# AN ESTIMATION OF COLLECTIVE ACTION COST IN CONDOMINIUM RECONSTRUCTION: THE CASE OF JAPANESE CONDOMINIUM LAW

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REAL 12-T-05 September, 2012

# An estimation of collective action cost in condominium reconstruction: the case of Japanese condominium law


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**Abstract**: This paper presents an empirical examination of the cost of collective action problems inherent in condominium reconstruction in Japan. Because of property co-ownership, problems associated with the decision-making process arise among owners of condominium units. Further, mechanisms of condominium law in Japan potentially induce a holdout problem in the decision-making process, resulting in the development of more serious collective action problems. By comparing the price functions of Japanese condominiums with those of rental apartments in Japan and condominiums in the United States, we clarify the presence of a collective action cost in Japanese condominium reconstruction and confirm that a deficiency exists in Japanese condominium law.


## 1 Introduction

A condominium provides a mixture of private ownership of a defined apartment unit, and co-ownership of a range of common property in the condominium complex, including, among others, hallways, roofs, elevators, gymnasiums, and swimming pools. The scale economies and the public goods properties of common spaces and facilities are two of the main reasons for the rapid growth of condominiums in Japan since the 1960s. Condominiums enable the property owner to enjoy these common properties and share the services they provide. By 2011, there were about 5.8 million condominium units in Japan, accounting for about 10% of the 53.5 million housing units in the country.

Although the co-ownership aspect of condominiums certainly provides a benefit to property owners, it often causes externalities and collective action problems. Substantial resources and effort are required to achieve collective decision-making when managing condominiums, and still more are needed to resolve the conflicts of interest that arise among property owners when reconstructing them. Today, about 20% of condominiums (some 1.18 million units) are more than 30 years old and face extensive renovation problems. Many of these older condominiums, that were built before the revision of the Building Standards Act in

1981, do not meet earthquake-resistance standards. Clearly, condominiums in Japan are characteristically not very robust;[1] however, it is surprising that only 167 condominiums had been reconstructed by October 2011.[2] Accordingly, in the very near future, many more owners of condominium units in urban Japan will be facing the difficult problem of reconciling the conflicts of interest among property owners and addressing the challenge of collective action.

Indeed, the delay in reconstructing old condominiums may be due in part to the difficulty inherent in managing the collective decision-making process among individuals of various backgrounds with different interests. However, the main reason for the reconstruction problem seems to be a lack of effective condominium declarations and mechanisms for minimizing the cost of decision-making, even though condominium law in Japan defines very specific and detailed provisions for enforcing the rules and procedures governing decision-making.

This study is the first to empirically examine the cost of collective action involved in the decision-making surrounding condominium reconstruction. The aim of this paper is to examine the impact of collective action problems surrounding Japanese condominium ownership and to evaluate the validity of the current Japanese condominium law. In particular, we conduct three empirical analyses. First, we explore which factors determine the collective decision-making time used during the reconstruction by examining 64 cases of condominium reconstruction in Japan. The estimation result shows that the number of housing units in a condominium building has a positive influence on the amount of collective decision-making time involved; a 1% increase in the number of units prolongs the decision-making time by about 0.3%. This indicates that the collective action becomes more complicated as the number of members involved in decision-making increases.

Secondly, we identify the presence of a collective action cost in Japanese condominium management by using the number of units as a proxy for the difficulty of the collective decision-making process in condominium reconstruction. For this purpose, we estimate the rent and property price functions of both condominiums and rental apartments. Since most rental apartments have a single owner, or are owned and securitized into a real estate investment trust

[1] The Construction Ministry (now the Ministry of Land, Infrastructure, Transport and Tourism) has estimated the average housing lifespan based on the lifespan of housing demolished. The estimated average lifespan of a housing unit in Japan is about 26 years, which is shorter than in many Western countries (44 years in the United States and 75 years in the United Kingdom). See Construction Ministry (2006) for further detail.

[2] For data, see the website of the Ministry of Land, Infrastructure, Transport and Tourism (http://www.mlit.go.jp/jutakukentiku/house/torikumi/manseidata.htm).

(REIT) by a single corporation, they do not involve collective action. Therefore, by controlling other factors, the number of units is expected to affect the price of condominiums to different degrees, in terms of collective action problems, compared with rental apartments. Finally, the price function of U.S. condominiums (or cooperative housing) is estimated for comparison of the efficiency of condominium laws in both countries.

In the latter two analyses, we use several methods to handle the statistical problems inherent in simultaneously estimating the rent and price functions. To start with, every household decides endogenously whether to rent or own a unit, which we refer to as the tenure choice problem. We use Heckman's (1979) two-step estimates of the rent and price functions of the condominium to handle this sort of endogeneity.

Another statistical problem is that of selection bias among the three types of apartments, Japanese condominiums, Japanese rental apartments, and U.S. condominiums. This problem arises for as an endogeneity problem in which the type of apartment the developer decides to build (condominium or rental apartment) is the one that maximizes the present value of his or her future returns, and because the sample is not a random selection from the population. We have no appropriate variables to serve as instruments, and given that we lack information on the distribution of the population, we select samples of the three types whose characteristics are as similar as possible for comparison.

The estimation results show that the number of units has a negative effect on the price of condominiums in Japan, although we cannot find significant impacts of the number of units on the price of rental apartments in Japan as well as condominiums in the United States. Furthermore, after handling the selection bias problem, we find that a 1% increase in the number of units induces a 0.065 to 0.088% reduction in the condominium price relative to the price change in the rental apartment in Japan. This finding ensures the presence of a collective action cost in Japanese condominium management. In addition, the difference in effects of the number of units on the price between condominiums in Japan and the United States is also found significant.[3] On this basis, we conclude that co-ownership and condominium law in Japan work against optimal decision-making in maintaining and reconstructing a condominium, and thus

[3]Schill et al. (2007) estimate the price functions of condominiums and cooperative housing, respectively, and report that owners of cooperatives have lower costs in the collective decision-making process than do 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.

decrease the value of the condominium.

The structure of the paper is as follows. An overview of the problems and issues surrounding condominium law in Japan and some contrast with the United States are provided in section 2. In Section 3, we use a simple development model to examine the optimal timing of restructuring and the effects of collective action problems in condominium management. In Section 4, we introduce the number of units as a proxy for the difficulty of collective action by referring to existing studies and by conducting simple estimations using Japanese condominium data. We then estimate the rent and price functions of the three types of apartment buildings to examine the collective action costs involved in Japanese condominium management in Section 5. Finally, Section 6 provides some concluding remarks.

## 2 Condominium Law in Japan: An Overview

To reconstruct a condominium, Japanese condominium law requires at least four-fifths agreement among condominium owners. Once the proposal for reconstruction is adopted, proponents have the right to ask dissenters to sell their ownership. However, the crucial problem behind this rule is that prices are ambiguous because actual property transactions on the market are lacking. Since dissenters have an incentive to delay the timing of reconstruction, proponents may have to provide the dissenters with additional funds to obtain their consent. In extreme cases, in which dissenters intend to raise the selling price of their ownership as high as possible, a holdout problem is induced, deterring the condominium from being reconstructed.[4] The principal outcome is that almost all condominium reconstruction projects in Japan are likely to proceed only when collective decision-making successfully achieves unanimity. Consequently, the current condominium law in Japan actually requires an extremely high degree of uniformity of interests among owners to rebuild a condominium.[5]

In contrast, most of the state laws in the United States 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 law. After a resolution is passed to terminate the condominium, the

[4] Grossman and Hart (1980) and Eckart (1985) argue that holdout problems cause making a takeover bid and land taking to be impossible. See also Menezes and Pitchford (2004), O'Flaherty (1994), and Plassman and Tideman (2010) for the relationship between land assembly and the holdout problem.
[5] See West and Morris (2003, p. 912).

general procedure is to sell the land to a new developer and redistribute the revenue to previous condominium owners, according to their individual ownerships. In principle, this termination rule has two advantages over Japanese condominium law. First, because the amount of the redistribution is clear, it leaves no room for a holdout among dissenters, and proponents do not need to exhaust time and effort persuading dissenters to leave the condominium. Secondly, as long as no other regulation governing land exists in that particular area, the land can be developed in any manner after termination of the condominium, to maximize the productivity of land use. In contrast, Japanese condominium law allows only condominiums to be rebuilt as a means of redevelopment.

In addition, many states in the United States allow condominium developers to stipulate rules through private contracts, including covenants, conditions, and restrictions (CC&Rs).[6] These rules can contribute to maintaining the quality of services in the common facilities and may avoid the need to decrease the price of the condominium itself. The profit-maximizing behavior of condominium developers may result in the developers describing the optimal declaration-stipulating rules regarding collective decision-making. For instance, Barzel and Sass (1990) argue that declarations and bylaws may help internalize the externalities caused by the behavior of property owners, thereby minimizing the cost of collective action. In brief, the apparent cost of collective action in condominium management in the United States may be much lower than that in Japan.

## 3 Model

Consider a condominium built at time $t = 0$ that will be rebuilt when the owners of the condominium make a collective decision on the reconstruction. The market imputed rent of the units in the condominium at time $t = 0$, $R_0$, depends on the quality of the services provided for the dwelling, including the number of bedrooms, facilities, location, and surrounding environment. The rent level at time $s$ (before the first reconstruction) is then

$$R_s = R_0(\boldsymbol{x}, s)e^{-\delta s}, \tag{1}$$

where $\boldsymbol{x}$ is a vector of factors determining services surrounding the dwelling. The price of the

[6] See West and Morris (2003, p. 925).

condominium at time $t$, $P_t$, is the net present value of the discounted future rent, taking future reconstruction into consideration:

$$P_t = E_t\left[\int_t^{T_1} R_s e^{-r(s-t)}ds + \sum_{m=1}^{\infty} \int_{T_m}^{T_{m+1}} R_s^m e^{-r(s-t)}ds - C_{T_m} e^{-r(T_m-t)}\right], \qquad (2)$$

where $r$ is a constant discount rate, $C_{T_m}$ is the reconstruction-related cost, $T_m$ is the timing of the $m$th reconstruction, and $R_s^m$ is the rent at time $s$ (after the $m$th reconstruction). The reconstruction-related cost includes the physical construction and teardown costs, the costs involved in decision-making and moving, and the accommodation costs of the co-owners during reconstruction. As we discuss later, we assume the latter forms of cost are positively correlated with the number of co-owners in a condominium.

In terms of social optimality, the value of the condominium is maximized through planning and executing the reconstruction. We assume that the reconstruction-related cost, $C_{T_m}$, and the rental value of a newly reconstructed condominium, $R_{T_m}^m$, remain constant over time. The price of a newly rebuilt condominium, $P_{T_m}$,[7] 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:

$$P_t^* = \max_{T_1} \int_s^{T_1} R_s e^{-r(s-t)}ds + \left(P^{n^*} - C\right)e^{-r(T_1-t)}. \qquad (3)$$

The necessary condition for this problem is

$$R_{T_1^*} = r\left(P^{n^*} - C\right), \qquad (4)$$

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. It is well known that the optimal timing for a reconstruction is when the rent becomes as low as the opportunity cost of postponing the reconstruction and equals the cost of interest of the net capital gain accrued from the reconstruction.

