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Published version

JALIL, Emy Ezura, GRANT, David, NICHOLSON, John and DEUTZ, Pauline (2016). Reverse logistics in household recycling and waste systems : a symbiosis perspective. *Supply Chain Management*, 21 (2), 245-258.

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REVERSE LOGISTICS IN HOUSEHOLD RECYCLING AND WASTE SYSTEMS: A SYMBIOSIS PERSPECTIVE

INTRODUCTION

Municipal solid waste (MSW) management services are reverse logistics (RL) operations of significant scale and importance throughout the developed world, and yet the topic has received limited attention within the logistics and supply-chain management (SCM) literature. When successful, activities underlying MSW management services can have a significant impact on sustainable living by increasing levels of recycling and decreasing the amount of MSW being sent to landfill or incineration (Beullens, 2004; McLeod *et al.*, 2008). The under-emphasis on MSW management services in the RL literature seems at odds with an increasing policy focus on sustainability issues. All OECD municipal RL service providers have become dedicated to diverting MSW from landfill by improved waste recovery planning (Dovidio, 2013).

Usual definitions of logistics discussing ‘point-of-origin to point-of-consumption’ (Grant, 2012) imply that consumers are the end node in a supply chain. However, in terms of being within a closed-loop supply chain and participating in the return, recycling or disposal of goods and waste, consumers are actually a pivot point node between forward (inbound) and reverse (outbound) flows (Anderson and Huge Brodin, 2005), and consumers as individuals or in households have a critical exchange role in working with a municipality or local authority (LA) as the first tier ‘supplier’ in an RL context. Further in this arrangement, consumers have an important role as both a source and initial separator of MSW. However, there is also limited consideration of this role in SCM literature and the role of consumers as a pivot point is not well understood.

This paper reports a research study of a symbiosis effect for exchange between consumers at that pivot point as first tier ‘suppliers’ of MSW in an RL system and LAs as first-tier ‘customers’. The behaviour of individual consumers and their households as collective agents is significant in enhancing or constraining household waste recycling systems (HWRS) (Wright *et al.*, 2011). Critically, the pivot point in a RL-HWRS system relies on sorting and separation of recyclables by a customer for kerbside collection services by an LA. Thus household recycling behaviour (HRB), and the attitudes and norms underpinning it, must increasingly be considered in conjunction with the provision and design of RL systems for MSW, e.g. sorting processes and guidelines, collection and transport.

If the objective of LA RL services in a HWRS is to increase the proportion of recyclables relative to the amount disposed of in landfill or by incineration, then it is essential to understand what the relationship is between LA-controlled factors, i.e., ‘situational’ or the physical characteristics of the RL system, and household characteristics and behaviour factors, i.e., ‘personal’. Thus, we examine the extent and manner in which this relationship, which we conceptualise as a symbiosis effect, is an element of successful RL operations in the context of HWRS.

A single discipline study has a limited ability to access the complex and multifaceted issues involved in managing household waste patterns and recycling behaviour (Choptiany *et al.*, 2014) and we approach our study through an interdisciplinary lens. We take the notion of a discipline to be a “*self contained and isolated domain of human experience which possesses its own community of experts*” (Nissani, 1997: 203). The dominant understanding of interdisciplinarity is an intention to synthesize or integrate knowledge from different disciplines (Holland, 2014). We define three primary disciplines of interest as being SCM (the recipient discipline for synthesis), consumer

behaviour, and waste management (referent disciplines). Nissani (1997) offers four realms in which such synthesis can take place: knowledge, education, research and theory. It is the synthesis of theory which we believe defines a dimension of contribution in this paper.

We use a pluralistic methodology and qualitative and quantitative approaches to develop both a rich and generalisable theoretical framework of the factors underpinning an effective first-stage RL system for MSW. Our empirical study was conducted with two English LAs and their respective consumers or households, and where success of HWRS is significantly reliant on HRB.

Our theoretical contribution addresses under-researched interactions of personal and situational characteristics in RL system design at the pivot point where a consumer's role is akin to that of a supplier. Further, our findings should inform management of municipal RL channels, particularly where greater involvement of consumers in the sort and separation of recyclables is desired. Finally, the findings advance the credibility of RL as a means of enhancing sustainable living.

This paper original intention was to address the following two research questions. As we will note later an additional question emerged from the first empirical research phase and was added for the second phase

1. Taking consumers as first tier suppliers to a municipal HWRS-RL channel, to what extent does a symbiosis effect influence the efficiency of a recycling operation?
2. What are the personal and situational factors that most significantly create a symbiosis effect?

The remainder of the paper is structured as follows. First we outline the role of RL in an end-of-life context, explain the two separate precursors of situational and personal factors that interact to create a symbiosis effect, and present our conceptual framework. We then outline our mixed methodology approach and provide details of the empirical study and present findings. We conclude with the contribution of the study, implications for RL theory and practice, and limitations.

THEORETICAL BACKGROUND

Reverse Logistics

The SCM literature has had a significant interest in matters of sustainable and green SCM for some time (Murphy and Poist, 2003; Carter and Easton, 2011; Grant *et al.*, 2015). Much work has also been done on reverse logistics (RL) concepts since the late 1990s (Carter and Ellram, 1998) and these concepts are also considered a crucial element in green supply chain management (Hervani *et al.*, 2005). We adopt Tibben-Lembke and Rogers' definition of RL for this study as "*the movement of product or materials in the opposite direction for the purpose of creating or recapturing value, or for proper disposal*" (2002: 271).

One under-investigated area in RL is how to deal with 'end-of-life' or 'end-of-use' goods (Bing *et al.*, 2014, Ritchie *et al.*, 2000, Xie and Breen, 2014), particularly regarding recycling or disposal of them (Mishra *et al.*, 2012). Wright *et al.* (2011: 10) suggest that "*little attention has been given to the best methods to develop overall recycling channels*". However, the burgeoning attention to the recycling and management of waste has followed the increasing prevalence of end-of-life take-back laws (Toffel, 2003); e.g. the European Union's waste electrical and electronic equipment (WEEE) directive that stipulates all such goods must be recycled and not disposed (Grant *et al.*, 2015).

There are two main streams discussing handling end-of-life products or outbound flows, commercial management and LA management particularly MSW management (Zhang *et al.*, 2011). These streams can also be sub-divided as having inbound flows from commercial and domestic origins (Belien *et al.*, 2014). In the latter classification there are situations where household consumers form a key stage in the RL system as both a recipient of inbound flows and initiator of outbound flows. The degree to which the success of RL operations are affected by household recycling behaviour is determined by the extent to which RL design involves collection of co-mingled recyclables, or whether source-separation is encouraged by LAs within the household (Bing *et al.*, 2014), which involves the supplier (i.e. consumer) presenting pre-sorted recyclables for collection. Post-collection separation of co-mingled recyclables occurs at a separation centre.

