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Urban Stud 2013 50: 128 originally published online 15 August 2012
DOI: 10.1177/0042098012452327

Urban Studies at 50

Urban Studies
50(1) 128–147, January 2013

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[Paper first received, September 2010; in final form, March 2012]

Abstract

Condominium residents are reluctant to join the management committees (MCs) and contribute to the management of local public goods because of free-riding problems. In studying a sample of condominiums in Taipei, it is found that some degree of outsourcing to third party managers (TPMs) is necessary when the scale of local public goods increases. However, higher management fees paid to TPMs are not directly related to higher utilities derived by the residents in the use of local public goods. When self-selectivity in the outsourcing decision is controlled, the results show that the efficiency in the provision of local public goods increases with the effort levels of the MC members. The MC members who adopt a hands-off approach by fully delegating the management responsibilities to TPMs deliver lower pay-offs in the provision of public goods.

1. Introduction

Public goods are goods that possess non-exclusive and non-rival properties. Olson (1965) defines a public good as either 'inclusive' or 'exclusive' based on the degree of non-rivalness of the good. 'Exclusive' public goods or common-pool resources (CPRs), a term used by Ostrom *et al.* (1994), are subtractable because benefits enjoyed by an individual consuming the goods are subtracted from the residual benefits for others in the group. Common amenities and facilities in condominiums are examples of local CPRs that are subtractable. Self-interested individuals who maximise their pay-offs by consuming more CPRs than required create overconsumption and overcrowding problems.

In the *The Logic of Collective Action*, Olson (1965) argues that self-interested individuals will not contribute to the provision of public goods, if they can free-ride on the contributions of others. He shows

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0042-0980 Print/1360-063X Online

DOI: 10.1177/0042098012452327

that transaction costs in organising collective action increase with the number of users. This paper aims to test Olson's thesis empirically in the context of managing local public goods (or CPRs) in condominiums. This study makes two contributions to the collective action literature. First, this study applies data envelopment analysis (DEA) to measure residents' utilities in the use of local public goods taking into account both the quality and quantity attributes of the goods. Secondly, we empirically test the relationship between the effort level (input) of members of the management committee (MC) and the residents' utilities of using CPRs (output). As the MC of a condominium could choose to partially or fully to outsource the CPR management functions to a third party manager (TPM), our results show that efforts put in by the MC members have a positive impact on the efficiency of the CPR management.

The remainder of the paper is organised as follows. Section 2 reviews the literature on CPR provisions in condominiums. Section 3 proposes a theoretical collective action model to explain the trade-offs of utilities between token residents, active members and TPM in the management of local public goods. Section 4 discusses the empirical methodology and design. Section 5 presents data analysis and the estimation of joint pay-offs in CPRs. Section 6 discusses empirical results on the relationship between the utilities of the CPRs and the effort levels of the active members. Section 7 concludes the findings.

2. Local Public Good Provisions in Condominiums

High-rise condominium living is prevalent in many Asian cities facing land scarcity and high population density problems. Shared facilities and amenities like 24-hour security, landscaped open space, swimming pools, tennis courts, barbeque pits, carparks and lifts are CPRs exclusively provided for the enjoyment of condominium residents. Attracting residents to join the MCs and undertake the responsibilities of governing the use of CPRs is challenging.

There are two types of institutions governing the local collective goods in condominiums: the common law system and the statutory law system. In the common law system, such as the Deed of Mutual Covenant (DMC) in Hong Kong, residents' rights as tenants in common are spelled out in the covenants. Whereas, in the statutory law system, such as the Condominium Management Ordinance in Taiwan and the strata title system in the US, Canada, Australia and Singapore, a MC is formed mandatorily to undertake the management of common property.[1] Free-rider problems are found in both systems. Some studies argue that transaction costs are higher in the common law systems where collective actions are organised through private contracts (Walters and Kent, 2000; Walters, 2002; and Yiu *et al.*, 2006). However, it is not the institutional structure of a self-organised group, but the rules devised to govern CPRs that matter. Ostrom (2000) argues that internally enforceable rules are more effective than externally imposed rules for self-organised groups to attain sustainable outcomes in governing CPRs.

Residents evaluate the time and efforts (private costs) they have to devote to serve as MC members in condominiums. If the private costs in collective good provisions are high, self-interested residents will not contribute in organising collective action. They will choose instead to be token contributors by only paying their shares of expenses. It is thus not easy to attract condominium residents to join MCs and undertake the responsibilities of governing

CPRs. Ostrom (2007) describes this free-rider problem as a 'social dilemma'.

A free-rider presumes that everyone else other than himself/herself would contribute in the provision of CPRs. Social scientists attribute the free-riding problem to the 'diffusion of responsibility'. In a study involving 1456 residents in Detroit's neighbourhoods, Oliver (1984) found that diffusion of responsibility was found among token members. The current and past active members of local resident communities were pessimistic about free-riding on others' efforts; and they stepped forward to serve because 'if we (I) don't do it, nobody else will'. Oliver (1984) also showed that free time and income level were not correlated with the level of activism in neighbourhood communities.[1] Rootedness in the community (Wandersman *et al.*, 1987), collective interests and selective incentives (Yau, 2011) are important factors that motivate active participation in neighbourhood organisations. Individuals are more likely to participate in collective management if perceived benefits of participation are higher relative to non-participation. Selective incentives including rewards and punishments are effective in promoting activism in the Hong Kong's housing management (Yau, 2011).

Residents face two levels of 'social dilemma' when organising collective actions in condominiums. The first-level dilemma is caused by the apathy of residents, whose optimal strategy is to free-ride and not to join the MCs. The second-level dilemma arises when residents, upon being elected into a MC, choose to minimise their private costs by outsourcing the management of CPRs to a TPM or through direct labour. This study examines the second-level dilemma of MC members in determining the optimal trade-offs between the private efforts and the level of outsourcing in the CPR management in condominiums.

The two models of the CPR management in condominiums are an owner-manager (OM) model and a third party manager (TPM) model. In the OM model, MC members either involve directly or employ direct labour in the day-to-day management of the public goods. The OM model mitigates agency problems found in TPMs (Chinloy and Maribojoc, 1998). In the TPM model, a principal–agent relationship between a MC and a TPM is established via a contractual arrangement (Knapp, 1991). The TPM offers professional CPR management services in return for fees. The MC retains 'residual' controls on major decisions including rights to replace an underperforming TPM. In the management of private goods like rental properties, some US studies have shown that the OM model is more effective than the TPM model in deriving higher payoffs for private owners (Rosenberg and Corgel, 1990; Sirmans and Sirmans, 1991; Springer and Waller, 1996; and Sirmans *et al.*, 1999). However, the TPM is a more popular model *vis-à-vis* the OM model for the CPR management in many Asian cities (Hung and Chang, 2002; Yip *et al.*, 2007; and Chen *et al.*, 2007). TPMs assume the CPR management functions, which reduces the private costs (efforts and time) of MC members. TPMs help to reduce the second-level free-rider problems.

