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DETERMINANTS OF HOUSEHOLDS' RECYCLING BEHAVIOUR – EVIDENCE FROM CHINA

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Abstract: *China's rapid rates of urbanization and income growth have led to a rapid escalation of domestic solid waste accumulated in landfills. Various policies have been adopted by the municipal governments to improve incentives for recycling in an attempt to reduce solid waste accumulation, but the effects of these efforts appear to have been mixed. The aim of this paper is to gain further understanding of the factors that influence households' recycling behaviour. We administered a survey to residents of Harbin city in the north-eastern China to measure their recycling frequency as well as their understanding of and attitudes towards household solid waste management. We find that knowledge and attitude about household waste management explain recycling behaviour well but that attitudes about government involvement and feeling of peer pressure do not. We find strong evidence that higher education is linked to higher frequency of recycling, weak evidence that age has a positive but diminishing effect on recycling and that income has a negative effect on recycling, and no evidence that gender affects recycling.*

JEL Classification: *Q01; Q53*

Keywords: *household solid waste; recycling; survey*

1. INTRODUCTION

In the wake of its recent globalization, the proportion of urban population in China has increased from just 29% in 1993 to 53% in 2013 (World Bank n.d. *a*). At the same time China's per-capita GDP grew from US$374 to US$6807, an increase of over 1700%, while the per-capita GDP of

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the US grew just 100% during the same time period (World Bank n.d. *b*). With this unprecedented urbanization and increase in the standard of living, consumption in China has increased rapidly, which has led to municipalities having to deal with skyrocketing of solid waste generation. Zhang *et al.* (2010) reported that municipal solid waste (MSW) generation increased from 31.3 million tons in 1980 to 212 million tons in 2006, 148 million tons of which was collected in 2006 (Zhang *et al.* 2010). The collection of MSW waste has continued to grow since and had reached 191 million tons in 2015 (Liu *et al.* 2017). The landfills are filling up faster than expected and new sites are hard to find within a distance that keeps transportation costs acceptable. Sanitary landfill sites are also very expensive and thus unaffordable to most municipalities given the current funding model. Incineration, the preferred method to treat MSW in developed countries, is not currently a viable option in most parts of China due to the large proportion of green waste that is included in MSW (Zhang *et al.* 2010).

To decrease the rate of accumulation of MSW in landfill sites, most researchers argue that the only effective solution is to separate waste at source (see for example Hopper and Nielsen 1991; Chen *et al.* 2010; Zhang *et al.* 2010), which includes green waste separation and recycling. In China, composting of organic material has not taken off, primarily because of lack of sorting facilities (Cheng and Hu 2010), which leaves recycling as the only practical option. In light of the urgent MSW problem, many urban municipalities have implemented recycling programs in the past two decades. The city of Harbin, which is the focus of our study, started developing its recycling programme in 2003. The current state of the Harbin recycling programme is discussed in Section 2.

The aim of our paper is to find out what factors affect participation in recycling in China. We administered a survey to 1500 households in Harbin to find out about their recycling frequency, knowledge about household solid waste management, environmental attitudes and social norms, attitudes towards government involvement in household solid waste management programmes and their susceptibility to peer pressure from neighbours. We also asked the respondents about their age, monthly household income, gender and education. Our main interest is how often the household recycles.

Our paper fits in with the vast literature that has examined the factors that contribute to better recycling outcomes, including the impact of collection methods, government policies, psychological factors and various socioeconomic characteristics. A necessary condition for the success of any recycling program is that residents have enough of *knowledge* about what and how to recycle. Many authors have found that practical information enhances recycling behaviour (see for example Vining and Ebreo 1990; De Young 1988-1989; Hansmann *et al.* 2006; Bernstad *et al.* 2013). Given the short history of recycling programs in China in particular, residents may lack knowledge and experience in how to recycle and what can be recycled. Chu (2012) found that familiarity with recyclable materials contributes positively to recycling in Harbin, China.[1] We find that familiarity about the household solid waste classification system and safe methods of treating household solid waste have a significant positive impact on recycling behaviour.

Much of the literature focuses on the effect on recycling of *attitudes* towards recycling looking at social norms (Hopper and Nielsen 1991; Bratt 1999; Hansmann *et al.* 2006; and Timlett and Williams 2008) and environmentalism (Hopper and Nielsen 1991; Bratt 1999;

Hansmann *et al.* 2006; Castro *et al.* 2009). When it comes to social norms, the takeaway message for governments is that pro-recycling campaigns should emphasize personalized benefits, appeal to the heart instead of head, create a sense that every little counts (Timlett and Williams 2008) as well as promote self-organization and attempt to refute any known subjective justifications not to recycle (Hansmann *et al.* 2006). We find that attitudes towards recycling being a moral obligation contribute positively to recycling frequency, which suggests that pro-recycling campaigns can be successful in China. Despite the evidence that people are concerned about their environment, research has indicated that conservation behaviours such as recycling typically lag well behind this concern, creating a 'conservation gap' (Hopper and Nielsen 1991; Bratt 1999; Hansmann *et al.* 2006; Castro *et al.* 2009). One hypothesis is that in the early stages of environmental concern the messages about the benefits of recycling can be fairly contradictory, creating ambivalence towards despite high concern for the environment (Castro *et al.* 2009). We find that some environmental concerns increase recycling while others do not, and therefore that the conservation gap may exist in China as well.

Peer pressure, or social norms maintained by an individual's social network, such as family and neighbours, can have a significant influence on recycling behaviour. Burn (1991) and Hopper and Nielsen (1991) conducted field experiments where consistent recyclers were recruited as "block leaders" to advocate recycling in their neighbourhoods and to deliver special recycling bags. They found that this was significantly more effective than delivering the same information and bags without the personal contact from block leaders. We find that while 70% of residents feel that their recycling behaviour is influenced by their neighbours' behaviour, these feelings do not translate to more recycling, possibly because of the way recycling is organised in China where it is often difficult to observe the behaviour of neighbours.

