INTERNATIONAL REAL ESTATE REVIEW

2017 Vol. 20 No.4: pp. 493 – 523

# The Collective Action Problem in Japanese Condominium Reconstruction

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Condominium reconstruction involves a difficult collective decision-making process among owners, which prevents older condominiums from being redeveloped efficiently. This paper aims to examine whether this type of collective action cost exists for Japanese condominiums. First, we discuss in the literature review and an empirical analysis that the number of units in a condominium complex is an appropriate proxy for the collective action problem. Then, by using the rent in the price function to control for housing characteristics, we show that the number of units has a negative impact on condominium price. Furthermore, the price function for condominiums is compared with that for single-owner rental apartments that are free from the collective action problem. The estimation results show that the number of units only negatively affects the price of condominiums and that the depreciation rate for the condominium price is greater than that for single-owner apartments. This finding is consistent with the hypothesis that a significant cost is associated with collective action problems in condominium reconstruction. Lastly, we conduct a comparative examination of condominiums in Japan and the United States, and the result suggests that revising the current Japanese condominium law could induce more efficient redevelopment of old condominiums.

**Keywords**

Condominium, Rental Apartment; Hedonic; Holdout; Collective Action; Development

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# 1. Introduction

Condominiums are a mixture of private ownership of a defined apartment unit and co-ownership of a range of common property in the condominium complex, including hallways, roofs, elevators, gymnasiums, and swimming pools. The economies of scale and the public goods property of commonly owned facilities are two of the main reasons that the number of condominiums has grown rapidly in Japan since the 1960s. In 2015, Japan had approximately 6.2 million condominium units, which accounted for approximately 10% of the total number of housing units in the country.

Although the co-ownership aspect of condominiums certainly provides property owners with various benefits, it usually also causes externalities and collective action problems. Substantial resources and efforts are required to make collective decisions that regard condominium management, and even more resources and greater efforts are required for condominium reconstruction. More than one million units of condominiums were built before the revision of the Building Standards Act in 1981, so they do not satisfy earthquake-resistance regulations and present a substantial risk to society. Nevertheless, only 211 condominiums had been rebuilt as of April 2015. In the very near future, more owners of condominium units in urban Japan will struggle with the difficult problem of reconciling the conflicts of interest among themselves.

One of the main reasons for the reconstruction problem in Japan is seemingly the lack of effective condominium declarations that minimize the cost of the decision-making process. To reconstruct a condominium, Japanese condominium law requires agreement among at least four-fifths of the condominium owners.[1] After the proposal for reconstruction is adopted, the approvers have to buy out the units of the dissenting owners at market value. However, the market value of these units is ambiguous due to the scarcity of information of the actual property transactions on the market, such that the dissenters are willing to set an arbitrarily high price for their unit. Such price negotiation is usually aborted, thereby interrupting the reconstruction, which is typical of the holdout problem.[2] Before 2003, most reconstruction projects in Japan were realized only when owners unanimously agreed on reconstruction (West and Morris, 2003, p. 918).

This paper aims to examine whether the decision-making process that surrounds collective action carries a significant cost in Japanese condominium

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[1] In principle, Japanese law does not allow an old condominium to be terminated and redeveloped for a different use; it only allows the reconstruction of a new condominium, which is different from the laws in most Western countries.

[2] Grossman and Hart (1980) argue that holdout problems make it impossible for developers to make a takeover bid. See also Menezes and Pitchford (2004), O’Flaherty (1994), and Plassman and Tideman (2010) regarding the relationship between land assembly and the holdout problem.

reconstruction. To do so, we use data on rental units and owner-occupied units in condominiums, and data on rental apartments in Japan, and our empirical results are consistent with the implication that condominium reconstruction involves a significant cost due to collective action problems. Our findings suggest that a revision of the current Japanese law may promote the reconstruction of condominiums and the efficient use of the land on which old condominiums are situated.

This article is structured as follows. Section 2 discusses the rationale for using the number of units in a condominium as a proxy for the difficulty of collective decision making based on previous literature and an empirical examination of the relationship between the number of owners and the collective action time associated with reconstruction.[3] However, the number of units influences the price not only through collective action problems but also through other factors related to housing characteristics.

Hence, Section 3 explains the empirical strategy for identifying the cost of collective action. In short, in the price function, we use the number of units and the imputed rent as explanatory variables. The imputed rent controls for the quality of various housing characteristics; the coefficient of the number of units in the price function thereby reflects the effect of price-specific factors such as the collective action cost.[4] We also compare the price functions between condominiums and rental apartments because the latter are owned by single owners and thus do not present collective action problems related to reconstruction.

The data and estimation results are then described in Section 4. In Section 5, we use the National American Housing Survey (AHS), conducted by the U.S. Census Bureau to compare Japanese condominiums with condominiums in the United States (U.S.) where distinctly different condominium laws are enforced. Finally, in Section 6, we present the concluding remarks.

## 2. Number of Units in a Condominium and Collective Action

The difficulty of collective action regarding reconstruction critically depends on the extent to which interests differ among condominium owners. If the interests of condominium owners are alike, there is little room for conflicts of interest and divergent opinions regarding reconstruction. Then, collective decision making can easily achieve unanimity with little cost or effort. However, the interests of unit owners usually differ in many respects, based on their age, income, and expectations about future rental prices, along with the

[3]Section 2 describes only the main findings of the empirical examination of the number of units and the negotiation time for reconstruction. Details of the estimation results are presented in Appendix I.
[4]Details of the development model are provided in Appendix II.

extent of any liquidity constraints and the opportunity costs involved in collective action.

As mentioned above, Japanese condominium law requires a high degree of agreement among owners to initiate a reconstruction. The collective decision-making process regarding condominium reconstruction becomes more complicated and inefficient as the number of owners increases. Strange (1995) models a bargaining game of land assembly in which landowners separately accept or respond with counteroffers based on the bids of the developers. He shows that equilibrium prices and the likelihood of failing to complete the agreement rise with the number of landowners. Eckart (1985) draws the same conclusion in a similar context of a land assembly bargaining game. He finds that the collective counteroffer for land decreases when collusion exists among landowners compared with when they make decisions independently.

A seminal study by Olsen (1965) explores the relationship between group size and collective action. Regarding condominiums, Hansmann (1991) and Barzel and Sass (1990) discuss the difficulty of collective decisions among large numbers of owners from legal and economic perspectives. West and Morris (2003) report on collective decision making in condominium reconstruction projects after the Kobe earthquake in 1995. They find a negative relationship between the number of units in a condominium and the speed of collective decision making regarding reconstruction.

In Appendix I, we use data on completed condominium reconstruction projects in Japan to examine the amount of time that owners spend on collective decision-making to reach consensus on reconstruction. We find that, when the number of units doubles, the time needed for the collective decision-making is extended by approximately 30%; however, the number of units is not found to influence the start time of the negotiation process. These results imply that an increase in condominium owners not only prolongs negotiations regarding reconstruction but also delays the reconstruction from occurring at the optimal time. Based on previous studies and our empirical results, we assume in the following analysis that the number of unit owners in a condominium can be used as a proxy variable for the collective action cost.

## 3. Estimation Strategy

The property value is generally determined by the net present value of expected future rents and reconstruction-related costs. Thus, the condominium price can be expressed as a function of current and future net rents, discount factors, and other price-specific factors, such as the collective action cost of the future reconstruction. A delay from the optimal time of future reconstruction and an increase in the collective decision-making cost, as discussed in the previous section, then degrade the condominium price. Therefore, the number of units, as a proxy for the collective action cost, is expected to negatively affect the condominium price with respect to collective action problems associated with reconstruction. A detailed description of the model can be found in Appendix II.

However, in the empirical setting, we cannot examine the collective action cost simply by noting the coefficient of the number of units in a standard hedonic price function because the number of units is possibly correlated with the rent, thus reflecting housing quality and services, through which the price may be "indirectly" affected. For instance, if a larger condominium complex has more luxurious amenities, the number of units is positively correlated with the rent; thus, the number of units in a complex has a positive effect on price through the rent. In the same way, irrespective of how the number of units is correlated with the rent, they can indirectly influence the price and the collective action problems associated with reconstruction.

In this regard, we need to know not only the price of a condominium unit but also the rent for a specific unit. Fortunately, we have data on units for sale and for rent in the same condominiums. We first estimate a building fixed-effect of condominiums - rent function, by using samples of condominium units for rent, from which predicted rents for all units in the same condominiums can be computed. We then use a predicted rent in the price function, by using samples of units for sale in the same condominium buildings, to control for housing quality and services to extract the price-specific effects.

Using data of the number of condominium units for sale, we estimate the price function as a function of the fitted rent along with the number of units and the age of the building. Current and future discounting factors, such as property tax rates and interest rates, can be omitted by introducing purchase-year dummies in the price function.

