Reverse logistics for recycling: The customer service determinants

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ABSTRACT

Customer service is a central concern in the logistics practice and a study topic in the forward logistics research. This article investigates the elements of customer service and their importance in reverse logistics for recycling. Since consumer is the first intervenient in any reverse system that aims to recycle household residues, the provision of an adequate customer service gains an increased importance. Applying multivariate statistical methods (exploratory factor analysis, confirmatory factor analysis and discriminant analysis) to the data from a sample of 267 Portuguese citizens, this study identifies the levels of customer service in this reverse logistics chain and evaluates their relative importance in achieving consumers' participation. The study finds that, as in forward logistics, the customer service in reverse channels for recycling also has a hard and a soft level, being the former more important than the later. The results of this research suggest important guidelines to improve such a complex logistics service.

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1. INTRODUCTION

Reverse logistics is the continuous logistic process through which shipped products move from the consumer back to the producer for possible reuse, recycling, remanufacturing or disposal (Johnson, 1998). The European Working Group on Reverse Logistics (RevLog, 2002) describes reverse logistics as "the process of planning, implementing and controlling the flows of raw materials, in process inventory, and finished goods, from a manufacturing, distribution or usage point to a point of proper disposal". The purpose of a reverse logistics process is to regain the value of returned materials or provide the means for proper disposal (Rogers and Tibben-Lembke, 1999, 2001). Forward logistics, in contrast to reverse logistics, focuses on the flow of goods from the producer to the consumer. As Maltz and Maltz (1998) propose, customer service in the forward logistics channels is a multifaceted concept that can encompass either objective or perceptual elements. Objective elements correspond to basic customer service (or hard service) such as inventory availability, on time delivery and order cycle time reliability. Perceptual elements (or soft service) are those related to the suppliers' ability to respond to specific customer requests such as after-sale service and effective handling of information requests. Several authors recognize that customer service is an issue of central concern in logistics research and practice (Byrne and Deeb, 1993; Emerson and Grimm, 1998; Fuller, 1978; Giuntini and Andel, 1995; Kopicki et al., 1993; Maltz and Maltz, 1998; Marien, 1998; Murphy, 1986; Stock, 1992; Zikmund and Stanton, 1971). Reverse logistics systems for recycling begin with the consumer and finishes with the end market (Jahre, 1995). These systems can be more or less complex depending on whether they possess intermediate levels, such as, the collection level, the transfer level and the processing level. Consumers have a particularly important role in this reverse logistics system since they are the first link in the overall logistics chain. Without consumer participation (through the sorting and disposing of recyclable materials), this system would not be possible. By providing a convenient system, customer service becomes the touchstone in creating value for consumers as well as in securing their participation (Turner et al., 1994). As recently pointed out, most research in the reverse logistics field is essentially descriptive and based on subjective evidence rather than on theoretical bases (Alvarez-Gil et al., 2007). In terms of the reverse logistics systems for recycling, one gap that remains open is the comprehensive investigation of the main elements of customer service that explain the consumer involvement in selective-collection programs. This analysis would provide fundamental information about the most important customer service elements and, thus, that require more attention and investment. The contribution of this study lies in bridging this research gap.Data for this research results from the outcome of a structured questionnaire collected from a random sample of 267 Portuguese citizens. This study uses a three-step procedure to assess the elements that comprise customer service. First, an exploratory factor analysis identifies the main levels of customer service (both hard and soft) that shape consumer participation in the Portuguese recycling program. Second, a confirmatory factor analysis validates the underlying levels and the corresponding elements. Third, a discriminant analysis identifies the level of customer service that strongly predicts consumer involvement, in this way offering future guidelines for the reverse logistics system at the collection stage. The structure of this paper is as follows. Section 2 summarizes the background literature in terms of: (1) concept and origins of reverse logistics and (2) reverse logistics for recycling. Section 3 proposes a conceptual model that forms the basis for this research and puts forward a set of research hypotheses. Section 4 describes the research methods used including data information and statistical techniques. Section 5 presents the results and provides conclusions based on the research hypotheses. Section 6 discusses the study's theoretical and managerial implications, identifies its limitations and proposes guidelines for further research.

2. BACKGROUND ON REVERSE LOGISTICS FOR RECYCLING

Recycling is a resources recovery option that enables the use of part or all materials from returned goods, either by their original producer(s) or by other industries (RevLog, 2002). The recycling process essentially encompasses two stages (Jahre, 1995). The first is the collection service stage and includes all the necessary procedures that make recyclables possible for further reprocessing. The second is the reprocessing stage from the collection of materials to the replacement of primary raw materials. Table 1 lists the studies that explore particular issues on reverse logistics for recycling.