However, as discussed, owners rarely achieve an optimal agreement in Japanese condominiums because of the difficulty of the collective decision-making process. We may

[7] 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.

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

$$\frac{\partial P_t}{\partial \Delta T} = -\left(R_{T_1^*} - R_{(T_1^*+\Delta T)}\right)e^{-r(T_1^*-t+\Delta T)} < 0.^{8} \qquad (5)$$

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

$$\frac{\partial P_t}{\partial C} = -e^{-r(T_1^*-t+\Delta T)}. \qquad (6)$$

Equations (5) and (6) show that the condominium price decreases as the expected delay in its future reconstruction becomes longer and as the construction-related cost becomes larger. By differentiating the price rate of the time change, $\widehat{P_t}\left(\equiv \frac{dP_t}{dt}/P_t\right)$,[9] with respect to $\Delta T$ and $C$, we can predict that the expected delay in future reconstruction and the increase in the decision-making cost accelerate a deterioration of the price:

$$\frac{\partial \widehat{P_t}}{\partial \Delta T} = -\frac{R_t^0}{(P_t)^2}\left(R_{T_1^*} - R_{(T_1^*+\Delta T)}\right)e^{-r(T_1^*-t+\Delta T)} < 0, \qquad (7)$$

$$\frac{\partial \widehat{P_s}}{\partial C} = -\frac{R_s^0}{(P_s)^2}e^{-r(T_1^*-s+\Delta T)}. \qquad (8)$$

Thus, we can predict that collective action problems in Japanese condominiums induce both lower prices and a more rapid decline in prices over time.

## 4. Number of units and collective action

In this section, we introduce the number of units in a condominium as a proxy for the difficulty of collective action. We first review the literature regarding relationships between the

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[8] In Eq. (5), 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 becomes the following:

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

This assumption makes the effects of the reconstruction delay more strongly negative than in Eq. (5), but it does not change any implications of the following discussion.

[9] Differentiating $P_t$ in Eq. (2) 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

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

size of a group and collective action, and then make assumptions about how the number of units in a condominium affects the collective decision-making process involved in reconstruction. To examine some of these assumptions, we conduct a simple regression analysis for the relationship between the number of units and the time involved in collective action.

### 4.1 Proxy of the difficulty of collective action

The difficulty of collective action involved in reconstruction depends crucially on the extent of diversity of interests among condominium owners. If the interests of condominium owners are alike, there will be little room for conflicts of interest and divergent opinions regarding reconstruction. No transaction costs will then arise from the decision-making process. However, unit owners can differ from each other in many respects, including expectations about future rental prices, their financial condition, the extent of any liquidity constraints, and costs involving collective action.

As mentioned, Japanese condominium law requires a high degree of uniformity among owners to execute a reconstruction. Therefore, it is easy to imagine that the collective decision-making process involved in condominium reconstruction becomes more complicated and inefficient as the number of owners increases. One of the leading studies on the relationship between group size and collective action is by Olsen (1965). Regarding condominiums, Hansmann (1991) and Barzel and Sass (1990) discuss the difficulty of collective decisions involving large numbers of owners from a legal and economic point of view. West and Morris (2003) also study collective decision-making in condominium reconstruction projects in the contexts of the law and economics 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 in reconstruction.

Following these literature studies, we may assume that an increase in the number of co-owners will make collective action more costly and potentially delay reconstruction. Consequently, in our empirical model, we use the number of units in each condominium as a proxy for the cost of the collective decision-making process. We hypothesize that its estimated coefficient in the price function of the condominium will be negative on the following grounds:

i. Having a large number of unit owners further complicates the process of collective decision-making in rebuilding condominiums, and thus delays reconstruction from the optimal timing.

ii. This additional difficulty in the collective decision-making process implies higher transaction costs, given that each unit owner living with a large number of other owners has to spend a longer time at and devote more effort toward achieving a collective decision relative to when fewer members are involved.

iii. A condominium comprising a larger number of units requires more time to reconstruct, so the cost per household during reconstruction tends to be higher as the number of units in the condominium increases. Here, residents will have to rent other housing while waiting for the reconstruction to be completed.[10]

The former point (i) is represented in equation (5), and the latter points (ii and iii) are expressed in (6). Although the final rationale (iii) is common to all condominiums, in Japan and elsewhere, the impacts of the former attributes (i and ii) can differ according to the efficiency of the mechanisms in condominium law.

### 4.2 Time required for collective action

In this subsection, we report on a simple regression analysis conducted to examine the first two assumptions (i and ii). In particular, we examine relationships between the number of owners of a condominium and the collective decision-making time. We use data provided by Meno (2004) and from a website[11] listing recently completed condominium reconstruction projects. The specification for the regression analysis is as follows:

$$\ln(TIME)_i = \alpha_0 + \alpha_1 \ln(UNITold)_i + \alpha_2 FAM_i + \alpha_3 UNITM_i + \alpha_4 SELFHAT_i$$

$$+\alpha_5 \ln(AGE)_i + \alpha_6 TOKYO_i + \varepsilon_i, \qquad (9)$$

where subscript $i$ indicates the $i$th condominium, *TIME* is the duration of the collective decision-making process surrounding reconstruction (in months),[12] *UNITold* is the number of

[10] Although the physical reconstruction cost itself may have a scale economy in terms of the number of units, we assume the cost of collective action as a whole is marginally increased with an increase in the number of owners. We examine this point further in Section 4, by comparing the price functions of condominiums and rental apartments that differ only in the collective action problem, not in the physical construction cost.

[11] 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.

[12] The duration of collective decision-making regarding reconstruction, *TIME*, is the number of years between the time when the first official meeting was held about reconstruction and the time when a consensus on reconstruction was reached. However, some data lack information on when the consensus was made. To cope with this problem, we obtain the time of the consensus by subtracting the estimated number of years for construction (the number of years required to tear down the old condominium and

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, *AGE* is the number of years that have passed between the time the old condominium was built and the time the first official meeting on the reconstruction takes place, *TOKYO* is a dummy variable indicating a condominium located in the Tokyo prefecture, and $\varepsilon$ is an error term.

Finally, *SELFHAT* is an 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 very serious and, consequently, requires less time for collective action. To take into consideration such an endogenous issue, we first use a probit estimate regressing *SELF* on *FAM*, *UNITM*, log(*AGE*), *TOKYO*, and *START* (the starting year of collective action) to obtain *SELFHAT*, the fitted value of *SELF*.

According to the basic statistics in table 1, reconstruction takes place after 39.52 years on average (ranging from 19 to 75 years) from the completion of the condominium, and the decision-making process takes 6.03 years on average (from 0.6 to 18.6 years) to achieve consensus on reconstruction. When looking at *FAM* and *UNITM*, we observe that reconstructed condominiums increase the total floor area and the number of units. In a newly reconstructed condominium, the total floor area and the number of units are increased on average by 176 and 79%, respectively. In fact, in only one condominium was the total floor area reduced after reconstruction. By expanding the total floor area of a condominium, owners can benefit from having more space in their own units, and they can sell extra units to cover the reconstruction cost, which will enable them to achieve consensus more easily.

*<<insert table 1 here>>*

The probit estimate of *SELF* is shown in column [2-1] in table 2. The coefficient of ln(*UNITold*) has a negative sign at the 5% significance level. This indicates that the collective action regarding reconstruction is more likely to be well managed without involving a third party if the number of property owners of the condominium is not large. Regarding other variables,

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build the new one) from the time of completion of a new condominium. The number of years for construction is estimated with coefficients obtained by regressing reconstruction time on the total floor area of the new condominium and the age of the old condominium, with samples having information on the duration of reconstruction.

only *TOKYO* shows a significant effect, at the 15% significance level, on *SELF*. This implies that collective decision-making in Tokyo is more difficult than in other prefectures, and therefore tends to involve a developer to manage the process efficiently.

*<<insert table 2 here>>*

Columns [2-2] and [2-3] in table 2 show estimation results for equation(9). In addition to ordinary least squares (OLS) estimates, we conduct a truncated regression because *TIME* is truncated in such a way that we do not observe the condominiums whose collective decision-making is still in progress.[13] The coefficients of ln(*UNITold*) show positive signs and they are statistically significant, verifying that an increase in the number of property owners requires more time to achieve consensus regarding reconstruction. In concrete terms, if the number of units doubles, the time needed for collective decision-making is extended by about 30%.

Regarding the other variables, the coefficients of *FAM* have positive signs. This may be because as part of the decision-making process, it takes more time to consider the method by which the surplus floor area will be used and operated. The coefficients of log(*AGE*) show that the time needed for collective decision-making is reduced by 45% if the age of the condominium is doubled. Although the significance levels are not strong (ranging from 10 to 15%), this result implies that property owners hurry their decision-making about reconstruction when their condominiums are more dilapidated. The coefficients of *SELFHAT* have remarkably negative effects on decision-making time, as expected, although their signs are not significant because of the presence of multicollinearity. Note that when we use *SELF* in (9) instead of the fitted value, the coefficients are -0.6623, with a 5% significance level in the truncated model, and -0.6609, with a 10% significance level in the OLS estimate.

Finally, coefficients of the variable *TOKYO* indicate that the collective decision-making time is about 47% longer in Tokyo than in other prefectures. Intuitively, this result makes sense because people in such a large city have various backgrounds and interests, which can complicate the process of collective action. Moreover, people relocate more frequently in Tokyo; thus, they are likely to have less incentive to contribute to community relations

[13] See Appendix 1 for a description of the truncated model in this case.

activities.[14]

These results verify that an increase in the number of owners of a condominium lengthens the collective decision-making process involved in reconstruction. However, if owners of condominiums are aware of the future reconstruction problem in advance, they may start collective action at an earlier stage to carry on the reconstruction at the optimal timing. To examine this issue, we regress ln(*AGE*) on ln(*UNITold*), *FAM*, and *TOKYO*.

As seen in the result in column [2-4] of table 2, 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. Regarding *TOKYO*, its coefficients show positive signs at the 10% significance level, meaning that condominium owners in Tokyo begin their discussion regarding reconstruction relatively late compared with those in other regions. As already implied in the former regression analyses, this provides additional evidence that people living in a metropolitan area such as Tokyo may have little interest in their neighborhood community and may feel reluctant to become involved in the management of their own condominiums.

