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Domestic waste recycling, collective action and economic incentive: The case in Hong Kong

Yung Yau *

Department of Public and Social Administration, City University of Hong Kong, Hong Kong, People’s Republic of China

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ABSTRACT

Efficacy of waste recycling is one of the key determinants of environmental sustainability of a city. Like other pro-environmental activities, waste recycling cannot be successfully accomplished by just one or two people, but only by a concerted effort of the community. The collective-action dilemma creates a common underlying difficulty in formulating workable solutions to many environmental problems. With a view to the non-excludability of the outcome, rationality drives people to free-ride efforts of others in waste recycling. To solve this free-rider problem, some scholars suggest the use of economic incentive. This article attempts to study the impacts of reward schemes on waste recycling behaviour of residents in 122 private housing estates in Hong Kong. The study is differentiable from the others as the latter mainly focus on domestic waste recycling in low-rise low-density housing while this one looks into the same in a high-rise high-density residential setting. According to the results of analyses on a set of aggregate data, reward schemes are found to have a significant positive relationship with the per-household weight of recyclables collected, keeping other things constant. The research findings suggest that economic incentives do work in promoting waste recycling in Hong Kong. Practical and policy implications follow.

1. Introduction

1.1. Background

Since the 1970s, Hong Kong’s wealth and prosperity have generated a negative by-product that increased to an alarming level. Hong Kong’s total amount of municipal waste generated per gross domestic product is high compared with other developed jurisdictions, as shown in Table 1. In 2008, the per-capita disposal rate of domestic waste was 0.87 kg per day (Environmental Protection Department, 2009). In the arena of sustainable development research, resource efficiency has been one of the major topics. To achieve a high level of resource efficiency, strategic waste management is generally regarded as indispensable (Tanaka, 2007; Kolikkathara et al., 2009). In the waste management hierarchy, waste reduction is usually placed at the top, followed by reusing and recycling (Wilson, 1996). Preferably, recycling or recovery of waste should be resorted only after doing everything possible to reduce the amount of waste at source (Hernández and Martín-Cejas, 2005). Yet, waste reduction, if not a remote ideal, is very difficult to promote because its realization usually requires a significant adjustment in lifestyle (Price and Joseph, 2000). In view of the urgency created by limited landfill space and air pollution from incineration, waste recycling has been taken as an intermediary measure to tackle the waste problem. With the prime aim to lessen environmental damage and achieve environmental sustainability, waste recycling can save energy, conserve resources, reduce emissions from incinerators and prolong life spans of landfills (Seik, 1997; Rondinelli and Berry, 2000; Ekins et al., 2003; Timmaz and Demir, 2006; Tsai, 2008).

In spite of the advantages, promotion of recycling is not an easy task. One should bear in mind that the success of waste recycling in a society is not only ascribed to the efforts paid by the Government, but also the active participation of the general public. However, similar to other pro-environmental activities, effectuation of waste recycling relies on collective action (e.g. Everett and Pierce, 1992; Lubell et al., 2006), and the environmental outcome of recycling is non-excludable. With these characteristics, waste recycling is highly prone to free-rider problem. Collective-action dilemma of this kind is not a dead end, and that it can be solved by the institutionalization of economic incentives (Olson, 1971). Nonetheless, domestic waste recycling has seldom been discussed from the perspective of environmental collectivism.

To fill the existing research gap, this article attempts to address the weaknesses in the literature by developing a model of waste recycling explicitly linked to the logic of collective action. In particular, whether economic incentives promote waste...
As far as waste recycling is concerned, it is certainly a typical collective action vulnerable to free-rider problem. Recycling aims to protect “common” resources such as clean air and water, open space, and energy resources. It can produce environmental benefits such as fewer litter, cleaner air, reduced energy use, and lower use of virgin natural resources. Yet, these benefits are non-excludable and non-rivalrous, and community participation is always confronted by the free-rider problem (Head, 1962; Olson, 1971). In his classic book The Logic of Collective Action, Olson (1971) explained the failures of groups to work in their collective interest to achieve group benefits, with the insights drawn from the rational choice theory. The crux lies in individuals’ self-interests or rationality. Given that other people engage in a behaviour that is necessary to achieve a collective good, a rational individual seeking to maximize utility or wealth can free-ride their efforts while still gaining the benefits of their behaviour. This rational individual also reasons that if he or she acts to achieve the collective good, the others will free-ride his or her efforts. Therefore, he or she will not pay any effort in the provision of the public good, and others will act in the same way. As a result, there will be no cooperation and no collective good is realized.