Table 1: Summary of articles on reverse logistics for recycling

Reference	Main topics investigated	Material (in)	Material (out)	Driver(s)
Guiltinan and Nwokoye (1975)	Reverse logistics networks	Recyclables in general	Materials	Social benefits Economic benefits
Pohlen and Farris (1992)	Reverse logistics networks Transportation issues	Plastics	(*)	Environmental concerns
Bronstad and Evans-Correia (1992)	Purchase of recycled materials	Paper	Paper	(*)
Kopicki et al. (1993)	Logistic implications of recycling (and reuse) programs	Recyclables in general	Materials	Social benefits Economic benefits
Gupta and Chakraborty (1994)	Planning and control of recovery activities	Glass scrap	Raw materials	Cost savings
Jahre (1995)	Reverse logistics networks	Household waste	Substitutes for primary materials	Legislation
Faria de Almeida and Robertson (1995)	Incentives to stimulate recovery (timely and clear information)	Batteries	Materials	(*)
Spengler et al. (1997)	Reverse logistics networks (private networks)	Steel products	Reusable products	Disposal cost saving Public waste management
Fuller and Allen (1997)	Reverse logistics networks	Post-consumer recyclables	Substitutes for primary materials	Legislation
Yender (1998)	Incentives to stimulate recovery (Easy and simple method of supply)	Batteries	Raw materials Batteries	(*)
Barros, Dekker and Scholten (1998)	Reverse logistics networks (public networks)	Construction waste	Sand	Waste disposal Environmental regulation
Nagel and Meyer (1999)	Information and communication for reverse logistics	End-of-use refrigerators	Plastics Metals	No longer needed Legislations Costs savings
Lowers, Kip, Peters, Souren and Flapper (1999)	Reverse logistics networks (private networks)	Carpets	Fibres, etc.	Image Expected legislation Economic advantages
Realff, Ammons and Newton (2000)	Reverse logistics networks (private networks)	Carpets	Fibres	(*)
Chang and Wei (2000)	Reverse logistics networks (public networks)	Household waste	(*)	Waste disposal Reducing costs Environmental concern

Note: (*) Not mentioned.

Although the concept of reverse logistics arises in the 1990s, the discussion on the structure of logistics channels begins much earlier. Guiltinan and Nwokoye (1975) identify the main types of logistics structures, functions and members that form part of the distribution channel. The study also points out a number of key factors for the future development of recycling channels, such as "[the need to expand] efforts in identifying potential markets and buyers of recycled materials; more extensive contact with, and promotion to, final buyers; [in expanding] capacity for moving increased volumes of material to achieve and maintain scale economies; and [in improving] flexibility in transportation" (Guiltinan and Nwokoye, 1975: 35).While the study of Guiltinan and Nwokoye (1975) does not focus specific recyclable materials, Table 1 presents other contributions that address particular reverse logistic networks for recycling.Pohlen and Farris (1992), for instance, analyze the set-up of recycling networks for plastics and propose a more complex structure for the reverse channel when compared to the general Guiltinan and Nwokoye (1975) approach. Pohlen and Farris (1992) discuss the main issues that affect reverse logistics channels for recycling, namely, efficiency improving factors in terms of existing channels and common forms of improving recyclables.As Table 1 shows, some of the studies that address the organization of recycling networks focus on public networks, while others describe private systems. In the first case, environmental concerns and waste disposal legislation are the main motivations underlying reverse logistics. Contrary to this notion are private reverse logistics networks that handle residues or end-of-life products in which recycling is economically more attractive. Private processors finance the transportation of these materials as well as the recycling process itself. For recycling to be economically viable, a significant amount of discarded products (or parts) need to be processed. The reverse logistics literature for recycling also explores the planning and control of recovery activities (i.e., the decisions about what to collect, disassemble and process, and in what quantities, how, when and where), the available information and communication systems (e.g., software, data requirements), the logistical implications of recycling, and the implementation of programs to increase the demand of recyclable materials. As Table 1 shows, the studies examining these issues explore only one type of recyclable material. Finally, the scope of this research explores the incentives that may stimulate a desired behavior in specific members who form part of the reverse channels. These incentives look for encourage / impose cooperation either in terms of reception or delivery of goods for recovery. In the first case, companies may have some goods that they wish to dispose of, and, through incentives, influence others (e.g., the goods' providers) in accepting such requests, in order to avoid high disposable costs. The second case includes situations in which the purpose is to encourage others (final consumers) to take part in efforts which allow companies to manage goods (products, parts, packaging) for recovery. Table 1 identifies three types of non-economic incentives: timely and clear information, general convenience, and an easy and simple method of supply. Table 1 evidences that only two studies on reverse logistics for recycling have specifically focused on household residues and they address the topic of how to design and manage the logistics networks (Jahre, 1995; Chang and Wei, 2000). In other words, despite the significant amount of research on reverse logistics during the last years, no study has so far identified what elements of customer service are important predictors of

consumer involvement in the reverse logistics system for recycling. To fulfil this research gab is the overall objective of the current study.