The physical aspects of RL channel design for source-separation starts with the provision of waste containment for the supplier or consumer, e.g. wheeled bins, kitchen food waste baskets, and biodegradable recycling bags. However, there is little research to date regarding this phenomenon at the supply chain ‘pivot point’ from forward to reverse logistics. This omission seems odd given the current global prioritisation of resource recovery from MSW (Dovidio, 2013). This appears to be a problem for logistics research in general and RL service design and implementation in particular.

The management of HWRS recycling can be defined as:

“...the process of systematically collecting, sorting, decontaminating and returning of waste materials to commerce as commodities for use or exchange” (Wiard and Sopko, 1991: 3).

Consumers have a critical role in determining whether end-of-life goods are captured by an RL system or are disposed of as waste. This is especially true for mundane household waste items such as food and beverage packaging, as opposed to the more durable electronic items covered by take-back regulations. However LA waste systems are relatively neglected in the RL literature compared to commercial RL systems.

Similar to other suppliers, an LA must treat consumers and/or households as an external element in an exchange relationship. However, there is no direct association of cost and service: financial penalties and rewards are not usually applied to households to incentivise recycling behaviour. The question becomes how to motivate them to separate waste, which is cheaper for LAs than post-source separation of co-mingled waste, but risks lower participation rates. A range of logistics design factors influence recycling behaviour (i.e., the situational factors), which controlled by the LA and which influences the extent to which customers or households comply. These can also be considered ‘hard’ factors that can be quantified and measured (Caplice and Sheffi, 1994). Strategically, physical aspects affect the degree to which consumers can be motivated to create multiple streams of separated recyclables, with the alternative being a single stream or a fully co-mingled supply of recyclables (Woodard *et al.*, 2006; Abbott *et al.*, 2011).

Prior studies have ascertained that ‘soft’ RL factors (Caplice and Sheffi, 1994) such as convenience, perceived improvement in recycling facilities communication and financial incentives from LAs tend to lead to higher household recycling levels (Abbott *et al.*, 2011; Keramitsoglou and Tsagarakis, 2013; Wright *et al.*, 2011). Given the many and varied RL schemes deployed by LAs in the UK it is difficult to separate the effects of hard and soft factors, hence we combine them as situational factors. All are controlled by the LAs in their effort to engage with the household as supplier-consumer.

The behavior and attitudes of consumers towards recycling are also important in the design of successful RL systems for MSW and it is the consumer's role as a first-stage supplier to a municipal RL system that is the focus of this study. A key question is the degree of voluntary involvement that consumers are willing to exhibit in delivering recyclable items to a point where the LA RL service provider accepts ownership of them. In sharp contrast to conventional supplier-customer relationships, many households do not attach a value to their waste. Thus, HWRS need to consider that the primary desire of consumers or households is to discard their tins, plastic, bottles, etc. within the bounds of culturally acceptable behaviour (Deutz and Frostick, 2009).

Household characteristics can also be precursors to effective recycling behaviour. Certain demographic personal factors such as nationality, cultural background, socio-economic contexts (e.g. property type, socio-economic level and residential type), age and income level have been found to be significant in affecting recycling performance (Abbott *et al.*, 2011; Bekin *et al.*, 2007; Keramitsoglou and Tsagarakis, 2013; Saphores *et al.*, 2012; Woodard *et al.*, 2005).

HWRS not only relies on situational factors but also on personal factors. Importantly, the aforementioned studies do not consider personal and situational factors in conjunction with one another and to date studies that integrate insights into sustainable RL in the context of HWRS are rare. Research exploring the first-stage of HWRS has focussed on the effective design and implementation of a recycling system i.e. situational factors regardless of the effects of personal factors in enhancing positive HRB (Dahlén and Lagerkvist, 2010). Equally, other studies that have focused on personal factors in recycling performance contain limited discussion of situational factors (Saphores *et al.*, 2012; Keramitsoglou and Tsagarakis, 2013). To date, the closest empirical study looking

at these two sets of factors holistically was Bhate (2005), who examined pro-environmental attitudes in the consumption of consumer goods.

Symbiosis Effect and Conceptual Model

We argue that without exploring a symbiosis effect, i.e. the interactions between personal and situational factors that will have a positive effect on HRWS, studies attempting to determine the effects of an HRWS cannot adequately explain why levels of collecting, sorting, decontaminating or recycling of waste materials have worsened or improved. Symbiosis is a term to be found primarily in the physical sciences but which has been applied in the social sciences to denote a favourable association between separate but interrelated items of consideration (Ehrenreich, 2002). We propose that the relationship between supplier (consumer or household) and their first tier customer (LA) in the RL channel can be understood as producing a symbiosis effect. Symbiosis has also been used in the context of industrial waste, or residues, to encapsulate a situation where the residue of one entity becomes the input of another, to the mutual benefit of both (Deutz, 2014). Extending the concept of industrial symbiosis to encompass post-consumer waste raises additional co-ordination challenges (Deutz, 2009). However the idea of a symbiotic relationship has not yet been employed in the analysis of an RL-HWRS for MSW.

Waste collecting, sorting, reduction of contamination and recycling are the outcomes of an effective RL system, and we hereinafter refer to these factors collectively as improved first stage RL efficiency and which we represent in Figure 1. Consideration of household motivation to sort and separate household waste is an element of a ‘multi-agent architecture’ for an entire RL system (Hervani *et al.* 2005) and we posit that a symbiosis effect occurs in the exchange between groups of agents or households and HWRS service providers or LAs, and that the householder’s role as the first tier supplier affects the entire RL channel going upstream.

Insert Figure 1 here.

To consider HRB as the first-stage of the RL system and to gain a better understanding of behaviour, we synthesize (blend) concepts drawn from the Theory of Planned Behaviour and Norm Theory. The most complex factors affecting HRB are the precursor personal factors which have two distinctive aspects: attitudinal and personal capabilities. Attitudinal factors are driven for instance by perceptions, predispositions, beliefs, norms, religion and culture and the Theory of Planned Behaviour suggests that people behave reasonably and are aware of the consequences of their actions (Ajzen, 1991).

Additionally, studies using Norm Theory also offer insight into matters of personal capabilities such as knowledge, social status and experiences that define individuals in socio-economic and demographic contexts. Under the assumption of these theories, individuals, and in combination households, collectively contain the ability to perform tasks such as recycling, sorting and separating, providing that they at least understand the basic materials such as paper, glass, plastics or aluminium that can be recycled (Tonglet *et al.*, 2004; Barr and Gilg, 2007). The degree to which they may be motivated to perform sort and separation activities is however a more complex matter (Barr *et al.*, 2001).

