase their houses. Local governments in Japan that promote housing transaction also place importance on the convenience of location. However, they do not necessarily make effective policies which consider importance on other factors such as the environmental aspect of houses and housing area. This study...
investigated the factors that influence housing transaction of local cities in Japan and the results will be expected to contribute for making local housing policy considering environmental aspects.

1.2. Previous studies
In the previous studies, there are many cases where the price formation factor was analyzed using the hedonic price method for the housing price or the land price of Japanese cities. Tanishita et al. (2012) analyzed the impact of regulation in district plans and building agreements on housing prices for housing transactions in Yokohama City. Shimada and Yoshida (2012) showed the impact of natural environmental factors such as nature, noise, and atmosphere on price formation for residential land prices in Kyoto City, Osaka City, and Kobe City. Sato et al. (2016) revealed that the influence of disaster risk information and flood risk information on the public land price is extremely limited in the analysis of land prices across the country in Japan. Maruyama et al. (1995) revealed that farmland has a negative marginal effect and green space has a positive marginal effect in analyzes targeting residential areas in Chiba city. In the analysis of land prices of Shiga prefecture and Kyoto prefecture, Akao and Hata (1995) pointed out that the marginal value of the forest is lower as the area of the forest with a radius of 5 km is larger and as the area of the rice field of 5 km radius is larger, the limit value of the forest is lower. Aikoh et al. (2008) presumed that park green spaces had an effect as a factor to raise land prices in residential exclusive areas of Sapporo. Though the data in their research are great value to provide importance suggestions, many of the cities to be analyzed were relatively large population size.

2. Method
We estimated hedonic prices and reveal characteristics of each region considering individual housing quality, the convenience of location and the environmental factors. In addition, we conducted a questionnaire survey in multiple detached house areas in order to clarify the factor of housing choice on the consumer side.

This study analyzed recent housing transactions of some local cities located about 100 km north of the center of Tokyo with a population from about two hundred thousand to five hundred thousand, e.g. Utsunomiya City, using the hedonic price method with open data that contained transaction prices and various attribute of residential. In addition, we conducted a questionnaire survey on residential environment in multiple detached house areas in Utsunomiya City to clarify the factor of housing choice on the consumer side.

2.1. The hedonic Price Method
The hedonic Price method is a price analysis method in which a theoretical foundation was formed by Rosen (1974). In the hedonic price method, the value of a certain commodity is regarded as a bundle of attributes such as various performances and functions, and the commodity price is estimated using a regression analysis. In the case of housing price as an example, we estimate factors that influence price formation by using data such as the performance of traded houses and its surrounding environment. It is simply described as follows.

\[ P = f(h_1, h_2, h_3 \cdots h_k) \]

P is housing price, and \( h_k \) is k-th attribute of the housing. After logarithmic transformation of the price and linear regression, we can express the estimation equation as follows.

\[ \ln p = \alpha + \sum_{k=1}^{n} \beta_k h_k + \mu \quad (1) \]

\( \alpha \) is a constant representing the base level of P, \( \beta_k \) is k-th regression coefficient, and \( \mu \) is error term. \( \beta_k \) is estimated by the least-squares method.
2.1.1. The Analysis objects. This study analyzed recent housing transactions of some local cities from the first quarter of 2015 to second quarter of 2018. The selected cities have a population size of about 200,000 to 500,000 people and are located about 100 km north of the center of Tokyo. In particular, we selected Utsunomiya City, Takasaki City and Mito City. The characteristics of each city are as follows Table 1.

Table 1: The characteristics of the selected cities

| City     | Population (number of people) | Population growth rate from 2010 to 2015 (%) | The number of households | Area (㎢) | Population density (people/㎢) | Average age (age) |
|----------|--------------------------------|---------------------------------------------|--------------------------|-----------|---------------------------------|------------------|
| Utsunomiya | 518,594                       | 1.3                                         | 210,482                  | 416.85    | 1244.1                          | 44.2             |
| Takasaki | 370,884                        | -0.1                                        | 150,180                  | 459.16    | 807.7                           | 46.3             |
| Mito     | 270,783                        | 0.8                                         | 117,590                  | 217.32    | 1246.0                          | 45.6             |

Source: Statistics Bureau, Ministry of Internal Affairs and Communications.