Lastly, to examine the robustness of our results, we compare the price function of condominiums with that of rental apartments. Although these two types of housing have physically similar building structures, rental apartments are owned by single owners and do not involve the collective action problems associated with reconstruction. Therefore, if we observe a negative impact of the number of units on the condominium price but not on the price of rental apartments, the collective action cost of the reconstruction problem is assuredly not negligible.

### 3.1 Rent Function

The following equation is the rent function of condominiums to be estimated:

$$\ln(REIT_i) = \beta_b + \beta_1 x_i + \varepsilon_i^R \qquad (1)$$

where subscript $i$ indicates a condominium unit and $b$ is the condominium building to which $i$ belongs. $\beta_b$ is an unobservable fixed effect of condominium $b$ on the rent; $x_i$ is a column vector of unit-specific housing characteristics; $\beta_1$ is a raw vector of parameters that correspond to $x_i$; and $\varepsilon_i^R$ is an error term. The variables in $x_i$ include the accessibility to the central business district (CBD), floor number of the unit, number of bedrooms, and dummy variables that indicate whether the unit has south-facing window(s) and whether the unit is located on the corner of the building.[5]

## 3.2 Price Function

The property value is determined by the net present value of expected future rental prices. If we assume constant discounting factors, the condominium price can then be expressed as a function of the current rent, expected future rents, including rents from later reconstructed condominiums, and reconstruction-related costs. As suggested in the literature and by the empirical examination in Appendix I, the number of units not only delays the reconstruction but also increases reconstruction-related costs, such as the difficulty in the collective decision-making process and the holdout problem among owners. Therefore, in terms of the collective action problem, the number of units should have a negative influence on the condominium price. To examine this hypothesis, we estimate the following price function for condominiums:

$$\begin{aligned}\ln(PRICE_i) &= \gamma_j + \gamma_1 z_i + \gamma_2 \ln(RENTHAT_t) + \gamma_3(UNITS_i) \\ &\quad + \gamma_4(AGE_i + 1) + \varepsilon_i^P\end{aligned} \tag{2}$$

where subscript $j$ is the region to which unit $i$ belongs. $\gamma_j$ controls for unobserved municipality-level regional fixed effects. ln(*RENTHAT*) is the fitted rent estimated in Equation (1); *UNITS* is the number of units; and *AGE* is the building age. Vector $z_i$ is a column vector of other variables that may directly affect the condominium price rather than affecting the price through rent, and $\varepsilon_i^R$ is an error term. We omit discount variables, such as the interest rate and the property tax rate[6], which are constant across the study area, by introducing year dummies in $z_i$. The coefficient of the number of units, $\gamma_3$, reflects the price-specific effect of the number of owners, which is expected to show a negative value if the effect of the collective action problem on reconstruction is not negligible.

[5]It is important to emphasize here again that the collective action problem associated with reconstruction has nothing to do with the rent because collective action concerns condominium owners and not tenants.

[6]Not only the property tax but also the bequest tax has an effect on property prices and land use in Japan (Yamazaki 1996, 1999).

In addition to Equation (2), we also estimate models with the cross-terms of unit number and building age as explanatory variables to capture the effects of the depreciation rate because of the collective action problem. Thus, we estimate the following alternative equation:

$$\begin{aligned}\ln(PRICE_i) &= \theta_j + \theta_1 z_i + \theta_2 \ln(RENTHAT_i) + \theta_3 \ln(UNITS_i) \\ &+ \theta_4 \ln(AGE_i + 1) + \theta_5 \ln(UNITS_i) \cdot \ln(AGE_i + 1) + e_i^P\end{aligned} \tag{3}$$

Here, we expect that $\theta_5 < 0$ under the influence of the collective action cost; that is, more severe collective action problems associated with reconstruction will result in higher depreciation rates of the property price.

### 3.3 Condominiums versus Rental Apartments

The coefficient for the number of units in the price function mostly shows the cost associated with the delay in reconstruction and the difficulty of collective decision making in condominiums for the following two reasons. First, we estimate a building fixed-effect (rent function) so that all of the unobserved effects of the number of units on the rent are captured by the predicted rent in the price function. Furthermore, the collective action problem is thought to be the only major channel through which the number of units can directly affect the condominium price (i.e., not through the rent). Therefore, we expect that $\gamma_3$ will have a negative value if the collective action cost of the reconstruction problem is significant for condominiums.

The other presumable possibility is that the number of units directly affects the condominium price through the land value due to scale economies. If a larger lot size is associated with a higher expectation regarding the redevelopment option value, the number of units, which is positively correlated with the land area, may have a positive effect on the condominium price. In consideration of this possibility, $\gamma_3$ may underestimate the effect of the collective action cost. As these two price-specific factors have opposite effects on the price, the negative coefficient of the number of units ensures the significance of the collective action cost.

To address price-specific factors such as scale economies, we compare the price function estimates between two types of apartment buildings, namely, condominiums and rental apartments. Although their building structure is almost indistinguishable, rental apartments are different from condominiums in that they are owned by single owners or securitized into a real estate investment trust (REIT) by single corporations; thus, rental apartments do not require collective action. Such a difference in ownership structure between the two types of apartment buildings enables us to separate the effect of collective action cost from other price-specific factors that may affect the coefficients of the number of units in the price functions. We expect that the number of units affects the condominium price more negatively than the price of rental apartments due to the collective action problem.[7]

Note that, for rental apartments, we use the actual rent, *RENT*, in the price function instead of the predicted rent because, unlike condominiums, we can observe both a rental revenue and a price on each sample of rental apartments. The next section explains the data on condominiums versus rental apartments.

# 4. Data and Estimation Results

## 4.1 Data

Our data consist of two types of apartments: condominiums and rental apartments.

*Condominiums*: First, we obtain data on Japanese condominiums from Tokyo Kantei, an independent real estate information service.[8] The data include unit (parcel)-specific information, such as the offered rent (if the sample unit is for rent) or the offered price (if the sample unit is for sale), number of floors, floor area, and number of bedrooms, and building-specific information, such as the building age, number of stories and units, and travel time to the CBD. These condominium samples were collected in 2005 for the Tokyo area alongside the Chuo, Keio, and Odakyu Lines of Japan Railway.

The Japanese condominium data provided by Tokyo Kantei present two issues. First, the data do not reveal whether each rental unit belongs to a condominium or a rental apartment. Thus, we use only the samples in buildings that have both units for sale and units for rent to ensure that they are located in condominiums. Second, data on the rent and the prices of condominiums are not transaction data; they are instead the monthly listed prices provided by condominium owners. To extract price and rent data that are comparable with transaction prices, when samples are listed consecutively for multiple months, we use only the most recent observations because the samples on the “for sale” or “for rent” list disappear once transactions take place. We exclude samples in which the floor area, rent per floor area, or price per floor area is above the 99$^{th}$ percentile or below the first percentile among the condominium samples. Finally, the “for rent” sample includes 679 units within 370 condominium buildings, and the “for sale” sample includes 577 units within 303 condominium buildings.

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[7] Schill et al. (2007) estimate the price functions of condominiums and cooperative housing and report that the owners of cooperatives have lower costs in the collective decision-making process than the owners of condominiums. They also find similar results, namely, that the number of units in the condominium has a negative coefficient, although they do not use “rent” data.

[8] For Tokyo Kantei, see the company homepage (http://www.kantei.ne.jp; in Japanese).

*Rental apartments*: Next, we collect data on rental apartments, including the asset sales prices of the buildings and their annual rental revenues and attributes, partly from Tokyo Kantei and partly from Japan REIT (JREIT).[9] For the data provided by Tokyo Kantei, we use the most recent observation when the same sample building appeared repeatedly for multiple months, as in the sample selection for condominiums. By contrast, the data from JREIT provide transaction values. The price and rent data provided by Tokyo Kantei are from 2005; for JREIT, the rent data ranges from 2005 to the first half of 2006, and the price data ranges from 2002 to 2006.[10]

Unlike the condominium data, the price and rent data for rental apartments are for the building, not the apartment unit. The price is the sale price of the building as ownership changes or someone purchases a newly constructed building to run a rental apartment. These data come along with the rent for the same building, which is the annual rental revenue from tenants. The data also show the vacancy rate and the number of operation dates for each year and various building characteristics, such as the number of units, year of completion, number of stories, total floor area, and presence of elevators. We exclude samples in which the floor area per unit, rent per floor area, or price per floor area is above the 99th percentile or below the first percentile among the rental apartment samples. Finally, the sample used in the rent function includes 487 rental apartment buildings, and that used in the price function includes 463 rental apartment buildings.