The collective-action problem can be best illustrated with the well-known game “prisoner’s dilemma”. In the simplest form as shown in Fig. 1, players A and B both have the choice between two alternative strategies, namely “cooperate” and “defect”. The outcome and the payoffs of each play are determined by the combination of each player’s strategy. The payoffs are indicated in the matrix in Fig. 1, with A’s payoffs on the left side and B’s on the right side in the boxes. The highest payoff on an ordinal scale is “4” and the lowest is “1”, and thus payoff of “4” is more preferable than payoff of “3”.

In case player B cooperates, player A can achieve a better payoff (“4” > “3”) by defecting. If player B defects, player A will choose to defect for a better payoff (“2” > “1”). Therefore, whatever player B chooses, player A will defect with a view to more preferable payoff. The inverse is also true: player B will defect irrespective of player A’s choice. That means whatever strategy one player chooses in the prisoner’s dilemma, the other will be better off by defecting. Consequently, “defect-defect” becomes the dominant strategy even though mutual cooperation would be the most profitable to all. This paradox is built upon the fact that an individual may find it more profitable to take a free-ride at the expense of the others. This game of prisoner’s dilemma has been used for conceptualizing environmental problems (e.g. Holzinger, 2001; Potoski and Prakash, 2004) because the resolution of environmental problems generally requires heterogeneous groups of individuals with no real connection to one another to change their behaviour for little or no economic gain (Carlson, 2001). As proposed by Hardin (1968), the two-person game presented above can be transformed into an n-person game by replacing player B with “others”. By the same logic discussed above, collective rationality eventually results in a “tragedy of the commons” (Hardin, 1968; Ostrom, 1971).

As far as waste recycling is concerned, it is certainly a typical collective action vulnerable to free-rider problem. Recycling aims to protect “common” resources such as clean air and water, open space, and energy resources. It can produce environmental benefits such as fewer litter, cleaner air, reduced energy use, and lower use of virgin natural resources. Yet, these benefits are non-excludable in nature. On the other hand, recycling involves a series of steps, including separating garbage into recyclables and non-recyclables and taking the sorted recyclables out to waste separation facilities (e.g. curbside collection point or drop-off centre), but it is not financially remunerative in most cases. To put it another way, time recycling behaviour in a high-rise setting is examined. Research of this kind is in need because a large body of literature like Vining and Ebreo (1990), Oskamp et al. (1991), Werner and Makela (1998) and Robinson and Read (2005) studied what motivate people to recycle but nearly all focussed on low-rise housing. While waste recycling by residents in a multi-family housing, particularly in high-rise housing estates, has been regarded challenging (De Young et al., 1995; Ooi, 2005), determination of recycling behaviour in such setting is largely omitted in the literature. Hong Kong, in which 80% of the total housing stock is high-rises, provides an excellent laboratory for studying collective environmental action like recycling in a high-rise high-density context.

In this regard, the aim of this research is to draw some insightful policy implications from an explanatory study which finds out what the exogenous factors affecting waste recycling behaviour in a high-rise setting are. This kind of research is timely and of ultimate importance to the contemporary Hong Kong because of the landfill crisis. Besides, what makes this study differentiable from the literature (e.g. Chung and Poon, 1996; Chan, 1998; Ko and Poon, 2009) lies on the methodology adopted. The previous studies employed information like self-reported behaviour or willingness to participate through surveys or interviews for exploratory analyses but such information may not truly reflect the respondents’ actual behaviour. On the other hand, outcome-based evidence, in terms of the amount of recyclables collected, is adopted in this study to get around this hitch.

This paper is organized as follows. The following section offers a framework conceptualizing collectivism in waste recycling. What comes next is an overview of waste recycling policies and practice in Hong Kong. The fourth section introduces the analytical model explaining waste recycling behaviour in private high-rise housing estates in Hong Kong, and the data are described. In the fifth section, the analysis results are presented and the corresponding practical and policy implications are discussed. Lastly, the article is concluded in the sixth section.

### 2. Collectivism in waste recycling

Environmental protection requires cooperation among nations and community participation. That is why environmental protection requires collective actions, and waste recycling is not an exception to this rule. By its nature, collective action is the voluntary provision of public goods (Chamberlin, 1976). As public goods, be they tangible or intangible, are ones with characteristics of “non-excludability” and “jointness of supply”, collective action is always confronted by the free-rider problem (Head, 1962; Olson, 1971). In his classic book The Logic of Collective Action, Olson (1971) explained the failures of groups to work in their collective interest to achieve group benefits, with the insights drawn from the rational choice theory. The crux lies in individuals’ self-interests or rationality. Given that other people engage in a behaviour that is necessary to achieve a collective good, a rational individual seeking to maximize utility or wealth can free-ride their efforts while still gaining the benefits of their behaviour. This rational individual also reasons that if he or she acts to achieve the collective good, the others will free-ride his or her efforts. Therefore, he or she will not pay any effort in the provision of the public good, and others will act in the same way. As a result, there will be no cooperation and no collective good is realized.