3. CONCEPTUAL FRAMEWORK AND RESEARCH HYPOTHESES

Incentives are of particular relevance in the context of encouraging consumer to separate and properly dispose of household packaging residues for recycling. In this case, the consumer is the starting point of any reverse logistics for recycling household waste and, therefore, his or her participation is a needed condition for a recycling system to exist. Although this topic has not been explored in the reverse logistics literature, in the field of environmental social-psychology, some studies address the predictive effect of a convenient recycling program in articulation with other potential determinants of environmentally friendly behavior. Essentially, the review of the literature shows that an increase in consumer involvement can result from the following aspects: (1) closer proximity of disposal recipients, (2) minimal complexity in storing and storage of recyclable materials, (3) accessible information on what is recyclable and the location of collection points, and (4) reliable frequency of collection. Table 2 summarizes the main characteristics and conclusions from these studies.

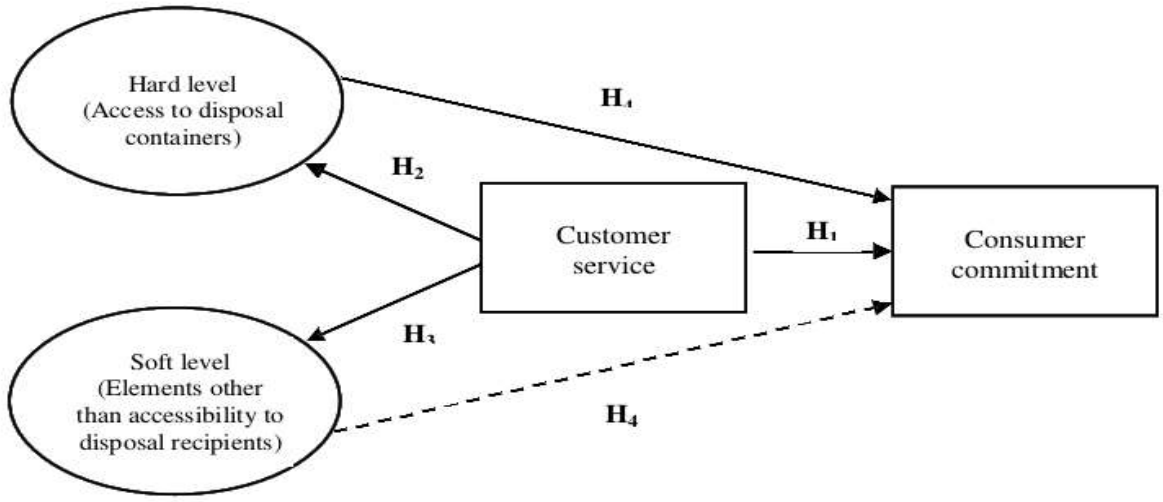
Table 2: Customer service elements as predictors of recycling behavior

Consumer-service levels	Reference	Variable under analysis	Participants	Finding (*)
Proximity of disposal recipients	De Young (1990)	Self-reported recycling	Residential households	+
	Folz (1991)	Participation in recycling	Residential households	+
	Folz and Hazlett (1991)	Participation in recycling	Residential households	+
	Vining and Ebreo (1992)	Self-reported recycling	Residential households	+
	Pelton, Strutton, Barnes and True (1993)	Willingness to participate in a recycling program	Residential households	+
	Margai (1997)	Self-reported frequency of recycling and observed amount of collected materials	Residential households	+
	Ludwig, Gray and Rowell (1997)	Participation in recycling	College students	+

Note:(*) Legend +: significant positive relationship; -: significant negative relationship; 0: non-significant relationship.