To summarize, we verified that an increase in the number of units in a condominium prolongs the collective decision-making process and delays the timing of reconstruction. This corresponds to the fact that the number is positively correlated with $C$ and $\Delta T$. Therefore, we can use the number of unit owners of a condominium as a proxy variable for the collective action cost. We can then expect that the number of units will have a negative effect on the price of a condominium, as shown in equations (5) and (6). In addition, as derived in (7) and (8), if people expect a delay in reconstruction, or if they expect a high cost for the decision-making process, then the price will decline more rapidly than the price of an equivalent rental apartment that is not affected by collective action problems.

## 5 Estimation of the collective action cost in condominium reconstruction

[14] 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 local regions; about 28% of the population in local regions have no or almost no relationships with neighbors, whereas the percentage increases to 45% in metropolitan areas. The interviewees living in the metropolitan areas reported 1) being absent from home during the daytime, and 2) residents being rapidly replaced as the two main reasons for these shallow relationships among neighbors. The report (in Japanese) is available at http://www.mlit.go.jp/hakusyo/mlit/h17/hakusho/h18/html/H1022100.html.

### 5.1 Estimation models and hypotheses

We pursue the following strategy to examine whether a collective action cost exists in Japanese condominiums. First, we obtain two data sets on rental and property prices for Japanese apartments: one for condominiums and the other for rental apartments that do not have the above-mentioned collective action problem. We can then compare the estimated coefficients for the number of units and the age of the building for both the rent and price functions to extract a measure of the collective cost. We also estimate the rent and price functions of condominiums or cooperative apartments in the United States for comparison. Although condominiums in both Japan and the United States involve a potential collective action problem, their costs may be different because of differences between the two countries in condominium laws and the dwelling environments.

Secondly, by simultaneously estimating the rent and price functions, we consider the endogenous decision of household tenure choice to own or rent. However, if we directly estimate each rent and price function using the OLS method, the estimation results might be biased. Therefore, we apply the two-step estimation procedure of Heckman (1979) to address the problems of endogeneity and sample selection bias. In the first stage of the procedure, we use a probit model to estimate the tenure choice function and to obtain the estimated inverse Mills ratios. In the second stage, we estimate the rent and price functions by OLS, with estimated inverse Mills ratios included as explanatory variables. Appendix 2 describes how to obtain the inverse Mills ratios and provides the estimation results of the tenure choice functions for condominiums in Japan and the United States.

We assume log linearity for the rent function in Eq. (10) with a constant term, an estimated inverse Mills ratio, $\hat{\lambda}_i^{Rent}$, and a stochastic error term, $\varepsilon_i^R$. We now have:

$$\ln(Rent_i) = \beta_0 + \boldsymbol{x}_i\boldsymbol{\beta}_1 + \beta_2 \ln(units_i) + \beta_3 \ln(age_i) + \beta_4 \hat{\lambda}_i^{Rent} + \varepsilon_i^R, \quad (10)$$

where subscript $i$ indicates an individual unit or building. Recall that $\boldsymbol{x}_i$ is a vector of variables determining the level of dwelling service, and $units_i$ and $age_i$ are the number of units and the age of the building, respectively.

In the rent function (10) to be estimated, we expect that the costs of collective action will have no effect on the rent because it is a matter for owners of a condominium, not for tenants.

Therefore, the number of units will not have a direct influence on the rent because of the collective action problem, although it may impose externalities for residents, given the presence of public goods property. For instance, an increase in the number of residents may bring about a feeling of insecurity because of the anonymity of owners and renters, and at the same time, condominiums with a large number of units may have ample common facilities, such as a larger lobby with a splendid chandelier and a stately cortile.

These externalities and public goods properties indeed reflect the rent but not the price directly because housing services of better quality increase the utility to residents. Thus, a higher utility level shifts the demand curve for housing upward to increase the current rent, which results in a higher price. It is noteworthy that if we control for the rent with the adequate variables, the external effect and the public goods property should not directly affect the price of the condominium. Rather, they can have an effect on the price only when they influence the current rent.

We next define the price function. We assume that the asset price of a condominium is a function of its current and future rent, the cost related to reconstruction, the expected delay in the timing of the reconstruction, and other discount factors, such as the rates of interest, depreciation, and property taxation. In accordance with this assumption, we define the price function of a condominium (before the first reconstruction) as

$$P_s = f\left(R_s^0, r, \delta, R_{T_m}^m, \Delta T(units), C(units)\right). \tag{11}$$

Recall that $\Delta T(units)$ and $C(units)$ are the reconstruction delay and the cost related to reconstruction, respectively, both of which we regard as major components of the collective action problem. Because we assume that these factors are increasing functions of the number of units, the number of units negatively affects the condominium price in both cases, as explained in Section 4.[15]

We estimate the following price function for condominiums:

$$\ln(Price_i) = \gamma_0 + \boldsymbol{z}_i\boldsymbol{\gamma}_1 + \gamma_2 \ln(\widehat{Rent}_i) + \gamma_3 \ln(units_i) + \gamma_4 \ln(age_i) + \gamma_5 \hat{\lambda}_i^{Own} + \varepsilon_i^P, \tag{12}$$

where $\ln(\widehat{Rent}_i)$ is a logarithmic value of the rent estimated in (10), and $\boldsymbol{z}_i$ is a vector of

[15] We can omit some discount variables, such as the interest rate and the property tax rate, by inserting year dummies.

variables that directly affect the condominium price rather than affecting it through rent.[16] Our hypothesis is that the condominium price correlates negatively with the number of units, hence $\gamma_3 < 0$. In addition, by using the estimation value of the current rent, we can compare the speed of decline in the property price of Japanese condominiums with that of rental apartments. Equations (7) and (8) imply that the speed of decline in the Japanese condominium price is faster than that for an apartment that does not have the collective action problem. Thus, we expect the coefficient $\gamma_4$ to be smaller than the coefficient estimated for rental apartments.[17]

## 5.2. Data

### 5.2.1 Japanese condominiums

We obtained data on Japanese condominiums from Tokyo Kantei, an independent real estate information service.[18] The data include the time distance from the central business district, offered rent (the rental price listed by owners in the housing market), price, number of floors, floor space, number of bedrooms, and so forth, all of which were collected in 2005 for the Tokyo area alongside Japan Railway's Chuo, Keio, and Odakyu lines. Although the original data do not indicate whether the building containing each unit is a condominium, we use data on apartments that provide information on units available for both for sale and rent, and hence can guarantee that they are condominiums. Note also that the data on the rent and the price of condominiums are not transaction data but the prices offered by existing co-owners. Thus, if we have more than a single observation for the same unit in different months, we extract only the most recent observation to collect the transaction price data, although the possibility remains that the owners may have withdrawn some of the units from the market list.

### 5.2.2 Rental apartments

We next obtain data on rental apartments for comparison. Since a single owner (or corporation through a REIT) owns each rental apartment, owners of rental apartments are able to carry out maintenance, rehabilitation, and reconstruction based on their own decisions and thus do not encounter the problems associated with collective action. We collect data on rental

[16] Dummy variables for years of purchase are included to control for the impact of changes in interest rates and property taxes on prices induced by the macroeconomy.
[17] We could also use the cross-terms of unit number and building age as explanatory variables to capture the effects indicated in the model. However, the variances of the coefficients for verifying our hypothesis become substantially large because of the presence of multicollinearity and the limitations on sample size. For our empirical setting, we separately specify the number of units and building age as explanatory variables, and leave further technical analysis as a future research direction.
[18] For the Tokyo Kantei Co., see the company homepage at http://www.kantei.ne.jp/ .

apartments, including the asset sales price and rental revenue of each building and its attributes, partly from Tokyo Kantei and partly from Japan REIT (JREIT).[19] Because the data on rental apartments from Tokyo Kantei provide the offer price, we extract samples in the same manner as for Japanese condominiums. In contrast, the price data in JREIT are transaction values, and their years of purchase range from 2002 to 2006. The data on rental revenue from Tokyo Kantei are for 2005, whereas the data from JREIT range from 2005 to the first half of 2006.

#### 5.2.3 U.S. condominiums

From the National American Housing Surveys (hereafter referred to as AHS)[20] conducted in 2002, 2004, 2005, and 2007, we use samples whose housing type is in the "condominium or cooperative" category. The data include such housing characteristics as the variables available in Japanese condominiums. However, unlike the data on Japanese condominiums, AHS has the transaction price and the date of purchase of the property if the household owns the property, and the current rental price if the household rents the property. Table 3 defines the variables used in equations (10) and (12), and table 4 provides descriptive statistics.

*<<insert Table 3 and 4 here>>*

### 5.3 Estimation results

The estimation results for the rent function (except for the coefficients for the regional dummies and year dummies) are presented in table 5. The two-step and OLS estimators for Japanese condominiums are shown in table 5 in columns [5-1] and [5-2], respectively, and the OLS estimators for rental apartment are shown in column [5-3]. The estimation results for condominiums in the United States are shown in columns [5-4] and [5-5].

*<<insert Table 5 here>>*

Let us first look at the coefficients of the number of units, ln(*UNITS*), for Japanese condominiums and rental apartments. The coefficients of ln(*UNITS*) for Japanese condominiums are negative and statistically significant, whereas the coefficients for rental apartments are not significant; the rent for a Japanese condominium decreases by about 4% if the number of units in the condominium building doubles. One possible explanation for this is that

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[19] For JREIT, see the homepage at http://www.ares.or.jp/jreit_e/index.html .

[20] Microdata of AHS were obtained from the United States Census Bureau website, available at http://www.census.gov/housing/ahs/.

efficient maintenance of condominiums is prevented because of the collective action problem among a large number of residents. Not only reconstruction, but also some important building maintenance, such as earthquake retrofitting, elevator maintenance, and building pest control, require consensus with three-fourths agreement or more among property owners. Regarding condominiums in the United States, the coefficient of ln(*UNITS*) is 0.049, with a 10% significance level by OLS; however, we did not find a significant effect for the two-step estimate. The positive effect of ln(UNITS) indicates that larger condominiums in the United States may have more variety of facilities such as a swimming pool and a recreation room. As expected, the age of the building, ln(*AGE*+1), has a negative effect on the rent in all types of apartments.

On the contrary, some other coefficients display different signs between condominiums in the two countries. For instance, when we look at coefficients of ln(*TIME*), although the time to the workplace has a positive correlation with the rent for condominiums in the United States, coefficients of the time to the central business district show negative signs in Japan. The floor level of a condominium unit, ln(*FLEVEL*+1), and the number of bedrooms, ln(*BEDRM*+1), also show different effects on prices between condominiums in Japan and the United States. Furthermore, the number of stories in a condominium building, ln(*STORIES*), has a great impact on the rent for condominiums in the United States. One of the main reasons for these differences may be that some of the condominium samples in AHS reported the floor level as being on the first floor even though these housing units actually have two stories. The samples of these kinds of two-floor luxury condominiums may have resulted in ln(*STORIES*) and ln(*BEDRM*+1) having positive signs and ln(*FLEVEL*+1) having a negative sign.