In Harbin and elsewhere in China, recycling is currently done on a voluntary basis, and it is possible that a government-mandated program could lead to a higher participation rate of recycling, especially if its enforcement is effective (Everett and Peirce 1993; Noehammer and Byer 1997). While our study does not attempt to shed light on the respondents' opinions about recycling being made compulsory, we study the impact of attitudes about *government* involvement on recycling frequency. We find only weak evidence that positive attitudes about government involvement influence recycling frequency.

The evidence of the effect of various demographic factors on recycling behaviour is varied. Vining and Ebreo (1990) found that demographic factors were at best weakly correlated with recycling – older and higher-income people were somewhat more likely to recycle than younger and lower-income people – but occupation, gender or household size played no significant role. Derksen and Gartrell (1993) also found that older people were more likely to recycle than younger people and that education played a positive but rather weak role. Gamba and Oskamp (1994) and Oskamp *et al.* (1991) found a positive link between recycling behaviour and income. Meneses and Palacio (2005) found that women play a larger role than men in recycling behaviour of the family, while others have found that gender plays no significant role (Neuman 1986; Vining and Ebreo 1990; Oskamp *et al.* 1991; Gamba and Oskamp 1994). Neuman also found that that recycling behaviour is unrelated to age, education, income and political stance. These somewhat inconsistent results could be due to a complex underlying structure where the variables of concern, together with omitted variables, interact with each other, but this interaction is not

captured because studies use simple correlation analysis instead of multivariate techniques. We find strong evidence that residents with university education recycle more than those with less education. We find weak evidence of age having a positive but diminishing effect on recycling and of increased income reducing recycling frequency, but this evidence is not robust across models. We find no evidence of gender playing a role in recycling.

Other factors studied in the literature but not directly addressed in this paper include convenience and financial rewards or penalties. Local governments can choose between many modes of recyclable collection including collection at depots, curbside collection, collection at buy-back centres or collection by a private contractor (Noehammer and Byer 1997). Convenience plays a major role in the success of recycling programs (see for example Vining and Ebreo 1990; Derksen and Gartrell 1993; Hansmann *et al.* 2006; Gamba and Oskamp 1994; Barr *et al.* 2001). In Harbin, as will be discussed in more detail in the following section, collection takes place in depots and buy-back centres, but there is no curbside collection. An informal door-to-door collection by private individuals has risen as a substitute for curbside collection, but this lacks the regularity of a formal curbside collection and cannot be relied on by households as the main method or recycling. The fairly inconvenient method of recycling has likely contributed to the low level of recycling in China. The finding of Chu (2012) that people are more likely to recycle if their closest collection point accepts a wide range of recyclable goods supports the hypothesis that convenience matters in China as well. Some studies have shown that incentives, such as prizes and contests, can increase recycling behaviour (Couch *et al.* 1978-1979 as cited by Hopper and Nielsen 1991; Geller *et al.* 1987 as cited by Hopper and Nielsen 1991; Timlett and Williams 2008), although it has been suggested that their influence can be short-lived (Stern and Oskamp 1987 as cited by Hopper and Nielsen 1991). In government-mandated programs, financial penalties on non-recycling behaviour have been shown to have a positive influence on recycling behaviour. So far, the penalties studied have been in terms of opportunity cost - for example a situation where recycling is free but disposing recyclables off in a garbage bag is not (Price 2001). Chu (2012) found that financial rewards and incentives were a poor predictor of recycling behaviour in China.

Our paper contributes to the literature by examining recycling behaviour in China, a country that is new to recycling and at a different stage of development than the countries that are the focus of most of the other papers in the literature. We gain insights about the factors that influence recycling in China and find many to be different from those found in studies conducted in the US, Canada and in Europe. Chu (2012) surveyed 391 households in Harbin to see the impact of their environmental attitudes, convenience of recycling, information and knowledge and economic incentives on recycling behaviour. Our paper extends the Chu (2012) study by having a larger sample of 1500 households, controlling for demographic and region-specific factors and using both logit and ordered logit models to interpret the statistical and economic significance of the results.

As always with the analysis of data, our study has some limitations. The most important limitation is that the study is based on self-reported data of recycling behaviour rather than an objective measure of actual recycling behaviour. It is highly likely that the respondents overstate their recycling frequency to please the interviewer or to fit in with their own perception of what is the right thing to do. This is particularly true given that the respondents knew that the survey

is about recycling behaviour. This issue is exasperated if the bias correlates with other variables measured, such as the demographic variables or the other survey responses that measure attitudes. (Bertrand and Mullainathan, 2001) Because of these limitations, our regression results must be interpreted with caution. The percentage of households that always recycle, obtained from our survey data, is almost certainly overstating the true percentage. Furthermore, because the interviewers made efforts to ensure that the survey respondent in each household was the one with the most information about recycling, the responses are not representative of the population as a whole when measured by individual although they can be representative of the households assuming that the most-informed person is the one who makes the recycling decision.

The rest of the paper is structured as follows. Section 2 describes the Harbin recycling program in detail. Section 3 discusses the method of data collection and summarizes the data. Section 4 covers the empirical models and Section 5 discusses the results. Section 6 concludes.

2. THE RECYCLING PROGRAM IN HARBIN

Harbin is the capital of Heilongjiang Province and one of the largest urban centres in the north-eastern region of China. In 2011, there were 4,728,000 people in the core urban region of Harbin that has a land area of 7086 km^2. A map of China indicating the location of Harbin is given in Appendix 2.

The city of Harbin started a recycling program in 2003 after a report by the Ministry of Environmental Protection gave Harbin a relatively low ranking in terms of the proportion of all MSW that is disposed of by recycling, composting, incineration or by sanitary landfilling, also known as the 'harmless treatment rate' in the literature. The residential MSW program in Harbin is managed with 'Harbin Municipal Solid Waste Management Act' and 'Harbin City Appearance and Environmental Sanitation Management Act'. Under the unified leadership of the municipal government, each district government implements residential MSW management in its own jurisdiction.

In 2012, the Harbin municipal government put forward a program to educate residents about recycling and to encourage them to participate in recycling.[2] The program established special publically funded positions responsible for the training and education of households about MSW recycling. A vigorous publicity and education campaign was carried out, including billboards that explained how to recycle and what can be recycled. The municipal government assigned some of its staff to provide 24-hour supervision for household MSW recycling to discourage residents from throwing out solid waste before separating recyclables. The city government also guides residents to separate organic parts from the household solid waste for composting to be used as plant fertilizer in the public gardens of the community.