3. The Theoretical Collective Action Model

Conditional on joining a MC, a resident chooses the effort level to contribute, $e(1-\alpha)$, where α has a value between 0 and 1 denoting the level of outsourcing of CPR management services to a TPM. We assume that α is a negative decreasing function of the effort level of MC members, such that $e(1-\alpha) < 0$ and $e'(1-\alpha) < 0$. Active members in an owner-manager

(OM) model contribute maximum effort, ($\alpha = 0$); whereas MC members who outsource a full range of CPR services to a TPM put in minimum effort, ($\alpha = 1$)—that is $[e(1) < e(0)]$.

TPMs deliver outputs (local public goods) with quality, q, and, in return, they are paid a fee, p, for their professional services. The quality factor, q, is a non-linear function of w, and two elasticity measures that are β on the output (users) side and λ on the input (producers) side capture asymmetry in the delivery of local public goods, such that [β—λ 0] implies efficiency gain in the process.

Based on these assumptions, the utility (pay-off) functions for the three parties involved in the provision of local public goods, U^k, where [k = a free-rider (f), an active member (m) and a TPM (t)], are defined. In an extreme case, where all residents are free-riders with no involvement of MC and TPMs, residents derive a minimal utility that is equal to the quantity of local public goods supplied, w. If a proportion of the local public goods, α, is managed by a TPM, residents derive marginal increase in utility of $\beta q \alpha w$. The service fees payable for outsourcing a proportion of shared services to a TPM are $p \alpha w$. Collectively, the utility function of the free-rider for the use of the local public goods is defined as follows

$$U^f = w + \beta q \alpha w - p \alpha w \tag{1}$$

where, $w + \beta q \alpha w > p \alpha w$ and $\beta > 0$; and β is an elasticity of marginal utility, which measures an increasing return to scale effect on the quality of CPRs in large condominiums.

For the active MC members, they incur negative utility (private costs) depending on the level of effort contributed, $e(1-\alpha)$, where the marginal increase in the effort level is negative, that is $e'(1-\alpha) < 0$. The utility function of the active MC members is defined as

$$U^m = (1+r)[w + \beta q \alpha w - p \alpha w] - e[(1-\alpha)w] \tag{2}$$

Substituting (1) into (2), we rewrite the utility function for the active members as:

$$U^m = (1+r)U^f - e[(1-\alpha)w] \tag{3}$$

We assume that the TPM's costs of delivering the expected local public goods, $K(q, w)$, increase with q at an increasing rate of returns to the scale, w. The utility function for a TPM in providing a full-range of local public goods is defined as

$$U^t = pw - K(q, w) \tag{4}$$

Taking the first-order derivation of the utility function (equation (4)) with respect to the quantity of the local public goods, the optimal price for the TPM services is equated to the marginal costs of delivering the services, such that $p = \frac{\partial K(q,w)}{\partial w}$, conditional on $\frac{\partial U^t}{\partial w} = 0$.

If the price (fee) of TPM services is made up of two components: a variable cost with an increasing return to scale, $c(w)$, where $c'(w) > 0$, and a quality (efficiency) premium, λq, where λ measures the 'production' efficiency, such that a more efficient TPM with $\lambda > 0$ is paid a higher fee for providing the same level of local public goods. The price of TPM services is represented as

$$p = \frac{\partial K(q, w)}{\partial w} = c(w) + \lambda q \tag{5}$$

We re-arrange the terms in equation (5) and define the function of the quality variable, q, as

$$q = \frac{1}{\lambda}[p - c(w)] \tag{6}$$

We assume that the supply of the local public goods is exogenous and normalise the quantity of public goods to$(w = 1)$. By substituting the optimal price (equation (5)) and the optimal quality (equation (6)) functions into equation (2), the utility function of the active MC members is rewritten as

$$\mathrm{U}^m = (1 + r)[1 + (\beta - \lambda)q\alpha - c(1)\alpha] - e(1 - \alpha) \tag{7}$$

$$\mathrm{U}^m = (1 + r)\left[1 + \frac{\beta}{\lambda}p\alpha - \frac{\beta}{\lambda}c(1)\alpha - p\alpha\right] - e(1 - \alpha) \tag{8}$$

Similarly, by substituting the optimal price (Equation 5) and the optimal quality (Equation 6), the utility function of the free-rider in Equation (1) can be re-written as:

$$\mathrm{U}^f = 1 + (\beta - \lambda)q\alpha - c(1)\alpha \tag{9}$$

$$\mathrm{U}^f = 1 + \frac{\beta}{\lambda}p\alpha - \frac{\beta}{\lambda}c(1)\alpha - p\alpha \tag{10}$$

The optimal outsourcing decisions, that are $\alpha^*(q,\lambda)$ or $\alpha^*(p,\lambda)$, are determined such that the active MC member and the free-rider jointly maximise the utility functions in equations (7)–(10), subject to the constraint (basic utility) of $(1 + \beta q > p)$, where the constrained utility has a value of 1 at zero outsourcing, $(\alpha = 0)$, and $(1 + \beta q > p)$ at a full-level outsourcing $(\alpha = 1)$. The free-riders will be indifferent at any level of outsourcing as long as they obtain a utility (equation (10)) that is greater than 1, that is $\left[1 + \frac{\beta}{\lambda}p\alpha - \frac{\beta}{\lambda}c(1)\alpha - p\alpha\right] > 11 + \frac{\beta}{\lambda}p\alpha - \frac{\beta}{\lambda}c(1)\alpha - p\alpha > 1$. By re-arranging the terms, we obtain $\left(\frac{\beta}{\lambda} - 1\right)p\alpha > \frac{\beta}{\lambda}c(1)\alpha > 0$, such that $(\beta > \lambda)$ is strictly binding.

Proposition 1: Based on the objective of maximising the private pay-off (utility) in the use of local public goods, free-riders will not object to an outsourcing strategy as long as there is positive efficiency gain in the delivery of the local public goods by TPMs, that is $(\beta > \lambda) > 0$.

If the active member and the free-rider both jointly maximise their pay-off functions in equations (7) and (9) or equations (8) and (10), we rearrange the Kuhn–Tucker conditions to derive the following equation

$$\frac{\partial \mathrm{U}^m}{\partial \alpha} = (1 + r)\frac{\partial \mathrm{U}^f}{\partial \alpha} + e'(1 - \alpha) = 0 \tag{11}$$

The joint optimal outsourcing outcome is obtained if both the active members and the free-riders obtain the same levels of utility (pay-offs) and the effort level of the active members is constant at $e'(1 - \alpha) = 0$. If the effort level of an active member follows a negative convex curve, $[e(1 - \alpha) < 0$ and $e'(1 - \alpha) < 0]$, the active member will increase the effort level such that he/she could reduce disutility associated with a high level of outsourcing.

Proposition 2: The joint pay-offs (utility) of active members and free-riders in choosing an optimal level of outsourcing are dependent on the marginal costs of active members in increasing the effort levels.