Based on the literature review, Figure 1 depicts the proposed model of consumer involvement in the reverse logistics system for recycling. The model establishes a direct causal-effect relationship of customer service in terms of consumer involvement. The following hypothesis establishes this connection:

Figure 1: Conceptual model of customer service in the reverse logistics system for recycling



Hypothesis 1: Customer service explains consumer involvement in the reverse logistics system for recycling household packaging. In terms of forward distributor channels, Maltz and Maltz (1998) state that the concept of customer service includes two common levels: (1) hard level that corresponds to objective or basic customer services, and (2) soft level that refers to perceptual customer service elements, besides those of basic service. The logistics literature widely accepts this classification of customer service levels (Dadzie et al., 2005; Mentzer et al., 1989; Stock and Lambert, 2001). Earlier research is clear about the meaning of basic customer service in forward reverse logistics. As Dadzie et al. (2005) summarize, this construct includes in-stock availability and cycle time. The literature on reverse logistics for recycling does not address this issue. This study proposes that the hard elements of customer service lie in the accessibility to the selective collection recipients. By providing this basic element to consumers, the reverse logistics system for recycling can operate. The remaining customer service elements that Table 2 presents depend on this element, that is, they are important only if communities have specific recipients for separated materials at their disposal. Consumers may perceive the separation process as satisfactory, understand how and why to separate, believe that, in general, the collection frequency is adequate, but without a collection service in place (well located and not too distant) they will not participate in the recycling program. The second research hypothesis represents these considerations: Hypothesis 2: The hard level of customer service in the reverse logistics system for recycling household packaging consists in the access to the selective collection facilities. Identifying the soft elements of customer service in the forward reverse logistics systems is not as clear as identifying hard elements. According to the definition proposed by Dadzie et al. (2005), soft elements are those other than in-stock availability or time cycle, that is, those that are not basic service. These elements are not objective but instead perceptual and result from suppliers' ability to respond to specific customer requests (Maltz and Maltz, 1998). In forwards reverse logistics systems, soft customer service elements include error correction, follow up on customer complaints, after sales services, and effectiveness in the handling of information (La Londe and Zinszer, 1976). The current study on the elements of customer service in reverse logistics for recycling follows a similar approach and considers that the soft elements go beyond just basic service, that is, beyond the easy access to specific disposal recipients for recyclable materials. As Maltz and Maltz (1998) refer, soft elements result from consumers' perceptions about customer service rather than from the objective characteristics of this service. Therefore, soft elements should necessarily include the perceived complexity in storing and separating the recyclable materials, the availability of information on how to recycle and where to dispose of the recyclable materials and a reliable periodic collection. Table 2 summarizes the existing research on these elements. Besides these elements, this study explores whether hygiene, design and security at the disposal locations, as well as available support and claim services have an important soft elements of customer service. Based on this discussion, the study establishes a third research hypothesis: Hypothesis 3: The soft level of customer service in the reverse logistics system for recycling household packaging includes all elements beyond accessibility to the selective collection facilities. As Table 2 shows, research has focused mostly on the proximity element of disposal recipients and, according to studies, has a consistent and positive effect on consumer participation in terms of recycling. This Table also suggests that the effect of the remaining elements (soft elements, as this study looks to show) on consumer participation is only moderately apparent. In fact, some studies show that the more complex the sorting process is, together with limited recycling information, the lower the recycling participation rates. However, a small number of studies find a non-significant relationship between these variables. Given these considerations, and the fact that soft level of customer service can only exist after the provision of the hard level, the final research hypothesis is as follows: Hypothesis 4: The hard level of customer service is the main determinant for consumer to commit to the reverse logistics systems for recycling, followed then by the soft level.

4. METHODS

4.1. Setting

The Green Dot Society (GDS) is a private company, created in 1997 with the purpose of managing the Integrated Recovery System of Packaging Waste Management (IRSPWM). Currently, GDS is the only company that develops this type of activity in Portugal. GDS is essentially a reverse logistics aggregator with a shareholder structure composed of three holdings that represent almost 200 companies. The first holding represents the packagers/importers, the second represents the distribution and retail trade, and the third represents the manufacturers and recyclers of packaging material. In compliance with national legislation, GDS aims to recover 60% of the overall packaging weight and recycle 55% of this material by the end of 2011. Recyclable materials include glass, paper/cardboard, lightweight packaging (plastic, metal) and wood. With the exception of this last type of material, drop-off systems, often referred to as eco-points, allows for the collection of packaging residues.As in other European countries, the IRSPWM relies on the principle of shared environmental responsibility. Packers and importers finance the system, based on the polluter-pays principle in which the amount and weight of the corresponding packaging material, commonly known as the green spot value, regulates the fee they must pay. In turn, packers and importers receive permission to mark their packaging with the Green Spot symbol, which shows that these companies transfer their recovery responsibility to GDS and the IRSPWM. The distribution role ensures that their commercial confines only sell non-reusable packaging through the Integrated System. The GDS's business structure does not include municipalities though they are responsible through contract agreement for the multi-material collection and sorting of household packaging residues. Consumers should necessarily separate and dispose of their packaging waste at the eco-point. The packaging manufacturers complete the cycle by securing the recycling of collected household packaging. The GDS's overall mission is to manage the reverse supply chain, finance and guarantee the functioning of the entire system. This corporation invests a major part of its annual overall income to compensate for the additional costs that municipalities incur with multi-material collection and sorting. GDS also sub-contracts transportation services that handle packaging residues for recycling companies and ensures that they receive, store and recycle recovered material.