As a part of the publicity campaign to raise awareness of recycling, the Harbin municipal government selected from each community residents whose recycling efforts stood out from the rest. These *block leaders* were given prizes, including drinking water, towels, rubber gloves and other daily necessities, delivered in person by the leaders of the Harbin Federation of Trade Unions. It was hoped that this would help guide more residents to participate in household MSW recycling.

Currently, paper, plastic, metal, glass, wooden articles and textiles can be recycled in Harbin. The municipal authority provides residents bins for collecting recyclable materials but there is no curbside collection for green waste or recyclables, unlike for other solid waste. Some recyclable material with economic value can be taken to and sold at recyclable distribution centers that sort the material for on-selling as raw material to various factories. Most households, however, do not find it worth their while taking their recyclables to these often far-away distribution centers because of the low economic value of a single household's recyclables and because of the inconvenience. The lack of curbside collection for recyclables and the ability to sell some recyclables at distribution centers have created an incentive for some residents to become scavengers and buyers of recyclable materials, travelling door-to-door to buy recyclables from households. However, this informal arrangement makes coordination and regulation of recyclable collection difficult for the municipal government, may cause sanitary issues when rubbish bins are scavenged for sellable recyclables and may expose the scavengers to harmful substances (Zhang *et al.* 2010). Households can also drop off recyclables at collection points that the government has established in every community. The average distance to these collection points is 500m and thus they are more conveniently located than distribution centers, but still not as convenient as taking the recyclables to the curbside or to building collection points, the norm in many cities in developed countries. Residents must also pay a fixed fee of 3-15 Yuan/ month for disposing recyclables in these collection points. Most people in Harbin live in small apartments where space is at a premium, creating a barrier to recycling: rather than store potentially smelly recyclables in living quarters, it is just easier for residents to put them into rubbish bags and dispose of them.

Compared to the state of many recycling programs in high-income countries, the current state of the Chinese municipal recycling programs is still very crude, and it is likely that more success can be achieved by making recycling more convenient. It would appear that there are a number of important candidates to explain the low participation in recycling in Harbin. As discussed above, curbside collection is one key element that has increased recycling behaviour in other countries, and this is still largely missing in Harbin outside of the informal and irregular door-to-door buyers of recyclables. Apartments are small and lack space for storing recyclables, which suggests that collection sites in each building could induce residents to recycle rather than throw out recyclables amongst other non-recyclable waste. The economic incentives are not high enough to make it beneficial for households to take their recyclables to recycling centres. As the residual waste collection is free of charge, there are no economic penalties associated with disposing of recyclables with other general waste. Changing the collection system is expensive and time consuming, so it is important to have a clear understanding of less-capital intensive techniques to increase recycling participation. We find support that further campaigns that inform households about the solid waste classification system and safe methods of treating household solid waste as well as campaigns that improve the environmental attitudes and social norms can be successful in enhancing participation in recycling.

3. SURVEY METHODS AND DATA

We collected and analysed survey data to study the factors that influence households' participation in recycling programs in Harbin, China. The survey covered five districts: Xiangfang, Nangang,

Pingfang, Daowai and Daoli. Multistage sampling was employed to select households to be surveyed. In each district, 15 communities were systematically sampled, and in each community, 20 families were randomly selected for an interview. The selected households were contacted in advance to set up a suitable time for an interview. Interviews were scheduled for late morning for retired people and either lunchtime or after work for working people. Phone interviews were used if a visit by the interviewer was not practical. If a family was unavailable for either a visit or a phone interview at the scheduled time, another similar family was chosen, giving us ultimately a 100% response rate. Thus, a total of 1500 individuals, one per family, were surveyed.

The survey was conducted in person by specially trained interviewers, recruited amongst students of the Department of Public Management of the Harbin Engineering University. The interviews took place between May 2013 and November 2013. At that stage effort was made to ensure that the person selected for the interview was the one with most knowledge about recycling in that family. Each interview was approximately 45 minutes long, and the interviewer filled out the questionnaire according to the respondent's dictation.

The questionnaire had 14 questions used in this study, shown in Appendix 1, where the responses are measured on a 5-point Likert scale. The question that we use as the dependent factor asked about the respondent's own recycling frequency (*Q1*). The rest of the questions attempted to measure the respondent's knowledge of and attitudes towards recycling. Five questions asked about the respondent's *knowledge* about MSW management, including knowledge of the existence of reusable materials in household solid waste (*Q2*), what waste can be reused (*Q3*), the classification system of solid waste (*Q4*), the ways solid waste can be safely treated (*Q5*), and what can be recycled (*Q6*). Four questions measured the respondent's *attitude* towards sorting (*Q7*), reuse (*Q8*), and the environmental effects of recycling (*Q9* and *Q10*). Three questions asked about attitudes about government involvement in the organization of solid waste management, including if the respondent believed that recycling should be promoted (*Q11*) and if the government should provide guidance (*Q12*) and plans (*Q13*) for recycling. Last, one question addressed the respondent's susceptibility to *peer pressure* by asking if he or she believes that his or her recycling decision could be influenced by neighbours' recycling participation (*Q14*). For each question, the respondent could choose one of five options between 1 (strongly disagree/totally unfamiliar with/never) to 5 (strongly agree/totally familiar with/always). The questionnaire also collected demographic data on the respondents, including their age, education level, monthly household income and gender.

Summary statistics of the survey responses are given in Table 1. Table 2 shows the breakdown of the demographic variables by district. We can see from Table 2 that there are some differences between the districts. District 1 has more female respondents than the other districts; District 2 has a lower average age than the other districts; District 3 has a lower average level of education; and District 5 has both a higher average level of education and a higher level of household income.