METHODOLOGY

One of the problems with gaining insight into a symbiosis effect is complexity. Consequently, our approach is pluralistic and supported by our multi-disciplinary backgrounds. We pursued a mixed methodology approach that allows methods and methodologies to be detached from their usual underlying paradigmatic assumptions, for example surveys and quantitative approaches coupled to the functionalist paradigm and interviews and qualitative approaches coupled to the interpretivist paradigm. Our

findings are therefore grounded in Yolles' (1996) notion of a 'virtual' or emergent paradigm with different underlying assumptions to those of functionalist and interpretative paradigms in isolation. This approach is arguably closer to how practitioners approach problem solving in practical contexts (Skyrme, 1997).

In our approach we combined the inductive exploratory value of qualitative approaches with deductive, generalisability and robustness advantages of a quantitative approach. Our samples were drawn from two English LAs and the two geographic areas were evenly represented. Secondary data was used to characterise the two LAs in terms of population, social considerations and approaches to household waste collection. We provide further details on methods pertaining to the two phases of fieldwork in the following section in juxtaposition to the findings from each phase.

FINDINGS AND DISCUSSION

Characterisation of the two study areas

The East Riding of Yorkshire Council (ERYC) and the Hull City Council (HCC) are neighbouring unitary LAs (i.e. responsible for waste collection and disposal) in the north east of England. ERYC is a geographically diverse territory (comprising suburban and urban but substantially rural communities) averaging 134 people/km², in comparison to HCC (densely urban and suburban), which averages 3,146 people/km². However, the total population size is similar for both LAs: 325,000 in ERYC, compared to 263,900 in HCC. Socially the two LAs are also quite distinct from each other and represent two distinct cases. According to the 2010 English Indices of Deprivations (DCLG, 2010), HCC has both a significantly higher proportion of its population classed as deprived, and a significantly larger proportion of its area containing a high proportion of deprived households (measured by indices including income, employment, health, education and housing).

These two contrasting LAs have co-operated on waste issues since their formation in 1996. They issued a joint waste management strategy in 1999 (KHCC and ERYC, 2004). With increasing prioritisation of recycling, a joint sustainable waste management strategy appeared in 2006 (ERYC and HCC, 2012) announcing plans for achieving a 45% recycling and composting rate. From 2000-01 to 2010-11 combined recycling and composting rates in these authorities followed the national improvement trajectory, albeit consistently below national average and ERYC's rate is higher than HCC as shown in Figure 2.

Insert Figure 2 here

However, since then HCC has achieved the LAs' self-imposed target before ERYC, and both LAs have consistently exceeded the national average rate since 2011. Notwithstanding their joint waste disposal contract, ERYC and HCC initially took different approaches to designing their HWRS. HCC was first to commence kerbside box collection of co-mingled recyclables in 2003 with separation road-side by collection staff (Deryagina, 2008). ERYC's scheme introduced in 2004-05 comprised a co-mingled wheeled bin collection that was separated at a waste transfer station (Aliyu, 2008). Both authorities have made adjustments over the intervening years (e.g., adding to the recyclates collected, adding green waste collections, reducing the frequency of reduce residual waste collections), and have converged to the same system. Both currently have three fortnightly collection rounds comprising co-mingled recyclates (paper, cardboard, glass, metal and plastic); garden and kitchen waste; and residual waste (ERYC, 2015; HCC, 2015).

First phase of the empirical study

The aim of the first inductive study phase was to explore the notion of a ‘symbiosis effect’ and intended to be both confirmatory and revelatory. Consistent with principles advocated for mixed-methodology research (Creswell, 2008; Tashakkori and Teddlie, 2002) a convenience sample was taken. The fieldwork involved conducting semi-structured interviews with fourteen respondents: two of whom were local authority officers – one each from ERYC and HCC. The demographic profile of the remaining twelve respondents in the sample was as follows: five respondents lived in ERYC and seven lived in HCC. The sample included nine female and five males aged between 24–52 years. More females (67%) than males (33%) participated in the interviews, which is consistent with past research in recycling (Smith, 2008) that has noted women were more likely to participate in research where environmental issues were the major concern. The recycling experience of respondents ranged from two to twenty years, with three of the respondents reporting that they had been recycling before LA recycling initiatives started.

The interviews were between 90 and 120 minutes long and digitally recorded, transcribed, and subsequently coded using NVivo software. Interviewing concluded in line with the principles of theoretical saturation (Lincoln and Guba, 2013), i.e., when addition interviews yielded no new insight. Themes were derived from a priori literature and thematic analysis of transcripts was used to confirm concepts drawn from literature, whilst also allowing new themes to emerge (Attride-Stirling, 2001; Braun and Clarke, 2006). Themes identified substantively corresponded to the conceptualisation of the HWRS problem outlined in Figure 1 and are summarised in Table 1 with the questions asked and both a priori and emergent themes identified from transcript analysis.

Insert Table 1 here.

The most commonly occurring themes were taken forward into the phase two quantitative study as shown in Figure 3. The themes of ‘self-awareness’, ‘knowledge’ and ‘experience’, ‘self-efficacy’, ‘social norms’ and what we term ‘household dynamics’ (number of persons per household and dwelling-type i.e. marital status, family, cohabitants), are considered personal factors. Most of these can be found in the behavioural literature (Park and Ha, 2014). In addition, situational factors were based on themes identifiable in logistics and supply chain discourse; particularly backwards movement (product, services or waste) and flows (Grant *et al.*, 2015). These included easy access or accessibility and availability of the point of reverse exchanges for example, the collection services, the drop-off centres and customer services. Both accessibility and availability are considered as one factor and precursors of an effective recycling system consistent with Pohlen and Farris (1992).

Insert Figure 3 here.

Other aspects such as the provision of services and facilities from LAs (wheeled bins, liners, schedule times, drop-in centres, customer services, etc.) are further considered here as ‘availability’ and ‘accessibility’ and the process of sorting with given instructions (i.e. an LA’s recycling manual) is considered here as ‘convenience’ (the ease of doing) and ‘education’ (LA involvement in inducing a recycling culture (Wagner, 2013; Young *et al.*, 2013), ‘advertising’ (getting awareness messages across to households, after) and ‘engagement’ (direct communication on recycling i.e. door-to-door consultation), and a road awareness program (Fischer *et al.*, 2012; Wong *et al.*, 2013).

A symbiosis effect was apparent in phase one as householder interviewees considered that HRB will alter in sympathy with changes made by recycling schemes introduced by LAs. Likewise the LAs were also responsive to the householders’ recycling practices.