Conditional on the optimal level of outsourcing, the MC members maximise the utility functions in equations (7) and (8) with respect to the 'production' elasticity factor of the most efficient TPM, λ, that are

$$\frac{\partial \mathrm{U}^m}{\partial \lambda} = -(1 + r)q\alpha \tag{12}$$

$$\frac{\partial \mathrm{U}^m}{\partial \lambda} = -\frac{\beta}{\lambda^2}(1 + r)[p - c(1)]\alpha \tag{13}$$

Proposition 3: The marginal pay-offs (utilities) of the active members decrease with respect to the input elasticity factor (production efficiency) of the TPMs.

Given that the service delivery standard of TPMs is tied to the fees, the MC trades-off between choosing the most efficient TPM and having lower pay-offs in the use of the local public goods. The marginal utilities are sensitive to changes to the elasticity factor, if the quality of the local goods and the professional fees charged by TPMs are high.

4. Empirical Design

4.1 Efficiency Measures

Unlike private goods, individual or joint pay-offs in the use of local public goods in condominiums are not directly observable. We apply data envelopment analysis (DEA) to measure empirically the efficiency in the provision of local public goods. Charnes *et al.* (1978) and Banker *et al.* (1984) propose two efficiency measures for the DEA models: technical efficiency (TE) and scale efficiency (SCALE). Technical efficiency is measured based on the type of production technology, either a constant return to scale technology (CRS) or a variable return to scale technology (VRS). The optimal output of a non-profit-oriented decision-making unit (DMU) based on given inputs and a fixed production technology is determined using the frontier methodology.

In an output-oriented VRS model,[3] the technical efficiency is solved in the optimisation process involving the following system of equations

$$Max_{\varphi,\lambda}\varphi \tag{14}$$

Subject to

$$\begin{aligned} -\varphi y_i + \mathbf{Y}\lambda &\geq 0 \\ x_i - \mathbf{X}\lambda &\geq 0 \\ \mathbf{NI}''\lambda &= 1 \\ \lambda &\geq 0 \end{aligned} \tag{15}$$

where, $\mathbf{Y}$ is a (M $\times$ N) aggregate output; $\mathbf{X}$ is a (K $\times$ N) aggregate input; $\mathbf{NI}$ is a (N $\times$ 1) identity vector; λ is a (N $\times$ 1) vector of constant; and $\phi - 1$ is the proportional increase in outputs that can be produced by i-th DMU using a fixed input given that $()1 \leq \phi < \infty$.

The technical efficiency of i-th DMU ($VRSTE_i$) based on a VRS output-oriented model is computed as $(1/\phi)$, which has a value between 0 and 1, such that the most efficient DMU has a value of 1. A DMU is said to be technically more efficient than other DMUs if it produces more outputs using a given sets of inputs in a given technology. Scale efficiency (SCALE) measures the relative efficiency based on the optimal outputs of two different technologies given a fixed input. The most efficient technology has a scale efficiency value of 1.

We use CRSTE, VRSTE and SCALE to measure efficiency in the provision of local public goods in the condominium samples using both non-price (quality-based) input and output factors. The output factors capture residents' utilities in the use of local public goods, which include factors such as the quality of the living environment, uninterrupted use of common facilities and social cohesiveness in the estate. The management fee is a tangible input factor. Other intangible input factors include effort levels of the MCs members and TPMs using non-price factors include type of maintenance activities, number of social events organised and number of MC meetings held.

4.2 Empirical Methodology

The efficiency measures estimated from the DEA methodology, [Y = CRSTE, VRSTE, SCALE], are the proxies for the utility (pay-off) derived from the use of the local public goods. We test the hypothesis that collective pay-offs of residents are positively correlated with the effort levels of active members in the provision of local public goods. The empirical model is written as:

$$Y_i = a + \mathbf{b}'\mathbf{Z}_i + c\mu_i + d\gamma_i + \varepsilon_i \qquad (16)$$

where, a is an intercept; and ε_i is a regression error. For the right-hand-side variables, the outsourcing level, γ_i, which has a value from 4 to 12, is converted into a binary variable based on a threshold value ($\bar{\gamma} = 8$), such that the outsourcing level is low, ($\psi = 0$), if ($\bar{\gamma} \leq 8$); and otherwise, the outsourcing level is high, ($\psi = 1$), when ($\gamma > 8$). The 'Outsource' variable inversely measures the effort level of the MC members, $e(1 - \alpha)$—that is, a high outsourcing level implies a low effort level of the MC member. The management fee, μ, is an indirect proxy of production efficiency for TPMs. The attribute vector, $\mathbf{Z}_i$, which includes size, type, rental unit ratio, vacant unit ratio, mix of units by floor area and the largest unit by floor area, controls for the heterogeneity of condominium samples; and the vector **b** coefficient captures the elasticity of the attributes.

If the outcome of collective action were directly related to the effort level of the active members, we expect the coefficient for the outsourcing variable to be negative and significant, [H_0: $d \leq 0$]; otherwise, the MC members will increase residents' utilities in use of the local public goods by outsourcing more of the works to TPMs. If the coefficient on the management fee (TPM efficiency), d, was significant and positive, that is [H_0: $c \geq 0$], the social outcome (joint utilities) is not related to the collective action problem. The social dilemma could be solved through externally organised actions, which include outsourcing the collective good provisions to independent parties (TPMs).

When an active member self-selects the effort level, his intention could be revealed through the outsourcing decisions. The endogenous effect can be separated using a two-stage approach proposed by Lee (1978) and Heckman (1976). We first estimate the outsourcing decision as a probit function of a vector $\mathbf{S}_i$ S_i that represents the types of CPR works, the ratio of public area to built-up area, '*Public*', and the management fees paid, μ_i. We identify three categories of works that have a high probability of being outsourced:

physical facilities and services ('Facility'); handling of management fee arrears ('Arrear'); and financial management and planning ('Fund'). The binary choice of outsourcing, that inversely reflects the effort levels of the MC members, $e(\psi \mid \gamma)$, where $\gamma = (1 - \alpha)$, can be represented as

$$\psi_i = \mathbf{p}'\mathbf{S}_i + q\mu_i + \zeta_i \qquad (17)$$

where, $\boldsymbol{p}$ is a vector coefficient for the regressor vector $\mathbf{S}$; q is a coefficient on the management fee variable; and ζ_i is a standard normalised error term. Based on the probit estimation of the binary choice of outsourcing

$$\psi_i = 1 \text{ if } \psi_i^* \geq 0, \text{ that is } \mathbf{p}'\mathbf{S}_i + q\mu_i \geq \zeta_i \qquad (18a)$$

$$\psi_i = 0 \text{ if } \psi_i^* < 0, \text{ that is } \mathbf{p}'\mathbf{S}_i + q\mu_i < \zeta_i \qquad (18b)$$

we compute the density function, $f(\psi_i)$, and the cumulative normal distribution function, $F(\hat{\psi}_i)$, where ($\hat{\psi}_i = \mathbf{p}'\mathbf{S}_i + q\mu_i$).