4. THE EMPIRICAL MODELS

We use two models - logit and ordered logit - to explain recycling participation. For both the models, the dependent variable is derived from the score to question *Q1* that measures how

Table 1
Summary statistics

variable		*mean*	*Std Dev*	*Min*	*Max*	*% of "5"*
Q1	*knowledge*	4.19	1.14	1	5	56%
Q2		4.15	1.23	1	5	57%
Q3		3.98	1.23	1	5	47%
Q4		4.08	1.20	1	5	51%
Q5		4.17	1.15	1	5	55%
Q6		4.46	0.86	1	5	65%
Q7	*attitude*	4.34	0.97	1	5	59%
Q8		4.33	0.96	1	5	58%
Q9		4.35	0.96	1	5	60%
Q10		4.50	0.85	1	5	68%
Q11	*government*	4.38	0.96	1	5	62%
Q12		4.41	0.88	1	5	61%
Q13		4.52	0.83	1	5	68%
Q14	*peer pressure*	4.54	0.82	1	5	70%
Age		45.41	15.64	20	74	
Gender (male=0; female = 1)		0.55	0.50	0	1	
Edu (junior school or less=0; senior school=1; ugrad degree or higher=2)		1.21	0.72	0	2	
Income (monthly household income)		5973.13	3050.80	1200	14994	

Table 2
Summary statistics of the demographic variables by district

variable	*avg./std.*	*District 1*	*District 2*	*District 3*	*District 4*	*District 5*
Age	average	47.03	**40.00**	46.10	46.62	47.29
	std.dev.	16.13	13.57	15.75	15.36	16.16
Gender	average	**0.73**	0.50	0.51	0.49	0.51
	std.dev.	0.45	0.50	0.50	0.50	0.50
Edu	average	1.23	1.12	**0.93**	1.27	**1.49**
	std.dev.	0.75	0.70	0.72	0.59	0.70
Income	average	5267.31	4990.78	4764.70	5833.69	**9009.18**
	std.dev.	2180.80	2191.83	2331.39	2088.93	3886.02

often the respondent recycles, where the answers range from 1 (never) to 5 (always). For the logit model, our regression specification is

$$drecycle_l = \beta_0 + \beta_i X_i + \gamma_i Z_i + \delta_i D_i + \varepsilon_i \quad (1)$$

where *drecycle* is a dummy variable equal to 1 if the respondent answered 5 (always) and 0 otherwise; X_i is the set of determinants of the recycling behaviour that we are interested, i.e. *knowledge*, *attitude*, *government* and *peer-pressure*; Z_i is the set of demographic controls; D_i is a dummy variable for the household's district and ε_i is the error term. The dummy variable *drecycle* is created to separate the consistent recyclers from the households that do not recycle or recycle inconsistently.

For the ordered logit model, our regression specification is

$$orecycleo_i = \beta_0 + \beta_i X_i + \gamma_i Z_i + \delta_i D_i + \varepsilon_i \quad (2)$$

variable *orecycle* takes a value of 0 if the respondent chose 1 or 2 (never or rarely); 1 if the respondent chose 3 or 4 (sometimes or often); and 2 if the respondent chose 5 (always). The mapping from the responses to *Q1* to these two dependent variables, including the interpretation of the new variables, is given in Table 3.

Table 3
Mapping of the original survey answers to Q1 to dependent variables drecycle and orecycle

Q1	*interpretation*	*drecycle*	*interpretation*	*orecycle*	*interpretation*
1	never	0	inconsistently or never	0	rarely or never
2	rarely	0	inconsistently or never	0	rarely or never
3	sometimes	0	inconsistently or never	1	inconsistently
4	often	0	inconsistently or never	1	inconsistently
5	always	1	always	2	always

For each of the logit and ordered logit models we run five different specifications with different sets of dependent factors. Specification 1 includes the set of survey questions that measures knowledge (*Q2-Q6*), specification 2 includes the set of survey questions that measures attitude (*Q7-Q10*), specification 3 includes the set of survey questions that measures attitudes towards government involvement (*Q11-Q13*), and specification 4 has the variable that measures peer pressure (*Q14*). Specification 5 includes all the survey question variables *Q2-Q14*. Each specification includes the demographic variables *age*, which is the respondent's age in years, *age2*, which is the respondent's age in years squared to capture any non-linearity in the response to age, *gender*, which is a dummy variable that is equal to 1 for women and 0 for men, *education*, which is a dummy variable that equals 1 if the respondent has a university degree (edu=2) and zero otherwise (edu={0,1}) and *lnincome*, which is the natural logarithm of the monthly household income. We also include the district dummies to capture any effects that arise through the districts being different from each other. These dummy variables will also capture any differences in the convenience of recycling between the districts or any other factors that may differ between the regions that affect recycling.

5. RESULTS

5.1. Results from the logit regression

The results for specifications 1-5 for the logit model are provided in Table 5. We report the marginal effects with their standard errors given in the parentheses. Specification 1 reports the results of the regression that includes the different *knowledge* variables. We find that all knowledge-based variables, with the exception of Q_2, have a positive and significant effect on the recycling behaviour of households. People recycle more if they have clearer ideas about what can be re-used (Q_3=1), the classification system of solid waste (Q_4=1), how solid waste can be treated (Q_5=1) and what can be recycled (Q_6=1). The marginal effects indicate that all else at mean values, the probability of recycling (*drecycle*=1) is 7.4 percentage points larger

Table 4
Correlation Table

	Q2	*Q3*	*Q4*	*Q5*	*Q6*	*Q7*	*Q8*	*Q9*	*Q10*	*Q11*	*Q12*	*Q13*	*Q14*
Q2	1												
Q3	0.30***	1											
Q4	0.32***	0.31***	1										
Q5	0.25***	0.29***	0.32***	1									
Q6	0.15***	0.19***	0.16***	0.27***	1								
Q7	0.14***	0.19***	0.32***	0.32***	0.34***	1							
Q8	0.17***	0.20***	0.25***	0.38***	0.39***	0.32***	1						
Q9	0.12***	0.23***	0.20***	0.31***	0.32***	0.33***	0.33***	1					
Q10	0.05*	0.10***	0.14***	0.16***	0.37***	0.26***	0.29***	0.30***	1				
Q11	0.14***	0.14***	0.23***	0.25***	0.38***	0.33***	0.33***	0.28***	0.30***	1			
Q12	0.11***	0.15***	0.19***	0.23***	0.31***	0.22***	0.28***	0.27***	0.33***	0.37***	1		
Q13	0.08**	0.04	0.19***	0.20***	0.39***	0.26***	0.29***	0.26***	0.39***	0.36***	0.37***	1	
Q14	0.11***	0.09***	0.21***	0.23***	0.40***	0.26***	0.35***	0.29***	0.40***	0.34***	0.35***	0.38***	1