Previous studies have pointed to cause and effect relations between improved recycling schemes and improved recycling rates (Williams and Cole, 2013; Woodard *et al.* 2005). In addition, we found that interaction and engagement from the municipality was of significant importance. The results of phase one provided support for our conceptual model in Figure 1 as a viable basis for further theoretical development. Using a ‘thematic analysis network’ in Figure 3 we illustrate the confirmed (C) and emergent (E) themes from phase one; it is the development of our original conceptual framework based on phase one findings and was taken forward for quantitative investigation in phase 2.

Second phase of the empirical study

For the second deductive phase of research, the target population consisted of residents from the two LA areas investigated in the first phase, ERYC and HCC, and the unit of analysis was the household. The total population of both of the LA’s remit areas was 588,900 at the time of the survey (ERYC, 2015; HCC, 2015).

A postal survey questionnaire was sent to 500 households from each area (1000 in total), out of which 200 usable responses were received in total. Analysis was undertaken using SPSS and Excel. In addition, to allow for the impact of low response rates normally associated with postal surveys, an online survey was also published via a social media platform. The affiliated community networks of the local municipalities is a a customer engagement portal where customers can comment and interact with each other without close supervision). Selected local companies also distributed the survey for the attention of employees living in Hull or the East Riding. This provided an additional 212 responses for a total of 412.

Based on comments and emergent themes in the first phase about the rationale behind HRB as perceived by the two LAs, we added an additional research question (RQ1) and also refined the other two for the survey of households as follows.

RQ1: What is the rationale or reasoning behind HRB in different municipalities?

RQ2: What are the different personal and situational factors associated with HWRS that may affect HRB?

RQ3: What are the interaction and symbiosis effects and the conditions that support the symbiosis effect between HWRS and HRB?

Inferential statistical analyses were carried out to address these three research questions and the items used in the survey instrument are presented in the Appendix except for the population profiles which were derived from secondary sources.

Insert Table 2 here.

Table 3 provides a summary of the socio-demographic profiles of the respondents. The sample was slightly dominated by female respondents (62%) and the majority of respondents fell within the 51 or older age group. Most respondents have more than four years of recycling experience (75%), and had been living in the same property for more than four years (69%). A frequency analysis showed that more than 90% of households were clearly aware of why they recycled. Many considered their motives for recycling as being grounded in a belief that recycling improved their environment and that they wanted to live in an environmentally conscious society.

Insert Table 3 here.

We considered four situational factors (convenience; advertising and education; engagement; accessibility and availability) alongside personal factors for correlation and predictive values.

Normality testing and reliability tests both satisfied Nunnally and Bernstein's (1994) recommendations before correlation and multi regression analysis were deployed. Pearson correlation was used to analyse the relationship between situational and personal factors before extending to multiple regression analysis, i.e. the interaction and strength of the relationship between the two sets of variables and whether the investigation of symbiosis effect really prevails in the analyses.

The Pearson's correlation revealed the relationship between the convenience, engagement and accessibility and availability (excluding advertising and education which showed a non-significant relation) with five demographic factors (age, employment, knowledge, experience and household dynamics) and a combination of three personal factors (self-awareness, self-efficacy and social norms). Items underlying the personal and situational factors were formed into relevant composite factors and then a statistical correlation was tested between these composite factors including all demographic items. Those representing a more than a 0.05 significance level were omitted from multiple regression analysis. The correlation between these two composite factors is illustrated in Table 4.

Insert Table 4 here.

Results detailed in Table 4 reveal that personal factors have a significant relationship to situational factors ($p < 0.01$) and vice versa; with a positive correlation ($r(412) = +0.41$). Four demographic items were also found to have positive relation with both factors ($r(412) > +0.07$) and a correlation between composite personal factors with those four

demographic items had a significant relationship ($p < 0.01$). However, household employment has a significant influence at ($p < 0.01$) on composite situational factors, thus the age of a household and household dynamics such as marital status were at a ($p < 0.05$) significant level. ‘Knowledge and experience’ of recycling had no significant correlation with composite situational factors. The analyses indicated that a socio-demographic profile of a local constituent has a positive correlation with factors contributing to HRB.

A correlation was also performed with composite personal factors and individual situational factors as shown in Table 4. The results showed that the personal factors had a significant relationship with engagement ($p < 0.01$) with positive correlation ($r(412) = +0.71$); as well as convenience ($p < 0.01$) with positive correlation ($r(412) = +0.44$) and accessibility and availability ($p < 0.01$) with positive correlation ($r(412) = +0.27$). Pearson’s correlation analyses have revealed that personal factors have a strong positive relationship with engagement. An incremental change in engagement by the LAs will have a positive effect on the HRB (Kalamas *et al*, 2014) even though in the study we found a positive relationship between personal factors with convenience and accessibility and availability factors, but with rather a moderate and weak intensity.

However, it cannot be determined whether situational factors influenced personal factors which later determined overall HRB. Therefore, we used multiple regression analysis for both factors and demographical items to understand more about the relation between predictor variables (situational) and a dependent or criterion variable (personal) as shown in Table 5. This analysis was relevant as it addressed the assessment of various relationships, using the information from independent variables to improve the accuracy in predicting values for the dependent variable (Green, 1991).

Insert Table 5 here.

The term ‘mutually dependent’ suggests either situational and/ or personal factors can be either the dependent or independent variables respectively. In the study we coded both factors interchangeably between analyses both dependent and independent variables. When we coded personal factors as dependent variable we found that engagement ($\beta=+0.32$, $p < 0.01$), convenience ($\beta=+0.16$, $p < 0.001$), and accessibility and availability ($\beta=-0.13$, $p < 0.01$) were significant predictors of recycling behaviour. The overall model fit was $r^2= 0.838$. The main effect of all situational factors was significant, $f(5, 406) = 191.61$ $MSE = 12.06$, $p < 0.01$ as shown in Table 6.

Insert Table 6 here.

The interaction of situational factors included the four demographic variables, with personal factors as dependent variable, is also significant when applying bivariate ANOVA as shown in Table 7: age $F(2, 409) = 53.34$, $MSE = 31.90$, $p < 0.01$, marital status $F(3, 408) = 36.47$, $MSE = 31.80$, $p < 0.01$, employment $F(4, 407) = 27.88$, $MSE = 31.73$, $p < 0.01$ and number of year recycling $F(5, 406) = 22.66$, $MSE = 31.68$, $p < 0.01$. In this bivariate model the analysis was extended to seek interaction between these two factors. Thus, the dependent variable (personal factors) is highly dependent on situational factors for HRB to progress positively.