4.2. Questionnaire

Data of this research result from personal interviews performed in April and May of 2006 based on a structured questionnaire (appendix 1). The questionnaire design took into account an extensive review of scientific and practitioner publications on recycling behavior, interviews on key elements of GDS management and benchmark studies carried out in other European countries (Spain, Italy and Belgium). The questionnaire encompasses three sections. Section 1 conducts an inquiry of the socio-demographic characteristics: gender, age, educational qualification, marital status, occupation, residence type, home ownership and family monthly income. Section 2 involves eleven elements (included in the earlier study) characterizing customer service in the reverse logistics system for recycling: (1) location of disposal recipients, (2) frequency of waste collection, (3) distance to the disposal recipients, (4) number of disposal recipients, (5) cleaning and maintenance of disposal recipients, (6) local safety, (7) emptying regularity, (8) available information, (9) support and claim service, (10) system adequacy to lifestyle, and (11) number and type of suitable waste materials. A Likert five-point scale assesses these elements, ranging from 1 – very unsatisfied to 5 – very satisfied.

Section 3 looks to measure consumer involvement in the recycling program and considers two questions. The first measures the self-reported household recycling behavior (scale: 1 – separates and selectively discards recyclable waste, 0 – does not separates and selectively discards recyclable waste). The second evaluates the frequency of separation and disposal of recyclable materials at the eco-points (scale: 1 – never, 2 – sometimes, 3 – always).

4.3. Sample and data

The study population encompassed the adult Portuguese citizens living in Faro city. Faro is the capital of Algarve, located in the southern Portugal, comprehending six parishes. Faro has a total population of 58 350 inhabitants and its most important economic activities are tourism and services. From this population, the study selected a random sample of 267 citizens. The calculation of the sample used the most conservative estimate for a single proportion (p = 0.5), a confidence level of 95% and a maximum error of 6%. The study used stratified sampling and the distribution of the interviews according to parishes was proportional to the resident population. In each parish the most important shopping street was selected as the location to perform the interviews. College students administered the questionnaires to respondents in those streets, with respondents chosen at random, according to a systematic procedure. A questionnaire was delivered to the first person (older than 14) passing near the interviewer at a defined hour. Then, a sampling interval of 5 people was established in order to select the remaining respondents and, thus, to fill the sample stratum defined to each parish. Each respondent received an explanation of the nature of the questionnaire. Table 3 summarizes the socio-demographic characteristics of the respondents along with some household features and participation patterns. Around 61% of respondents replied as being active participants in the recycling program. The profile of the respondents corresponds roughly to that in the previous national study (GDS, 2000). Most respondents were females (59.4%), between the ages of 26– 35 (27.2%) and 36–45 (18.2%), married (51.1%) and university degree holders (34.2%).

Table 3. Characteristics of the sample

Variables	Distribution of answers	
Gender	59.4 % female	40.6% male
Age	14 – 25: 15.1% 26 – 35: 27.2% 36 – 45: 18.2%	46 – 55: 17.0% 56 – 65 :11.0% 66 – 94: 11.5%
Education level	4 years: 10.1% 6 years: 7.3% 9 years: 9.0% 12 years: 26.7%	technical/ professional: 12.7% College or higher: 34.2% Median education level: 12 years
Occupation	Farmer/fisher: 1% Workman: 14.1% Services worker: 22.4% Public worker: 8.2% Teacher: 7.3% Liberal worker: 5.4%	Manager: 9.2% Retired: 5.1% Housewife: 4.3% Student: 18.0% Other: 5.1%
Marital status	Married: 51.1% Single: 34.0%	Divorced: 9.8% Widow:5.1%
Residence type	Apartment: 63% House: 27%	Farm: 10%
Home ownership	Own/are buying: 75% Renting: 18%	Familiar: 7%
Monthly family income	Less than 324 €: 2.1% 324 € – 499 €: 10.3% 500 € – 999 €: 39.3%	1000 € – 1999 €: 31.2% 2000 € – 2999 €: 11.7% At least 3000 €: 5.4%
Self-reported recycling behavior	Uses to separate and selectively dispose of: 61%	Do not separate nor selectively dispose of: 39%
Frequency of separation and disposal of recyclable materials	Never: 22% Sometimes: 27%	Always: 51%