We now move on to the price functions. Using the estimated values of rent in columns [5-1] to [5-5] in table 5, we obtain the corresponding price functions shown in columns [6-1] to [6-5] in table 6. When we look at the coefficients of ln(*UNITS*), we find that Japanese condominiums are the only apartment type whose coefficients show significant negative signs. According to column [6-1], the price of Japanese condominiums decreases by 2.34% when the number of units doubles. On the contrary, the coefficients of ln(*UNITS*) in the price functions of rental apartments and condominiums in the United States are not statistically different from zero. These results appear to confirm the devaluation of condominiums in Japan resulting from the inefficiency of Japanese condominium law, causing a serious collective action problem.

*<<insert Table 6 here>>*

When comparing the coefficients for ln(*AGE*+1), we find a tendency for Japanese condominiums to be valued lower than the other two types of apartments as the building becomes older. This appears to reinforce our hypothesis that the collective action problem for Japanese condominiums accelerates the rate of decline in prices. In this regard, however, we cannot simply compare the magnitude of coefficients across different types of apartments because we have not successfully treated the sample selection bias in these estimations. Accordingly, we carry out a robustness check by estimating the following regressions with a more careful treatment of the data.

### 5.4 Robustness check

This subsection aims to examine the differences in coefficients of the rent and price functions among buildings with different types of contracts. For this purpose, we consider two statistical problems. The first problem is the limits of our chosen econometric methods in handling the endogeneity of the tenure choice problem. Condominium data include both rented and owner-occupied units, enabling us to use a probit model to estimate the tenure choice function. On the contrary, by its very nature, the rental apartment data do not contain observations on owner-occupied housing. As a result, in the first analysis, in which we estimated the rental and price functions separately by type of building, we apply only the two-step regression procedure to the condominium data.

A second problem arises from bias in the distribution of housing characteristics. In conducting a comparison analysis of hedonic housing price functions that include two or more types of apartments, it is necessary to cope with sample bias problems so that prices and error terms of the functions are not correlated across apartment types. However, as can be seen in the basic statistics presented in table 4, Japanese condominiums tend to be larger than the other two types; in addition, rental apartments are new. These biases are due to the different methods of collecting samples of each apartment type and to the endogeneity problem of developers deciding which type of apartment to build, namely, condominiums or rental apartments.

With these conditions in mind, we conduct a second analysis as follows. First, we select samples by limiting the number of units and the building ages.[21] By using propensity score-matching methods, we then extract rental apartments and condominiums in the United States that have characteristics similar to the Japanese condominiums.[22] Secondly, by using the selected pooled data on Japanese condominiums with rental apartments and on condominiums in the United States, we estimate the rent and price functions with cross-terms of variables and a dummy variable indicating Japanese condominiums. These cross-terms enable us to compare the coefficients of variables between Japanese condominiums and the other apartment type. For rental apartments, we use the extrapolated inverse Mills ratio for the tenure choice problem, based on estimated tenure choice functions regarding Japanese condominiums. This estimation method is carried out successfully under the assumption that housing units in a rental apartment are treated in the same manner by households as housing units in a condominium upon the tenant's or owner's tenure choice.

#### 5.4.1 Japanese condominiums compared with rental apartments

We first look at estimations comparing Japanese condominiums with rental apartments. Table 7 shows the estimation results for the rent functions. The first three columns, [7-1] to [7-3], are results based on OLS and the remaining three columns, [7-4] to [7-6] are based on the two-step method. Each column shows an estimation using samples selected by a different range of calipers in the propensity score matching. As we restrict the range of calipers from 0.5 to 0.1, we observe that the sample size becomes small and standard errors for the estimates increase. *D* in this table indicates the condominium dummy; therefore, cross-terms, such as *D**ln(*UNITS*), show the difference in coefficients of the variables in the rent function of Japanese condominiums from the coefficients of rental apartments.

*<<insert Table 7 here>>*

The coefficients of ln(*UNITS*) are all positive, although these significance levels are not strong enough to have an influence on the rent. On the contrary, *D**ln(*UNITS*) has a negative effect on the rent, implying that the rent of Japanese condominiums devalues more than the rent of rental apartments when the number of units increases, while its significance level is at most

[21] In particular, we excluded apartments that contained more than 100 units and those built before 1981, when the Japanese government began to require all buildings to be built using new earthquake-resistance standards.

[22] Appendix 3 briefly describes the algorithm for the propensity score-matching methods we use to conduct the analysis and estimate the propensity scores.

10%. Recall that when we estimate the rent functions separately by apartment type with full observations, we observe a significant negative effect on rent of the number of units for Japanese condominiums but no effect for the others. However, when we compare the coefficients between apartment types after treatment of the selection bias issues, we do not find strong statistical evidence of a difference. In this sense, the question of whether a collective action problem exists in terms of the maintenance of condominium buildings remains ambiguous. A larger sample size may be required to verify the collective action problem in condominium maintenance. Alternatively, collective decision-making in building maintenance may not actually be problematic enough that it can be verified statistically. In fact, the coefficients of *D**ln(*AGE*+1) are not significantly different from zero, meaning that there is little difference in the speed of depreciation of rental values between Japanese condominiums and rental apartments. For other variables that are relevant to both apartment types, such as *TIME*, *STORIES*, and *EV*, their cross-terms also have no influence on the rent. These results imply that little structural difference in rent functions exists between Japanese condominiums and rental apartments; the *F*-test does not reject, at a 10% significance level, the hypothesis that the coefficients of ln(*UNITS*), ln(*AGE*+1), ln(*TIME*), ln(*STORIES*), and *EV* are equal.

Table 8 provides estimation results for the price function. The estimation results are consistent with the results of the earlier estimations using separated data. The coefficients of *D**ln(*UNITS*) show that the condominium price declines by about 6.9 to 8.8% compared with the price change in rental apartments as the number of units in the building doubles. Further, we observed a significant difference for the coefficient of ln(*AGE*+1) between the two apartment types. Although the price of rental apartments decreases by merely 4.4 to 7.1% as the age of the building doubles, condominiums devalue by an extra 18.7 to 21.1%. These results provide further evidence of the existence of a collective action cost related to the reconstruction problem in Japanese condominiums. Although even easy building maintenance requires three-fourths agreement or more among owners, reconstruction involves all residents in the weighty task of negotiations. As mentioned, an extremely high degree of agreement among condominium owners is necessary for reconstruction because of the current condominium law in Japan; thus, considerable time and energy are required to achieve consensus.

*<<insert Table 8 here>>*

### 5.4.2 Condominiums in Japan compared with the United States

One of the ways to examine Japanese condominium law is by conducting a comparative analysis among societies with different legal systems. Although controlling all other factors to extract the effect of the collective action problem would seem to be a challenging task, it is worth analyzing this problem by using U.S. condominiums for comparison. We select U.S. condominiums having characteristics similar to Japanese condominiums and then examine the rent and price functions in the same manner as in the previous analysis. The estimation results for the rent functions are presented in table 9. As with the previous estimates for Japanese condominiums and rental apartments, we do not find significant differences in the coefficients of ln(*UNITS*) and ln(*AGE*+1) between condominiums in Japan and the United States. The rent function for condominiums in the United States is different from that in Japan in that the age of the building, the number of bedrooms, the time to the workplace, and the floor level of the unit have no influence on the rent. Recall that in table 5, in which we present estimates of the rent functions separately by apartment type, the coefficients of ln(*AGE*+1) show significant negative signs; however, they are no longer significant after the sample selection treatment, in which we restrict the samples of condominiums to those built after 1981. Regarding the number of bedrooms, although it seems natural to assume a negative sign for the coefficient because of scale economies, the coefficient does not show the expected sign in the case of U.S. condominiums. This may be because the housing size and the quality of the dwelling may be positively correlated in the United States; for instance, residents may have better neighbors and live in a better environment in areas where the housing size is larger, or larger condominium units may be more likely to be equipped with better furniture and facilities in the United States.

*<<insert Table 9 here>>*

Finally, Table 10 shows the estimated price functions. We can see positive signs for the coefficients of ln(*UNITS*), some of which are statistically different from zero. This implies that in the United States, people have some positive expectations about the future rent of condominiums. Recall that in the United States, the land on which condominiums are constructed can be used in various ways after the condominiums are terminated, whereas Japanese condominium law naturally allows only reconstruction of condominiums on those lands. In general, a highly productive property, such as a commercial facility and office building, requires a sufficiently large tract of land, whereas it is difficult to use land productively if it is too small. Accordingly, the number of units, which correlates positively with the size of the land, may have a positive effect on the price of condominiums in the United States. The coefficients of $D$*ln($UNITS$) and $D$*ln($AGE$+1) are negative and statistically significant, indicating that Japanese condominiums devalue more as the number of units and the age of the building increase compared with condominiums in the United States. These results suggest that a revision in Japanese condominium law may reduce the collective action cost and, at the same time, improve the productivity of land use along with condominium redevelopment in the future.

*<<insert Table 10 here>>*

## 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 more than 30 years ago, and many of them are in need of restructuring to meet earthquake-resistance standards. However, the complexity and difficulty of the collective decision-making process involved in reconstruction prevents old condominiums from being redeveloped efficiently.

The purpose of this paper is to examine whether a collective action cost exists for Japanese condominiums. Initially, by using 64 cases of condominium reconstruction projects in Japan, we find that the time used for collective decision-making regarding reconstruction becomes longer as the number of units in the condominium increases; in essence, the estimation results indicate that if the number of units doubles, the collective decision-making time involved in reconstruction will increase by about 30%.

By using the number of units as a proxy for the difficulty of collective action, we then estimate both the rent and price functions for Japanese condominiums as well as for two other types of apartment buildings, rental apartments in Japan and condominiums in the United States. Here, we use rental apartments for comparison with condominiums because rental apartments are owned by single owners and do not naturally involve collective action problems. We also obtain data on condominiums in the United States to explore the effect of the difference in condominium laws. Estimating the price functions, we use estimated values for rent obtained from the rent functions. This enables us to identify the direct effect of the number of units on the price. Collective action problems involved in rebuilding may have a direct effect on the property price of condominiums, but not through a change in the current rent.

The results show that, among the three types of buildings, only the price of Japanese condominiums is negatively affected by the number of units. This implies that a remarkable cost of collective action problems is inherent in condominium ownership in Japan. We also compare the coefficients of price functions between Japanese condominiums and two other types of buildings after carefully considering the sample selection bias. The coefficients for the number of units and the age of the building in the price functions of Japanese condominiums are significantly lower than those for the other two types of dwellings. The results confirm the existence of a collective action cost for Japanese condominiums, which implies that the current condominium law in Japan is preventing condominium owners from engaging in an efficient decision-making process for reconstruction and from productive land use, and thus requires revision.