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### Table 1
Comparative figures of total amount of municipal waste generated per gross domestic product in developed jurisdictions (Environmental Protection Department, 2009; Eurostat, 2010; The World Bank Group, 2010; author’s calculation).

| Country or City | Municipal waste per gross domestic product (g/US$) |
|-----------------|--------------------------------------------------|
|                 | Year 2007 | Year 2008 |
| Hong Kong       | 16.62     | 15.97     |
| Germany         | 14.43     | 13.06     |
| France          | 12.96     | 11.81     |
| Finland         | 10.96     | 10.22     |
| Sweden          | 10.43     | 9.89      |
| United Kingdom  | 12.59     | 13.11     |
| Norway          | 5.99      | 5.19      |
| Switzerland     | 12.88     | 11.58     |
| Czech Republic  | 17.47     | 14.74     |
| Spain           | 18.43     | 16.33     |
| Austria         | 13.32     | 12.04     |
cost is incurred for an individual to recycle. In the two-person recycling game shown in Fig. 2, player A chooses not to recycle no matter what player B chooses because the former can achieve a better payoff (i.e. a greater net benefit). The same reasoning applies to player B. Consequently, both players, driven by rationality, will not take any effort to recycle. As suggested by Garcés et al. (2002), active participation in collective environmental actions generates individual benefits. These benefits may not be enough to cover the costs incurred in the action of recycling. Even worse, the environmental benefits of waste recycling are universal to the collective, and do not produce "any substantial, immediate benefit at an individual level" (Carlson, 2001, p. 1242).

Recycling presents a classic collective-action problem because to achieve the widespread benefits of recycling, a significant portion of the polluters must participate. As pinpointed by Olson and his followers like Elster (1989), if all members are rational egoists, collective incentives alone will not guarantee collective action. Lubell (2002) surmised that the collective-action problem would lead to an undersupply of environmental goods or oversupply of environmental harms. As put forward by Olson (1971), nonetheless, the collective-action dilemma can be solved if one party has such a large interest in the collective good that he or she would be prepared to provide it all by himself or herself. To put it another way, self-interested actions do not necessarily result in the worst situation and market option provides a mechanism which harnesses individually self-interested actions to the good of all if it is suitably designed and implemented.

This circumstance can come true in the recycling game with the institutionalization of some economic incentives (or disincentives). For example, if a service fee is charged on the amount of waste disposed, people will reduce refuse generation or increase recycling. In the United States and Europe, various pricing schemes like "pay-as-you-throw" have gained their popularity in encouraging citizens to recycle. Alternatively, reward schemes can be implemented so that waste collected for recycling can be exchanged for goods with value. For example, residents in Windsor and Maid-enhead, England can earn reward points by recycling designated domestic waste, and the reward points can be used for to buy goods and services from a wide range of local and national shops and businesses (RecycleBank, 2009). This kind of reward scheme increases the payoffs of the recyclers, as illustrated in the payoff matrix in Fig. 3. In this modified game, payoffs for player A are more preferable if he or she chooses to recycle ("4" > "3" in case player B recycles and "2" > "1" in case player B does not recycle), and the same logic applies to player B. Ultimately, both players are motivated by individual economic benefits to recycle no matter what the other player chooses, and "recycle-recycle" becomes the dominant strategy. This is an example of utilizing self-interested behaviour in this way which lies behind proposals for the use of economic instruments in environmental policy. Through the operation of the "invisible hand" of the market, self-interested individuals are driven by the economic incentive to produce a public good for all. To be rational is just to be able to choose the most effective, most efficient and most economical means to achieving what one wants, whatever that happens to be. In theory, therefore, rationality does not always lead to results against collective interests.