In the second stage, the interactive effects of the selectivity variables on the utilities (efficiency) of the local public goods are tested independently in two different models: a low effort level of active members (i.e. high outsourcing, $\psi = 1$) and a high effort level of active members (i.e. low outsourcing, $\psi = 0$

$$Y_{i,\psi=1} = a_1 + \mathbf{b}_1\mathbf{Z}_1 + c_1\mu_1 \text{-} d_1\gamma_1 + g_1\left[-\frac{f(\psi_i)}{F(_i)}\right] + \varepsilon_1 \quad (19)$$

$$Y_{i,\psi=0} = a_2 + \mathbf{b}_2\mathbf{Z}_2 + c_2\mu_2 \text{-} d_2\gamma_2 + g_2\left[-\frac{f(\psi_i)}{F(_i)}\right] + \varepsilon_2 \quad (20)$$

5. Data Analysis

We use the responses of residents in a questionnaire survey on the use of shared facilities and living environment of condominiums to construct relevant utility measures (efficiency indicators). The survey data were collected from July to September in 2005 by the Taiwan Real Estate Research Centre at the National Chengchi University. The survey respondents include MC members and directors of registered condominiums located in Taipei city and county. Serving as the communication channel with non-active residents, the MC members could provide an objective review of the levels of satisfaction of the community cohesion and participation in the condominiums. Face-to-face interviews with selected respondents were also conducted to understand the roles of the MC members in organising activities to enhance social outcomes in the provision of local public goods.

As the CPRs for mix-use developments are more diverse and heterogeneous, we have excluded them from the study. Our sample includes only 143 single-use condominiums in Taipei city. After removing the outliers and the responses with incomplete information, a final sample of 128 condominiums was used.

5.1 Estimating Efficiency Measures Using the DEA Model

Treating a condominium as a DMU, four qualitative measures of general satisfaction levels of residents (Output) are identified, which include quality of property facilities and services ('Living'), activities promoting social cohesiveness and neighbourliness ('Social'), enforcement of rules and execution of work plans ('Rules') and interruptions and lapses in selected services ('Down'). Based on a set of questions (see the Appendix), the respondents were asked to rate the service quality on a five-point scale, in descending order with 5 being the most satisfactory and 1 being the most unsatisfactory. The two 'input' indicators—the frequency of maintenance services planned ('Maintain') and the number of meetings and social events organised ('Event')—were rated by the respondents based on a five-point scale with 5 being the most important and 1 being the least important. The monthly management fee per unit is used as a price-based input factor.

Based on the summary statistics in Table 1, we found that the respondents were most satisfied with the MC's efforts in minimising interruptions and downtimes in the facilities and services ('Down'), as well as enforcing by-laws and implementing work plans ('Rules'), which have the highest average scores of 4.716 and 4.323 respectively. In terms of the inputs, the frequency of maintenance services scores the highest at an average 3.365 ('Maintain') compared with the social activities indicator with an average score of 2.188 ('Event'). The standard deviations are higher for the input indicators reflecting the variations in the respondents' views.

Based on the estimated input and output indicators, we compute the technical efficiency indicators (TE_{crs} and TE_{vrs}) and the scale efficiency indicator (SCALE) using the

Table 1. List of variables and descriptive statistics

Variable	*Symbol*	*Mean*	*Median*	*Maximum*	*Minimum*	*S.D.*	*Skewness*	*Kurtosis*
Input/ Output factors for DEA								
Quality of living environment	LIVING	3.728	3.800	5.000	2.000	0.455	−0.343	4.162
Enforcement of rules and execution of work plans	RULE	4.323	4.400	5.000	2.800	0.462	−0.658	3.303
Interruptions in services	DOWN	4.716	4.667	5.000	3.333	0.308	−1.263	5.285
Community cohesion and neighbourliness	SOCIAL	3.766	3.778	5.000	1.778	0.475	−0.978	5.941
Frequency of maintenance services	MAINTAIN	3.365	3.414	4.400	1.600	0.492	−0.474	3.389
Meetings and social events	EVENT	2.188	2.250	3.750	1.250	0.537	0.475	3.005
Management fee	FEE	75.077	61.818	250.000	20.000	45.382	1.316	4.596
Variables for regression models								
Dependent variables								
Technical efficiency in constant return to scale technology	CRSTE	0.767	0.745	1.000	0.538	0.123	0.503	2.256
Technical efficiency in variable return to scale technology	VRSTE	0.967	1.000	1.000	0.800	0.043	−1.237	4.224
Scale efficiency	SCALE	0.793	0.769	1.000	0.538	0.118	0.332	2.103
Independent variables								
Size of development by strata unit	SIZE	49.297	28.500	298.000	5.000	54.892	2.338	8.708
Height of buildings	HEIGHT	2.063	2.000	3.000	1.000	0.411	0.447	5.679
Age of development	AGE	10.258	9.000	35.000	3.000	7.881	1.082	3.186
Proportion of rental unit to total unit	RENTAL	2.289	2.000	5.000	1.000	1.364	0.869	2.496
Proportion of vacant unit to total unit	VACANT	1.539	1.000	5.000	1.000	0.878	1.951	6.771
Mix of floor type by area	MIX	1.594	1.000	5.000	1.000	0.934	1.703	5.417
Maximum unit by floor area	MAX	4.070	5.000	5.000	1.000	1.178	−0.948	2.712
Aggregate outsourcing	OUTSOURCE	8.180	8.000	12.000	4.000	2.105	0.326	2.134
Management fee	FEE	75.077	61.818	250.000	20.000	45.382	1.316	4.596
Variables for probit model								
Handling of management fee arrears	ARREAR	0.852	1.000	5.000	0.000	1.087	1.625	5.868
Financial management	FUND	2.109	2.000	4.000	0.000	0.796	−1.137	4.981
Physical facilities and services	FACILITY	3.461	4.000	6.000	0.000	1.474	−0.116	2.114
Ration of public space to built-up area	PUBLIC	0.213	0.203	0.330	0.150	0.057	0.599	2.228
Management fee	FEE	75.077	61.818	250.000	20.000	45.382	1.316	4.596

DEA.[4] Table 1 shows that the variable return to scale (VRS) technology has the highest mean efficiency scores of 0.967, compared with the mean efficiency score of 0.767 for the constant return to scale (CRS) technology. The mean scale efficiency (SCALE) score was estimated at 0.793. The CRS technical efficiency scores have the highest standard deviation of 0.123. The three efficiency indicators represent joint utilities (pay-offs) in the use of local public goods.

5.2 Independent Variables

The descriptive statistics are summarised in Table 1. The sample size ranges from 5 units for the smallest condominium to 298 units for the largest condominium. The mean size of sample condominiums is 49.3 units. The age of the sample condominiums varies from 3 years to 35 years. The mean age of the sample condominiums is 10.26 years. By the building height, the sample condominiums are sorted into three groups comprising low-rise developments with buildings below 5 storeys in height, medium-rise developments with buildings between 6 and 12 storeys in height and high-rise developments with buildings greater than 13 storeys in height. The average 'Height' of 2.06 indicates that slightly more than half of the sample consists of medium- to high-rise condominiums.