* p<0.05, ** p<0.01, *** p<0.001

Table 5
Determinants of Recycling Behaviour - Logit Regressions

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
Variables	*Knowledge*	*Attitude*	*Government*	*Peer-Pressure*	*All*
Q2	-0.0249				-0.0199
	(0.0259)				(0.0251)
Q3	0.0742***				0.0631**
	(0.0265)				(0.0257)
Q4	0.1546***				0.1127***
	(0.0242)				(0.0244)
Q5	0.1563***				0.0959***
	(0.0238)				(0.0246)
Q6	0.0897***				0.0037
	(0.0257)				(0.0281)
Q7		0.1603***			0.0994***
		(0.0237)			(0.0247)
Q8		0.1059***			0.0434*
		(0.0249)			(0.0262)
Q9		0.1743***			0.1341***
		(0.0238)			(0.0242)
Q10		0.0016			-0.0156
		(0.0275)			(0.0286)
Q11			0.1304***		0.0507*
			(0.0263)		(0.0262)
Q12			0.0643**		0.0128
			(0.0268)		(0.0259)
Q13			0.0996***		0.0539*
			(0.0283)		(0.0281)
Q14				0.1492***	0.0179
				(0.0265)	(0.0287)
Age	0.0075	0.0042	0.0010	-0.0009	0.0092*
	(0.0052)	(0.0052)	(0.0053)	(0.0054)	(0.0051)
Age2	-0.0001	-0.0000	-0.0000	-0.0000	-0.0001*
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Gender	-0.0017	0.0097	0.0067	0.0062	0.0058
	(0.0237)	(0.0236)	(0.0245)	(0.0248)	(0.0231)
Education	0.1825***	0.1999***	0.2315***	0.2789***	0.1333***
	(0.0395)	(0.0400)	(0.0404)	(0.0395)	(0.0403)
Ln (income)	-0.0338	-0.0590*	-0.0628**	-0.0601*	-0.0366
	(0.0309)	(0.0306)	(0.0316)	(0.0320)	(0.0300)
District 1	-0.1424***	-0.0589	-0.1153***	-0.1623***	-0.0508
	(0.0399)	(0.0412)	(0.0423)	(0.0423)	(0.0399)
District 2	-0.1686***	-0.1261***	-0.1980***	-0.2531***	-0.0833**
	(0.0404)	(0.0418)	(0.0421)	(0.0414)	(0.0407)
District 3	-0.1256***	-0.0622	-0.0633	-0.1103**	-0.0520
	(0.0414)	(0.0418)	(0.0437)	(0.0434)	(0.0420)
District 4	-0.1995***	-0.1704***	-0.1300***	-0.1881***	-0.1409***
	(0.0402)	(0.0387)	(0.0414)	(0.0406)	(0.0409)
Observations	1,500	1,500	1,500	1,500	1,500
Pseudo R2	0.1421	0.1455	0.0995	0.0813	0.1805

Notes: Coefficients reported are marginal effects. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All survey variables *Q1-Q14* are defined in Appendix 1.

when Q_3=1, 15.5 percentage points larger when Q_4=1, 15.6 percentage points larger when Q_5=1 and 9 percentage points larger when Q_6=1 compared to when Q_i (i = 3, 4, 5, and 6) takes a value of zero, respectively. This suggests that educating households on the classification system of household solid waste, the safe methods of treating household solid waste and what can be recycled can have a significant impact in further increasing recycling behaviour in China. This is consistent with the literature from the US and Europe that suggests that knowledge has a positive effect on recycling (Vining and Ebreo 1990; De Young 1988-1989; Hansmann *et al.* 2006) as well as an earlier study conducted in Harbin, China, that suggested that environmental policy knowledge and familiarity with recyclable materials influence recycling (Chu 2012). An interesting exception to the above is variable Q_2, measuring the household's agreement with there being reusable materials in household solid waste, that has a negative but insignificant coefficient. This may suggest that households view reusing and recycling as substitutes – those who believe that there are reusable materials in household solid waste may not recycle more or may in fact be inclined to recycle less because there is less to recycle with more reuse.

In specification 2, which includes the *attitude* variables, we find that social norms and environmental attitudes also affect recycling uptake positively. Those with stronger beliefs that household waste should be sorted and disposed of in specific collection places (Q_7=1) and those with more positive attitude towards reusing (Q_8=1) recycle more often. Furthermore, those who believe that improper treatment of solid waste can cause pollution (Q_9=1) recycle more although the same does not hold for those who believe that recycling itself improves the environment (Q_{10}=1). While these results may seem contradictory, they are consistent with the literature that has, on the one hand, found evidence of knowledge of environmental harm increasing recycling behaviour (e.g. Ewing 2001) but, on the other hand, found evidence that recyclers and non-recyclers have similar beliefs of environmental harm (e.g. Hopper and Nielsen 1991; Vining and Ebreo 1990). This is also consistent with the conservation gap hypothesis that conservation behaviour often lags behind the concern about conservation (Castro *et al.* 2009). The results strongly indicate that households with better attitude towards environmental waste management are somewhere between 10.6 percentage points to 17.4 percentage points more likely to always recycle compared to others.

The estimates in specification 3, which includes the *government* variables, suggests that the attitudes towards government involvement in household solid waste management correlate well with recycling behaviour but that these variables become only weakly significant or insignificant once the other survey variables are added (see specification 5). This suggests that the attitude towards government involvement does not play as large a role in recycling behaviour of households as knowledge and attitudes about recycling and the environment.

In specification 4, we test a popular belief that peer-pressure affects household recycling behaviour. The results indicate a positive link between peer pressure and recycling. However, this effect ceases to be significant once we control for the knowledge and attitude of the households (see specification 5). This could be because households may not be able to observe their neighbours recycling due to the lack of curbside collection, so while they might recycle more if they observed their neighbours recycling, they don't feel the peer-pressure because neighbours usually don't observe recycling their peers.