In a household survey conducted by Chung and Poon (1996) in Hong Kong, the respondents were found to have a stronger willingness to return batteries if there was a refundable deposit. While some environmental researchers (e.g. Schultz et al., 1995; Williams and Taylor, 2004; Bennett et al., 2008) and local authorities (e.g. Department of Environment Food and Rural Affairs, 2007) claimed that economic instruments are highly effective in increasing community participation in waste recycling, the effectiveness of the reward or incentive schemes in promoting domestic waste recycling is doubtful. Allen et al. (1993) studied the successfulness of a coupon scheme in promoting aluminium recycling in the United States, and concluded that the economic incentive could at best boost up recycling among previous recyclers. The scheme was found to be ineffective in changing the behaviour of previous non-recyclers. Similarly, the study by Scott (1999) also found that the introduction of an economic incentive did not have significant impacts on the recycling intensity in four communities within the Greater Toronto Area. In another occasion, the local council of Portsmouth, England implemented a reward scheme in which green scores were assigned to each household periodically if the recyclables disposed were not contaminated, and the household could use the scores to redeem some rewards of value (Timlett and Williams, 2008). Timlett and Williams found that only 13% of the surveyed households stated that the reward scheme was a main motivator for waste recycling. From above, the effectiveness of economic incentive in actuating recycling is still not conclusive based on the results of the previous empirical studies. In this light, this study aims to investigate if incentive scheme in Hong Kong works in promoting domestic waste recycling.

3. Promotion of waste recycling in Hong Kong

Like many other cities, landfill crisis has been a big challenge in Hong Kong. Extending existing landfill sites or creating new ones is extremely costly because of the limited land resource in Hong Kong. Yet, the Environmental Protection Department (2005) estimated that based upon the prevailing waste generation rates, the existing landfills would be full in 6–10 years. Against this background, the Hong Kong Government regards recycling as an intermediate approach to solve the waste problem. Nonetheless, in comparison with the western counterparts, the promotion of domestic waste recycling in Hong Kong started quite late. Since the establishment of the Environmental Protection Unit in 1977, waste recycling had never been put at the top of policy agenda until the handover of Hong Kong in 1997. Starting from June 1997, the Hong Kong Government established a number of Waste Reduction Task Forces to pursue waste reduction initiatives in different sectors in the city. At that time, domestic waste recycled or reused amounted only 8% of total domestic waste disposed in the city (Chan, 1998). To raise the domestic waste recovery rate to 14%

![Player A](attachment:image1.png)

![Player B](attachment:image2.png)
by 2004 and 20% by 2007, the Hong Kong Government set out a ten-year implementation programme in the Waste Reduction Framework Plan in 1998 (The Hong Kong Special Administrative Region Government, 1998). To boost up the waste recycling rate, waste separation bins were provided on the ground floor or in designated common areas in public housing estates to collect waste paper, aluminium cans and plastic bottles (Waste Reduction Committee, 2000). Since provision of recycling facilities in private housing was voluntary in nature, the Government lured the developers to provide space for refuse storage and waste recovery in the original building designs by permitting such space to be non-accountable for gross floor area calculation under the Building (Planning) Regulations in 2000.

A one-year Dry and Wet Waste Separation Pilot Programme at four housing estates in the Eastern District was launched by the Environmental Protection Department in 2003 (Waste Reduction Group, 2006). The Department introduced another pilot scheme, namely the Programme on Source Separation of Domestic Waste (PSSDW), at thirteen public housing estates in the same district in August 2004 (Waste Reduction Group, 2006). Under the PSSDW, each participating housing estate tailor-made its own mode of waste separation and recovery to fit its specific constraints and characteristics. In the policy document A Policy Framework for the Management of Municipal Solid Waste (2005–2014) published in 2005, the Government further pushed up the target recovery rate of domestic waste to 26% by 2012 (Environmental Protection Department, 2005). Upon the satisfactory results of the pilot PSSDW, the Government decided to roll out the programme territory-wide, and targeted to have 80% of the city’s population to participate in the programme by 2010 (Environmental Protection Department, 2007). With an aim to wide participation in the programme, pecuniary supports were offered to housing estates with financial difficulties in setting up waste separation facilities through the Environment and Conservation Fund (Waste Reduction Group, 2006). In January 2007, the Environmental Protection Department implemented a trial PSSDW for single-block residential buildings in Sham Shui Po, with an aim to identify appropriate arrangements for waste recycling in this type of building (Audit Commission, 2008).