2.1.2. Housing Price data and attribute of the housing. “Official land price” released by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is often used as price data in a similar study. While they have an advantage in that the location can be specified accurately, it is not necessarily sufficient for sample size for local cities. We used property price information and their attributes such as Floor space, structure and location provided by The Transaction Price Information Service (TPIS). “The MLIT produces the information by combining the registry data from the Ministry of Justice on transactions of raw land, built property, and condominiums with corresponding survey result from property buyers.” (Yoshida et al., 2008, p.5)

2.1.3. Surrounding environment of the housing. We examined the impact of housing surrounding environment on housing transaction prices. Specifically, we considered the environmental factors of the district of the city where traded houses were located. The National Land Numerical Information (NLNI) operated by The MLIT provides the geographic information of the city, e.g. land-use data as Shapefile. We leveraged it using Open source software, “QGIS”. In addition, we used building density data measured by Fundamental Geospatial Data published by Geospatial Information Authority of Japan (GSI) and examined the influence of the density of the building in the area where it was located on the housing price.

2.1.4. Variables and Estimation formula. Variables used for regression analysis are shown in Table 2 below and their Descriptive Statistics for each city are shown in Table 3. The estimation formula in this research basically followed Eq. (1). “Ground area” and “Floor space” were logarithmically converted. The building density was assumed to change according to the numerical value, and the square term was added. We estimated using statistical software “R”.
### Table 2: The Variables used in the regression analysis

| Symbols | Variables | Contents | Classification | Unit | Time | Source |
|---------|-----------|----------|----------------|------|------|--------|
| PRICE   | Housing transaction price | Transaction price of houses with land. | | yen | | |
| GA      | Ground area | Ground area. | | m² | | |
| FS      | Floor space | Floor space. | | m² | | |
| ST      | Structure | Lightweight steel frame house 1, Wooden house 0. | | House characteristics | (0,1) | |
| AGE     | Number of years since construction | Period between the year of construction and the year of transaction. | | year | | |
| ROAD    | Front Road widths | Front Road Widths. | | m | | |
| D3060   | Time distance from station | 30 to 60 min, other time distance 0. | | (0,1) | | |
| D6090   | Time distance from station | 60 to 90 min, other time distance 0. | | (0,1) | | |
| DO90    | Time distance from station | Over 90 min, other time distance 0. | | (0,1) | | |
| COM     | Commercial area dummy | Commercial area 1, other area 0. | | Surrounding environment | (0,1) | |
| IND     | Industrial area dummy | Industrial area 1, other area 0. | | Surrounding environment | (0,1) | |
| TT      | Time trend (yearly) | CY2015=0, CY2016=1, CY 2017=2, CY2018=3. | | Price Trend | (0,1,2,3) | |
| BD      | Building density | Building density of the subregion of the city. | | m²/m² | | |
| RISK    | Sediment disaster risk | Percentage of sediment-related disaster warning area. | | % | | |
| FOREST  | Land used as forest | Percentage of forest area | | % | | |
| PARK    | Land used as park | Percentage of park area | | % | | |