Accordingly, the data on condominiums and rental apartments differ. The data on condominiums are compiled by housing unit (rent or price per unit, floor area per unit, etc.), whereas the data on rental apartments are compiled for the entire building (annual rental revenue or price of the building, total renter-occupied floor area in the building, etc.). We use the floor-unit price (i.e., the price divided by the floor area) and monthly floor-unit rent (i.e., for a condominium unit, the monthly rental price divided by the floor area and, for a rental apartment, the monthly rental revenue divided by the occupied floor area) to allow the estimates to be comparable between the two apartment types.[11] Table 1 defines the variables used in the rent and price functions, and Table 2 provides the descriptive statistics.

[9]For JREIT, see their homepage (http://index.ares.or.jp/index-en.php).

[10]Dummy variables for years of purchase are included in the price function to control for the impact of changes in interest rates and property taxes on prices induced by the macroeconomy.

[11]For rental apartments, the monthly rental price per square meter is computed as the monthly rental revenue divided by the floor area of occupied units, whereas the price per square meter is computed as the purchase price divided by the floor area of all units.

**Table 1 Variables in the Rent and Price Functions**

| Variable | Definition |
|---|---|
| Rent function | |
| *RENT* | Monthly rent per floor area (¥/$m^2$ or \$/$ft^2$) |
| *UNITS* | Total number of dwelling units in the apartment building |
| *AGE* | Apartment age (years) |
| *TIME* | Travel time (minutes) from the apartment to the central business district (for Japanese condominiums and rental apartments) or to the workplace (for U.S. condominiums) |
| *STORIES* | Number of stories in the apartment building |
| *FLEVEL* | Floor number of the unit |
| *BEDRM* | Number of bedrooms in the unit |
| *EV* | Binary variable indicating an apartment building with an elevator or more |
| *SOUTH* | Binary variable indicating a unit with south-facing windows |
| *CORNER* | Binary variable indicating a corner unit |
| *BRAND* | Binary variable indicating an apartment managed by one of the eight most highly valued real estate companies (Mitsui, Nomura, Daikyo, Sumitomo, Tokyu, Tokyotatemono, Mitsubishizisyo, Touwa) |
| *Data Year* | Year dummies for data sources and time at which the property was purchased |
| *Building* | Building dummies for Japanese condominiums |
| *Municipality* | Municipality dummies for Japanese rental apartments |
| *SMSA* | SMSA (metropolitan statistical area) dummies for the U.S. condominiums |
| Price function | |
| *PRICE* | Price per floor area (¥10,000/$m^2$ or \$/$ft^2$) |
| *RENTHAT* | Fitted value of rent per floor area for Japanese and U.S. condominiums (¥/$m^2$ or \$/$ft^2$) or actual rent per floor area for Japanese rental apartments (¥/$m^2$) |
| *UNITS* | Total number of dwelling units in the building |
| *AGE* | Building age (years) at the time of purchase |
| *RENOVATED* | Binary variable indicating a unit maintained before selling |
| *Data Year* | Year dummies for data sources |
| *Purchase Year* | Year dummies for time at which the property was purchased |
| *Municipality* | Municipality dummies for Japanese rental apartments |
| *SMSA* | SMSA (metropolitan statistical area) dummies for U.S. condominiums |

**Table 2 Basic Statistics on Variables Used in the Rent and Price Functions**

| Variable | Item | Unit | Minimum | Median | Maximum | Mean |
|---|---|---|---|---|---|---|
| *RENT* | [CJ] | (¥10,000/$m^2$) | 0.12 | 0.29 | 0.55 | 0.30 |
| | [RJ] | (¥10,000/$m^2$) | 0.16 | 0.39 | 0.70 | 0.40 |
| | [CU] | (\$/$ft^2$) | 0.14 | 0.88 | 3.73 | 0.97 |
| *PRICE* | [CJ] | (¥10,000/$m^2$) | 13.92 | 44.71 | 94.29 | 44.86 |
| | [RJ] | (¥10,000/$m^2$) | 23.22 | 73.53 | 163.52 | 75.74 |
| | [CU] | (\$/$ft^2$) | 12.33 | 98.30 | 461.77 | 119.68 |
| *UNITS* | [CJ] | | 6.00 | 94.00 | 1192.00 | 180.93 |
| | [RJ] | | 3.00 | 29.00 | 288.00 | 39.73 |
| | [CU] | | 2.00 | 10.00 | 747.00 | 37.99 |
| *AGE* | [CJ] | (years) | 0.00 | 22.00 | 46.00 | 21.70 |
| | [RJ] | (years) | 0.00 | 3.00 | 43.00 | 7.27 |
| | [CU] | (years) | 0.00 | 22.50 | 44.50 | 22.59 |
| *Year of completion* | [CJ] | | 1959.00 | 1983.00 | 2005.00 | 1983.30 |
| | [RJ] | | 1962.00 | 2003.00 | 2006.00 | 1998.44 |
| | [CU] | | 1962.50 | 1982.50 | 2006.00 | 1981.52 |
| *BEDRM* | [CJ] | | 0.00 | 2.00 | 3.00 | 1.54 |
| | [RJ] | | — | — | — | — |
| | [CU] | | 0.00 | 2.00 | 4.00 | 1.96 |
| *TIME* | [CJ] | (minutes) | 1.00 | 21.00 | 56.00 | 21.74 |
| | [RJ] | (minutes) | 3.00 | 15.00 | 55.00 | 17.54 |
| | [CU] | (minutes) | 0.00 | 20.00 | 180.00 | 22.58 |
| *FLEVEL* | [CJ] | | 1.00 | 4.00 | 31.00 | 4.89 |
| | [RJ] | | — | — | — | — |
| | [CU] | | 1.00 | 1.00 | 21.00 | 2.10 |
| *STORIES* | [CJ] | | 3.00 | 9.00 | 31.00 | 8.99 |
| | [RJ] | | 2.00 | 7.00 | 30.00 | 7.51 |
| | [CU] | | 1.00 | 2.00 | 21.00 | 3.56 |
| *BRAND* | [CJ] | | — | — | — | — |
| | [RJ] | | 0.00 | 0.00 | 1.00 | 0.11 |
| | [CU] | | — | — | — | — |
| *EV* | [CJ] | | 0.00 | 1.00 | 1.00 | 0.83 |
| | [RJ] | | 0.00 | 1.00 | 1.00 | 0.65 |
| | [CU] | | 0.00 | 0.00 | 1.00 | 0.20 |
| *CORNER* | [CJ] | | 0.00 | 0.00 | 1.00 | 0.25 |
| | [RJ] | | — | — | — | — |
| | [CU] | | — | — | — | — |
| *SOUTH* | [CJ] | | 0.00 | 1.00 | 1.00 | 0.60 |
| | [RJ] | | — | — | — | — |
| | [CU] | | — | — | — | — |
| *RENOVATED* | [CJ] | | 0.00 | 0.00 | 1.00 | 0.09 |
| | [RJ] | | — | — | — | — |
| | [CU] | | | — | — | — |

***Notes:*** [CJ]: condominiums in Japan; [RJ]: rental apartments in Japan; [CU]: condominiums in the United States.

## 4.2 Estimation Results

*Rent function*: The result in the first column, or Column [3-1] of Table 3, is the rent function of Japanese condominiums based on Equation (1). As this function estimates building fixed effects, only the coefficients of unit-specific variables are reported. A higher floor level and fewer bedrooms are associated with higher rent per floor area. The negative correlation between the number of bedrooms and the rent per floor area is due to the economy of scale, where the average fixed rental cost per floor area (such as the use of the kitchen and bathroom) decreases as the number of bedrooms increases.

**Table 3 Rent Function**

| | [3-1] | | [3-2] | | [3-3] | |
|---|---|---|---|---|---|---|
| Apartment type: | Japanese condominium | | | | Rental apartment | |
| Dependent variable: | ln(*RENT*) | | ln(*RENT*) | | ln(*RENT*) | |
| | Coeff. | t-stat. | Coeff. | t-stat. | Coeff. | t-stat. |
| Building-specific variable | | | | | | |
| ln(*UNITS*) | | | –0.042*** | -4.7 | 0.009 | 0.4 |
| ln(*AGE* + 1) | | | –0.111*** | -8.8 | –0.031** | -2.5 |
| ln(*TIME*) | | | –0.074*** | -3.2 | –0.091*** | -2.6 |
| ln(*STORIES*) | | | 0.015 | 0.8 | 0.055 | 1.2 |
| *EV* | | | 0.033 | 1.4 | –0.080* | -1.9 |
| *BRAND* | | | | | 0.080*** | 2.8 |
| Unit-specific variable | | | | | | |
| ln(*BEDRM* + 1) | –0.131*** | -3.5 | –0.279*** | -22.3 | | |
| ln(*FLEVEL* + 1) | 0.034*** | 2.6 | 0.033*** | 3.3 | | |
| *SOUTH* | –0.012 | -0.7 | –0.018+ | -1.5 | | |
| *COURNER* | –0.012 | -0.6 | –0.008 | -0.6 | | |
| Fixed effect | Building (370) | | Municipality (22) | | Municipality (35) | |
| Other dummy variables | | | | | Data year (2005, ’06) | |
| Observations | 679 | | 679 | | 487 | |
| $R^2$ | 0.9697 | | 0.8241 | | 0.5590 | |

***Notes:*** The symbols ***, **, *, and + indicate statistical significance at the 1, 5, 10, and 15% levels using two-tailed tests. Values in parentheses in the fixed-effect level row are the numbers of regional fixed effects in the estimations. The coefficients of the dummy variables for regions and years of data are not shown in the table.