Insert Table 7 here.

The findings suggest that different demographic profiles have an effect on the recycling intention of householders. Previous literature contained suggestions that different localities based on geographical setting such deprived versus affluent areas strongly

impact recycling performance (Abbott *et al.*, 2011). However, we found the householders in both localities have the same motivation towards recycling. Both respond similarly to the municipalities in response to improvements to convenience, engagement, accessibility and availability. Even though HCC is considered more deprived than ERYC the study does not conclude deprivation level is a major predictor in HRB. This may be due to the fact both personal and situational factors are representative of a more complex symbiotic relationship, supporting Akil and Ho (2014).

Notwithstanding the different social characteristics of the two LAs, both have managed significant improvements to recycling rates over the same time period by adopting the same HWRS discussed above and shown in Figure 2. Abbott *et al.* (2011) stated that the variation of recycling performance throughout the United Kingdom especially England were influenced more than just socio-demographic element but the influence can be derived from geographical spatial setting (rural versus urban area) and situational factors of the HWRS provided by the municipalities. The first phase findings suggested however that HCC residents (urban type area) were inclined towards ‘up-cycling’ such as reusing or reselling most of the recyclable items or giving those items to extended families or friends. On the other hand, ERYC households were more likely to send their reusable items to various charities. It is clear that both LAs have the same intention towards recycling (recover back the item to secondary channel) but the presupposition of recyclates are distinctly different.

We found the second phase analyses demonstrated significance and greater confidence in the factors (summarised in Figure 4) than the first phase. First, the interaction between accessibility and availability, as well that between convenience and engagement (situational factors) with personal factors, were found to be the main predictors of positive HRB. Second, the composite personal factors interaction between engagement or

convenience or accessibility and availability (situational factors) point to enhancement in HRB. Third, to project or manifest HRB in a way that increase recycling performance, households must be motivated by the right stimuli such as the engagement, convenience, accessibility and availability in HRWS. Keramitsoglou and Tsagarakis (2013) discuss such matters in respect of convenience and engagement.

Insert Figure 4 here.

Personal factors can be usefully sub-classified into five aspects represented to the left column of Figure 4. In the quantitative analyses, personal factors (self-awareness, self-efficacy, and social norms) were transformed into a composite excluding some demographic aspects (age, employment, knowledge and experience and household dynamics such as number of dwelling per household and marital status). The composite of personal factors was considered robust as the contribution of each item to the composite score was weighted to reflect the target construct (DeCoster, 2004).

The demographic factors have been established as an aspect of personal factors as well as an extraneous variable that DeCoster (2004) referred to as a ‘confounding’ variable that correlates directly or inversely with both the dependent variable and the independent variable. However, the findings suggest that knowledge of recycling in households and how long they have been recycling, or experience, positively interact with situational factors and contribute to an improvement in HRB consistent with Thøgersen (2006). Two situational factors, advertising and education were found to be insignificant in the study and hence their deletion in Figure 4.

This quantitative phase confirmed the proposition of a symbiosis effect from the first phase and demonstrated and validated the first stage findings that higher interaction and

engagement influences sustainable HRB, and higher reverse exchanges of service provision and availability of recycling facilities in turn pushing the performance of recycling initiatives by LAs.

CONCLUSIONS

We proposed that a symbiosis effect occurs at a pivot point between forward and reverse logistics. Consumers or households were addressed in this study as occupying that pivot point as a first tier supplier in a RL system devised by an LA who is the first tier customer for the recycled material. The terrain of many findings in extant literature in our recipient and referent disciplines have, in examining HRWS, largely considered personal factors in the context of HRB and situational factors in the context of RL in isolation from each other. Our central finding is that a symbiosis effect exists for exchanges between HWRS and HRB and that an effect between households or consumers and LAs significantly influences the effectiveness of recycling schemes. The results of the study therefore support the importance of considering interaction between situational factors and personal factors when examining the effectiveness of an entire HWRS.

We sought to determine the personal and situational factors that most significantly create a symbiosis effect. Our findings suggest that personal factors interact with situational factors and that HRB transforms in accordance with how effective the design and implementation by LAs of situational factors of ‘accessibility’, ‘availability’, ‘convenience’ and ‘engagement’ are as LAs perceive them for HRB. Personal factors identified as significant in the symbiosis effect are ‘self-awareness’, ‘knowledge and experience’, ‘self-efficacy’, ‘social norms’ and ‘household dynamics’.

In addressing these questions, this paper has made contributions in a number of ways. While the study presented here has an interdisciplinary grounding, our stated intent was

to blend theories into, and thus contribute to, a receiving discipline of SCM. SCM literature has had a significant interest in matters of sustainability (e.g. Carter and Easton, 2011; Grant *et al.*, 2015) and green SCM (e.g. Murphy and Poist, 2003; Mishra *et al.*, 2012). The thrust of this work has substantively examined situational factors rather than personal factors. In pursuit of sustainable and green SCM credentials there seems to have been only limited interest in recycling and we have addressed that neglect here.

Recycling and RL have been co-examined in a small number of studies. To date, the studies in core SCM journals have examined RL in the context of recovering and recycling plastics, (Bing *et al.*, 2014), household medicines (Xie and Breen, 2014) and hospital waste (Ritchie *et al.*, 2000). We have therefore provided a contribution to the previously underexplored context of RL and recycling, more specifically to the context of LA or municipal RL channels and HWRS. Our study therefore should have interdisciplinary interest in both the SCM and waste management scholars

From a practical perspective the findings should inform RL-HWRS design by LAs and municipalities looking to more effectively manage MSW and enhance recycling and sustainability. Waste collection is one of the most visible and universal of local authority services: improving the relationship between service user and service provider is to the mutual satisfaction of both. RL practitioners should introduce systems to support recovery of MSW in sympathy with communication and education initiatives to affect HRB and should also appreciate a symbiosis effect in the design of HWRS

The findings also suggest there can be profound social implications for improved recycling performance in LAs; even incremental improvements in HWRS performance can lead to enhanced sustainability through higher recycling rates, reduced MSW diversion to landfill, decreased pollution levels, reduced carbon footprints, and reduced

depletion of scarce natural resources. Consideration of a symbiosis effect, and the situational and personal factors proposed in this paper would be of particular value to practitioners when attempting to move from one mode of waste collection (i.e. co-mingled) to another which requires greater commitment by a household at the pivot point (i.e. source separation). For RL channel design the paper has provided a strong foundation for the consideration of a symbiosis effect by channel designers. . The principle of a symbiosis effect should also be examined with respect to other policy areas (e.g., transportation) where public engagement with policy is important.