### Table 3: Descriptive Statistics

| Symbols | City of Utsunomiya (N=1,254) | City of Takasaki (N=602) | City of Mito (N=391) |
|---------|-------------------------------|--------------------------|----------------------|
|         | Average | Median | SD   | Average | Median | SD   | Average | Median | SD |
| PRICE (yen) | 26,228,230 | 25,000,000 | 17,388,066 | 21,716,681 | 22,000,000 | 11,977,527 | 20,667,263 | 19,000,000 | 16,085,781 |
| GA (m²) | 221 | 195 | 136 | 208 | 185 | 103 | 223 | 200 | 78 |
| ST | 124 | 110 | 65 | 107 | 105 | 27 | 110 | 105 | 28 |
| AGE (yearly) | 10.6 | 1.0 | 14.5 | 12.1 | 1.0 | 16.8 | 10.6 | 1.0 | 16.1 |
| ROAD (m) | 6.2 | 6.0 | 3.1 | 5.7 | 5.5 | 2.8 | 5.7 | 5.5 | 2.6 |
| D3060 | 0.34 | 0.00 | 0.47 | 0.25 | 0.00 | 0.43 | 0.28 | 1.00 | 0.49 |
| D6090 | 0.14 | 0.00 | 0.35 | 0.04 | 0.00 | 0.21 | 0.07 | 0.00 | 0.26 |
| DO90 | 0.11 | 0.00 | 0.31 | 0.02 | 0.00 | 0.13 | 0.03 | 0.00 | 0.16 |
| COM | 0.02 | 0.00 | 0.15 | 0.06 | 0.00 | 0.23 | 0.02 | 0.00 | 0.15 |
| IND | 0.04 | 0.00 | 0.19 | 0.07 | 0.00 | 0.26 | 0.09 | 0.00 | 0.29 |
| TT | 1.15 | 1.00 | 0.94 | 1.25 | 1.00 | 1.01 | 1.24 | 1.00 | 0.94 |
| BD (%) | 19.51 | 20.22 | 7.62 | 19.47 | 19.98 | 6.37 | 19.84 | 22.87 | 5.77 |
| RISK (%) | 0.23 | 0.00 | 1.12 | 1.69 | 0.00 | 6.61 | 0.40 | 0.00 | 1.72 |
| FOREST (%) | 3.85 | 0.37 | 6.50 | 3.60 | 0.00 | 11.82 | 7.68 | 5.12 | 7.07 |
| PARK (%) | 1.47 | 0.51 | 3.54 | 3.02 | 0.38 | 9.72 | 3.68 | 0.72 | 7.07 |
2.2. Questionnaire survey in the detached house areas

In order to clarify the factor of housing choice on the consumer side, we conducted a questionnaire survey on residential environment in multiple detached house areas in Utsunomiya City. We distributed 50 questionnaire forms to each of the four major detached house areas in Utsunomiya City, and collected them by mail at a later date. The selected areas and their characteristics are as follows Figure 1.

Figure 1: The characteristics of the detached house areas

| Area   | Year of development | Number of planned housing | Distance from Utsunomiya Station (km) | Building density (%) | North-south adjacent space (m) | Average composition area (㎡) | Green ratio (%) | Average number of buses (per hour) |
|--------|---------------------|---------------------------|----------------------------------------|----------------------|-------------------------------|-----------------------------|---------------|----------------------------------|
| A      | 1978                | 2,050                     | 3.0                                    | 4.5                  | 5.8                           | 21.5                        | 2.7           | 21.3                             |
| B      | 1985                | 360                       | 3.2                                    | 22.4                 | 4.5                           | 20.7                        | 3.2           | 25.4                            |
| C      | 2003                | 338                       | 3.0                                    | 21.3                 | 5.6                           | 23.0                        | 3.0           | 13.2                            |
| D      | 2011                | 3,990                     | 8.6                                    | 5.0                  | 5.0                           | 29.7                        | 7.3           | 10.8                            |

3. Results

3.1. The Result of regression analysis

The result of regression analysis is shown below Table 4. After making estimations using the forced entry method for Utsunomiya City, variables were selected using the Stepwise method. Takasaki City and Mito City were estimated using the same estimation formula that used for variable selection in Utsunomiya City for comparison.