The recovery rate of domestic waste in Hong Kong increased continuously from 10% in 2001 to 20% in 2006 and 23% in 2007 (Environmental Protection Department, 2008a). With a firm belief in the relationship between recycling efficacy and convenience, the Government planned to have “waste separation facilities set up on each floor of most residential buildings” (Environmental Protection Department, 2007, p. 19). HK$5 million was set aside from the Environment and Conservation Fund in September 2005 as a partial sponsorship for residents’ associations and property management companies to provide waste separation facility on each floor of buildings (Environment and Conservation Fund Committee, 2007). In 2006, a proposal was file by the Government to amend the Building (Refuse Storage and Material Recovery Chambers and Refuse Chutes) Regulations to necessitate the provision of a refuse storage and material recovery room on every domestic floor of new buildings. Upon the approval by the Legislative Council, the Building (Refuse Storage and Material Recovery Chambers and Refuse Chutes) (Amendment) Regulation 2008 came into operation on 1 December 2008.

Other than the Government’s initiatives, domestic waste recycling has also been promoted in the private sector. For example, local property management companies launched different reward schemes to motivate the residents in the housing estates under their management to recycle. The operations of these reward schemes vary. In some schemes, recyclers can exchange daily goods (e.g. shampoo, toilet tissues, bleaching agents and detergents) and foodstuffs (e.g. instant noodles and biscuits) with recyclables on designated recycling days. Owing to the difficulties in storage and handling of the items for exchange, some companies adopt a “green point” system in which recyclers earn green points by recycling and they can use the green points to redeem cash coupons anytime in the property management offices. Given the increasing accent on corporate social responsibility, more and more enterprises, other than property management companies, are willing to voluntarily promote various environmental protection services. Inter-sectoral collaborations evolve in environmental activities, and one of the notable exemplars is the partnership formed between Kai Shing Management Services Limited and Maxim’s Group to launch a pilot waste recycling campaign titled “Small Changes! Greener Environment!” in June 2009 (Maxim’s Group, 2009). Under the scheme, residents in the participating housing estates managed by Kai Shing Management Services Limited earned green points if they recycled household waste like paper, plastic and metals, or if they participated in environmental protection activities. The residents could use the green points to redeem food products or dining coupons. As explicated before, rational individuals seeking to maximize their utility are expected not to recycle for little or no economic gain. The reward schemes just discussed may install economic incentives in the non-recyclers and change their behaviour, and this study explores whether institutionalization of economic incentives can solve the free-rider problem in domestic waste recycling in Hong Kong.

4. Analytical model and data description

In this study, high-rise residential buildings, with at least ten storeys, are targeted because they predominate the private housing stock in the territory. Besides, since the exploration of waste recycling behaviour in the literature mostly focus on low-rise housing, this study on high-rise housing helps straddle the existing research gap.

4.1. Analytical model of waste recycling behaviour

When constructing an analytical model of waste recycling behaviour for empirical research, it is first necessary to understand what factors drive an individual to recycle domestic waste. A number of determining factors are identified through a thorough literature review, and they come under four categories. The first category contains individuals’ socio-demographic characteristics, including education level (Judge and Becker, 1993; Owens et al., 2000), gender (Vicente and Reis, 2007), age (Vining and Ebreo, 1990; Granzin and Olsen, 1991; Belton et al., 1994; Gamba and Oskamp, 1994; Scott, 1999), income (Saltzman et al., 1993; Gamba and Oskamp, 1994; Owens et al., 2000; Smallbone, 2005) and household size (Judge and Becker, 1993). The second category encompassed housing characteristics, including tenure mode (Oskamp et al., 1991; Mainieri et al., 1997; Margai, 1997; Owens et al., 2000; Nixon and Saphores, 2009) and dwelling size (De Young, 1989; Derksen and Gartrell, 1993). Location of the recycling facility represents the third category. Plentiful evidence (Cummings, 1977; De Young, 1989; Judge and Becker, 1993; Margai, 1997; Ludwig et al., 1998; Vencatasawmy et al., 2000; Smallbone, 2005) suggests that convenience is a strong motivator for residents to recycle waste. The last category is the institutionalization of economic incentives which is the focus of this study. It is hypothesized that regular reward schemes promote residents’ participation in waste recycling.

1 Kai Shing Management Services Limited is a wholly-owned subsidiary of Sun Hung Kai Properties Limited specialized in property and facility management. Maxim’s Group is one of the largest catering companies in Hong Kong. Brands under the group include Maxim’s MX, Maxim’s Cakes, Arome and Genki Sushi.
From above, recycling behaviour (RB) can be assumed to be a function (f) of education level (EDU), gender (GEN), resident age (AGE), income (INC), household size (HSIZE), tenure mode (TEN), dwelling size (DSIZE), level of convenience (CONV) and economic incentives (ECON), or mathematically,

\[
RB = f(EDU, GEN, AGE, INC, HSIZE, TEN, DSIZE, CONV, ECON; \gamma)
\]  