The heterogeneity of units in the sample condominiums is controlled using two categorical variables (with value ranging between 1 and 5)—'Mix' that counts the type of unit by floor areas in the development and 'Max' that identifies the largest unit available in the developments. The mean value of Mix is 1.59 indicating that half of the sample condominiums have less than two different floor area types; whereas the mean value of Max is 4.07 indicating that more than half of the sample has the largest units with more than 41 'ping' by floor area.[5] We also control for the user types in the sample condominiums by measuring the proportion of rental units ('Rental') and vacant units ('Vacant') to total units. The mean of 2.29 for 'Rental' shows that the majority of the developments are owner-occupied. The vacancy rate in the sample developments is not more than 2 per cent as indicated by the mean 'Vacant' value of 1.54.

The average monthly fee ('Fee') contributed by the sample condominium residents is NTD$75.08 per unit area (ping) and the maximum fee is reported at NTD$250 per month per ping.[6,7] The mode of outsourcing is a cardinal variable that has the values [1 = self-managed, 2 = via direct labour, and 3 = third party managed]. The respondents indicate the mode of outsourcing for four local public services, which include 'security', 'cleaning and conservancy', 'mechanical, electrical and fire equipment' and 'administrative work and social events' (Figure 1). The 'Outsourcing' variable, γ_1, is computed as the sum of the values of the contract mode for the four local public goods, which range from a minimum of 4 (full OM model) to a maximum of 12 (full TPMs model). The mean 'Outsource' value of 8.18 indicates some degree of outsourcing, either by direct labour or TPMs. As shown in Figure 1, 58 per cent of the sample condominiums outsource works that are more technical in nature, such as the maintenance of mechanical, electrical and fire safety equipment. Direct labour is employed to carry out less technical and more routine works, such as security and cleaning and conservancy services. Some 76 per cent of the MC members self-manage administrative work and social events.

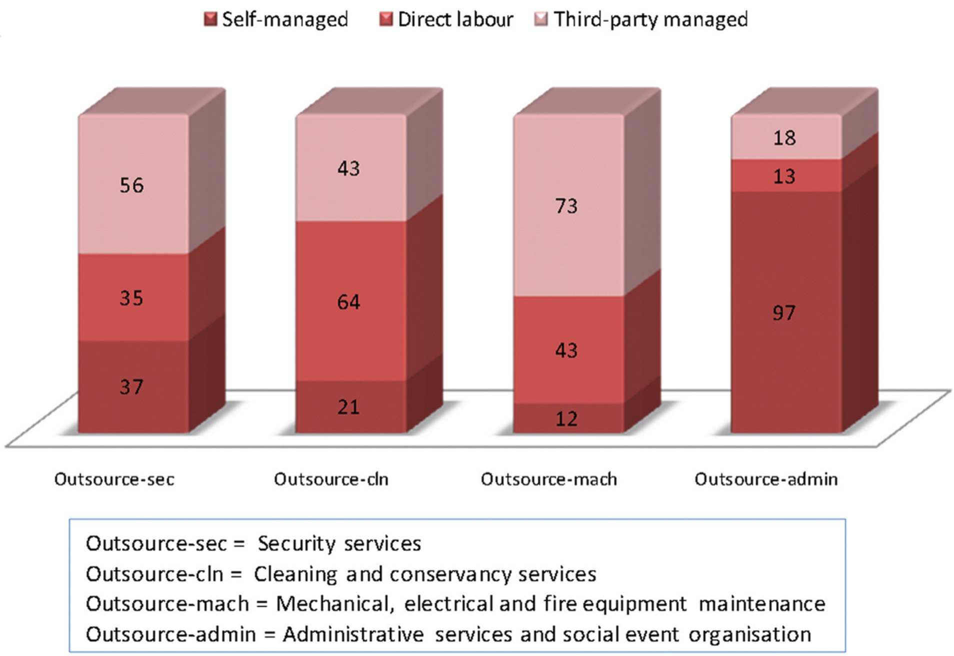

Figure 1. Outsourcing of property management services.

6. Empirical Results

6.1 Outsourcing and Efforts of MC Members

Based on the specification in equation (16), we estimate an OLS model and a semi-log model with the efficiency indicators in logarithm terms as dependent variables. As the efficiency indicators have a value bounded between 0 and 1, we also run a censored Tobit regression model, where the dependent variables are censored at both ends of the distributions, ($Y_i = Y_i^*$, if $0 \leq Y_i^* \leq 1$; or $Y_i = 0$ otherwise). The empirical results are summarised in Table 2.

The regression results are robust and consistent across different models. In terms of the goodness of fit, the VRSTE models have the lowest adjusted R^2 compared with the CRSTE and the SCALE models. Among the attribute vectors, $\mathbf{Z}_i$, the condominium size (Size) is the most consistent in all models. It is significant, but has negative effects on the efficiency indicators. The results show that residents' satisfaction levels decline when the local public goods are shared by a large group of residents. The coefficients on 'Mix' and 'Height' are both negative and significant. The results imply that collective goods are less efficiently provided in condominiums with more diverse types of units, as well as in more densely built condominiums with many high-rise blocks.

The coefficient on the 'Fee' variable is significant, but negative at less than the 1 per cent level in the CRSTE and SCALE models. It is only marginally significant in the VRSTE model. The hypothesis [H_0: $c \geq 0$] is rejected. The results support Proposition 3 that marginal pay-offs (utilities) are inversely related to the management fees, of which a large fraction is used to pay the TPM services. The MCs trade-off between attaining lower utilities and paying higher management fees in the delivery of local