Further research should investigate multiple case studies among more geographically distant and distinctive LAs. Non-UK case studies could examine the effect if different socio-cultural settings, as well as different policy regimes. Further research examining the symbiosis effect over an extended time period would add substance to its existence. Further research should also address how the relationship between households and LA evolves, how incoming residents adapt to practices of their new LA, how do LAs cope with a transient population, and how consumers in this scenario influence each other.

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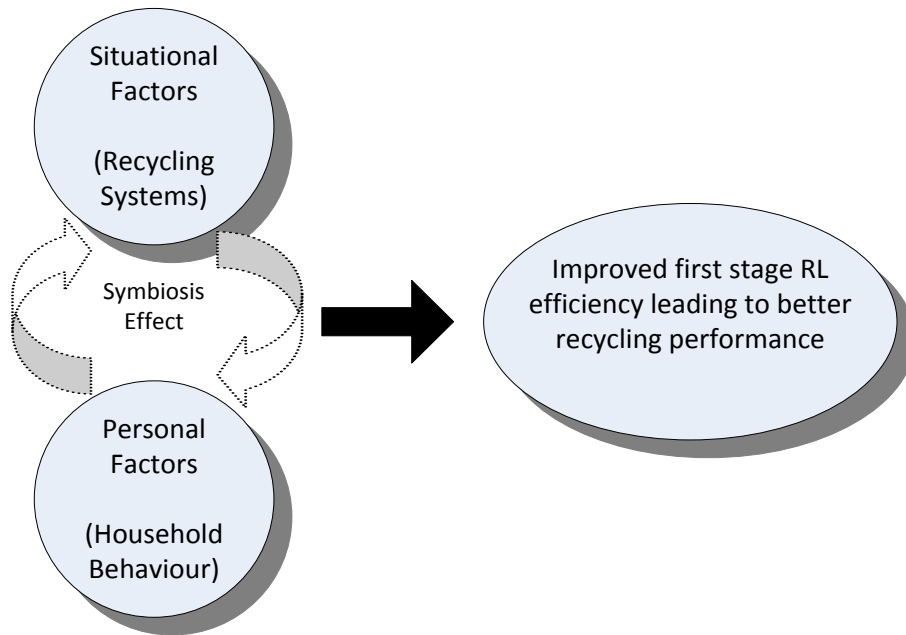


Figure 1: Proposed theoretical framework

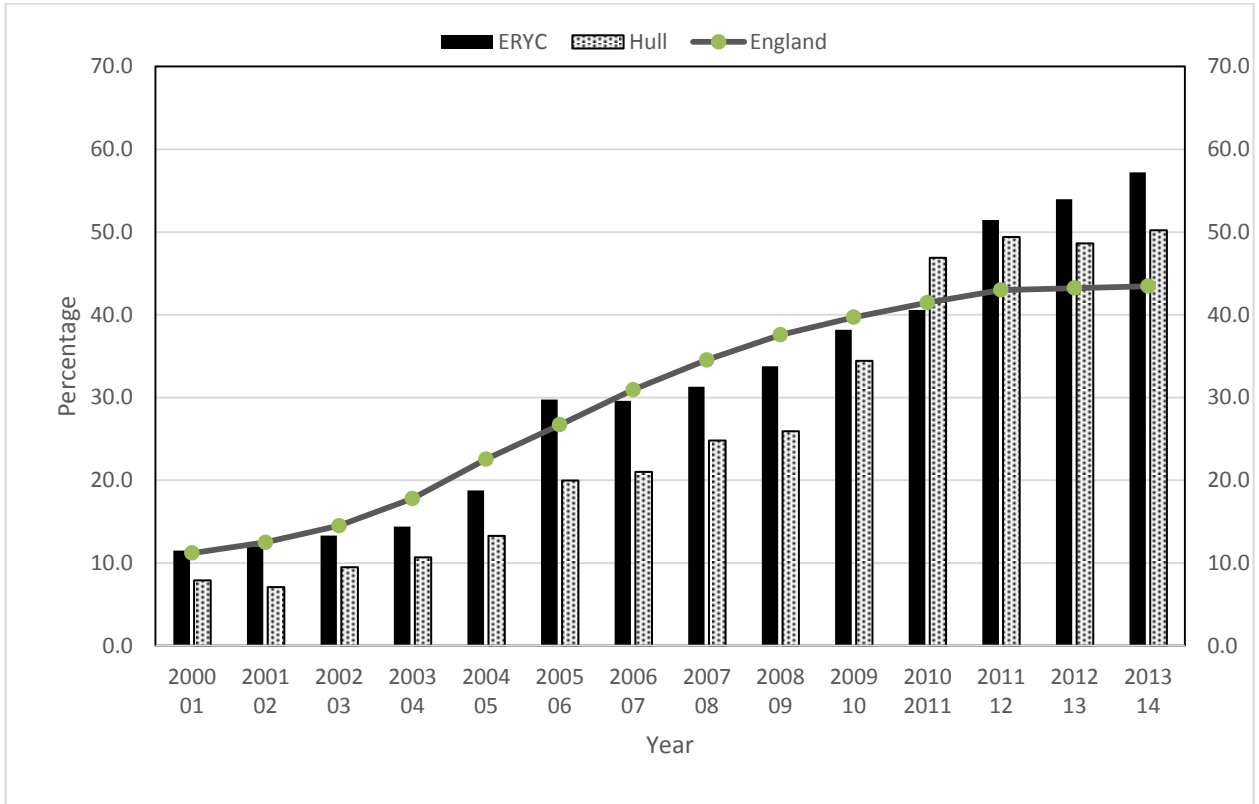


Figure 2: Percentage of household waste recycled or composted for the two local authorities and an average for England (sourced from statistics reported to the UK Department of the environment, farming and rural affairs by local authorities.)