(1)

where \( \gamma \) denoted the unknown parameters impinging on an individual’s recycling behaviour. In the operationalization of this analytical model, research constraints have to be portrayed in the first place. A vast majority of previous empirical studies investigated the determinants of recycling behaviour at an individual or household level but they usually used subjective willingness to participate or self-reported recycling rate. With a view to a more credible examination of effects of economic incentives on recycling behaviour, objectively measurable and conformable data are used in this study. However, the most precise data on residents’ socio-demographic characteristics officially announced in Hong Kong are available in a street-block level only.\(^2\) In other words, building-based data are not available, and thus data analyses have to be conducted on an estate basis.\(^3\) Despite the fact that the use of the aggregate data may unrealistically assume a homogeneous population of waste recyclers in each housing estate (Parfitt et al., 1994), the preciseness of the aggregate data is well enough for the study of community’s collective action in domestic waste recycling.

Secondly, to objectively “measure” recycling behaviour, rate of waste recycling (i.e. the ratio of the amount of waste collected for recycling to the total amount of waste disposed) is a commonly used indicator. However, information of the total amount of waste disposed in each housing estate is not available in Hong Kong. In this respect, the total amount of waste collected per domestic household\(^4\) for recycling is employed as a proxy for recycling rate. With a view to a more credible examination of effects of economic incentives on recycling behaviour, objectively measurable and conformable data are used in this study. However, the most precise data on residents’ socio-demographic characteristics officially announced in Hong Kong are available in a street-block level only.\(^2\) In other words, building-based data are not available, and thus data analyses have to be conducted on an estate basis.\(^3\) Despite the fact that the use of the aggregate data may unrealistically assume a homogeneous population of waste recyclers in each housing estate (Parfitt et al., 1994), the preciseness of the aggregate data is well enough for the study of community’s collective action in domestic waste recycling.

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\[
\text{WASTE}_i = f\left(\text{ITEDU}_i, \text{MALE}_i, \text{AMGE}_i, \text{MHINC}_i, \text{AHSIZE}_i, \text{OWN}_i, \text{AROOM}_i, \text{FLOOR}_i, \text{REWARD}_i; \gamma\right)
\]  

(2)

where \( \text{WASTE}_i \) is the amount of recyclables collected per household in estate \( i \) in one year (measured in kg per household); \( \text{ITEDU}_i \) is the percentage of residents with post-secondary education attainment in estate \( i \); \( \text{MALE}_i \) is the percentage of male population in estate \( i \); \( \text{AMGE}_i \) is the median age of resident in estate \( i \) (measured in years); \( \text{MHINC}_i \) is the median income of household in estate \( i \) (measured in HK$); \( \text{AHSIZE}_i \) is the average size of household in estate \( i \); \( \text{OWN}_i \) is the percentage of households owning and occupying their properties in estate \( i \); \( \text{AROOM}_i \) is the average number of rooms in each dwelling unit in estate \( i \); \( \text{FLOOR}_i \) is a dummy variable that equals one if waste separation facilities are provided on each domestic floor of the buildings in estate \( i \), and zero if otherwise; and \( \text{REWARD}_i \) is a dummy variable that equals one if a regular reward scheme is practised in estate \( i \), and zero if otherwise. Independent variables other than \( \text{REWARD}_i \) are incorporated in the model as control variables. Since the functional form of \( f(\cdot) \) in Eq. (1) is not known a priori, various common forms, including linear, quadratic and log-linear, are used for model estimation.

### 4.2. Data for empirical analyses

In this study, a total of 122 private housing estates in Hong Kong were studied, and the data used for model estimation originate from various sources. Recycling intensity is measured as the total weight of paper, plastic and metal collected for recycling per household in an estate from 1 January 2008 to 31 December 2008. This information was obtained from the property management companies managing the 122 housing estates. In the city, recyclables collected by property management companies are sold to recyclers or recycling companies, and the sale proceeds net administrative costs then go to the management accounts of the respective estates. In most cases, the property management companies keep formal records on the amount of recyclables collected every month, providing a reliable information source for this study. Apart from recycling intensity, information about the implementation of regular reward schemes and locations of waste separation facilities was also accessed via the property management companies. Similar to the findings of Perrin and Barton (2001), paper was found to be recyclable type with the largest collection quantity in this study. The per-household weight of paper collected ranged from 10 kg to 136 kg, with a mean of 58.5 kg. This category represented, on average, 86.7% of the stock of recyclables collected in the 122 estates. At the other extreme, plastics was the least collected recyclable.