Table 2. Regression models on determinants on utilities of local public goods

Regression model	*OLS*		*OLS*		*Semi-log*		*Tobit*	
Dependent variable: technical efficiency in constant return to scale technology (CRSTE)								
Constant	1.241	(7.829)***	1.243	(7.913)***	0.294	(1.464)	1.243	8.312***
SIZE	−0.001	−(3.297)***	−0.002	−(2.556)**	−0.002	−(2.463)**	−0.002	−2.685***
HEIGHT	−0.054	−(2.378)**	−0.052	−(2.277)**	−0.072	−(2.491)**	−0.052	−2.392**
AGE	−0.002	−(1.571)	−0.002	−(1.371)	−0.002	−(1.292)	−0.002	−1.440
RENTAL	−0.001	−(0.075)	0.000	−(0.055)	0.000	−(0.026)	0.000	−0.058
VACANT	0.005	(0.496)	0.004	(0.401)	0.004	(0.317)	0.004	0.421
MIX	−0.020	−(1.848)*	−0.023	−(2.056)**	−0.029	−(2.066)**	−0.023	−2.159**
MAX	0.004	(0.472)	0.003	(0.358)	0.005	(0.383)	0.003	0.376
FEE	−0.001	−(5.269)***	−0.001	−(4.856)***	−0.002	−(4.975)***	−0.001	−5.101***
OUTSOURCE	−0.045	−(1.283)	−0.039	−(1.104)	−0.038	−(0.854)	−0.039	−1.159
$OUTSOURCE^2$	0.002	(1.136)	0.001	(0.699)	0.001	(0.489)	0.001	0.734
OUTSOURCE*SIZE			0.000	(1.774)*	0.000	(1.672)*	0.000	1.863*
Adjusted R^2	0.380		0.391		0.391		$0.767^{\#}$	
S.E. of regression	0.097		0.096		0.123		0.097	
Dependent variable: Technical efficiency in variable return to scale technology (VRSTE)								
Constant	0.959	(13.737)***	0.960	(13.863)***	−0.041	−(0.558)	0.960	14.564***
SIZE	0.000	−(0.758)	−0.001	−(1.853)*	−0.001	−(1.851)**	−0.001	−1.947*
HEIGHT	0.011	(1.066)	0.012	(1.185)	0.013	(1.197)	0.012	1.245
AGE	0.000	−(0.168)	0.000	(0.029)	0.000	(0.042)	0.000	0.030
RENTAL	−0.002	−(0.659)	−0.002	−(0.645)	−0.002	−(0.596)	−0.002	−0.678
VACANT	0.002	(0.487)	0.002	(0.395)	0.002	(0.334)	0.002	0.415
MIX	−0.012	−(2.465)**	−0.013	−(2.665)***	−0.014	−(2.764)***	−0.013	−2.800***
MAX	0.004	(0.976)	0.004	(0.869)	0.004	(0.871)	0.004	0.913
FEE	0.000	−(1.807)*	0.000	−(1.444)	0.000	−(1.463)	0.000	−1.517
OUTSOURCE	0.003	(0.205)	0.006	(0.383)	0.006	(0.368)	0.006	0.402
$OUTSOURCE^2$	0.000	−(0.269)	−0.001	−(0.665)	−0.001	−(0.644)	−0.001	−0.699
OUTSOURCE*SIZE			0.000	(1.716)*	0.000	(1.725)*	0.000	1.803*
Adjusted R^2	0.032		0.048		0.049		$0.967^{\#}$	
S.E. of regression	0.043		0.042		0.045		0.043	
Regression model	OLS		OLS		Semi-Log		Tobit	
Dependent variable: scale efficiency (SCALE)								
Constant	1.272	(8.223)***	1.274	(8.253)***	0.335	(1.733)*	1.274	8.669***
SIZE	−0.001	−(3.222)***	−0.001	−(2.036)**	−0.002	−(1.848)*	−0.001	−2.139**
HEIGHT	−0.064	−(2.888)***	−0.063	−(2.805)***	−0.085	−(3.050)***	−0.063	−2.947***
AGE	−0.002	−(1.499)	−0.002	−(1.348)	−0.002	−(1.358)	−0.002	−1.416
RENTAL	0.001	(0.157)	0.001	(0.172)	0.002	(0.203)	0.001	0.181
VACANT	0.004	(0.382)	0.003	(0.312)	0.003	(0.203)	0.003	0.328
MIX	−0.011	−(0.999)	−0.012	−(1.139)	−0.015	−(1.091)	−0.012	−1.197
MAX	0.001	(0.134)	0.000	(0.051)	0.001	(0.071)	0.000	0.053
FEE	−0.001	−(4.844)***	−0.001	−(4.507)***	−0.001	−(4.613)***	−0.001	−4.734***
OUTSOURCE	−0.046	−(1.351)	−0.042	−(1.217)	−0.044	−(1.027)	−0.042	−1.278
$OUTSOURCE^2$	0.002	(1.225)	0.002	(0.899)	0.002	(0.754)	0.002	0.944
OUTSOURCE*SIZE			0.000	(1.262)	0.000	(1.073)	0.000	1.326
Adjusted R^2	0.359		0.363		0.363		$0.793^{\#}$	
S.E. of regression	0.095		0.095		0.118		0.095	

Notes: We run OLS, semi-log and Tobit models on the three efficiency indicators. In the semi-log model, the efficient estimate is converted into logarithm terms. The table reports the regression coefficients and t-statistics (in parentheses) of the respective models. The significance level of each coefficient is denoted: *** 1 per cent significance; ** 5 per cent significance; * 10 per cent significance. For Tobit model, the mean of the dependent variable is reported.

Table 3. Probit regression model of a binary outsourcing variable ($N = 128$)

Independent variable	*Symbol*	*Coefficient*	*z-statistic*
	Constant	−4.912	−6.240***
Handling of management fee arrears	ARREAR	−0.080	−0.583
Financial management	FUND	0.057	0.293
Physical facilities and services	FACILITY	0.399	3.208***
Ratio of public space to built-up area	PUBLIC	9.926	3.795***
Management fee	FEE	0.012	3.590***
McFadden R^2		0.403	
Mean dependent variable		0.391	
S.D. dependent variable		0.490	
S.E. of regression		0.365	
Observations with $\psi = 0$		78	
Observations with $\psi = 1$		50	

Notes: The dependent variable of the Probit model is a binary variable that has a value of 1, if OUTSOURCE > 8, and 0 otherwise. The estimation method: ML - Binary Probit (Quadratic hill climbing). The table reports the coefficient of the estimate and the numbers in parentheses are z-statistics of the respective coefficient. The significance of each coefficient is indicated by: *** 1 per cent significance; ** 5 per cent significance; * 10 per cent significance.

public goods. The high fees indicate productivity gains by outsourcing to TPMs on the one hand; the high fees reduce the marginal utilities of the residents on the other hand. Therefore, the social dilemma cannot be solved by paying for TPMs.

In testing the second hypothesis, [H_0: $d \leq 0$], the coefficient on 'Outsource' is insignificant, which rejects Proposition 2 that MC members contributing high effort levels produce incremental collective action outcomes, compared with MC members who put in the minimum level of effort. However, the significant and positive coefficient on the interactive variable, 'Outsource*Size', suggests that some degree of outsourcing to the TPMs generates incremental social pay-offs (efficiency gains) for residents, when the scale of public goods is relatively large.

6.2 Self-selectivity of Active Members

Through outsourcing to TPMs, the MC members could self-select to minimise private costs (effort levels) incurred in the management of local public goods. The results of the first-stage Probit model on the binary outsourcing decisions (equation (17)) are summarised in Table 3. Condominiums with more physical facilities and services and larger public space are more likely to outsource CPR management activities. The management fee is also a positive predictor of the probability of outsourcing. From the Probit regression, we compute the density function, $f(\hat{\psi}_i)$, and the cumulative normal distribution function, $F'(\hat{\psi}_i)$, where ($\hat{\psi}_i = \mathbf{p}'\mathbf{S}_i + q\mu_i$), and define the two selectivity variables: $IMILLS1 = \left[-\frac{f(\psi_i)}{F(\psi_i)}\right]$ and $IMILLS2 = \left[\frac{f(\psi_i)}{1-F(\psi_i)}\right]$.