4.4. Data analysis methods

This study uses the following methods of multivariate data analysis: exploratory factor analysis (EFA), confirmatory factor analysis (CFA) and discriminant analysis (DA). EFA and CFA enable the assessment of hypotheses 2 and 3. DA permits to test hypotheses 1 and 4. The application of EFA with varimax rotation on the set of eleven elements of customer service allows for the reduction of the proposed instrument's dimensionality (Hair et al., 1998; Reis, 1997). The computation of the Kaiser-Meyer-Olkin (KMO) statistic and the results from the Bartlett test establishes whether using EFA is possible in this research. The KMO statistic is a ratio that ranges from 0 to 1, and should be at least 0.7 for EFA be acceptable. The Bartlett test examines whether the correlation matrix of the variables is significantly different from the identity matrix. The use of EFA is adequate if this test rejects the null hypothesis that these matrices are equal.

The Alfa Cronbach coefficients evaluate the reliability of the final customer service factors that result from the EFA.CFA evaluates the factors' psychometric properties in terms of reliability and validity, based on the AMOS 6 software package. The prior EFA defines the model that CFA requires to associate the latent factors to the observed customer service elements (the observed variables). Given the absence of normality in the data, this analysis uses the weighted least squares estimation method (Schumacker and Lomax, 1996).The analysis of the overall model fit relies on three types of measures: absolute fit, incremental fit and parsimonious fit (Hair et al., 1998). The absolute fit evaluation adopts the Chi-square goodness-of-fit test, the goodness of fit index (GFI) (Joreskog and Sorbom, 1986) and the root mean square residual of approximation (RMSEA) (Steiger, 1990). The Chi-square test is a general indicator of how well the estimated model fits with the data. The Chi-square value should be low and not statistically significant to achieve goodness of fit. Similarly, the GFI should exceed 0.9

(GFI range from 0 to 1 with 1 meaning perfect fit) and the RMSEA show be low (zero suggests a perfect fit). This study considers the following incremental fit measures: the adjusted goodness of fit index (AGFI) (Joreskog and Sorbom 1986), the normed fit index (NFI) (Bentler and Bonnet, 1980), the Tucker and Lewis index (TLI) (Tucker and Lewis, 1973), the incremental fit index (IFI) (Bollen, 1988) and the comparative fit index (CFI) (Bentler, 1990). These measures range from 0 (no fit) to 1 (perfect fit). The parsimonious fit index that this study observes is the normed Chi-square measure (Joreskog, 1969) that should range from 1 to 5, ideally. The interpretation of the results of CFA follows with a reliability assessment of the proposed measurement model. Reliability analysis refers to whether the observed variables (i.e., the customer service elements), chosen to indicate each latent variable (i.e., each customer service factor or level), are actually measuring the same concept. This study considers two measures of reliability: composite reliability and variance extracted. Composite reliability shows the degree to which the observed variables adequately represent the corresponding latent variable. Variance extracted complements the composite reliability and expresses the total variance of the observed variables that the latent variable explains. The latent variables present appropriate levels of reliability if composite reliability and variance extracted exceeds the acceptance level of 0.7 and 0.5, respectively (Scharma, 1996). Next, the analysis focuses on the evaluation of the convergent and discriminant validity of each latent variable (customer service level). Convergent validity evaluates whether the observed variables really measure the corresponding latent construct. The significance and the size of the observed variables' weights permit evaluating of this type of validity (Bollen, 1989). Discriminant validity focuses on whether strong correlations exist between the latent constructs (which indicates poor discriminant validity) or weak correlations (which suggests strong discriminant validity). Within the CFA method, the matrix of standardized correlations between the latent variables allows assessment of this type of validity. This study expects a significant correlation between the latent constructs since they represent the dimensions of a general construct, the customer service. Another expected result is that these correlations, although statistically significant, are not very high, because the latent constructs should be measuring different levels of customer service (hard and soft). Hair et al. (1998) suggest that, for purposes of discriminant validity, the correlations between latent variables should not exceed 0.7. DA uses the final customer service levels that EFA and CFA suggest as discriminant variables. This study carries out two DAs. In the first one, the dependent variable represents self-reported recycling behavior, with two categories (1 – separates and selectively discards reusable waste, 0 – does not separate nor selectively discards reusable waste), giving rise to one discriminant function. For the second DA, the dependent variable is the frequency of separation and disposal of recyclable materials at the eco-points, which is tri-categorical (1 – never, 2 – sometimes, 3 – always), producing two discriminant functions. In each case, the Box M's test assesses the underlying assumption of the DA, that is, that the matrices of variances and covariances for all groups that the dependent variable defines are equal. For each DA, the estimation of the discriminant functions uses a random sample of half of the cases (the analysis sample). The other half (holdout sample) allows validation of DA (Fernández and Martinez, 2000). For each analysis, the Wilks's lambda statistics test whether the discriminating function(s) significantly differentiates the groups defined by the dependent variable. In this test, the null hypothesis is that the groups defined by the dependent variable have the same mean in the discriminating function(s). To assess the predictive ability of the discriminant function(s), this study analyses the classification matrix that results from each DA. Inside this matrix, the number of cases that the analysis correctly classifies within each group appears on the principal diagonal. The overall hit ratio is the global percentage of correct classifications in all the groups. Two procedures evaluate the classification accuracy of the discriminant functions (Huberty, 1994; Klecka, 1980). The first procedure compares the overall hit ratio for both samples (the analysis sample and the validation sample) either with the maximum chance criterion or with the proportional chance criterion. The maximum chance criterion is the percentage of cases in the larger group. Alternatively, the proportional chance criterion takes into account the proportion of cases in all groups. In particular, for a dependent variable with k categories (i.e., k groups), the expression is as follows:

$$C_{pro} = \sum_{i=1}^{k} p_i^2$$

where p_i is the percentage of cases in group i (i=1,2,…k). The second procedure is to establish and evaluate the Press' Q statistic. This statistic tests the null hypothesis which states that the discriminating ability of the classification function(s) is not significantly different than the classification by chance. The null hypothesis in this test is that the number of cases correctly classified resulting from the discriminant analysis does not exceed the number of cases correctly classified by chance. The Press' Q statistic should be high and statistically significant for the purpose of DA's validation.

5 .RESULTS

5.1. Exploratory factor analysis

EFA allows the reduction of the original eleven elements into two factors, in which both account for 71.3% of the total variance (KMO = 0.87; Bartlett test p = 0). Table 4 summarizes the main results of this analysis. The observation of the elements with higher loadings for each factor justifies the corresponding chosen label. Factor 1, hard level, gathers the customer services elements (CSE) that reflect the availability and accessibility to selective collection recipients: the distance to the disposal recipients, their location and the available quantity. Factor 2, soft level, includes the remaining elements such as aspects relating to disposal conditions (indicated by local safety, cleaning and maintenance and frequency of waste collection), available information on recycling (indicated by information availability, support and claim services) and system adequacy (indicated by system adequacy to lifestyle and number and type of accepted materials). The high Cronbach's alpha coefficients for each factor suggest that they have a very good degree of internal consistency. The factors take into account the hypothesized customer service elements, a sign in support of hypotheses 2 and 3.

Table 4: Customer service elements (CSE) and factors (After varimax rotation)

Factors	Loadings	% of Explained Variance and Cronbach α
Factor 1 – Hard level		
CSE3 – Distance to the disposal recipients	0.86	42.1%
CSE1 – Location of disposal recipients	0.78	Cronbach α=0.92
CSE4 – Number of disposal recipients	0.56	
Factor 2 – Soft level		
CSE2 – Frequency of waste collection	0.84	29.2%
CSE6 – Local safety	0.81	Cronbach α=0.87
CSE11 – Number and type of accepted waste materials	0.73	
CSE7 – Emptying regularity	0.71	
CSE5– Cleaning and maintenance of disposal recipients	0.69	
CSE8 – Available information	0.64	
CSE9 – Support and claim service	0.62	
CSE10 – System adequacy to lifestyle	0.59	

5.2 . Confirmatory factor analysis

Figure 2 shows the standardized estimates on the CFA model. Regarding the absolute fit evaluation, the Chi-square statistic reports a low and not statistically significant value ($p > 0.05$), suggesting that the model adequately describes the data. The remaining measures of overall fit also present favorable results, indicating an adequate incremental and parsimonious fit: the GFI exceeds 0.9 and the RMSEA are close to 0; the AGFI, the NFI, the TLI, the IFI and the CLI exceed 0.9; the normed Chi-square lies in the 1 to 5 interval. For the latent variable hard level, the composite reliability coefficient is 0.76 and the variance extracted is 0.51. For the soft level, the reliability measures are 0.89 and 0.50, correspondingly. For both latent variables, these values exceed the minimum threshold of 0.7, in terms of composite reliability, and are at least 0.5, in terms of the variance extracted. These results support the EFA findings concerning the factors' reliability, according to the Cronbach's alpha coefficients. In terms of the convergent validity analysis, Figure 2 shows that all observed variables have positive weights that exceed the acceptable level of 0.4 (Hair et al., 1998). All weights are statistically significant (t tests: $p = 0.00$). In terms of discriminant validity, Figure 2 reveals that the correlation level between the latent variables is 0.58. This correlation is moderately high, indicating a correlation between the two latent variables (i.e., both represent levels of the same construct: customer service) which is not too strong (i.e., each level captures a somewhat different perspective of the customer service construct). Thus, EFA and CFA specify two final customer services levels whose contents provide support to research hypotheses 2 and 3.