The following points can be pointed out mainly from Table 4.
- "House characteristics" were statistically significant in each city except “ROAD” in Mito City.
- The sign of "Time distance from station" in Takasaki and Mito was negative and the price decreased with distance from the station. In Utsunomiya City, the property corresponding to “D3060” may have a higher price than a house within 30 minutes from the nearest station.
- "COM" in Utsunomiya and Mito contributed positively to the house price.
- "IND" and “RISK” in Utsunomiya did not give a significant difference in results.
- There was a price upward trend in Utsunomiya, but a downtrend was in Mito.
Increasing building density in the district boosted property prices in Utsunomiya, but the effect diminished. There may be an optimal building density for the city.

The prices decreased as “FOREST” increased in Utsunomiya, while the prices increased as “PARK” increased.

There were differences in the influence of surrounding environmental factors on housing prices for each city analyzed. In particular, the results from Utsunomiya suggested that the proximity from the nearest station may not necessarily lead to a rise in property prices and that there may be an optimal building density for the city. It is surmised that environmental factors other than convenience are also required as a good living environment in housing selection in local cities.

### Table 4: The Result of regression analysis

| Classification | Variables | The upper row: Coefficient | The lower row: Std. Error |
|----------------|-----------|----------------------------|--------------------------|
| (Intercept)    |           | 12.270                     | 12.272                   |
|                |           | (0.257)***                 | (0.258)***               |
|                |           | 12.029                     | 11.868                   |
|                |           | (0.490)***                 | (0.438)***               |
|                | ln(GA)    | 0.501                      | 0.502                    |
|                |           | (0.056)***                 | (0.056)***               |
|                | ln(FS)    | 0.419                      | 0.419                    |
|                |           | (0.069)***                 | (0.069)***               |
|                | ST        | 0.153                      | 0.152                    |
|                |           | (0.038)***                 | (0.036)***               |
|                | AGE       | -0.030                     | -0.030                   |
|                |           | (0.001)***                 | (0.001)***               |
|                | ROAD      | 0.013                      | 0.013                    |
|                |           | (0.004)***                 | (0.004)***               |
|                | D3060     | 0.039                      | 0.040                    |
|                |           | (0.029)**                  | (0.022)**                |
|                | D6090     | -0.094                     | -0.092                   |
|                |           | (0.031)***                 | (0.031)***               |
|                | DO90      | -0.104                     | -0.105                   |
|                |           | (0.036)***                 | (0.036)***               |
|                | COM       | 0.471                      | 0.464                    |
|                |           | (0.126)***                 | (0.122)***               |
|                | IND       | 0.030                      | -                        |
|                |           | (0.050)                    | -                        |
| Price Trend    | TT        | 0.039                      | 0.040                    |
|                |           | (0.010)***                 | (0.010)***               |
|                | BD        | 0.020                      | 0.019                    |
|                |           | (0.009)**                  | (0.009)**                |
|                | BD²       | -0.001                     | -0.000                   |
|                |           | (0.000)***                 | (0.000)***               |
|                | RISK      | -0.004                     | -                        |
|                |           | (0.011)                    | -                        |
|                | FOREST    | -0.007                     | -0.007                   |
|                |           | (0.002)***                 | (0.002)***               |
|                | PARK      | 0.013                      | 0.013                    |
|                |           | (0.003)***                 | (0.003)***               |
| Adjusted R-squared | 0.7086 | 0.7090 | 0.7097 | 0.7315 |

Note1: Std. Error was modified by method of White (1980).
Note2: The right column of "Utsunomiya" is the estimation result by the stepwise method.
Note3: The asterisks *, **, *** indicate that the coefficients are statistically different from zero at the 10, 5, and 1 percent level, respectively.

### 3.2. The Result of the questionnaire survey

We collected 92 sheets, which is 46% of the 200 questionnaires distributed. In this paper, we touched on the points that residents emphasized when choosing residential areas in the questionnaire results to try to clarify the factor of housing choice on the consumer side.