In addition to Equation (1), we also use regional fixed effects at the municipality-level (instead of building fixed effects) to estimate the rent functions for both condominiums and rental apartments, such that the effects of building-specific variables (such as the number of units, building age, and travel time to the CBD) between the two types of apartments can be compared. The second and the third columns, Columns [3-2] and [3-3], show the rent functions of condominiums and rental apartments in Japan, respectively. The number of units has a negative effect on the rent for Japanese condominiums but no significant effect on rental apartments. Moreover, the depreciation rate for rental apartments is lower than that for condominiums. One possible reason for these results is the lack of efficient major building maintenance, which requires more than agreement among three-fourths of the property owners. On the one hand, a moral hazard among owners with regard to common-area maintenance may become more severe in a condominium with more owners, which may result in lower rent and a higher depreciation rate. On the other hand, the owner of a rental apartment can maintain the common area to maximize the property value without triggering a collective action problem.[12]

*Price function*: Using the fitted rent estimated from Equation (1), we obtain the price functions for condominiums. The estimation results of price functions based on Equations (2) and (3) are shown in Columns [4-1] and [4-2] in Table 4, respectively. By contrast, for rental apartments, we use actual rent data in the price function. The results are shown in Columns [4-3] and [4-4].

According to the results in Column [4-1], the condominium price decreases by 3.7% when the number of units doubles. By contrast, the number of units has no significant effect on the price of rental apartments in Column [4-3]. As stated before, the difference between condominiums and rental apartments in terms of the coefficients for the effect of the number of units on the price is likely to be attributed to the magnitude of the collective action cost associated with the reconstruction problem. This result is consistent with the implication that the collective action cost of condominium reconstruction is significant in Japan.

According to the results in Columns [4-2] and [4-4], the coefficient of the cross-term, $\ln(UNITS)*\ln(AGE + 1)$, is negative and significant for Japanese condominiums, whereas it is not statistically significant for rental apartments. This finding indicates that the deterioration rate accelerates as the collective action problem becomes more severe. Last, when substituting $AGE = 0$ into the estimation result in Column [4-2], we cannot find a negative and significant effect of the number of units on the condominium price. However, the negative and significant coefficient of $\ln(UNITS)*\ln(AGE + 1)$ shows that the price of condominiums with a greater number of units deteriorates more rapidly. Thus, the positive but not significant coefficient of $\ln(UNITS)$ is consistent with the hypothesis that a larger lot area may have a greater option value, making a wider variety of redevelopment plans possible. These results also suggest that buyers

[12]Condominium owners are reluctant to engage in building maintenance because of free-rider problems. One way to keep a condominium building maintained is to outsource the management to a third party under the provisions of condominium management. Chu et al. (2013) analyze a survey of condominium owners in Taipei and show that efficiency in the provision of condominium management improves with the level of effort that owners expend on management committees.

of newly built condominiums are not fully aware of the potential collective action cost that will arise among the owners in the future, and the collective action problem is gradually revealed to the owners as condominiums age.[13]

**Table 4 Price Functions: Japanese Condominiums and Rental Apartments**

| | [4-1] | | [4-2] | | [4-3] | | [4-4] | |
|---|---|---|---|---|---|---|---|---|
| Apartment type: | Japanese condominium | | | | Rental apartment | | | |
| Dependent variable | ln(*PRICE*) | | ln(*PRICE*) | | ln(*PRICE*) | | ln(*PRICE*) | |
| | Coeff. | t-stat. | Coeff. | t-stat. | Coeff. | t-stat. | Coeff. | t-stat. |
| ln(*RENTHAT*) | 0.492*** | 3.9 | 0.484*** | 3.9 | 0.688*** | 6.4 | 0.686*** | 6.4 |
| ln(*UNITS*) | –0.037*** | -3.7 | 0.079 | 1.3 | 0.005 | 0.4 | 0.021 | 1.1 |
| ln(*AGE* + 1) | –0.325*** | -17.2 | –0.141+ | -1.6 | –0.063*** | -5.8 | –0.029 | -1.0 |
| ln(*UNITS*)* ln(*AGE* + 1) | | | –0.038** | -2.0 | | | –0.011 | -1.1 |
| ln(*RENTHAT*) | Fitted value from [3-1] | | | | ln(*RENT*) | | | |
| Fixed effect level | Municipality (21) | | | | Municipality (35) | | | |
| Other dummy variables | *RENOVATED* | | | | Purchase year (2002–2006) | | | |
| Observations | 577 | | 577 | | 463 | | 463 | |
| $R^2$ | 0.7934 | | 0.7962 | | 0.8444 | | 0.8450 | |

***Notes:*** The symbols ***, **, *, and + indicate statistical significance at the 1, 5, 10, and 15% levels using two-tailed tests. Values in parentheses in the fixed-effect level row are the numbers of regional fixed effects in the estimations. The coefficients of dummy variables for regions and years of data or purchase are not shown in the table.

## 5. Additional Analysis: U.S. Condominiums

In this section, using U.S. data from the AHS, we show the results of an analysis similar to that presented in the previous section. This section seeks to compare the collective action cost of two countries with distinctly different legal systems. An empirical comparison across countries usually requires elaborate data across multiple markets. Nevertheless, the use of the imputed rent in the price function helps us to separate the price-specific effect from the "indirect" effect through rent. As a result, our comparative analysis of the collective action problem may

[13] The reviewers point out that the difference in ownership structures between condominiums and rental apartments may have a substantial influence on the estimation results and suggest that it would be desirable to compare the price functions between matched samples of the two types of apartments with similar structural characteristics. Accordingly, in Appendix III, we compare the estimates of the two types by employing the propensity score matching method to select samples with similar characteristics and compare the price functions among them. The estimation results in the appendix give the same implication as the ones in this section.

be highly plausible insofar as the imputed rent is correctly computed, even with limited variation in the data samples.

Although a future examination with extended datasets would be helpful in gaining further insight into the collective action problem, we find providing the provisional results of this comparative analysis between the U.S. and Japan to be worthwhile. We empirically show that the number of units does not reduce the condominium price in the U.S. These results suggest that owners would potentially benefit from a revision of the Japanese laws that surround condominium redevelopment. Here, we briefly explain why many state laws that govern condominiums are more efficient than Japanese law in terms of condominium redevelopment.

### 5.1 Condominium Law

As described earlier, Japanese condominium law has very specific provisions for enforcing the procedure for condominium reconstruction, which creates the potential risk of a holdout problem. As a result, most reconstruction projects in Japan only occur when the owners agree unanimously. By contrast, most state laws in the U.S. have no defined rules regarding the decision-making process involved in condominium reconstruction. Instead, a condominium can be terminated by voting, which usually requires four-fifths or three-fourths agreement, depending on the state laws and bylaws. After a resolution is passed to terminate the condominium, the general procedure involves selling the land to a new developer and redistributing the revenue to previous condominium owners in accordance with their individual ownership.[14]

In principle, this termination rule has two advantages over Japanese condominium law. First, because the amount of redistribution is unambiguous, it leaves no room for a holdout among dissenters once the resolution is passed, and proponents do not need to expend time and effort to persuade dissenters to leave the condominium. Second, as long as no other regulation exists that governs the land in that particular area, the land can be developed in any manner after the condominium is terminated, thus maximizing the land value.

By contrast, Japanese condominium law only allows condominiums to be rebuilt as a means of redevelopment. Moreover, before December 2014, selling a condominium and the land to a third party was not allowed unless unanimous agreement was achieved. Since December 2014, a revision to the law has reduced the requirement to four-fifths agreement. However, several conditions must still be met to sell a condominium and the land; for instance, the land cannot be developed for any other use than the construction of a new

[14]The National Conference of State Legislatures has a website that lists state laws related to condominiums (http://www.ncsl.org/research/environment-and-natural-resources/state-condo-laws.aspx).

condominium, and this law applies only to condominiums that do not meet the earthquake-resistance standard.[15]

In addition, many states in the U.S. allow condominium developers to stipulate rules through private contracts, including covenants, conditions, and restrictions (CC&Rs).[16] These rules can help maintain the quality of services in common facilities and may avoid the risk of decreasing the price of the condominium by allowing developers to stipulate optimal declaration rules on collective decision making. Barzel and Sass (1990) argue that declarations and bylaws may help to internalize the externalities caused by the behaviors of property owners, thereby minimizing the cost of collective action. In brief, the collective action cost for condominium management seems to be remarkably lower in the U.S. than in Japan.