In specification 5, we regress all the determinants of recycling behaviour of households along with the demographic controls and district dummies. Overall, the results indicate that knowledge and attitude towards environmental waste management variables remain statistically and economically significant. However, as mentioned earlier, the government and peer-pressure variables are not statistically significant anymore in this specification.

In all the specifications, we find strong evidence that education increases the probability of recycling. Across the five specifications, we find that those who have a university degree are 13.3 percentage points to 18.3 percentage points more likely to consistently recycle compared to others. Our results are a fairly stark contrast to Derksen and Gartrell (1993) that found a positive but weak role of education on recycling in Edmonton, Canada and Neuman (1986) that found no link between education and recycling behaviour in Southern California. Our results suggest that education may play a larger role in China than elsewhere. We also find some evidence that age has a concave effect on recycling – getting older increases recycling uptake but at a decreasing rate. However, this effect is not robust. It is significant at 10% level in specification 5, while insignificant in the other specifications. This finding is consistent with earlier literature that shows that older people are more likely to recycle (Vining and Ebreo 1990; Derksen and Gartrell 1993). We do not find much evidence that recycling behaviour of households differ by income. While there is some weak evidence in specifications 2-4 that income has a negative effect on recycling, this effect is not robust across all specifications.[3] Our results are somewhat consistent with Neuman (1986) that found no effect of income on recycling but in contrast to Gamba and Oskamp (1994) and Oskamp *et al.* (1991) that found a positive link between income and recycling. One reason for why China does not have a positive link between recycling and income may be that it is possible to make a small profit by selling recyclables to distribution centres, which gives low-income people an added incentive to recycle. Last, we find that gender has no effect on recycling, consistent with Vining and Ebreo (1990), Gamba and Oskamp (1994) and Oskamp *et al.* (1991) but at odds with Meneses and Palacio (2005) who find that women recycle more.

5.2. Results from the ordered logit regression

Tables 6a-6c report results from the ordered logit model. Following similar regression specifications to the one presented in Table 5, we report the different specifications in columns 1 – 5 in all three tables, respectively. In Table 6a, we report the marginal effects from the ordered logit regressions for the outcome that the household recycles rarely or never (*orecycle*=0). The results are insightful. Specification 1 suggests that holding all else at their mean values, the probability of recycling rarely or never is approximately 1.9 percentage points to 4.9 percentage points less for households with a strong knowledge about recycling, i.e. when variables *Q3-Q6* take a value of one. The result for *Q2* confirms our finding from the logit model that suggests that households with a better knowledge of reusing view reusing and recycling as substitutes and they are 2.2 percentage points more likely to re-use and not recycle.

Specifications 2, 3 and 4 confirm the results of the logit model. Specification 2 indicates that households with the strongest attitudes towards environmental waste management are 2.4 percentage points to 5.2 percentage points less likely to not recycle, and specification 3 implies that households with strongest beliefs about government involvement are 2.3 percentage points

Table 6A
Determinants of Recycling Behaviour - Ordered Logit Regressions (Outcome = 0)

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
Variables	*Knowledge*	*Attitude*	*Government*	*Peer-Pressure*	*All*
Q2	0.0219***				0.0211***
	(0.0077)				(0.0073)
Q3	-0.0186**				-0.0124
	(0.0082)				(0.0077)
Q4	-0.0422***				-0.0305***
	(0.0086)				(0.0081)
Q5	-0.0485***				-0.0304***
	(0.0090)				(0.0084)
Q6	-0.0208**				-0.0040
	(0.0087)				(0.0085)
Q7		-0.0478***			-0.0308***
		(0.0092)			(0.0086)
Q8		-0.0242***			-0.0115
		(0.0084)			(0.0082)
Q9		-0.0516***			-0.0394***
		(0.0094)			(0.0088)
Q10		0.0081			0.0080
		(0.0078)			(0.0080)
Q11			-0.0365***		-0.0129
			(0.0097)		(0.0083)
Q12			-0.0105		-0.0009
			(0.0087)		(0.0077)
Q13			-0.0230**		-0.0101
			(0.0099)		(0.0088)
Q14				-0.0230**	0.0120
				(0.0096)	(0.0079)
Age	-0.0014	-0.0009	-0.0001	0.0006	-0.0018
	(0.0016)	(0.0015)	(0.0017)	(0.0017)	(0.0015)
Age2	0.0000	0.0000	0.0000	-0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Gender	-0.0039	-0.0073	-0.0062	-0.0067	-0.0055
	(0.0072)	(0.0071)	(0.0077)	(0.0079)	(0.0068)
Education	-0.0836***	-0.0944***	-0.1092***	-0.1411***	-0.0678***
	(0.0200)	(0.0212)	(0.0229)	(0.0254)	(0.0189)
Ln (income)	0.0059	0.0114	0.0134	0.0142	0.0057
	(0.0094)	(0.0092)	(0.0099)	(0.0103)	(0.0089)
District 1	0.0247	0.0026	0.0221	0.0408**	0.0013
	(0.0152)	(0.0131)	(0.0160)	(0.0180)	(0.0125)
District 2	0.0414**	0.0271*	0.0614***	0.0870***	0.0140
	(0.0171)	(0.0159)	(0.0199)	(0.0224)	(0.0140)
District 3	0.0123	-0.0033	0.0033	0.0197	-0.0048
	(0.0142)	(0.0125)	(0.0145)	(0.0163)	(0.0122)
District 4	0.0440**	0.0406**	0.0354**	0.0572***	0.0277*
	(0.0171)	(0.0162)	(0.0170)	(0.0190)	(0.0154)
Observations	1,500	1,500	1,500	1,500	1,500

Notes: Coefficients reported are marginal effects for outcome 0. Standard errors are reported in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 6 B
Determinants of Recycling Behaviour - Ordered Logit Regressions (Outcome = 1)