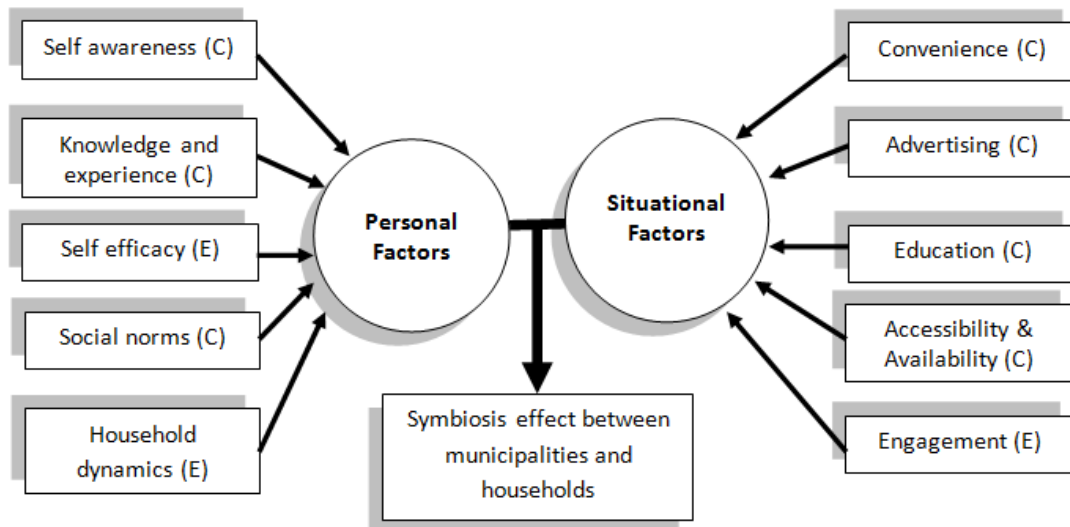


Figure 3: Thematic analysis network of symbiosis effect between personal and situational factors

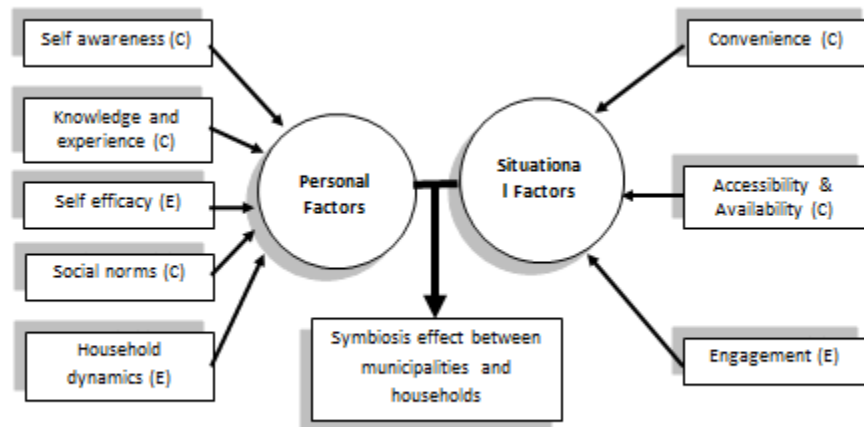


Figure 4: Model with supported elements

Table 1: Interview questions with key themes derived from literature and phase one study

1. What are the different factors associated with HWRS that may affect HRB, (Targeted at local authority (LA) staff).

- Why were changes made to HWRS?
- Who were the most significant contributors to ensure these changes to HWRS led to successful outcomes?
- Why were these changes to HWRS seen as significant?

A priori themes supported: sustainability (diversion from landfills, reduction of CO₂ emissions were imposed on the operators and incineration has been chosen as the best recovery option for HCC residents). Situational factors (new improved schemes scheduling for blue and black bins for HCC residents; ERYC had opted for co-mingled strategy a bit later than HCC however ERYC introduced brown bins (similar to HCC) which had increased their composting performance which as a whole increased their recycling performance in comparison to HCC. Accessibility (closer distances for drop-in) and availability (public amenities) in the recycling systems were probed and responses were that financial constraints were a major barrier to providing such services to households. Marketing initiatives were an important factor in promoting HRB; however limited financial resources deterred local authorities from engagement with households.

Emergent themes: integration between institutions (university, retailers, schools etc.), the importance of roles played by the central government through relevant agencies (DEFRA, WRAP, Environment Agency etc) and their development of effective policies in tackling environmental issues.

2. How is HRB manifested in different Local Authorities (Targeted at households)

- When I say “recycling” what is the first thing comes to mind?
- How do you feel when you are sorting and separating your rubbish for recycling?
- Is it convenient for you to do this on a daily basis?
- What would make it easier?

A priori themes supported: situational factors (collection schedules, distances, bins,

sorting, information, engagement, education, rewards, distance, convenience, availability, accessibility and fees), personal factors (knowledge, awareness, recycling attitudes, neighbourhood norms, local authority engagement, education, easy to understand pamphlets, family norms, brands/ retailers that promote recycling) and situational factors.

3. What are the interaction and symbiosis effects and what are the conditions that support the symbiosis between HWRS and HRB? (Targeted at households and LA staff).

- I'd like to ask you... before the three wheelie bins were introduced in 2009 and looking at your current address, can you recall a time when you felt the need for changes in how the LA managed your waste.
- Do you feel current practices amount to a convenient way of recycling?
- Do you find it important for you to be able to recycle?
- When I say "sustainability" what does this term mean to you, your neighbourhood and environment?
- What is it about the environment that you value?
- Do you think that you are recycling enough?
- Are communications from your LA clear and easy to understand?

A priori themes supported: personal factors (self-awareness, responsible attitude, social and family norms, doing good to society) and situational factors (advertising, information, education, public engagement)

Emergent themes: personal factors (self-efficacy and creativity) and situational factors (retailers' engagement and institutional engagement)

Table 2: Sources of items for quantitative survey instrument

Research Questions	Section	Sources for survey questions	Items
RQ1: What is the reasoning behind HRB in different municipalities?	Personal	Barr et al. (2001)	11
RQ2: What are the different factors associated with household recycling systems that may affect HRB?	Situational	Tibben-Lembke and Rogers (2002); Woodard et al. (2005)	15
RQ3: What are the interaction and symbiosis effects and the conditions that support the symbiosis between household recycling system and household recycling behaviour?	Interaction	Barr et al. (2001); Woodard et al. (2006)	28
RQ2: What are the different factors associated with household recycling systems that may affect HRB?	Population Profile(s)	Developed from Office of National Statistics (ONS) (2013)	10

Table 3: Respondent demographic details (n=412)

	N	%
Age		
20 or under	21	5.1
21-30	85	20.6
31-40	96	23.3
41-50	59	14.3
51 or older	151	36.7
Gender		
Male	157	38.1
Female	255	61.9
Recycling Experience (years)		
More than 4	307	74.5
Less than 4	105	25.5
Living in current property (years)		
More than 4	286	69.4
Less than 4	126	30.6

Table 4: Correlation table

Factors	<i>PEARSON CORRELATION</i>					<i>Sig. (2-tailed)</i>
	Situational	Age	Household Dynamic	Employment	Knowledge and Experience	
Personal	0.41	0.24	0.20	0.23	0.15	0.00
Situational	1	0.10	0.12	0.17	n.s	0.01