The present analysis does not consider the effect of the tenure security law in Japan, which prevents owners from evicting renters. Such eviction control may bring about further difficulties in rebuilding. In this situation, owners consenting to reconstruction not only have to persuade dissenting owners to comply, but also have to evict any renters. Because the tenancy law in Japan excessively secures renters against eviction, it reinforces condominium law in discouraging the incentive for rebuilding. Accordingly, we may have to distinguish between the condominium discount assumed by the condominium law itself and that arising from the tenant protection law. A challenge for future research is to separate the effects of tenant protection law and condominium law in Japan.

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Table 1. Descriptive statistics for 64 cases of condominium reconstruction in Japan.

| Variable | Description | Minimum | p50 | Maximum | Mean | S.D. |
|---|---|---|---|---|---|---|
| *TIME* | Months spent on collective decision-making | 0.6 | 4.9 | 18.6 | 6.03 | 4.59 |
| *YEARold* | Year when the construction of a previous condominium was completed | 1926 | 1962 | 1981 | 1961.49 | 11.11 |
| *YEARnew* | Year when the reconstruction of a new condominium was completed | 1975 | 2004 | 2012 | 2001.01 | 8.32 |
| *START* | Year when the first meeting on the reconstruction was held | 1969 | 1992.4 | 2008.5 | 1994.73 | 9.34 |
| *RecAGE* | Number of years between the year of completion of a new and a previous condominium | 19 | 38 | 74 | 39.52 | 11.31 |
| *AGE* | Number of years between the year when a previous condominium was completed and the year when residents began to discuss reconstruction | 13 | 33 | 59.5 | 33.66 | 10.34 |
| *UNITold* | Number of housing units in a previous condominium | 16 | 62.5 | 368 | 89.19 | 83.03 |
| *UNITnew* | Number of units in a new condominium | 20 | 96.5 | 644 | 150.71 | 136.03 |
| *FAold* | Floor area ($m^2$) of a previous condominium | 880 | 3,400 | 18,510.87 | 4,737.26 | 3,722.33 |
| *FAnew* | Floor area ($m^2$) of a new condominium | 1,166 | 9,274.19 | 57,336.67 | 13,438.65 | 12,287.30 |
| *FAM* | Ratio of increase in floor area after the reconstruction | 0.82 | 2.62 | 6.34 | 2.76 | 1.09 |
| *UNITM* | Ratio of increase in the number of units after the reconstruction | 0.71 | 1.63 | 4.2 | 1.79 | 0.73 |
| *SELF* | Dummy variable indicating that a reconstruction was conducted by residents (without the support of a developer) | 0 | 0 | 1 | 0.09 | 0.28 |
| *TOKYO* | Dummy variable indicating a condominium is located in the Tokyo prefecture | 0 | 1 | 1 | 0.58 | 0.50 |

*Source:* Meno (2004), and a website listing past reconstructions ( http://www.manshon.jp/tatekae/ta_jirei_index.html ).

Table 2. Estimations of collective action time in reconstruction.

| | [2-1] | [2-2] | [2-3] | [2-4] |
|---|---|---|---|---|
| | Model | | | |
| | Probit | Truncated | OLS | OLS |
| Dependent variable | *SELF* | ln(*TIME*) | ln(*TIME*) | ln(*AGE*) |
| ln(*UNITold*) | -1.3421** | 0.2938** | 0.2954** | 0.0166 |
| | (0.5410) | (0.1262) | (0.1324) | (0.0465) |
| *FAM* | -0.1357 | 0.1864** | 0.1869* | 0.0303 |
| | (0.2500) | (0.0911) | (0.0957) | (0.0435) |
| *UNITM* | | -0.0069 | -0.0047 | |
| | | (0.1221) | (0.1282) | |
| *TOKYO* | -0.8876+ | 0.4724*** | 0.4705** | 0.1357* |
| | (0.5546) | (0.1814) | (0.1906) | (0.0751) |
| ln(*AGE*) | 0.3724 | -0.4417* | -0.4469+ | |
| | (1.0147) | (0.2623) | (0.2759) | |
| *SELFHAT* | | -0.5460 | -0.5330 | |
| | | (0.7041) | (0.7403) | |
| *START* | -0.0220 | | | |
| | (0.0389) | | | |
| *LAMBDA* | | 0.6681*** | | |
| | | (0.0511) | | |
| *CONSTANT* | 47.1534 | 1.0562 | 1.0598 | 3.2352*** |
| | (75.5879) | (1.0535) | (1.1098) | (0.1944) |
| Observations | 64 | 64 | 64 | 64 |
| $R^2$ | | | 0.346 | 0.069 |
| Log likelihood | -14.25 | -64.73 | | |

***, **, *, + indicate statistical significance at the 1, 5, 10, and 15% levels using two-sided tests. Figures in parentheses are robust standard deviations. OLS: ordinary least squares.

Table 3. Variables in the rent and price functions.

| Variable | Definition |
|---|---|
| Rent function | |
| *RENT* | Offer monthly rent plus service charge divided by floor space (¥/m$^2$ or \$/ft$^2$). Offer monthly rent is a price listed by owners in the housing market. |
| *UNITS* | Total number of dwelling units in the apartment building |
| *AGE* | Age of the apartment (months) |
| *TIME* | Walking time from the apartment to the central business district/workplace (minutes) |
| *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 |
| *SOUTH* | Binary variable indicating a unit with south-facing windows |
| *CORNER* | Binary variable indicating a unit located on a corner of the floor |
| *NEW* | Binary variable indicating an apartment built within the last year |
| *BRAND* | Binary variable indicating an apartment managed by one of the seven most highly valued real estate companies (Mitsui, Nomura, Daikyo, Sumitomo, Tokyu, Tokyotatemono, Mitsubishizisyo, Touwa) |
| *LAMBDA* | Estimated inverse Mills ratio, $\hat{\lambda}_i^{Rent}$ |
| *YEAR* | Year dummies for data sources and time of purchasing the property |
| *REGION* | Regional dummies for cities/metropolitan areas |
| Price function | |
| *PRICE* | Offer price (condo) and sale price (rental apartment), each divided by floor space (¥10,000/m$^2$)/(\$/ft$^2$) |
| *RENTHAT* | Estimated value of the rent (¥/m$^2$)/(\$/ft$^2$) |
| *UNITS* | Total number of dwelling units in the apartment building |
| *AGE* | Age of the apartment (months) |
| *RENOVATED* | Binary variable indicating a unit maintained prior to selling |
| *LAMBDA* | Estimated inverse Mills ratio, $\hat{\lambda}_i^{Own}$ |
| *YEAR* | Year dummies for data sources and time of purchasing the property |
| *REGION* | Regional dummies for cities/metropolitan areas |

Table 4. Basic statistics on variables used in the rent and price functions.

| Variable | | | Minimum | p50 | Maximum | Mean | S.D. |
|---|---|---|---|---|---|---|---|
| *RENT* | [CJ] | (¥10,000/$m^2$) | 0.12 | 0.29 | 0.54 | 0.30 | 0.09 |
| | [RA] | (¥10,000/$m^2$) | 0.16 | 0.39 | 0.70 | 0.40 | 0.10 |
| | [CU] | ($/$ft^2$) | 0.14 | 0.88 | 3.73 | 0.97 | 0.49 |
| *PRICE* | [CJ] | (¥10,000/$m^2$) | 13.92 | 44.64 | 94.12 | 44.71 | 16.07 |
| | [RA] | (¥10,000/$m^2$) | 23.22 | 73.07 | 163.52 | 75.38 | 25.89 |
| | [CU] | ($/$ft^2$) | 12.33 | 98.30 | 461.77 | 119.68 | 79.98 |
| *UNITS* | [CJ] | | 6 | 94 | 1192 | 180.93 | 234.97 |
| | [RA] | | 3 | 28 | 288 | 38.92 | 34.87 |
| | [CU] | | 2 | 10 | 747 | 37.98 | 79.93 |
| *AGE* | [CJ] | (year) | 1 | 22 | 46 | 21.70 | 9.71 |
| | [RA] | (year) | 0 | 3 | 43 | 7.36 | 8.40 |
| | [CU] | (year) | 0 | 22.5 | 44.5 | 22.58 | 11.69 |
| *Year of completion* | [CJ] | | 1959 | 1983 | 2005 | 1983.30 | 9.71 |
| | [RA] | | 1968 | 2004 | 2006 | 2001.38 | 5.48 |
| | [CU] | | 1962.5 | 1982.5 | 2006 | 1981.53 | 11.56 |
| *TIME* | [CJ] | (minutes) | 1 | 21 | 56 | 21.74 | 12.64 |
| | [RA] | (minutes) | 3 | 15 | 55 | 17.67 | 9.76 |
| | [CU] | (minutes) | 0 | 20 | 180 | 22.57 | 19.58 |
| *BEDRM* | [CJ] | | 0 | 2 | 3 | 1.54 | 1.27 |
| | [RA] | | 1 | 1 | 1 | 1.00 | 0.00 |
| | [CU] | | 0 | 2 | 4 | 1.96 | 0.68 |
| *SPACE* | [CJ] | ($m^2$) | 10.44 | 47.98 | 130.67 | 46.48 | 22.76 |
| | [RA] | ($m^2$) | 2.63 | 32.71 | 257.56 | 40.38 | 29.89 |
| | [CU] | ($ft^2$) | 99.00 | 1,049.50 | 3,500.00 | 1,114.61 | 404.48 |
| *FLEVEL* | [CJ] | | 1 | 4 | 31 | 4.89 | 3.52 |
| | [RA] | | 1 | 3 | 15 | 3.70 | 2.11 |
| | [CU] | | 1 | 1 | 21 | 2.10 | 2.89 |
| *STORIES* | [CJ] | | 3 | 9 | 31 | 8.99 | 4.64 |
| | [RA] | | 2 | 6 | 30 | 7.41 | 4.22 |
| | [CU] | | 1 | 2 | 21 | 3.56 | 3.94 |
| *FLRATIO* | [CJ] | | 0.08 | 0.56 | 4.29 | 0.56 | 0.28 |
| | [RA] | | 0.50 | 0.50 | 0.50 | 0.50 | 0.00 |
| | [CU] | | 0.05 | 0.50 | 1.00 | 0.61 | 0.26 |
| *BRAND* | [CJ] | | 0.00 | 0.00 | 1.00 | 0.11 | 0.31 |
| | [RA] | | — | — | — | — | — |
| | [CU] | | — | — | — | — | — |
| *NEW* | [CJ] | | — | — | — | — | — |
| | [RA] | | 0 | 0 | 1 | 0.15 | 0.35 |
| | [CU] | | 0 | 0 | 1 | 0.07 | 0.25 |
| *EV* | [CJ] | | 0 | 1 | 1 | 0.83 | 0.38 |
| | [RA] | | 0 | 1 | 1 | 0.63 | 0.48 |
| | [CU] | | 0 | 0 | 1 | 0.20 | 0.40 |
| *CORNER* | [CJ] | | 0 | 1 | 1 | 0.60 | 0.49 |
| | [RA] | | — | — | — | — | — |
| | [CU] | | — | — | — | — | — |
| *SOUTH* | [CJ] | | 0 | 0 | 1 | 0.25 | 0.43 |
| | [RA] | | — | — | — | — | — |
| | [CU] | | — | — | — | — | — |
| *RENOVATED* | [CJ] | | 0 | 0 | 1 | 0.09 | 0.28 |
| | [RA] | | — | — | — | — | — |
| | [CU] | | — | — | — | — | — |

[CJ]: Condominiums in Japan; [RA]: rental apartments in Japan; [CU]: condominiums in the United States.