In Table 5, the attributes of respondents for the whole and detached house areas are shown. Relatively young people responded to Area C and D while older people answered Area A and B.
Table 6 shows the points that residents emphasized in selecting residential areas. In this question, the respondents ranked by picking up to five points from 18 items that were important when purchasing residential areas. According to the so-called "Borda rule", we weighted 3 points in 1st place, 2 points in 2nd place and 1 point in 3rd place, then calculated the ratio of total score.

Looking at the consciousness of consumers, although the "Convenience" factor of “D1” to “D3” had a large influence on residential area selection, the "Environmental" factor represented by "Quietness" obtained many votes after "Convenience" factor.

According to Table 7, from the viewpoint of comparison for each detached house area, the "Environment" factor was emphasized in the relatively elderly area (Area A and B), whereas in the relatively young people's area (Area C and D) “Convenience” factor was emphasized.

Regarding Area A and B, looking at the environmental factors in detail, while emphasis on “Quietness” is emphasized in both of the areas, “the richness of green” was important in Area B and the importance of air cleanliness was important in Area A.

Although this questionnaire was a judgment sampling and the result couldn’t generalize, we were able to confirm the possibility that environmental factors have affected to a certain extent on consumer's choice of houses.

### Table 5: The Attributes of respondents

| SEX | Number | % Age | total | Address | Age (Number of responses) |
|-----|--------|-------|-------|---------|--------------------------|
| Men | 51 | 55.4 | 20s | 8.7 | 20s |
| Women | 41 | 44.6 | 30s | 15.2 | |
| Total | 92 | 100 | 20s | 18.3 | 30s |

### Table 6: The importance at point of selection of land place

#### Table: The score by detached house area

| Category/Area | Area A | Area B | Area C | Area D |
|---------------|--------|--------|--------|--------|
| Environment   | 41.4   | 54.0   | 27.6   | 20.2   |
| Sociality     | 21.9   | 11.1   | 11.5   | 8.9    |
| Economy       | 22.9   | 13.5   | 8.6    | 20.2   |
| Convenience   | 16.2   | 19.0   | 50.0   | 50.0   |
| Others        | 7.6    | 2.4    | 2.3    | 0.8    |

### Table 7: The score by detached house area

#### Environmental category of Area A and B

| Area/Symbol | A1 | A2 | A3 | A4 | A5 | A6 |
|-------------|----|----|----|----|----|----|
| Area A      | 0.0 | 4.8 | 11.4 | 3.8 | 11.4 | 0.0 |
| Area B      | 20.6 | 3.2 | 0.0 | 4.8 | 18.3 | 7.1 |

Note: We scored 3 points for the 1st place, 2 points for the 2nd place and 1 points to the 3rd place. The numbers are percentage of total score.
4. Discussion

Based on the analysis results of this paper, we would like to point out three points on the implications and future directions of the results.

First, the aging will progress more and more in the local cities of Japan in the future. Administrative departments that affect the location of houses need to develop not only convenience and economic efficiency but also policy of attracting houses in consideration of the environmental factors such as the quietness of the residential area, greening, and landscape and so on.

Second, housing makers and developers are required to build houses reflecting the needs of residents that emphasize environmental factors of housing. While increasing the density of houses may improve the price of the house in the area, it may cause decrease environmental condition, for example prevent to sunlight, bad ventilation, noise problems. Therefore, it is required for them to increase housing density with paying attention to environmental factors to improve value of houses.

Finally, this research suggests that environmental factors may influence housing selection and price formation. However, information on environmental factors in residential areas is not sufficiently prepared and it is difficult for consumers and residents to obtain it. It will be necessary to prepare it and to create a framework for housing evaluation that considers not only convenience and economy but also environmental factors.

5. Conclusion

This study investigated the factors that influence housing transaction of local cities in Japan. We were able to confirm the possibility that environmental factors have affected to a certain extent on consumers' choice of houses. It is necessary to maintain more information on the living environment so that residents can make a better choice of housing.

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