## 5.2 Empirical Strategy and Data

We follow the same estimation procedure as for Japanese condominiums. We use the condominium units occupied by tenants to estimate the rent function, and the imputed rent to estimate the price function based on the condominium units occupied by owners. The data are obtained from the AHS[17] for 2002, 2004, 2005, and 2007. We use samples in which the housing type falls under the "condominium or cooperative" category. Those in the AHS samples above the 99$^{th}$ percentile or below the first percentile for floor area, rent per floor area, or price per floor area are excluded. The samples include 562 rental units with rental prices and 1058 owner-occupied units with prices.

Two distinctions can be found between the Japanese and U.S. condominium data. First, unlike the Japanese condominium data, each sample in the AHS belongs to a different building. Therefore, when estimating the rent function, we use metropolitan statistical area fixed effects (instead of building fixed effects) along with building-specific variables (e.g., number of units, building age, and travel time to workplace) and unit-specific variables (i.e., number of units and floor level). Second, a sample in the AHS shows the transaction price if the household owns the property, or the current rental payment if the household rents the property. Accordingly, in the price function, we include purchase-year dummies, which range between 1963 and 2007, data-year dummies (2002, 2004, 2005, and 2007) and regional fixed effects (standard metropolitan statistical area (SMSA)). Regarding the other explanatory variables, we use the same variables that we used for Japanese condominiums,

[15]As the reviewers suggest, it would be beneficial to test how the legal reform in 2014 has affected the condominium price in Japan by using a richer panel data as a future research topic.
[16]See West and Morris (2003, p. 925).
[17]Microdata on the AHS were obtained from the United States Census Bureau website, available at http://www.census.gov/housing/ahs/.

except for *SOUTH*, *CORNER*, and *RENOVATED*, which are not available in the AHS.[18]

## 5.3 Estimation Results

*Rent function*: The estimation results for the rent function are shown in the first column, or Column [5-1], of Table 5. In contrast to Japanese condominiums, the number of units in U.S. condominiums is positively correlated with the rent. Many reasons may explain this finding. To name a few, a condominium with more units may have more luxurious amenities than a small condominium, which outweighs the negative externality of the number of units on the rent. In addition, with SMSA-regional fixed effects in the regression, the positive coefficient for the number of units may imply an endogenous sample bias among condominiums within an SMSA. Taking into account that the number of stories is positively correlated with the rent, a neighborhood with a higher population density in the U.S. (i.e., the area where condominiums have more units) may tend to be richer than a neighborhood of condominiums with a lower population density.

This international comparative analysis barely shows a plausible interpretation of the differences in rent functions, although such a comparison involves addressing many unobservable factors. However, using the predicted rent in the price function is quite advantageous because it enables us to separate the price-specific effect of the number of units from any potential indirect effect on the price through rent.

*Price function*: The results in Columns [5-2] and [5-3] show the price functions of condominiums in the U.S. based on Equations (2) and (3), respectively. We find that, in the U.S., the number of units does not significantly affect the condominium price directly, even though we observed a negative and significant effect for Japanese condominiums in the previous section. In addition, the coefficient of the cross-term of $\ln(UNITS)*\ln(AGE + 1)$ is not significant, although it shows the expected negative sign. These results are consistent with the interpretation that, in the U.S., an increase in the number of owners of a condominium does not significantly impede collective action, whereas Japanese condominium law may cause a serious collective action problem in Japanese condominiums.

It is interesting that the absolute value of the coefficient of $\ln(AGE + 1)$ in [5-2] is much smaller for U.S. condominiums relative to Japanese condominiums (0.325), which means that the price of condominiums depreciate more rapidly in Japan than in the U.S. Also, the coefficient of the number of units in Column [5-3] is positive and significant, thus implying that the effect of the scale

[18] Tables 3 and 4 present definitions of the variables and basic statistics for them, respectively.

economies in the U.S. is greater relative to Japan. Recall that in the U.S., the land can be developed in any manner after the condominium is terminated, whereas Japanese condominium law has been allowing condominiums to be rebuilt only as a means of redevelopment. The estimation results are consistent with the hypothesis that, in the U.S., the land-use policy that surrounds condominium development is more efficient than the regulation in Japan, and thus, the positive effect of the scale economies overweighs the negative effect of the collective action problems in the U.S. condominiums.[19] On the other hand, the negative sign of the coefficient of the number of units on the condominium price in Japan ensures the presence of a significant cost associated with collective action problems in Japanese condominiums.

**Table 5 U.S. Condominiums**

| | [5-1] Rent function | | [5-2] Price function | | [5-3] | |
|---|---|---|---|---|---|---|
| Apartment type: | U.S. condominiums | | U.S. condominiums | | | |
| Dependent variable: | ln(*RENT*) | | ln(*PRICE*) | | ln(*PRICE*) | |
| | Coeff. | t-stat. | Coeff. | t-stat. | Coeff. | t-stat. |
| ln(*RENTHAT*) | | | 0.474* | 1.8 | 0.465* | 1.8 |
| Building-specific variable | | | | | | |
| ln(*UNITS*) | 0.049* | 1.8 | 0.030 | 1.0 | 0.078** | 2.0 |
| ln(*AGE* + 1) | –0.114*** | -3.4 | -0.090** | -2.5 | –0.038 | -0.7 |
| ln(*UNITS*)*ln(*AGE* + 1) | | | | | –0.020 | -1.2 |
| ln(*TIME*) | 0.038 | 1.4 | | | | |
| ln(*STORIES*) | 0.118* | 1.7 | | | | |
| *EV* | 0.034 | 0.4 | | | | |
| Unit-specific variable | | | | | | |
| ln(*BEDRM* + 1) | –0.225** | -2.3 | | | | |
| ln(*FLEVEL* + 1) | –0.050 | -0.9 | | | | |
| ln(*RENTHAT*) | | | Fitted value from [5-1] | | | |
| Fixed effect | SMSA (73) | | SMSA (85) | | | |
| Other dummy variables | Data year (2002, ’04, ’05, ’07) | | Purchase year (1963–2007), Data year (2002, ’04, ’05, ’07) | | | |
| Observations | 562 | | 1058 | | 1058 | |
| $R^2$ | 0.3263 | | 0.4069 | | 0.4079 | |

***Notes:*** The symbols ***, **, *, and † indicate statistical significance at the 1, 5, 10, and 15% levels using two-tailed tests. Values in parentheses in the fixed-effect level row are the numbers of regional fixed effects in the estimations. The coefficients of dummy variables for regions and years of data or purchase are not shown in the table.

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[19] Considering that laws and land-use policies vary among states and cities in the U.S., the data and empirical strategy need to be elaborated for further comparative analysis.

## 6. Concluding Remarks

The reconstruction of condominiums is becoming a serious social problem in Japan. More than 1 million condominium units in Japan were built over 30 years ago, and many of them do not satisfy the current earthquake-resistance standards. However, reconstruction in Japan requires a difficult collective decision-making process, which prevents the efficient redevelopment of older condominiums. This paper aims to examine whether a collective action cost exists for Japanese condominiums.

The number of units is used as a proxy for the difficulty of collective action. The positive relationship between the number of owners and the collective action cost has been addressed in numerous studies in the literature, both empirical and theoretical papers. Using data on completed condominiums in Japan, we find that an increase in the number of units prolongs the duration of collective decision making and delays reconstruction.

We estimate the price function of condominiums by using the imputed rent, as predicted from the rent function, to differentiate the direct effect of the number of units on the price from the indirect effect of the number of units via rent. We also use data on rental apartments to observe whether the price functions of two types of buildings, those with and those without a collective action problem, differ. While collective action is required to rebuild a condominium, a rental apartment, which is held by a single entity, does not involve a collective action cost. Furthermore, we obtain data on condominiums in the U.S. to explore the significance of the different circumstances under which condominiums are managed and redeveloped. The results show that, among the three types of buildings, the number of units negatively affects only the price of Japanese condominiums and that the depreciation rate of the condominium price in Japan is greater than that for the other two building types. These results imply that a substantial cost is inherent in the collective action problems associated with condominium reconstruction in Japan.

Most condominium laws in the U.S. specify that a condominium should be terminated prior to development, and allow the land to be developed in any manner as long as it satisfies area-specific regulations, such as land-use policies and building codes. By contrast, Japanese condominium law dictates that reconstruction is the only method of condominium redevelopment. Under Japanese law, the collective decision-making process associated with reconstruction causes a serious holdout problem among owners. A recent revision of Japanese law allows a condominium to be sold to a developer, although the law still requires the reconstruction of a new condominium on the same site. Further studies with extended data on the collective action problem and condominium property values will be helpful in examining the policy implications of the Japanese law.

## Acknowledgement

The authors would like to thank the anonymous reviewers for their constructive comments to improve the final version of the paper. The authors would also like to thank the editor for her support during the review process.