Table 5. Rent functions by apartment type.

| | [5-1] | [5-2] | [5-3] | [5-4] | [5-5] |
|---|---|---|---|---|---|
| | Apartment type | | | | |
| | Japanese condominium | | Rental apartment | U.S. condominium | |
| Model | Heckit | OLS | OLS | Heckit | OLS |
| ln(*UNITS*) | -0.0426*** | -0.0417*** | 0.0098 | -0.0266 | 0.0490* |
| | (0.0084) | (0.0088) | (0.0213) | (0.0284) | (0.0273) |
| ln(*AGE*+1) | -0.1230*** | -0.1107*** | -0.0789*** | -0.2236*** | -0.1174*** |
| | (0.0127) | (0.0126) | (0.0167) | (0.0382) | (0.0378) |
| ln(*TIME*) | -0.0752*** | -0.0744*** | -0.0857** | 0.0697** | 0.0374 |
| | (0.0237) | (0.0236) | (0.0339) | (0.0275) | (0.0277) |
| ln(*BEDRM*+1) | -0.1254*** | -0.2790*** | | 0.3689*** | -0.2250** |
| | (0.0296) | (0.0125) | | (0.1267) | (0.0986) |
| ln(*FLEVEL*+1) | 0.0382*** | 0.0331*** | | -0.2283*** | -0.0491 |
| | (0.0099) | (0.0102) | | (0.0590) | (0.0540) |
| ln(*STORIES*) | 0.0141 | 0.0154 | 0.0292 | 0.4204*** | 0.1181* |
| | (0.0196) | (0.0203) | (0.0421) | (0.0751) | (0.0711) |
| *EV* | -0.0195 | 0.0330 | -0.0667* | 0.1573* | 0.0344 |
| | (0.0244) | (0.0230) | (0.0400) | (0.0909) | (0.0925) |
| *BLAND* | | | 0.0832*** | | |
| | | | (0.0274) | | |
| *NEW* | | | -0.1807*** | | |
| | | | (0.0613) | | |
| *SOUTH* | -0.1014*** | -0.0180+ | | | |
| | (0.0188) | (0.0122) | | | |
| *CORNER* | -0.0472*** | -0.0083 | | | |
| | (0.0160) | (0.0143) | | | |
| *LAMBDA* | -2.8700*** | | | -4.8487*** | |
| | (0.5512) | | | (0.6508) | |
| Observations | 679 | 679 | 502 | 548 | 562 |
| $R^2$ | 0.8340 | 0.8241 | 0.5822 | 0.3838 | 0.3263 |

Dependent variable is ln(*RENT*). ***, **, *, + indicate statistical significance at the 1, 5, 10, and 15% levels using two-sided tests. Figures in parentheses are robust standard deviations. Coefficients of dummy variables for regions and years of data are not shown in the table. OLS: ordinary least squares. Heckit: Heckman's two-step estimates.

Table 6. Price functions by apartment type.

| | [6-1] | [6-2] | [6-3] | [6-4] | [6-5] |
|---|---|---|---|---|---|
| | Apartment type | | | | |
| | Japanese condominium | | Rental apartment | U.S. condominium | |
| Model | Heckit | OLS | OLS | Heckit | OLS |
| *RENTHAT* | 0.3561*** | 0.2440*** | 0.5938** | 0.5725*** | 0.5478** |
| | (0.0977) | (0.0591) | (0.2439) | (0.1670) | (0.2573) |
| ln(*UNITS*) | -0.0234** | -0.0257** | 0.0056 | 0.0246 | 0.0154 |
| | (0.0102) | (0.0101) | (0.0199) | (0.0225) | (0.0361) |
| ln(*AGE*+1) | -0.2849*** | -0.3008*** | -0.0722*** | -0.0681+ | -0.0788** |
| | (0.0234) | (0.0208) | (0.0148) | (0.0432) | (0.0363) |
| *LAMBDA* | 0.7807** | | | 0.1826 | |
| | (0.3874) | | | (0.3271) | |
| *RENOVATED* | 0.0495** | 0.0538*** | | | |
| | (0.0193) | (0.0191) | | | |
| Observations | 577 | 577 | 478 | 1,003 | 1,058 |
| $R^2$ | 0.7945 | 0.7946 | 0.7020 | 0.4017 | 0.4085 |

Dependent variable is ln(*PRICE*). ***, **, *, + indicate statistical significance at the 1, 5, 10, and 15% levels using two-sided tests. Figures in parentheses are robust standard deviations. Coefficients of dummy variables for regions and years of data or purchase are not shown in the table. OLS: ordinary least squares. Heckit: Heckman's two-step estimates.

Table 7. Rent function: Condominiums and rental apartments in Japan.

| | [7-1] | [7-2] | [7-3] | [7-4] | [7-5] | [7-6] |
|---|---|---|---|---|---|---|
| | Model | | | | | |
| | Heckit | | | OLS | | |
| Caliper | $\delta = 0.5$ | $\delta = 0.3$ | $\delta = 0.1$ | $\delta = 0.5$ | $\delta = 0.3$ | $\delta = 0.1$ |
| ln(*UNITS*) | 0.0192 | 0.0224 | 0.0144 | 0.0345+ | 0.0362+ | 0.0357 |
| | (0.0243) | (0.0256) | (0.0297) | (0.0225) | (0.0240) | (0.0272) |
| ln(*AGE*+1) | -0.0626*** | -0.0643*** | -0.0700*** | -0.0758*** | -0.0803*** | -0.0851*** |
| | (0.0141) | (0.0146) | (0.0169) | (0.0172) | (0.0183) | (0.0218) |
| ln(*BEDRM*+1) | -0.1705*** | -0.1705*** | -0.1705*** | -0.2778*** | -0.2778*** | -0.2778*** |
| | (0.0636) | (0.0637) | (0.0642) | (0.0180) | (0.0180) | (0.0181) |
| ln(*TIME*) | -0.0865** | -0.0857** | -0.0688* | -0.0829** | -0.0874** | -0.0736** |
| | (0.0355) | (0.0374) | (0.0351) | (0.0334) | (0.0352) | (0.0345) |
| ln(*FLEVEL*+1) | 0.0561*** | 0.0561*** | 0.0561*** | 0.0464*** | 0.0464*** | 0.0464*** |
| | (0.0166) | (0.0166) | (0.0167) | (0.0154) | (0.0155) | (0.0156) |
| ln(*STORIES*) | -0.0405 | -0.0506 | -0.0841 | -0.0304 | -0.0432 | -0.0693 |
| | (0.0485) | (0.0535) | (0.0629) | (0.0462) | (0.0509) | (0.0605) |
| *EV* | -0.0665+ | -0.0735+ | -0.0497 | -0.0628+ | -0.0673+ | -0.0534 |
| | (0.0439) | (0.0475) | (0.0493) | (0.0411) | (0.0440) | (0.0470) |
| *D**ln(*UNITS*) | -0.0458 | -0.0490+ | -0.0410 | -0.0539* | -0.0556* | -0.0551+ |
| | (0.0323) | (0.0334) | (0.0367) | (0.0313) | (0.0324) | (0.0349) |
| *D**ln(*AGE*+1) | -0.0102 | -0.0085 | -0.0028 | 0.0019 | 0.0064 | 0.0112 |
| | (0.0265) | (0.0269) | (0.0283) | (0.0286) | (0.0293) | (0.0317) |
| *D**ln(*TIME*) | 0.0205 | 0.0197 | 0.0028 | 0.0202 | 0.0247 | 0.0109 |
| | (0.0477) | (0.0492) | (0.0476) | (0.0456) | (0.0471) | (0.0466) |
| *D**ln(*STORIES*) | 0.0269 | 0.0370 | 0.0705 | 0.0382 | 0.0510 | 0.0771 |
| | (0.0542) | (0.0587) | (0.0675) | (0.0525) | (0.0567) | (0.0655) |
| *D***EV* | 0.0394 | 0.0464 | 0.0226 | 0.0196 | 0.0241 | 0.0102 |
| | (0.0542) | (0.0572) | (0.0588) | (0.0516) | (0.0540) | (0.0566) |
| *BLAND* | 0.0805*** | 0.0784*** | 0.0896** | 0.0857*** | 0.0834*** | 0.0935*** |
| | (0.0289) | (0.0300) | (0.0348) | (0.0290) | (0.0300) | (0.0345) |
| *NEW* | -0.1501** | -0.1547** | -0.1469** | -0.1842*** | -0.1975*** | -0.1900*** |
| | (0.0623) | (0.0629) | (0.0612) | (0.0625) | (0.0657) | (0.0700) |
| *D***SOUTH* | -0.0485+ | -0.0485+ | -0.0485+ | -0.0022 | -0.0022 | -0.0022 |
| | (0.0324) | (0.0325) | (0.0327) | (0.0176) | (0.0176) | (0.0177) |
| *D***CORNER* | -0.0429* | -0.0429* | -0.0429+ | -0.0175 | -0.0175 | -0.0175 |
| | (0.0259) | (0.0260) | (0.0261) | (0.0187) | (0.0187) | (0.0188) |
| *LAMBDA* | -0.6355 | -0.6504 | -0.9541 | | | |
| | (0.5408) | (0.5844) | (0.6625) | | | |
| *D***LAMBDA* | -1.2763 | -1.2613 | -0.9576 | | | |
| | (1.2817) | (1.3028) | (1.3469) | | | |
| Observations | 725 | 700 | 627 | 748 | 720 | 645 |
| $R^2$ | 0.9775 | 0.9775 | 0.9804 | 0.9774 | 0.9775 | 0.9802 |

Dependent variable is ln(*RENT*). ***, **, *, + indicate statistical significance at the 1, 5, 10, and 15% levels using two-sided tests. Figures in parentheses are robust standard deviations. Coefficients of dummy variables for regions and years of data are not shown in the table. OLS: ordinary least squares. Heckit: Heckman's two-step estimates.