In the second-stage regression, we test the interactive effects of the selectivity variables (IMILLS1 and IMILLS2) on the utilities (efficiency) of the local public goods in a high outsourcing model, ($\psi = 1$) (Equation (19)), and a low outsourcing model, ($\psi = 0$) (equation (20)), using the OLS and the semi-log models. The results in Table 4 are

Table 4. Regression models corrected for selection biases

Dependent variable	*Technical efficiency in constant return to scale technology (CRSTE)*				*Technical efficiency in variable return to scale technology (VRSTE)*				*Scale efficiency (SCALE)*			
	OLS		*Semi-log*		*OLS*		*Semi-log*		*OLS*		*Semi-log*	
Regressions with high outsourcing samples (ψ = 1)												
Constant	0.948	(12.222)***	−0.017	−(0.169)	0.951	(24.280)***	−0.051	−(1.243)	0.995	(12.151)***	0.034	(0.319)
SIZE	−0.001	−(1.981)*	−0.001	−(2.122)**	0.000	−(1.366)	0.000	−(1.364)	0.000	−(1.445)	−0.001	−(1.526)
HEIGHT	−0.089	−(3.400)***	−0.122	−(3.523)***	0.006	(0.438)	0.006	(0.443)	−0.096	−(3.489)***	−0.128	−(3.580)***
AGE	0.000	−(0.253)	−0.001	−(0.232)	0.001	(0.744)	0.001	(0.732)	−0.001	−(0.465)	−0.001	−(0.507)
RENTAL	−0.010	−(1.140)	−0.013	−(1.133)	−0.002	−(0.547)	−0.002	−(0.504)	−0.009	−(0.961)	−0.011	−(0.898)
VACANT	0.011	(0.780)	0.015	(0.783)	0.008	(1.128)	0.009	(1.129)	0.005	(0.332)	0.006	(0.320)
MIX	0.006	(0.375)	0.011	(0.493)	0.008	(1.024)	0.009	(1.011)	−0.001	−(0.032)	0.002	(0.087)
MAX	0.025	(2.100)**	0.032	(2.047)**	0.002	(0.365)	0.002	(0.374)	0.024	(1.935)*	0.030	(1.840)*
FEE	−0.001	−(2.630)**	−0.001	−(2.690)**	0.000	−(1.538)	0.000	−(1.569)	−0.001	−(2.048)**	−0.001	−(1.991)*
IMILLS1	0.011	(0.396)	0.017	(0.440)	−0.004	−(0.300)	−0.005	−(0.301)	0.015	(0.490)	0.021	(0.546)
Adjusted R^2	0.275		0.299		−0.028		−0.025		0.229		0.238	
S.E.	0.079		0.104		0.040		0.042		0.083		0.108	
Regression with low outsourcing samples (ψ = 0)												
Constant	0.892	(8.786)***	−0.093	−(0.725)	0.945	(22.448)***	−0.057	−(1.278)	0.936	(9.659)***	−0.035	−(0.296)
SIZE	−0.001	−(2.785)***	−0.001	−(2.780)***	0.000	−(0.822)	0.000	−(0.786)	−0.001	−(2.737)***	−0.001	−(2.686)*
HEIGHT	−0.012	−(0.341)	−0.022	−(0.491)	0.006	(0.425)	0.007	(0.422)	−0.017	−(0.508)	−0.029	−(0.690)
AGE	−0.003	−(1.943)*	−0.004	−(1.815)*	−0.001	−(0.780)	−0.001	−(0.753)	−0.003	−(1.739)*	−0.003	−(1.665)
RENTAL	0.004	(0.406)	0.007	(0.517)	−0.001	−(0.128)	0.000	−(0.092)	0.005	(0.507)	0.007	(0.591)
VACANT	0.016	(1.193)	0.017	(1.030)	0.000	(0.013)	0.000	−(0.048)	0.017	(1.307)	0.018	(1.123)
MIX	−0.033	−(2.229)**	−0.044	−(2.357)**	−0.024	−(3.925)***	−0.026	−(4.027)***	−0.014	−(0.972)	−0.018	−(1.016)
MAX	−0.002	−(0.150)	−0.002	−(0.105)	0.009	(1.584)	0.009	(1.601)	−0.009	−(0.749)	−0.011	−(0.712)
FEE	−0.001	−(2.923)***	−0.002	−(3.073)***	0.000	(0.384)	0.000	(0.378)	−0.001	−(3.193)**	−0.002	−(3.441)***
IMILLS2	0.054	(2.632)**	0.062	(2.392)**	0.013	(1.519)	0.014	(1.529)	0.044	(2.243)**	0.048	(1.990)*
Adjusted R^2	0.413		0.408		0.205		0.211		0.390		0.389	
S.E.	0.099		0.125		0.041		0.044		0.095		0.117	

Notes: The table reports regression estimates for OLS and semi-log model. The numbers in parentheses are the t-statistics. The significance level of each coefficient is denoted by: *** 1 per cent significance; ** 5 per cent significance; * 10 per cent significance. The selectivity variables, $IMILLS1 = \left[-\frac{f(\psi_i)}{F(\psi_i)}\right]$ and $IMILLS2 = \left[\frac{f(\psi_i)}{1-F(\psi_i)}\right]$, are derived from the probability density $f(\psi_i)$ and cumulative probability density function, $F(\psi_i)$, of the binary outsourcing decision estimated in the earlier Probit model.

consistent with the results in Table 3, except for the VRSTE model.

The 'Size', 'Height' and 'Mix' variables are significant and the signs are the same in the CRSTE and SCALE models. The coefficients on 'Max' and 'Age' are also significant in the models. The coefficient on 'Max' is positive and significant in the high outsourcing models (panel A), whereas the coefficient on 'Age' is negative and significant in the low outsourcing model (panel B). The 'Fee' variable is significantly negative at less than the 5 per cent level in the CRSTE and SCALE models. The results reaffirm Proposition 3 that paying for higher efficiency in TPMs (higher management fees) reduces the residents' marginal utilities in the use of local public goods.

The selectivity variable, IMILLS2, which controls for the endogenous outsourcing decision, is significant in the low outsourcing models, ($\psi = 0$), but the IMILLS1 is not significant in the high outsourcing models ($\psi = 1$). The positive sign for IMILLS2 implies that the earlier estimates in the OLS and the semi-log models are biased downward. The self-selectivity in the outsourcing decision decreases the residents' utilities in the use of local public goods in the low-outsourcing model. The result is consistent with Proposition 2, which implies that, by choosing a low level of outsourcing, the MC members have to contribute more effort to produce higher social outcomes (joint marginal utilities). The two selectivity variables are, however, not significant in the VRSTE model.

7. Conclusion

In the self-organised CPR regimes, the active members' efforts have a positive impact on the collective (social) pay-offs. Using the efficiency indicators estimated by the data envelopment analysis (DEA) as proxies for the joint utilities (social payoffs), we test the determinants for the incremental utilities in the provision of CPRs. Our results show that the management fees have a significant but negative impact on the efficiency indicators (Proposition 3). The negative coefficient implies that residents do not enjoy higher marginal utilities by paying higher fees for the services of the TPMs.