Table 5: Model coefficients

<i>Model 1</i>	<i>Unstandardized Coefficients</i>		<i>Standardized Coefficients</i>	<i>T</i>	<i>Sig.</i>
	B	Std. Error	Beta		
(Constant)	15.093	1.851		8.154	0.000
Engagement	0.316	0.032	0.359	9.890	0.000
Convenience	0.156	0.048	0.106	3.225	0.001
Accessibility and Availability	-0.125	0.031	-0.126	-3.994	0.000

Table 6: Model fit and univariate ANOVA Table

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.838	0.702	0.699	3.473

ANOVA						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	11555.827	5	2311.165	191.607	0.000
	Residual	4897.171	406	12.062		
	Total	16452.998	411			

Table 7: Multiple regression univariate ANOVA

ANOVA						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	960.799	1	960.799	25.427	0.00
	Residual (age)	15492.199	410	37.786		
	Total	16452.998	411			
	Regression	639.494	1	639.494	16.580	0.00
	Residual (marital status)	15813.503	410	38.570		
	Total	16452.998	411			
	Regression	868.746	1	868.746	22.855	0.00
	Residual (employment)	15584.252	410	38.010		
	Total	16452.998	411			
	Regression	391.910	1	391.910	10.005	0.002
	Residual (num. year recycling)	16061.087	410	39.173		
	Total	16452.998	411			

Appendix: Survey Questionnaire

Situational factors (RQ1)

	Strongly Agree				Strongly Disagree
I am aware that environmental issues are becoming more urgent than before.	5	4	3	2	1
I know recycling is helping the environment.	5	4	3	2	1
I check product labels for disposal information when I go shopping.	5	4	3	2	1
Given a choice, I would definitely purchase a product that is easier to dispose of than similar alternatives.	1	2	3	4	5
Given a choice, I select products with the recycling symbol.	5	4	3	2	1
I recycle most of my recyclable items.	5	4	3	2	1
I would definitely recycle If I received information that recycling has become more important to the environment than previously believed.	5	4	3	2	1
I would still recycle if I received information that recycling is less important to the environment than previously believed.	5	4	3	2	1

Knowledge of households about recyclates (RQ1).

Which goods/materials are you currently recycling...? Please tick <input checked="" type="checkbox"/> all that apply.	
Aluminium (packaging materials)	
Glass (bottles, jars and containers)	
Newspaper/Magazines/Pamphlets	
White A4 Paper	
Cardboard boxes (packaging materials)	
Plastic (bottles, tubs and containers)	
Plastic Bags	
Tin Cans	
Clothing and textiles	
Others (Please state the items)_____	
I recycle...: Please tick <input checked="" type="checkbox"/> all that apply.	
To comply with regulations	
Improve the environment	
To represent a good image	
To serve an environmentally conscious society	
Financial gains from the sale of recyclable products	
Do not know	
Other:_____	
Separation and Sorting the wastes are usually done by:	a. Myself b. Other member of the household _____ c. The whole household

Activities and stimulants derived from situational factors (RQ2).

	Always				Never
Most of the recyclables are being disposed by					
Putting them in with the rest of my rubbish (i.e. they are not separated).	5	4	3	2	1
Putting them separately from the rest of my rubbish.	5	4	3	2	1
Informing the right operator for collection (especially for larger items - furniture, electrical appliances or garden wastes).	5	4	3	2	1
Dropping them off to recycling centres (e.g. at a supermarket or household waste and recycling centre).	5	4	3	2	1
Would you be willing to drop off recycling items if given convenience (closer to residential and accessible) location?					
It is good that the environment is taken more into account, and for me personally it is a disadvantage that more effort is expected to protect the environment.	1	2	3	4	5
It is good that the environment is taken more into account, but for me personally it is an advantage that I can now increase my effort to protect the environment.	5	4	3	2	1
If necessary, I would be willing to pay extra for recycling services to be provided.	5	4	3	2	1
My recycling bins are usually fuller than my general bins.	5	4	3	2	1
The bins' collection times really affect my recycling routines	5	4	3	2	1
The size and ease of use of the wheeled bins affect how I manage my waste and recycling routines	5	4	3	2	1
The liners or bags provided affect how I manage my waste and recycling routines	5	4	3	2	1
I have my own separation system in my house to make me and other occupants participate more in recycling at home.	5	4	3	2	1
I often find it difficult to dispose of larger items (mattresses, old furniture, electrical appliances)	5	4	3	2	1
I would definitely dispose of my larger items properly if there a collection services periodically in my residential area.	5	4	3	2	1
I would definitely improve my recycling routines if there were more recycling bins in public areas (shopping complexes, leisure centres, recreational centres, main streets)	5	4	3	2	1

Attributes and elements derived from the interaction between situational personal factors (RQ3).

	Strongly Agree				Strongly Disagree
The reasons people are not recycling are:					
They do not use goods/materials that can be recycled	5	4	3	2	1
They are not aware which goods and materials could be recycled	5	4	3	2	1
The cost associated with recycling	5	4	3	2	1
The accessibility to recycling facilities	5	4	3	2	1
The time required to prepare goods for recycling	5	4	3	2	1
Their lack of knowledge about recycling programmes	5	4	3	2	1
My major sources of information about recycling include:					
Magazines and newspaper	5	4	3	2	1
The Internet	5	4	3	2	1
Television	5	4	3	2	1
Local Councils	5	4	3	2	1
Environmental Community Group or Non-Governmental Organizations	5	4	3	2	1
I would like a pick up facility for my larger recyclable items.	5	4	3	2	1
What services would you expect from local council disposal facilities?					
Dependable scheduled pick-ups	5	4	3	2	1
Councils employees separate goods/materials (glass, aluminium, etc.)	5	4	3	2	1
Provision of storage unit recyclables (trash cans, bins, etc.)	5	4	3	2	1
I am aware of a facility where I can take recyclable items that I may wish to dispose of.	5	4	3	2	1
I find out about recycling centres from:					
Council's webpage	5	4	3	2	1
Friends / family tell me	5	4	3	2	1
I read about it in the local paper	5	4	3	2	1
Information mailed to me by my local council	5	4	3	2	1
I enquired at my local council	5	4	3	2	1
I use the bulk rubbish collection service provided by my local council.	5	4	3	2	1
If the council provides all the necessary facilities (in public areas and near the residential areas) for recycling, I would definitely use it.	5	4	3	2	1
The distances from my residence to the recycling centres have a major impact on my recycling habits.	5	4	3	2	1
What would be the best way to communicate information regarding recycling facilities and services to you and your residence?					
Television advertising / promotion	5	4	3	2	1
Information in the local community paper	5	4	3	2	1
A letter from the council providing details of the facility	5	4	3	2	1
Awareness programmes held by government agencies or Non-Governmental Organisations	5	4	3	2	1