Table 8. Price function: Condominiums and rental apartments in Japan.

| | [8-1] | [8-2] | [8-3] | [8-4] | [8-5] | [8-6] |
|---|---|---|---|---|---|---|
| | Model | | | | | |
| | Heckit | | | OLS | | |
| Caliper | $\delta = 0.5$ | $\delta = 0.3$ | $\delta = 0.1$ | $\delta = 0.5$ | $\delta = 0.3$ | $\delta = 0.1$ |
| *RENTHAT* | 0.6039** | 0.7023*** | 1.2166*** | 0.6067** | 0.6793*** | 0.9788*** |
| | (0.2533) | (0.2635) | (0.2822) | (0.2593) | (0.2567) | (0.2593) |
| ln(*UNITS*) | 0.0053 | -0.0001 | 0.0190 | 0.0049 | -0.0031 | 0.0099 |
| | (0.0237) | (0.0270) | (0.0282) | (0.0240) | (0.0270) | (0.0287) |
| ln(*AGE*+1) | -0.0673*** | -0.0641*** | -0.0442*** | -0.0707*** | -0.0694*** | -0.0522*** |
| | (0.0139) | (0.0143) | (0.0137) | (0.0144) | (0.0148) | (0.0129) |
| *D*RENTHAT* | -0.4543+ | -0.5528* | -1.0671*** | -0.5564** | -0.6291** | -0.9286*** |
| | (0.3024) | (0.3113) | (0.3283) | (0.2738) | (0.2715) | (0.2742) |
| *D**ln(*UNITS*) | -0.0743** | -0.0689* | -0.0880** | -0.0734** | -0.0654* | -0.0784** |
| | (0.0359) | (0.0382) | (0.0393) | (0.0360) | (0.0381) | (0.0395) |
| *D**ln(*AGE*+1) | -0.1875*** | -0.1906*** | -0.2106*** | -0.1872*** | -0.1884*** | -0.2057*** |
| | (0.0412) | (0.0415) | (0.0417) | (0.0403) | (0.0406) | (0.0402) |
| *D*RENOVATED* | 0.0113 | 0.0113 | 0.0113 | 0.0112 | 0.0112 | 0.0112 |
| | (0.0366) | (0.0367) | (0.0372) | (0.0362) | (0.0363) | (0.0365) |
| *LAMBDA* | -0.1458 | -0.2360 | 0.2709 | | | |
| | (0.5199) | (0.7060) | (0.6859) | | | |
| *D*LAMBDA* | 0.5644 | 0.6546 | 0.1477 | | | |
| | (0.7773) | (0.9136) | (0.9025) | | | |
| Observations | 653 | 613 | 516 | 653 | 632 | 565 |
| $R^2$ | 0.9974 | 0.9973 | 0.9978 | 0.9974 | 0.9973 | 0.9978 |

Dependent variable is ln(*PRICE*). ***, **, *, + indicate statistical significance at the 1, 5, 10, and 15% levels using two-sided tests. Figures in parentheses are robust standard deviations. Coefficients of dummy variables for regions and years of data or purchase are not shown in the table. OLS: ordinary least squares. Heckit: Heckman's two-step estimates.

Table 9. Rent function: Condominiums in Japan and the United States.

| | [9-1] | [9-2] | [9-3] | [9-4] | [9-5] | [9-6] |
|---|---|---|---|---|---|---|
| | Model | | | | | |
| | Heckit | | | OLS | | |
| Caliper | $\delta = 0.5$ | $\delta = 0.3$ | $\delta = 0.1$ | $\delta = 0.5$ | $\delta = 0.3$ | $\delta = 0.1$ |
| ln(*UNITS*) | -0.0094 | -0.0418 | -0.0045 | 0.0206 | -0.0161 | 0.0045 |
| | (0.0589) | (0.0607) | (0.0722) | (0.0595) | (0.0659) | (0.0755) |
| ln(*AGE*+1) | -0.0165 | -0.0114 | -0.0233 | -0.0145 | 0.0037 | -0.0262 |
| | (0.0445) | (0.0436) | (0.0479) | (0.0527) | (0.0531) | (0.0503) |
| ln(*BEDRM*+1) | 0.1349 | 0.0550 | -0.0809 | -0.0746 | -0.1077 | -0.1259 |
| | (0.1713) | (0.1591) | (0.1634) | (0.1459) | (0.1424) | (0.1582) |
| ln(*TIME*) | 0.0298 | 0.0398 | 0.0344 | 0.0401 | 0.0457+ | 0.0390 |
| | (0.0280) | (0.0279) | (0.0281) | (0.0289) | (0.0284) | (0.0274) |
| ln(*FLEVEL*+1) | -0.0682 | -0.1414+ | -0.0566 | 0.0528 | 0.0186 | 0.0123 |
| | (0.0866) | (0.0925) | (0.0866) | (0.0781) | (0.0780) | (0.0817) |
| ln(*STORIES*) | 0.1475* | 0.1993** | 0.1040 | 0.0598 | 0.0804 | 0.0746 |
| | (0.0838) | (0.0914) | (0.0975) | (0.0912) | (0.0952) | (0.1074) |
| *EV* | -0.0025 | 0.0344 | 0.0262 | -0.0340 | -0.0468 | -0.0221 |
| | (0.1032) | (0.1021) | (0.1189) | (0.1079) | (0.1061) | (0.1218) |
| *D**ln(*UNITS*) | -0.0172 | 0.0152 | -0.0221 | -0.0400 | -0.0033 | -0.0239 |
| | (0.0630) | (0.0647) | (0.0756) | (0.0637) | (0.0698) | (0.0789) |
| *D**ln(*AGE*+1) | -0.0563 | -0.0615 | -0.0495 | -0.0594 | -0.0776 | -0.0477 |
| | (0.0503) | (0.0496) | (0.0533) | (0.0579) | (0.0583) | (0.0557) |
| *D**ln(*BEDRM*+1) | -0.3054* | -0.2255 | -0.0896 | -0.2032 | -0.1701 | -0.1520 |
| | (0.1838) | (0.1724) | (0.1764) | (0.1471) | (0.1437) | (0.1593) |
| *D**ln(*TIME*) | -0.0958** | -0.1058** | -0.1004** | -0.1028** | -0.1084** | -0.1018** |
| | (0.0436) | (0.0435) | (0.0436) | (0.0436) | (0.0434) | (0.0427) |
| *D**ln(*FLEVEL*+1) | 0.1243 | 0.1975** | 0.1127 | -0.0063 | 0.0278 | 0.0342 |
| | (0.0883) | (0.0941) | (0.0883) | (0.0798) | (0.0797) | (0.0833) |
| *D**ln(*STORIES*) | -0.1611* | -0.2129** | -0.1176 | -0.0520 | -0.0726 | -0.0668 |
| | (0.0900) | (0.0972) | (0.1029) | (0.0963) | (0.1001) | (0.1117) |
| *D*EV* | -0.0245 | -0.0614 | -0.0532 | -0.0091 | 0.0037 | -0.0211 |
| | (0.1084) | (0.1074) | (0.1235) | (0.1128) | (0.1110) | (0.1261) |
| *NEW* | 0.4221* | 0.4644* | 0.2911 | 0.1947 | 0.2604 | 0.1825 |
| | (0.2531) | (0.2564) | (0.2706) | (0.2458) | (0.2548) | (0.2718) |
| *D*SOUTH* | -0.0485 | -0.0485 | -0.0485 | -0.0022 | -0.0022 | -0.0022 |
| | (0.0340) | (0.0339) | (0.0339) | (0.0185) | (0.0185) | (0.0185) |
| *D*CORNER* | -0.0429+ | -0.0429+ | -0.0429+ | -0.0175 | -0.0175 | -0.0175 |
| | (0.0271) | (0.0271) | (0.0271) | (0.0196) | (0.0197) | (0.0197) |
| *LAMBDA* | -1.5367*** | -1.5421*** | -0.6820+ | | | |
| | (0.5250) | (0.5351) | (0.4654) | | | |
| *D*LAMBDA* | -0.3750 | -0.3697 | -1.2298 | | | |
| | (1.3255) | (1.3290) | (1.2998) | | | |
| Observations | 465 | 456 | 421 | 468 | 461 | 431 |
| $R^2$ | 0.9557 | 0.9591 | 0.9655 | 0.9526 | 0.9562 | 0.9647 |

Dependent variable is ln(*RENT*). ***, **, *, + indicate statistical significance at the 1, 5, 10, and 15% levels using two-sided tests. Figures in parentheses are robust standard deviations. Coefficients of dummy variables for regions and years of data are not shown in the table. OLS: ordinary least squares. Heckit: Heckman’s two-step estimates.

Table 10. Price function: Condominiums in Japan and the United States.

| | [10-1] | [10-2] | [10-3] | [10-4] | [10-5] | [10-6] |
|---|---|---|---|---|---|---|
| | Model | | | | | |
| | Heckit | | | OLS | | |
| Caliper | $\delta = 0.5$ | $\delta = 0.3$ | $\delta = 0.1$ | $\delta = 0.5$ | $\delta = 0.3$ | $\delta = 0.1$ |
| *RENTHAT* | 0.0830 | 0.4155+ | 0.9900** | -0.1036 | 0.2729 | 1.1210** |
| | (0.2054) | (0.2690) | (0.4889) | (0.3177) | (0.3252) | (0.4893) |
| ln(*UNITS*) | 0.0541* | 0.0861* | 0.1210 | 0.0947*** | 0.0949** | 0.1069 |
| | (0.0324) | (0.0455) | (0.0918) | (0.0353) | (0.0387) | (0.0783) |
| ln(*AGE*+1) | -0.1355*** | -0.0967* | -0.0740 | -0.1121*** | -0.0717 | -0.0060 |
| | (0.0416) | (0.0560) | (0.0952) | (0.0398) | (0.0508) | (0.0730) |
| *D*RENTHAT* | 0.0666 | -0.2659 | -0.8405+ | 0.1538 | -0.2227 | -1.0707** |
| | (0.2661) | (0.3187) | (0.5185) | (0.3306) | (0.3381) | (0.4983) |
| *D**ln(*UNITS*) | -0.1231*** | -0.1551*** | -0.1900** | -0.1632*** | -0.1634*** | -0.1754** |
| | (0.0426) | (0.0534) | (0.0960) | (0.0449) | (0.0478) | (0.0834) |
| *D**ln(*AGE*+1) | -0.1192** | -0.1580** | -0.1807* | -0.1458*** | -0.1862*** | -0.2519*** |
| | (0.0575) | (0.0689) | (0.1035) | (0.0558) | (0.0644) | (0.0833) |
| *D*RENOVATED* | 0.0113 | 0.0113 | 0.0113 | 0.0112 | 0.0112 | 0.0112 |
| | (0.0375) | (0.0379) | (0.0383) | (0.0376) | (0.0379) | (0.0386) |
| *LAMBDA* | -1.0910*** | -1.0898* | -1.8075** | | | |
| | (0.4184) | (0.6090) | (0.9044) | | | |
| *D*LAMBDA* | 1.5096** | 1.5084* | 2.2260** | | | |
| | (0.7250) | (0.8533) | (1.0877) | | | |
| Observations | 640 | 531 | 438 | 702 | 592 | 493 |
| $R^2$ | 0.9908 | 0.9901 | 0.9899 | 0.9912 | 0.9907 | 0.9906 |

Dependent variable is ln(*PRICE*). ***, **, *, + indicate statistical significance at the 1, 5, 10, and 15% levels using two-sided tests. Figures in parentheses are robust standard deviations. Coefficients of dummy variables for regions and years of data or purchase are not shown in the table. OLS: ordinary least squares. Heckit: Heckman's two-step estimates.