Regarding the data on socio-demographic factors and housing characteristics, they were acquired from the dataset of the 2006 By-census conducted by the Census and Statistics Department. For the sake of statistical reliability and information privacy, the Census and Statistics Department only released census data as detailed as the street-block level. With this constraint, as aforementioned, it is impossible to conduct the research on a building basis, and that is why an estate-based exploration is resorted in this study. In this study, the boundaries of the 122 private housing estates under investigation resemble those of street blocks delineated by the Census and Statistics Department. In other words, no street block contains more than one housing estate or other developments. Given the households living in the same housing estates share similar socio-demographic characteristics, internal variations of the data is not a big concern in this study even data aggregation is practised. The descriptive statistics of the continuous variables for mode estimation are summarized in Table 3. Among the 122 housing estates, regular reward schemes were

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2 Many residential developments in Hong Kong are estate-typed developments in which housing blocks are developed by the same developer and managed by the same property management company. In many cases, the boundaries of housing estates fit those of street blocks delineated by the Census and Statistics Department.

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4 As defined by the Census and Statistics Department (2009), a domestic household consists of a group of persons who live together and make common provision for essentials for living.

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| Year | Average daily quantity of domestic waste (tonnes/day) | Per-capita domestic waste disposal rate (kg/person/day) | Recycling rate for domestic waste (%) |
|------|-----------------------------------------------------|-----------------------------------------------------|---------------------------------------|
| 2001 | 7551                                                | 1.12                                                | 10                                    |
| 2002 | 7519                                                | 1.11                                                | 13                                    |
| 2003 | 7402                                                | 1.10                                                | 14                                    |
| 2004 | 7014                                                | 1.03                                                | 14                                    |
| 2005 | 6828                                                | 1.00                                                | 16                                    |
| 2006 | 6634                                                | 0.97                                                | 20                                    |
| 2007 | 6372                                                | 0.92                                                | 23                                    |
| 2008 | 6081                                                | 0.87                                                | Not yet available                     |
practised in 45 estates (36.9%), and waste separation facilities were provided on each domestic floor of buildings in 43 estates (35.2%).

5. Analysis results and discussions

5.1. Results of the empirical analyses

The empirical analyses were run with EViews (version 6.1), a commonly used statistical software. Tables 4–6 summarize the Ordinary Least Square estimations of the explanatory model in different functional forms. The adjusted $R^2$-squared returned ranges from 0.35 to 0.38, which means at least 35% of the variation in the per-household amount of recyclables collected can be explained by the variations in the independent variables. As far as the control variables are concerned, none of the housing factors show significant impacts on the dependent variable, regardless of the functional forms. The analysis results show that socio-demographic factors such as education level, gender and household size do not hold any relevancy in determining waste recycling behaviour. MHINC is the only socio-demographic factor with significant relationships with WASTE (at the 10% level at least). This confirms the findings of Saltzman et al. (1993), Gamba and Oskamp (1994) and Owens et al. (2000) that wealthier residents tend to be more active recyclers. As for median age of resident, a positive relationship significant at the 5% level is found with the weight of recyclables collected in both the linear and log-linear models (but not in the quadratic one).

In this study, placement of waste separation facility in the housing estates serves as a proxy of recycling convenience. The estimated coefficients of the dummy variable FLOOR are positive in sign in the three estimations but they are statistically insignificant even at the 10% level. While most of the previous studies suggested that enhanced convenience could motivate people to recycle, putting waste separation facility on each domestic floor of building was found to be unable to increase the average amount of recyclables collected in the housing estates investigated in Hong Kong. Perhaps, the London study by Robinson and Read (2005) gives hints for explaining these results. Robinson and Read evidenced that people living in high-density housing opted for drop-off sites while usage of curbside service was higher in areas with a high concentration of single-family dwellings. It is thus crystal that density of living place matters. In Hong Kong, communal areas (e.g. corridors and staircases) in multi-storey residential buildings are usually confined or with limited natural ventilation. In high-density living environment, keeping the place clean and hygiene is vital for the health-being of residents in high-rises. Recycling bins placed in the communal areas of the upper domestic floors can become a source of contamination or a breeding place of rodents if some irresponsible recyclers dispose soft-drink cans to the bins without prior cleansing. The worry about unhygienic conditions overwhelms particularly after the painful lesson of the outbreak of Severe Acute Respiratory Syndrome. Therefore, residents did not prefer to use the waste separation facilities located closer to them in view of the potential high health costs.