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# Appendices

## Appendix I Collective Decision-Making Time in Condominium Reconstruction

Here, we report on a simple regression analysis conducted to examine relationships between the number of owners in a condominium and the collective decision-making time. We use the data provided by Meno (2004) and from a website[20] that lists recently completed condominium reconstruction projects. The specification for the regression analysis is as follows:

$$\ln(CDMtime)_t = \alpha_0 + \alpha_1 \ln(UNITold)_i + \alpha_2 FAM_i + \alpha_3 UNITM_i + \alpha_4 SELFHAT_i + \alpha_5 \ln(AGEstart)_i + \alpha_6 TOKYO_i + \varepsilon_i \quad \text{(A1)}$$

where subscript $i$ indicates the $i^{th}$ condominium; *CDMtime* is the duration of the collective decision-making process for reconstruction (in months);[21] *UNITold* is the number of units in the previous condominium; *FAM* is the floor area of the new condominium divided by the floor area of the previous condominium; *UNITM* is the number of units in the new condominium divided by the number of units in the old condominium; *AGEstart* is the number of years that have passed between the time that the old condominium was built and the time that the first official meeting on the reconstruction takes place; *TOKYO* is a dummy variable that indicates a condominium located in the Tokyo prefecture; and $\varepsilon$ is an error term.

Finally, *SELFHAT* is the expected value for a dummy variable, *SELF*, which is assigned 0 if a developer is involved in the decision-making process and 1 if residents plan and carry out the procedure themselves. The decision-making procedure can be better managed without the support of others when a collective action problem is not serious and thereby requires less time for collective action. To consider such an endogenous issue, we first use a probit estimate that regresses *SELF* on *FAM*, *UNITM*, ln(*AGEstart*), *TOKYO*, and *START* (the starting year of collective action) to obtain *SELFHAT*, the fitted value of *SELF*.

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[20] The URL of the website from which we collected the data on condominium reconstructions in August 2011 is http://www.manshon.jp/tatekae/ta_jirei_index.html.

[21] The duration of collective decision making on reconstruction, *CDMtime*, is the number of years between the time when the first official meeting regarding reconstruction is held and the time at which a consensus regarding reconstruction is reached. However, some data lack information regarding when the consensus is reached. To cope with this problem, we obtain the time to reach consensus by subtracting the estimated number of years for construction (the number of years required to tear down the old condominium and build the new one) from the time at which the new condominium is completed. The number of years for construction is estimated with coefficients obtained by regressing the reconstruction time on the total floor area of the new condominium and the age of the old condominium, with the samples that have information on the duration of reconstruction.

**Table A1 Descriptive Statistics of 64 Cases of Condominium Reconstruction in Japan**

| Variable | Definition | Minimum | Median | Maximum | Mean |
|---|---|---|---|---|---|
| *CDMtime* | Months spent on collective decision making | 0.6 | 4.9 | 18.6 | 6.03 |
| *YEARold* | Year when the construction of a previous condominium was completed | 1926 | 1962 | 1981 | 1961.49 |
| *YEARnew* | Year when the reconstruction of a new condominium was completed | 1975 | 2004 | 2012 | 2001.01 |
| *START* | Year when the first meeting regarding reconstruction was held | 1969 | 1992.4 | 2008.5 | 1994.73 |
| *RecAGE* | Number of years between the year of completion of the previous and the new condominium | 19 | 38 | 74 | 39.52 |
| *AGEstart* | Number of years between the year when the previous condominium was completed and the year when residents began to discuss reconstruction | 13 | 33 | 59.5 | 33.66 |
| *UNITold* | Number of housing units in the previous condominium | 16 | 62.5 | 368 | 89.19 |
| *UNITnew* | Number of units in the new condominium | 20 | 96.5 | 644 | 150.71 |
| *FAold* | Floor area ($m^2$) of the previous condominium | 880 | 3,400 | 18,511 | 4,737 |
| *FAnew* | Floor area ($m^2$) of the new condominium | 1,166 | 9,274 | 57,337 | 13,439 |
| *FAM* | Ratio of the increase in floor area after reconstruction | 0.82 | 2.62 | 6.34 | 2.76 |
| *UNITM* | Ratio of the increase in the number of units after reconstruction | 0.71 | 1.63 | 4.2 | 1.79 |
| *SELF* | Dummy variable indicating that reconstruction was conducted by residents (without the support of a developer) | 0 | 0 | 1 | 0.09 |
| *TOKYO* | Dummy variable indicating the condominium is located in the Tokyo prefecture | 0 | 1 | 1 | 0.58 |

***Source:*** Meno (2004), and a website that lists past reconstruction projects (http://www.manshon.jp/tatekae/ta_jirei_index.html).

According to the basic statistics in Table A1, on average, reconstruction takes place in 39.52 years (ranging from 19 to 74 years) after the completion of the condominium, and the decision-making process takes 6.03 years (from 0.6 to 18.6 years) to achieve consensus regarding reconstruction. With regard to *FAM* and *UNITM*, we observe that new condominiums have a larger total floor area and a larger number of units after reconstruction. In a newly reconstructed condominium, the total floor area and the number of units increase, on average, by 176 and 79%, respectively. In fact, a reduction in the total floor area after reconstruction is found in only one condominium. With the total floor area of a condominium expanded, owners can benefit from having more space in their own units, and sell extra units to cover the reconstruction cost, which will enable them to achieve consensus more easily.

The probit estimate of *SELF* is shown in Column [A2-1] of Table A2. The coefficient of ln(*UNITold*) has a negative sign at the 5% significance level. Therefore, collective action regarding reconstruction is more likely to be well managed without the involvement of a third party if the number of property owners in the condominium is not large. Regarding other variables, only *TOKYO* shows a significant effect, at the 15% significance level, on *SELF*. This finding implies that collective decision making in Tokyo is more difficult than in other prefectures and thus tends to involve a developer to manage the process efficiently.

Columns [A2-2] and [A2-3] in Table 2 show the estimation results for Equation (A1). In addition to ordinary least squares (OLS) estimates, we have conducted a truncated regression because *CDMtime* is truncated in such a way that we do not observe the condominiums in which collective decision making is still in progress. The coefficients of ln(*UNITold*) show positive signs, and are statistically significant, thus verifying that an increase in the number of property owners increases the time needed to achieve consensus on reconstruction. In concrete terms, if the number of units doubles, the time needed for collective decision making is extended by approximately 30%.

Regarding the other variables, the coefficients of *FAM* have positive signs, which may be because, as part of the decision-making process, consideration of the method by which the surplus floor area will be used and operated takes more time. The coefficients of ln(*AGEstart*) show that the time needed for collective decision making is reduced by approximately 45% if the condominium age is doubled. Although the significance levels are not strong (ranging from 10% to 15%), this result implies that property owners hasten their decision making on reconstruction when their condominiums are more dilapidated. As expected, the coefficients of *SELFHAT* have remarkably negative effects on decision-making time, although their signs are not significant because of the presence of multicollinearity.[22] Finally, the coefficients of the variable *TOKYO* indicate that the collective decision-making time is approximately 47% longer in Tokyo than in other prefectures. This result makes intuitive sense because people in such a large city have diverse backgrounds and interests, which can complicate the process of collective action. Moreover, people relocate more frequently in Tokyo; thus, they are likely less incentivized to contribute to community relations activities.[23]

**Table A2 Estimations of the Collective Decision-Making Time for Reconstruction**

| Model: | [A2-1] Probit | | [A2-2] Truncated | | [A2-4] OLS | |
|---|---|---|---|---|---|---|
| Dependent variable: | *SELF* | | ln(*CDMtime*) | | ln(*AGEstart*) | |
| | Coeff. | t-stat. | Coeff. | t-stat. | Coeff. | t-stat. |
| ln(*UNITold*) | $-1.342^{**}$ | -2.5 | $0.294^{**}$ | 2.3 | 0.017 | 0.4 |
| *FAM* | –0.136 | -0.5 | $0.186^{**}$ | 2.0 | 0.030 | 0.7 |
| *UNITM* | | | –0.007 | -0.1 | | |
| *TOKYO* | $-0.888^{+}$ | -1.6 | $0.472^{***}$ | 2.6 | $0.136^{*}$ | 1.8 |
| ln(*AGEstart*) | 0.372 | 0.4 | $-0.442^{*}$ | -1.7 | | |
| *SELFHAT* | | | –0.546 | -0.8 | | |
| *START* | $-1.342^{**}$ | -2.5 | | | | |
| *LAMBDA* | | | $0.668^{***}$ | 13.1 | | |
| *CONSTANT* | 47.153 | 0.6 | 1.056 | 1.0 | $3.235^{***}$ | 16.6 |
| Observations | 64 | | 64 | | 64 | |
| $R^2$ | | | | | 0.3460 | |
| Log likelihood | –14.25 | | –64.73 | | | |

***Notes**:* The symbols ***, **, *, and + indicate statistical significance at the 1, 5, 10, and 15% levels using two-tailed tests. The figures in parentheses are robust standard deviations. Probit: probit regression model. Truncated: truncated regression model due to unobserved samples of condominiums in the negotiation process regarding reconstruction. OLS: ordinary least squares.