## Appendix 1. Truncated model

The collective action time, *TIME*, is observed only if the collective decision has been made before the outcome of the data. In other words, we do not observe data whose collective decision-making is still in process. Therefore, the empirical model is as follows:

$$\begin{cases} \ln(TIME_i) = \boldsymbol{Z}_i\boldsymbol{\mu} + \nu_i & \text{if } \; DataYear_i > StartYear_i + TIME_i \\ \text{unobserved} & \text{if } \; DataYear_i < StartYear_i + TIME_i \end{cases},$$

where *i* indicates the *i*th condominium, $\boldsymbol{Z}$ is a vector of the independent variables explaining *TIME*, *StartYear* is the year when the collective action for reconstruction first takes place, and *DataYear* is the year when the data are collected. We assume that $\nu$ follows a normal distribution, with variance $\sigma$ across samples. Data are observed only if the year when the collective decision is made, *StartYear* + *TIME*, is prior to the year when the data are collected, *DataYear*.

Now, let $c_i \equiv DataYear_i - StartYear_i$; then the conditional expectation of ln(*TIME*) of sample *i* is

$$\begin{aligned} E(\ln(TIME_i)\,|TIME_i < c_i, \boldsymbol{Z}_i) &= E(\ln(TIME_i)\,|v_i < \ln(TIME_i) - \boldsymbol{Z}_i\boldsymbol{\mu}, \boldsymbol{Z}_i) \\ &= \boldsymbol{Z}_i\mu + E(v_i|v_i < \ln(TIME_i) - \boldsymbol{Z}_i\boldsymbol{\mu}, \boldsymbol{Z}_i) \\ &= \boldsymbol{Z}_i\boldsymbol{\mu} + \sigma\int_{-\infty}^{\frac{\ln(TIME_i) - \boldsymbol{Z}_i\boldsymbol{\mu}}{\sigma}} s\frac{\sigma\phi(\mathrm{s})}{\Phi\left(\frac{\ln(TIME_i) - \boldsymbol{Z}_i\boldsymbol{\mu}}{\sigma}\right)}ds = \boldsymbol{Z}_i\boldsymbol{\mu} - \frac{\sigma\phi\left(\frac{\ln(TIME_i) - \boldsymbol{Z}_i\boldsymbol{\mu}}{\sigma}\right)}{\Phi\left(\frac{\ln(TIME_i) - \boldsymbol{Z}_i\boldsymbol{\mu}}{\sigma}\right)} \end{aligned}$$

where $\phi()$ and $\Phi()$ are the density function and the cumulative density function of a normal distribution. As shown in the equation above, because we observe only samples with error terms that take below certain values, we overestimate the coefficients in OLS. In the truncated model, we obtain estimates by maximizing the following likelihood:

$$L(\mu, \sigma) = \Pi_i f(\ln(TIME_i)\,|TIME_i < c_i, \boldsymbol{Z}_i) = \Pi_i \frac{\sigma\phi\left(\frac{\ln(TIME_i) - \boldsymbol{Z}_i\boldsymbol{\mu}}{\sigma}\right)}{\Phi\left(\frac{\ln(TIME_i) - \boldsymbol{Z}_i\boldsymbol{\mu}}{\sigma}\right)}.$$

## Appendix 2. Tenure choice function and inverse Mills ratio

### A2.1. Tenure choice function

In this paper, we consider the tenure choice problem of a household regarding the decision whether to rent or own housing, although the problem in general involves many other kinds of decisions, such as the timing of a move, the types of housing, and their locations. More precisely, we focus on the tenure choice between rental units and owner-occupied units in condominiums.

A substantial number of empirical studies have presented the development of models for tenure choice. The pioneering studies by Henderson and Ioannides (1983) and Miceli (1989) are among those showing that households with high incomes tend to own large houses. Similarly, using individual information, including the attributes of both houses and households, Rosen (1979) and Bourassa (1995) find that households with a large number of family members are more likely to own a house than to rent a house.

In accordance with these studies, we estimate tenure choice functions in Japan and the United States by using a probit model, in which we introduce floor space as an instrumental variable and use the number of bedrooms as an explanatory variable, which is also used in the rent functions. The dependent variable is a dummy variable, *OWN*, which takes a value of 1 if the housing is listed for sale on the market, and 0 if it is listed on the market as rental housing.

All explanatory variables in the rent function are used in estimating the tenure choice function for condominiums in the United States, except that we use the floor-level ratio, *FLRATIO* (floor level of the unit divided by total stories in the condominium), instead of the floor level, *FLEVEL*. In contrast, for the tenure choice function for Japanese condominiums, we exclude variables for the location and attributes of the condominium because Japanese condominium data are not randomly sampled from the population but are obtained only when we observe both types of units, those for sale and those for rent, within the same apartment complex. Given such a data set, to avoid serious bias, we need to limit our explanatory variables to attributes of the unit in the building when estimating the tenure choice function for Japanese condominiums.

The results of the probit estimates of the tenure choice function are shown in Appendix Table 1. According to previous studies, such as those by Henderson and Ioannides (1983) and Bourassa (1995), the coefficients for the floor space and the number of bedrooms in the unit, ln(*SPACE*) and ln(*BEDRM*+1), are expected to be positive. In our estimation, both of the coefficients display their predicted positive signs.

Appendix Table 1. Tenure choice function.

| | [A1-1] | [A1-2] |
|---|---|---|
| | Apartment type | |
| | Japanese condominium | U.S. condominium |
| ln(*SPACE*) | 0.0053* | 0.0007*** |
| | (0.0028) | (0.0001) |
| ln(*UNITS*) | | -0.0012** |
| | | (0.0006) |
| ln(*AGE*+1) | | -0.0044 |
| | | (0.0035) |
| *NEW* | | 0.5553*** |
| | | (0.1843) |
| ln(*BEDRM*+1) | 0.0434 | 0.1035+ |
| | (0.0511) | (0.0642) |
| *FLRATIO* | 0.0220 | -0.3344** |
| | (0.1158) | (0.1337) |
| ln(*STORIES*) | | 0.0287* |
| | | (0.0163) |
| ln(*TIME*) | | 0.0508 |
| | | (0.0391) |
| *EV* | | 0.0751 |
| | | (0.1161) |
| *SOUTH* | -0.1538** | |
| | (0.0727) | |
| *CORNER* | -0.0632 | |
| | (0.0773) | |
| *CONSTANT* | -0.4112*** | -0.4040 |
| | (0.1328) | (0.2821) |
| Observations | 1,481 | 1,701 |

***, **, *, + indicate statistical significance at the 1, 5, 10, and 15% levels using two-sided tests. The figures in parentheses are robust standard deviations.

**A2.2. Inverse Mills ratio**

As introduced by Heckman (1979), even though samples are not randomly selected, unbiased parameters can be obtained by implementing an inverse Mills ratio, $\lambda_i$, as an additional explanatory variable in a regression. The estimated inverse Mills ratio can be calculated as $\hat{\lambda}_i = \phi/(1-\Phi)$, where $\phi$ is the standard normal density function and $\Phi$ is the standard normal cumulative distribution function evaluated from the first-step probit estimate.

The respective vectors of explanatory variables and estimated parameters in the above tenure choice function are denoted by $\boldsymbol{z}_i$ and $\widehat{\boldsymbol{\theta}}$. The inverse Mills ratio inserted in the rent function in Eq. (10) is then $\hat{\lambda}_i^{Rent} = \phi(\boldsymbol{z}_i{}'\widehat{\boldsymbol{\theta}})/\left(1-\Phi(\boldsymbol{z}_i{}'\widehat{\boldsymbol{\theta}})\right)$, and the inverse Mills ratio for the price function in Eq. (12) is $\hat{\lambda}_i^{Own} = -\phi(\boldsymbol{z}_i{}'\widehat{\boldsymbol{\theta}})/\Phi(\boldsymbol{z}_i{}'\widehat{\boldsymbol{\theta}})$.

**Appendix 3. Selection by propensity score matching**

In Subsection 4.4 on the robustness check, our aim is to evaluate the difference in the collective action cost between different apartment types. To cope with the sample selection bias between condominiums and rental apartments in Japan, we could have used the two-step procedure of Heckman (1979) as in the tenure choice problem if we had adequate instrumental variables for the decision-making problem of developers and if data for both Japanese condominiums and rental apartments were random samples of the population. However, we met neither of these conditions. Furthermore, we are interested in a comparison of the condominiums in Japan and in the United States, whose economic systems are substantially different.

To reduce the bias in the estimation, we compare the rent and price functions among samples having similar characteristics. For sample selection, we first select samples by restricting the number of units and the year of completion. We then use the propensity score-matching method advocated by Rosenbaum and Rubin (1984) to select rental apartments and U.S. condominiums that have characteristics, $z$, similar to condominiums such that $f_1(\bullet), f_0(\bullet) \perp D|z$, where $f_1(\bullet)$ and $f_0(\bullet)$ are functions to be estimated using Japanese condominium data, given by $D = 1$, and using data on rental apartments and U.S. condominiums, $D = 0$, respectively. Rosenbaum and Rubin prove that conditioning on $\Pr(D = 1|z)$ is equivalent to conditioning on $z$, which means that the sample bias between rental apartments and condominiums is reduced by matching those whose conditional probabilities, called propensity scores, are close to being a condominium.

To obtain propensity scores, we conduct probit estimates in which we use $D$ as a dependent variable and the number of units and year of completion as explanatory variables. We do not include other housing characteristics as the explanatory variables because these characteristics between condominiums in Japan and the United States are not comparable; thus, the propensity score-matching method fails to select adequate numbers of samples based on all the characteristics. Consequently, we extract samples that have a similarity in terms of the number of units and the year of completion, whose sample selection bias is of the most concern. Based on the estimated propensity score, we select rental apartments or U.S. condominiums whose propensity scores fall within a certain radius (caliper) of the scores of condominiums.

We then estimate the rent and price functions for these selected samples having less bias between different types of apartments. We should note, however, that this matching method does not absolutely eliminate the sample bias between condominiums and rental apartments, although it does help to reduce bias to some extent.