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
Variables	*Knowledge*	*Attitude*	*Government*	*Peer-Pressure*	*All*
Q2	0.0616***				0.0649***
	(0.0217)				(0.0224)
Q3	-0.0515**				-0.0377
	(0.0224)				(0.0234)
Q4	-0.1126***				-0.0904***
	(0.0214)				(0.0228)
Q5	-0.1254***				-0.0887***
	(0.0209)				(0.0229)
Q6	-0.0545**				-0.0121
	(0.0214)				(0.0252)
Q7		-0.1228***			-0.0882***
		(0.0210)			(0.0229)
Q8		-0.0656***			-0.0342
		(0.0216)			(0.0240)
Q9		-0.1306***			-0.1100***
		(0.0206)			(0.0220)
Q10		0.0234			0.0249
		(0.0228)			(0.0251)
Q11			-0.0834***		-0.0379
			(0.0204)		(0.0236)
Q12			-0.0254		-0.0026
			(0.0208)		(0.0233)
Q13			-0.0534**		-0.0297
			(0.0215)		(0.0250)
Q14				-0.0504**	0.0377
				(0.0196)	(0.0256)
Age	-0.0040	-0.0024	-0.0002	0.0014	-0.0054
	(0.0043)	(0.0043)	(0.0041)	(0.0040)	(0.0045)
Age2	0.0000	0.0000	0.0000	-0.0000	0.0001
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Gender	-0.0107	-0.0205	-0.0152	-0.0155	-0.0167
	(0.0196)	(0.0197)	(0.0188)	(0.0183)	(0.0204)
Education	-0.1533***	-0.1671***	-0.1629***	-0.1752***	-0.1448***
	(0.0236)	(0.0227)	(0.0200)	(0.0168)	(0.0276)
Ln (income)	0.0162	0.0321	0.0330	0.0333	0.0172
	(0.0259)	(0.0260)	(0.0245)	(0.0241)	(0.0269)
District 1	0.0609*	0.0072	0.0497	0.0804***	0.0038
	(0.0332)	(0.0360)	(0.0325)	(0.0295)	(0.0373)
District 2	0.0944***	0.0673*	0.1159***	0.1404***	0.0395
	(0.0317)	(0.0345)	(0.0282)	(0.0242)	(0.0370)
District 3	0.0322	-0.0095	0.0080	0.0425	-0.0149
	(0.0350)	(0.0364)	(0.0348)	(0.0323)	(0.0385)
District 4	0.0991***	0.0946***	0.0749**	0.1049***	0.0732**
	(0.0311)	(0.0308)	(0.0306)	(0.0269)	(0.0354)
Observations	1,500	1,500	1,500	1,500	1,500

Notes: Coefficients reported are marginal effects for outcome 1. Standard errors are reported in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Table 6C
Determinants of Recycling Behaviour - Ordered Logit Regressions (Outcome = 2)

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
Variables	*Knowledge*	*Attitude*	*Government*	*Peer-Pressure*	*All*
Q2	-0.0835***				-0.0860***
	(0.0291)				(0.0294)
Q3	0.0701**				0.0501
	(0.0304)				(0.0311)
Q4	0.1548***				0.1210***
	(0.0290)				(0.0303)
Q5	0.1739***				0.1191***
	(0.0286)				(0.0307)
Q6	0.0753**				0.0161
	(0.0298)				(0.0337)
Q7		0.1705***			0.1190***
		(0.0290)			(0.0310)
Q8		0.0898***			0.0456
		(0.0297)			(0.0321)
Q9		0.1822***			0.1493***
		(0.0287)			(0.0300)
Q10		-0.0315			-0.0329
		(0.0306)			(0.0331)
Q11			0.1199***		0.0507
			(0.0295)		(0.0317)
Q12			0.0359		0.0035
			(0.0295)		(0.0310)
Q13			0.0764**		0.0398
			(0.0312)		(0.0338)
Q14				0.0734**	-0.0497
				(0.0290)	(0.0334)
Age	0.0054	0.0033	0.0003	-0.0021	0.0071
	(0.0059)	(0.0059)	(0.0058)	(0.0058)	(0.0060)
Age2	-0.0001	-0.0000	-0.0000	0.0000	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Gender	0.0146	0.0278	0.0214	0.0222	0.0222
	(0.0268)	(0.0268)	(0.0264)	(0.0262)	(0.0271)
Education	0.2370***	0.2615***	0.2722***	0.3163***	0.2126***
	(0.0416)	(0.0415)	(0.0398)	(0.0370)	(0.0452)
Ln (income)	-0.0220	-0.0435	-0.0464	-0.0476	-0.0229
	(0.0352)	(0.0352)	(0.0344)	(0.0343)	(0.0357)
District 1	-0.0856*	-0.0097	-0.0718	-0.1212**	-0.0050
	(0.0482)	(0.0490)	(0.0483)	(0.0471)	(0.0498)
District 2	-0.1358***	-0.0944*	-0.1773***	-0.2274***	-0.0535
	(0.0483)	(0.0502)	(0.0472)	(0.0448)	(0.0510)
District 3	-0.0445	0.0128	-0.0113	-0.0622	0.0197
	(0.0491)	(0.0490)	(0.0493)	(0.0485)	(0.0507)
District 4	-0.1431***	-0.1352***	-0.1102**	-0.1621***	-0.1009**
	(0.0477)	(0.0464)	(0.0472)	(0.0451)	(0.0506)
Observations	1,500	1,500	1,500	1,500	1,500

Notes: Coefficients reported are marginal effects for outcome 2. Standard errors are reported in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

to 3.7 percentage points less likely to not recycle. We also find in specification 4 that household who feel the strongest peer-pressure regarding recycling are also 2.3 percentage points less likely to not recycle. In specification 5, we regress all the determinants and find that the *knowledge* and *attitude* variables remain significant, while government and peer-pressure variables are not significantly robust.

Among the demographic variables, the most notable result comes again from the education variable. We find a strong significant result that households with an undergraduate degree or higher are 6.9 percentage points to 14.1 percentage points less likely to not recycle than others.

In Tables 6b and 6c (*orecycle=1* or *2*), we report the marginal effects of the outcome being in category 1 or 2, respectively, conditional on $X_i=1$, where i = *knowledge*, *attitude*, *government* and *peer-pressure* and other demographic variables. The results are similar to what was predicted by the logit model. Households are more likely to always recycle if they have better knowledge and attitudes about recycling as well as having higher education. The hypothesis that reusing and recycling are substitutes shows up stronger in Table 6c with the negative and significant coefficient for *Q2*. All the other signs and significance of the determinants of recycling found earlier remain consistent with the earlier analysis.