[22] Note that, when we use *SELF* in Equation (1) instead of the fitted value, the coefficients are –0.6623 (at the 5% significance level) in the truncated model and –0.6609 (at the 10% significance level) in the OLS estimate.

[23] According to a survey conducted by the Ministry of Land, Infrastructure, Transport and Tourism in 2005, neighbor relationships are tenuous in metropolitan areas relative to those in local regions; approximately 28% of residents in local regions have no or almost no relationships with neighbors, whereas this percentage increases to 45% in metropolitan areas. Regarding the two main reasons for these superficial relationships among neighbors, the interviewees living in metropolitan areas report that (1) they are not at home during the daytime and (2) residents are rapidly replaced. The report (in Japanese) is available at http://www.mlit.go.jp/hakusyo/mlit/h17/hakusho/h18/html/H1022100.html.

If owners of condominiums are aware of the future reconstruction problem in advance, they may start collective action at an earlier stage to carry out the reconstruction at the optimal time. To examine this issue, we regress ln(*AGEstart*) on ln(*UNITold*), *FAM*, and *TOKYO*. The results are shown in Column [A2-4]. The number of units does not significantly influence the timing of the collective action, which ensures that the collective action is not driven by the property value-maximizing behaviors of condominium owners. These results verify that an increase in the number of owners in a condominium prolongs the collective decision-making process involved in reconstruction.

## Appendix II Redevelopment Model of a Condominium

The price of the condominium at time $t$, $P_t$, is the expected net present value of the discounted future rent, taking future reconstruction into consideration. The price of the condominium at time $t$, $P_t$, is then

$$P_t = E_t\left[\int_t^{T_1} R_s e^{-r(s-t)}ds + \sum_{m=1}^{\infty}\int_{T_m}^{T_{m+1}} R_s^m e^{-r(s-t)}ds - C_{T_m} e^{-r(T_m-t)}\right] \quad \text{(A2)}$$

where $R_s$ is the rent of the condominium unit at time $s$, $r$ is a constant discount rate, $C_{T_m}$ is the reconstruction-related costs, $T_m$ is the timing of the $m$th reconstruction, and $R_s^m$ is the rent at time $s$ (after the $m$th reconstruction).

In terms of social optimality, the value of the condominium is maximized through the planning and execution of the reconstruction. We assume that the reconstruction-related costs, $C_{T_m}$, and the rental value of a newly reconstructed condominium, $R_{T_m}^m$, will remain constant over time. The price of a newly rebuilt condominium, $P_{T_m}$,[24] is then equal for all $m$ under the optimal decisions of the community. Hereafter, we can relate $C_{T_m}$, $R_{T_m}^m$, and the optimal $P_{T_m}$ to $C$, $R^n$, and $P^{n^*}$, respectively. Thus, we can rewrite the maximization problem for the timing of reconstruction as follows:

$$P_t^* = \max_{T_1}\int_s^{T_1} R_s e^{-r(s-t)}ds + \left(P^{n^*} - C\right)e^{-r(T_1-t)} \quad \text{(A3)}$$

The necessary condition for this problem is

$$R_{T_1^*} = r\left(P^{n^*} - C\right) \quad \text{(A4)}$$

where $T_1^*$ is the optimal timing of the first reconstruction and $R_{T_1^*}$ is the rent (before the first reconstruction) at the time of the optimal reconstruction. The optimal timing for a reconstruction is when the rent becomes as low as the

[24] Note that the prices immediately after reconstruction and after an optimal reconstruction are the same as long as we expect every reconstruction to be carried out optimally in the future.

opportunity cost of postponing the reconstruction, which equals the cost of interest on the net capital gain accrued from the reconstruction. It is noted that, although a maintenance cost is not considered explicitly in this model, it can also play an important role in determining the timing of reconstruction. Careful maintenance of the building structure slows the speed of depreciation and postpones the reconstruction. [25]

As discussed, owners of Japanese condominiums rarely achieve an optimal agreement because of the difficulty of the collective action process. We may then assume that reconstruction is usually delayed from the optimal timing. The price change from the expected delay of the next reconstruction by $\Delta T$ from the optimal timing $T_1^*$ is then[26]

$$\frac{\partial P_t}{\partial \Delta T} = -\left[ R_{T_1^*} - R_{\left(T_1^* + \Delta T\right)} \right] e^{-r\left(T_1^* - t + \Delta T\right)} < 0 \tag{A5}$$

Furthermore, the price of the condominium depreciates more when the cost, one of the reconstruction-related cost factors, is higher:

$$\frac{\partial P_t}{\partial C} = -e^{-r\left(T_1^* - t + \Delta T\right)} \tag{A6}$$

Equations (A5) and (A6) show that the condominium price decreases as the expected delay in its future reconstruction becomes longer and the construction-related costs become higher. Lastly, by differentiating the price rate of the time change, $\widehat{P_t}\left(\equiv \frac{dP_t}{dt}/P_t\right)$,[27] with respect to $\Delta T$ and $C$, we can predict that the expected delay in future reconstruction and the increase in the cost will accelerate the deterioration of the price:

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[25]This important issue about the relationship between the maintenance cost and the timing of reconstruction is pointed out by one of reviewers. It can be indeed more realistic to consider such an interaction between maintenance and overall reconstruction of buildings in the model. Although such dynamic modeling involves substantial complications, which are beyond the scope of what can be tested with our data, it seems to be an interesting open question to analyze with a richer data how this dynamic relationship affects the collective action and the timing of reconstruction.

[26]In Equation (A5), we assume that only the first forthcoming reconstruction is delayed. If instead we assume that every reconstruction in the future will be equally delayed, the differentiation is as follows:

$$\frac{\partial P_t}{\partial \Delta T} = -\left[R_{T_1^*} - R_{(T_1^*+\Delta T)}\right] \frac{e^{-r(T_1^*-t+\Delta T)}}{1-e^{-r(T_1^*-t+\Delta T)}} \leq 0.$$

This assumption makes the effects of the reconstruction delay more strongly negative than in Equation (A5), but does not change any implications of the following discussion.

[27]Differentiating $P_t$ in Equation (A2) with respect to $t$ yields

$$\frac{dP_t}{dt} = E_t\left[-R_t + \int_t^{T_1} R_s e^{-r(s-t)} ds + r \sum_{m=1}^{\infty} \int_{T_m}^{T_{m+1}} R_s^m e^{-r(s-t)} ds - C_{T_m} e^{-r(T_m - t)}\right]$$

$$= -R_t^0 + rt;$$

hence, the price of the time change rate is

$$\widehat{P_t}\left(\equiv \frac{dP_t}{dt}/P_t\right) = -\frac{R_t}{P_t} + r.$$

$$\frac{\partial P_t}{\partial \Delta T} = -\frac{R_t}{(P_t)^2}\left[R_{T_1^*} - R_{\left(T_1^* - \Delta T\right)}\right] e^{-r(T_1^* - t + \Delta T)} < 0 \qquad \text{(A7)}$$

$$\frac{\partial P_t}{\partial C} = -\frac{R_t}{(P_t)^2} e^{-r(T_1^* - t + \Delta T)} \qquad \text{(A8)}$$

## Appendix III Robustness Check

This appendix provides a robustness check by examining the differences in coefficients for the price functions among three types of apartments: Japanese condominiums, Japanese rental apartments, and U.S. condominiums. In particular, we attempt to carefully address the comparison of the marginal effects of the number of units, which is the primary focus of our study.

In our estimations, we adopt log-linear functions to enable comparisons among the three different types of apartments. A log-linear function assumes that price elasticity is constant at any level of the variable of interest. However, if the price elasticity of the number-of-units potentially varies depending on the number of units, the magnitude of the coefficient can be influenced by its distribution. Ideally, we would like to evaluate the marginal effects of a variable at the same sample means among all apartment types, whereas the basic statistics presented in Table 2 show that samples of Japanese condominiums tend to be larger than samples of the other two types of housing.

With this in mind, we conduct a second analysis as follows. First, we select samples by limiting the number of units. In particular, we exclude apartments that contain more than 105 units, which is the 95$^{th}$ percentile in the samples of rental apartments. We also exclude samples of apartments that were built before 1981, the year when the Japanese government introduced the new earthquake-resistance regulations.[28] Second, we apply the propensity score-matching method to select rental apartments and condominiums in the U.S. that have similar characteristics, in terms of the number of units and the building age, to those of Japanese condominiums.[29] The sample selections in the matching method are performed by computing the propensity scores. These scores are estimated by using a probit model with a dummy variable which indicates the Japanese condominium as a dependent variable and the number of units and year of completion as the explanatory variables. We then select samples of rental apartments or U.S. condominiums with propensity scores that fall within

[28]As can be seen in Table 2, condominiums tend to be older than the samples of rental apartments.