In the explanatory model in Eq. (2), the estimated coefficient of REWARD measures the partial effect of regular reward scheme on the amount of recyclables collected, keeping other things constant. No matter which model specification was used, the estimation results show a positive, significant (at the 1% level) coefficient for this dummy variable, suggesting that regular reward scheme is a strong motivator for domestic waste recycling. By these results, one can conclude that residents in Hong Kong are positively stimulated by the economic incentives to take pro-environmental behaviour,
and the deduction by Olson (1971) applies to the game of domestic waste recycling in the city. Beyond reasonable doubts, changing existing life style to a more pro-environmental one is demanding (Price and Joseph, 2000). More importantly, when the benefits of collective environmental actions like waste recycling cannot cover the costs, no rational individuals will undertake collective action. With a view to the analysis results of this research, the Hong Kong Government should consider incorporating different economic incentives in their schemes promoting domestic waste recycling. For example, government-operated collection centres directly to encourage domestic waste recycling. Therefore, in a long run, the Government is required to mobilize the resources in the private sector to offer economic incentives for promoting domestic waste recycling. Recognitions or tax concessions can be given to those private enterprises contributing to recycling promotion voluntarily. These help to foster a culture of inter-sectoral partnership in promoting pro-environmental activities in Hong Kong.

6. Concluding remarks

On account of the alarming landfill crisis, the Hong Kong Government attempted promotion of waste recycling or recovery to divert waste from landfills. However, without a clear understanding of the nature of waste recycling, all the efforts undertaken for its promotion would be in vain. This article discussed the behaviour of domestic waste recycling from a rational choice perspective. Waste recycling is prone to collective-action problem which arises where an individual's contribution to the activity is at most a tiny part of a much larger whole, and where others cannot be excluded from enjoying the favourable outcome of one's action. Therefore, people have a strong motivation to free-ride on others, and collective environmental action will neither be initiated nor maintained. Olson (1971) put forward that collective action can be resulted in the presence of economic incentives which make every single individual find profitable in one way or another to take part. Olson's solution to collective-action problem was testified in this study in the arena of domestic waste recycling.

Based on a set of aggregate data, the recycling intensity in 122 private housing estates in Hong Kong was investigated. According to the analysis results, reward schemes were found to have a significant positive relationship with the per-household weight of recyclables collected, ceteris paribus. Valuable insights can be drawn from these findings. The Hong Kong Government should build in different economic incentives in their schemes promoting domestic waste recycling. Moreover, as implied by the research findings, determinants of waste recycling behaviour differ between high-rise and low-rise settings so due care has to be taken in the transfer of policies regarding waste recycling from overseas to Hong Kong. The author hopes that this study can stimulate further research on the determination of waste recycling behaviour in a high-rise setting and the incentive schemes promoting waste recycling. For example, rewards in incentive schemes may vary, and we can see what type of reward (e.g. foodstuffs, daily goods or cash coupons) has a stronger motivating effect. Besides, it is worthwhile studying whether recycling intensity in a housing estate will reduce after the termination of a regular reward scheme.

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Table 6 Results of the Ordinary Least square estimation of Eq. (2) in log-linear form.

| Variable | Coefficient | Standard error | t-statistic | P-value |
|----------|-------------|----------------|-------------|---------|
| Constant | -572.0658   | 153.0904       | -3.736784   | 0.0003  |
| Ln(TEDU) | -12.92357   | 11.4687        | -1.126856   | 0.2622  |
| Ln(MALE) | -15.37678   | 36.55991       | -0.420591   | 0.6749  |
| Ln(MAGE) | 56.63734    | 26.82786       | 2.112495    | 0.0364  |
| Ln(MHINC) | 33.72368    | 12.03258       | 2.802713    | 0.0080  |
| Ln(AHIZE) | 3.293777    | 23.5377        | 0.139817    | 0.8891  |
| Ln(PER)  | -0.514232   | 10.3177        | -0.04984    | 0.9603  |
| Ln(AROOM) | 23.03255    | 17.79533       | 1.294303    | 0.1982  |
| FLOOR    | 1.539936    | 4.971181       | 0.309773    | 0.7573  |
| REWARD   | 20.34532    | 5.109444       | 3.891804    | 0.0001  |

Notes: All coefficients were estimated with White's Heteroskedasticity-consistent standard errors and covariance.

*** denotes the estimated coefficient of the variable to be significant at the 1% level.
*** denotes the estimated coefficient of the variable to be significant at the 5% level.

Log likelihood: -545.8604
Durbin-Watson statistic: 1.942284
No. of included observations: 122
Dependent variable: WASTE

Valuable insights can be deduced after the termination of a regular reward scheme.
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