We also find that the effort levels of active members and the scale of local public goods are jointly and positively significant in influencing the incremental outcomes in the use of CPRs. When the CPR scale increases, some degree of outsourcing to TPMs is necessary to increase the pay-offs (utilities) in the management of CPRs. When the self-selectivity in the outsourcing decision is controlled, we find that the effort levels of active members do positively influence the efficiency in the model with low outsourcing of local public goods (Proposition 2).

Notes

1. Common property has legal definition in Strata Titled Acts, which cover parts of land and buildings jointly shared and used by residents. Residents have undivided interests in the common property.
2. Oliver (1984) uses the number of children and the unemployment status of active members as proxies for free time. However, free time is not directly related to the effort levels of the members in the provision of local public goods.
3. The choice of an output-oriented model over an input-oriented model in this study has no significant impact on the efficiency scores.
4. We thank Professor Timothy Coelli for sharing the DEAP Version 2.1 computer programme. The data envelopment analysis frontier technique is available at: http://www.uq.edu.au/economics/cepa/deap.htm.

5. Ping is a traditional measure of area in Taiwan: 3.305 square metres is equivalent to 1 ping.
6. The unit '$' is measured in New Taiwan dollars (NTD$).
7. The monthly management fees that are not reported on a per unit ping basis are converted using the average floor area of the sample development. The outliers with a management fee below NTD$20 per unit area are dropped.

Funding Statement

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

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Appendix

Table A1. Questionnaire design and derivation of variables

Variable	*Symbol*	*Survey questions used to construct the variable*	*Scale*	*Remarks*
A. Input/output factors for DEA				
Quality of living environment	LIVING	Preserving and enhancing property value Providing good public security in the estate Maintaining cleanliness of amenities and landscaping Maintaining public facilities and common areas Organising social activities and building community bonding	5 = highly satisfactory; 4= satisfactory; 3 = neutral; 2 = unsatisfactory; 1= very unsatisfactory	Compute the AVERAGE of the categorical scales of the questions
Enforcement of rules and execution of work plans	RULE	Annual meetings and implementation of resolutions Arrears in payments of management fees Residents' co-operation and compliance with rules Extension works to balcony, rooftop and empty space Waste disposal and encroachment in common areas	5 = highly satisfactory; 4= satisfactory; 3 = neutral; 2 = unsatisfactory; 1= very unsatisfactory	Compute the AVERAGE of the categorical scales of the questions
Interruptions in services	DOWN	Breakdowns of mechanical, electrical and fire services Public safety and security lapses Slackness in security checks at entrance	5= nil; 4 = not frequent/ sporadic; 3 = normal; 2= frequent ; 1= very frequent	Compute the AVERAGE of the categorical scales of the questions
Community cohesion and neighbourliness	SOCIAL	Sense of belonging Interaction and communication Active participation in community activities Consensus on important matters on communal living Harmonious and friendly living environment Contributing voluntarily in improving living environment Compatibility of social status of owners in the estate Friendship and bonding between residents Strong sense of community and ownership pride	5= very important; 4 = important; 3 = neutral; 2 = not important; 1 = least important	Compute the AVERAGE of the categorical scales of the questions
Frequency of maintenance services	MAINTAIN	Lift maintenance Public space cleaning including lift lobby, stairway, courtyard, atrium Mosquito extermination and pest control at carpark and basement Cooling tower cleaning Cleaning of function rooms and club houses Cleaning of gymnasium and recreational facilities Landscaping and gardening works Security services	5= high standard; 4 = good standard; 3 = average; 2= below average ; 1= very poor	Compute the AVERAGE of the categorical scales of the questions

(continued)

Table A1. (Continued)

Variable	*Symbol*	*Survey questions used to construct the variable*	*Scale*	*Remarks*
Meetings and social events	EVENT	Management council/ corporation meetings Annual general meetings Social events and community days Regular gatherings and community learning activities	5= very frequent; 4 = frequent; 3 = normal; 2= sporadic ; 1= rare	Compute the AVERAGE of the categorical scales of the questions
Management fee	FEE	Monthly management fee per ping	NTD$ per ping per month	
B. Independent variables for regression models				
Size of development by strata unit	SIZE	Development scale by unit ownership count	Number of strata-titled units in the development	
Height of buildings	HEIGHT	Building height by number of storeys	1 = below 5 storeys; 2 = 6–12 storeys; 3 = above 13 storeys	
Age of development	AGE	Age (in years) of the development at the time of survey	By year since completion	
Proportion of rental unit to total unit	RENTAL	Ratio of rental units to owner-occupied units in the development	1 = 0 per cent; 2 = 2–5 per cent; 3 = 6–10 per cent; 4 = 11–20 per cent; 5 = above 21 per cent	
Proportion of vacant unit to total unit	VACANT	Ratio of vacant units to total units in the development	1 = 0 per cent; 2 = 2–5 per cent; 3 = 6–10 per cent; 4 = 11–20 per cent; 5 = above 21 per cent	
Mix of floor type by area	MIX	Mix of unit by floor area (proxy of the homogeneity of unit in the development)	Number of different unit design/type by floor area	
Maximum unit by floor area	MAX	Size of the largest unit in the estate	1 = below 20 ping; 2 = 21–30 ping; 3 = 31–40 ping; 4 =41–50 ping; 5 = above 51 ping	
Aggregate outsourcing	OUTSOURCE	Security services Cleaning and conservancy services Mechanical, electrical and fire equipment maintenance Administration and social events organisation	1 = owner-managed; 2= direct labour; 3= third party managers	Aggregate SUM of the categorical scale of the four types of outsourced services
Management fee	FEE	Monthly management fee per ping	NTD$ per ping per month	

(continued)

Table A1. (Continued)

Variable	*Symbol*	*Survey questions used to construct the variable*	*Scale*	*Remarks*
C. Variables for probit model:				
Handling of management fee arrears	ARREAR	Communication modes in management fee arrears collection: by circulars or letters by management boards/ management executives via notice board by registered mail court / legal summons	1= yes; 0 = no	Compute the AVERAGE of the categorical scales of the questions
Financial management	FUND	Set-up common sinking fund Guidelines on the use of sinking fund management Excess fund from management will be transferred to sinking fund Proportion of management fee to be set aside as sinking fund Alternative sources for sinking fund	1= yes; 0 = no	Compute the AVERAGE of the categorical scales of the questions
Physical facilities and services	FACILITY	Security services / guards Lifts Function rooms and club houses Gymnasium and recreational facilities Open garden and landscape	1= yes; 0 = no	Compute the AVERAGE of the categorical scales of the questions
Ration of public space to built-up area	PUBLIC	Ratio of common areas and public facilities to total built-up areas	Percentage value	
Management fee	FEE	Monthly management fee per ping	NTD$ per ping per month	