[29]Deng et al. (2012) and McMillen (2012) show applications of the propensity score-matching method in the housing market, and demonstrate how a housing price index can be created by matching housing samples with similar characteristics.

a certain range (caliper) of any score computed for Japanese condominiums.[30] Finally, by pooling data on Japanese condominiums with those from another selected dataset (either rental apartments or condominiums in the U.S.), we estimate the rent and price functions with cross-terms of the variables and a dummy variable that indicates Japanese condominiums. The coefficients of the cross-terms reveal differences in the magnitude of the coefficients between Japanese condominiums and the other apartment types.

***Japanese Condominiums versus Japanese Rental Apartments***

We first observe estimations that compare Japanese condominiums with rental apartments. Table A3 shows the estimation results for the price functions. Column [A3-1] corresponds with the result based on Equation (2), and Column [A3-2] corresponds with the result based on Equation (3).[31] In this table, $D$ indicates a condominium dummy; therefore, cross-terms, such as $D$*ln($UNITS$), show the difference in coefficients for the variables in the rent function for Japanese condominiums compared with the coefficients for rental apartments.

The estimation results are consistent with the results of the preceding estimations which use separate data. In the first column, the coefficient for $D$*ln($UNITS$) shows that the condominium price declines by 8.2% relative to the price change in rental apartments when the number of units in the building doubles. Furthermore, we observe a significant difference in the coefficient for ln($AGE$ + 1) between the two apartment types. Although the price of rental apartments decreases by 6.9% as the building age doubles, the value of condominiums depreciates by an additional 19.3%. In the last three columns, although the coefficient of $D$*ln($UNITS$)*ln($AGE$ + 1) is statistically weak because of multicollinearity, it shows the expected negative signs.

***Japanese Condominiums versus U.S. Condominiums***

In the same manner, we select condominiums in the U.S. that are similar to Japanese condominiums in terms of the number of units and the building age, and then examine the rent and price functions. Table A4 shows the estimated price functions. The coefficients of ln($UNITS$) are positive, thus indicating that residents in the U.S. expect a higher future rent for a larger condominium. As discussed above, in the U.S., the land on which condominiums are constructed

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[30]We do not use other building characteristics in the matching procedure because our interest is in checking the robustness of the effects of two variables (i.e., the number of units and the building age) in the price function while maintaining as many observations as possible. Using other variables, such as *TIME* and *STORIES*, in the matching procedure reduces the sample size so significantly that we would not have sufficient observations to conduct the comparative analysis.

[31]Using the propensity score-matching method, we estimate the price functions with samples selected by various ranges of calipers (0.5, 0.3 and 0.1), but only the results where a caliper is set to be 0.1 are shown in the table. The other results are available upon request.

can be used in various ways after the condominiums are terminated. In general, a highly productive property, such as a commercial facility or an office building, requires a sufficiently large tract of land; in other words, economies of scale do not work for the smaller tracts of land where condominiums with a small number of units are located. Accordingly, the number of units, which is positively correlated with the size of the lot, may have a positive effect on the price of condominiums in the U.S.

**Table A3 Price Function: Condominiums and Rental Apartments in Japan.**

| Dependent variable: | [A3-1] ln(*PRICE*) | | [A3-2] ln(*PRICE*) | |
|---|---|---|---|---|
| | Coeff. | t-stat. | Coeff. | t-stat. |
| Rental apartments | | | | |
| ln(*RENTHAT*) | $0.719^{***}$ | 5.3 | $0.717^{***}$ | 5.3 |
| ln(*UNITS*) | 0.012 | 0.6 | 0.006 | 0.1 |
| ln(*AGE* + 1) | $-0.069^{***}$ | -3.7 | –0.082 | -1.3 |
| ln(*UNITS*)*ln(*AGE* + 1) | | | 0.003 | 0.2 |
| Condominiums – rental apartments | | | | |
| *D**ln(*RENTHAT*) | $-0.528^{***}$ | -2.7 | $-0.529^{***}$ | -2.7 |
| *D**ln(*UNITS*) | $-0.082^{**}$ | -2.4 | 0.193 | 1.1 |
| *D**ln(*AGE* + 1) | $-0.193^{***}$ | -4.6 | 0.186 | 0.7 |
| *D**ln(*UNITS*)*ln(*AGE* + 1) | | | $-0.100^{+}$ | -1.6 |
| Observations | 494 | | 494 | |
| $R^2$ | 0.8866 | | 0.8874 | |

***Notes:*** In these estimations, the samples are restricted to Japanese condominiums and rental apartments that have similar characteristics in terms of the number of units and the apartment age: we first exclude the apartments with more than 105 units (the 95th percentile in the samples of rental apartments) and those built before 1981 (the year when the Japanese government introduced the new earthquake-resistance regulations), and we then select rental apartments using propensity score matching by setting a caliper to 0.1. The estimation results with samples selected by propensity score matching using different calipers (0.5 and 0.3) are not shown in the table, but they are available upon request. The symbols ***, **, *, and + indicate statistical significance at the 1, 5, 10, and 15% levels using two-tailed tests. The coefficients of the constant term and dummy variables for condominiums, regions, and years of data or purchase are not shown in the table. *D* is the indicator of Japanese condominiums, such that coefficients of cross-terms with the indicator indicates differences in the coefficients of the two types of apartments. ln(*RENTHAT*) is the predicted value from column [3-1] of Table 3 for Japanese condominiums, whereas it is ln(*RENT*), a logarithmic value of the actual rental revenue, for Japanese rental apartments.

In the first column, Column [A4-1], the coefficient for *D**ln(*UNITS*) and *D** ln(*AGE* + 1) is negative and statistically significant, which indicates that Japanese condominiums devalue more than condominiums in the U.S. as the number of units and the building age increase. This result is consistent with the implication that the value of condominiums remains high under U.S. condominium law relative to the same value under Japanese law. Introducing the possibility of terminating condominiums might improve the future productivity of land use along with condominium redevelopment. In Column [A4-2], the coefficient of *D**ln(*UNITS*)*ln(*AGE* + 1) shows the expected negative sign, although it is not statistically significant.[32] In future research, a more careful examination and extended data are needed to evaluate the explicit benefits of implementing such a policy.

**Table A4 Price Function: Condominiums in Japan and the United States**

| Dependent variable: | [A4-1] ln(*PRICE*) | | [A4-2] ln(*PRICE*) | |
|---|---|---|---|---|
| | Coeff. | t-stat. | Coeff. | t-stat. |
| Rental apartments | | | | |
| ln(*RENTHAT*) | 0.458 | 0.8 | 0.611 | 1.0 |
| ln(*UNITS*) | 0.124+ | 1.5 | 0.152* | 1.8 |
| ln(*AGE* + 1) | –0.078 | -1.3 | 0.020 | 0.2 |
| ln(*UNITS*)*ln(*AGE* + 1) | | | –0.024 | -1.0 |
| Condominiums – rental apartments | | | | |
| *D**ln(*RENTHAT*) | –0.381 | -0.6 | –0.532 | -0.8 |
| *D**ln(*UNITS*) | –0.197** | -2.3 | 0.048 | 0.2 |
| *D**ln(*AGE* + 1) | –0.178** | -2.4 | 0.096 | 0.3 |
| *D**ln(*UNITS*)*ln(*AGE* + 1) | | | –0.074 | -1.1 |
| Observations | 394 | | 394 | |
| $R^2$ | 0.6897 | | 0.6885 | |

***Notes:*** In these estimations, the samples are restricted to Japanese condominiums and U.S. condominiums that have similar characteristics in terms of the number of units and the apartment age: we first exclude apartments with more than 105 units and those built before 1981, and we then select the U.S. condominiums using propensity score matching by setting a caliper to 0.1. The estimation results with the samples selected by propensity score matching using different calipers (0.5 and 0.3) are not shown in the table, but they are available upon request. The symbols ***, **, *, and + indicate statistical significance at the 1, 5, 10, and 15% levels using two-tailed tests. The coefficients of a constant term, dummy variables for condominiums, regions, and years of data or purchase are not shown in the table. *D* is the indicator of Japanese condominiums, such that coefficients of cross-terms with the indicator indicates differences in the coefficients of the two types of apartments. ln(*RENTHAT*) is the predicted value from [3-1] of Table 3 for Japanese condominiums and the predicted value from [5-1] of Table 5 for U.S. condominiums.

[32]The coefficients remain significant at a 15% level in the results for samples selected by propensity score matching with larger calipers (0.5 and 0.3), but are no longer significant when the caliper is set to 0.1.