Comparing the marginal effects of the determinants in Table 6a and 6c, we find that the coefficients of *knowledge*, *attitude* and *education* are all significant but the signs are the opposite. This relationship is robust across all specifications. The result re-confirms that the predicted sign and magnitude from our logit model is robust. For example, comparing the marginal effects of *Q5* between Table 6a and 6c, we find that households with the best knowledge about safe methods of treating different household solid waste are 3 percentage points *less* likely to never recycle (specification 5 in Table 6a), and 12 percentage points *more* likely to always recycle (specification 5 in Table 6c). Similar comparisons between Tables 6a and 6c yield consistent and robust results.

6. CONCLUSION

This paper administered a survey to 1500 households in Harbin, China, to study the factors that influence households' recycling behaviour. Our dependent factor was the households' frequency of recycling obtained from our survey. We used logit and ordered logit regressions to investigate how the recycling frequency is affected by the responses in the other survey questions, categorised under knowledge, attitude, government and peer pressure, as well as the respondent's income, education level, age and gender.

We found strong support that knowledge and attitude towards environmental waste management are positively correlated with recycling. The evidence that attitudes towards government involvement and peer pressure affect recycling was found to be weak at best. We also found strong evidence that education increases the probability of recycling among households. The main implication of these results is that recycling can be enhanced by educating households about the household solid waste system and safe methods of treatment. Furthermore, campaigns that enhance the sense amongst households that recycling is a moral obligation would be successful in increasing recycling behaviour. We found some evidence of a conservation gap, which suggests that knowledge campaigns about the environmental effects

of waste may need to be continued for a long time before they will. It may be too early to rely on peer pressure techniques, such as block leaders, given that it may be hard to observe neighbours' recycling behaviour.

Our results on the effects of demographic variables on recycling frequency are to some extent different from the literature from developed countries. The strong effect we found of higher education on recycling behaviour is in contrast to earlier studies that have found either a weak link or no link between education and recycling. We found some evidence of age increasing recycling behaviour in the logit model, which is consistent with some earlier findings, although this evidence is only significant at 10% level in our study. We also found some evidence that income reduces the likelihood of recycling, although this was only found in the logit model when knowledge variables were not included. Previous studies have either found no effect or positive effect of income on recycling. We found no evidence of gender correlating with recycling, in line with some previous research but contradicting others.

It is important to note that the recycling program in Harbin is still very crude compared to many developed countries where recycling programs have a long history. The results of our study highlight some ways that the government can make progress to increase recycling participation without any major capital outlays, with the main avenues being information campaigns about the solid waste classification system and safe methods of treatment as well as campaigns that improve the environmental attitudes and social norms. However, it is likely that larger gains could be made by bringing recycling to the curbside, as is currently done with general waste disposal.

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Notes

1. While the survey in Chu (2012) was also conducted in Harbin, the convenience variable was self-expressed and cannot be used in this study because the survey did not cover the same districts as our survey. However, the introduction of the district dummies helps control for any differences in convenience that may exist across the districts.
2. The literal translation of the name of this program is 'Patriotic sanitation six times into community activity'.
3. We also ran separate regressions including an interaction term between income and education but found no significant results for this term.

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Appendix 1: Survey questions and response options

Knowledge	Q1	Do you separate recyclable materials from household solid waste?	1-Never; 2-Rarely; 3-Sometimes; 4-Often; 5-Always
	Q2	Do you agree that there are reusable materials in household solid waste?	1-Strongly disagree; 2-Disagree; 3-Neither agree or disagree; 4-Agree; 5-Strongly agree
	Q3	Are you familiar with the types of household solid waste that can be reused?	1-Totally unfamiliar with; 2-Mostly unfamiliar with; 3- Partly familiar with; 4-Mostly familiar with; 5-Totally familiar with
	Q4	Are you familiar with the classification system of household solid waste?	1-Totally unfamiliar with; 2-Mostly unfamiliar with; 3- Partly familiar with; 4-Mostly familiar with; 5-Totally familiar with
	Q5	Are you familiar with the safe methods of treating different materials in household solid waste?	1-Totally unfamiliar with; 2-Mostly unfamiliar with; 3- Partly familiar with; 4-Mostly familiar with; 5-Totally familiar with
	Q6	Are you familiar with what household solid waste items can be recycled?	1-Totally unfamiliar with; 2-Mostly unfamiliar with; 3- Partly familiar with; 4-Mostly familiar with; 5-Totally familiar with
Attitude	Q7	Do you agree that household solid waste should be sorted and disposed of in specified collection places?	1-Strongly disagree; 2-Disagree; 3-Neither agree or disagree; 4-Agree; 5-Strongly agree
	Q8	Do you agree that households should reuse some recyclable materials in their solid waste?	1-Strongly disagree; 2-Disagree; 3-Neither agree or disagree; 4-Agree; 5-Strongly agree
	Q9	Do you agree that improper treatment of household solid waste can result in severe pollution?	1-Strongly disagree; 2-Disagree; 3-Neither agree or disagree; 4-Agree; 5-Strongly agree
	Q10	Do you agree that recycling of household solid waste helps to improve the environment?	1-Strongly disagree; 2-Disagree; 3-Neither agree or disagree; 4-Agree; 5-Strongly agree
Government	Q11	Do you agree that recycling household solid waste needs to be further promoted?	1-Strongly disagree; 2-Disagree; 3-Neither agree or disagree; 4-Agree; 5-Strongly agree
	Q12	Do you agree that government should guide households how to recycle?	1-Strongly disagree; 2-Disagree; 3-Neither agree or disagree; 4-Agree; 5-Strongly agree
	Q13	Do you agree that the government should formulate recycling plans for families?	1-Strongly disagree; 2-Disagree; 3-Neither agree or disagree; 4-Agree; 5-Strongly agree
Peerpress	Q14	Do you agree that your neighbours' participation in recycling affects your initiative to participate?	1-Strongly disagree; 2-Disagree; 3-Neither agree or disagree; 4-Agree; 5-Strongly agree

Appendix 2: Map of Harbin showing the location of the Heilong Province in China (left) and the five districts of Harbin (right)