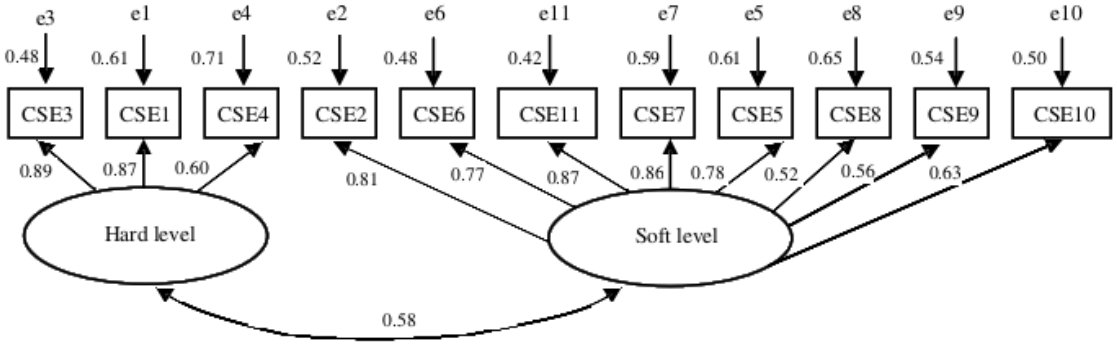


Figure 2: Confirmatory factor analysis of customer service elements. Standardized estimates

Note: Chi-square = 59.6 ($p = 0.07$), GFI = 0.94, RMSEA = 0.03, AGFI = 0.91, NFI = 0.89, TLI = 0.97, IFI = 0.97, CFI = 0.98, Normed Chi-square = 1.32.

5.3. Discriminant analysis

The first DA uses the two factors produced by the EFA as independent or discriminating variables and the self-reported recycling behavior as the dependent variable (Box's M test p = 0.17). For the second DA, the dependent variable indicates participation frequency (Box's M test p = 0.08). In both cases, the Wilks's lambda tests reveal that the groups, defined by the dependent variables, are statistically different in terms of the customer service satisfaction level (Wilks's lambda tests: p = 0). The two discriminant functions arising from the second DA, are both significant in separating the groups (canonical correlation for the first discriminant function = 0.93; canonical correlation for the second discriminant function = 0.86; explained variance for the first discriminant function = 68.8%; explained variance for the first discriminant function = 31.2%). Thus, these findings support the research hypothesis that variables related to customer service elements determine consumer involvement in the reverse logistics system for recycling (Hypothesis 1). The overall hit ratio for both the analysis and holdout samples evaluates the predictive accuracy of the discriminant functions (one in the first DA, two in the second DA). These ratios (72% and 68.2%, respectively, in the first DA and 69% and 65.4%, in the second DA) significantly exceed the levels of the proportional chance criterion and the maximum chance criterion (in both analyses, and in terms of both criteria, Press Q statistic > $\chi^{2(1)}$ for a significance level of 0.05). Table 5 reports the structural coefficients, representing the correlations between the discriminating variables and the discriminant functions. Both levels are statistically significant in discriminating the groups because in the both DAs and in all the discriminant functions, the structural coefficients exceed the minimum absolute value of 0.3 (Hair et al., 1998). However, as this table shows, of the two variables in the first DA, the hard level has the highest structural coefficient and, thus, this factor discriminates the most; on the contrary, the soft level reports the lowest structural coefficient and, therefore, this factor discriminates the least. The same finding occurs in the second DA in terms of the first discriminant function, this of which is the most important. In other words, the fourth research hypothesis (Hypothesis 4) should not be rejected.

Table 5: Structure matrix of discriminant analyses

Discriminating Variables	Structural Coefficients		
	DA1	DA2	
		Discriminant function 1	Discriminant function 2
Hard level	0.75	0.71	-0.33
Soft level	0.62	0.54	0.68

6. DISCUSSION AND CONCLUSION

Consumers are the foremost and decisive link in a reverse logistics chain that aims to recycle household packaging residues. In fact, without consumers' involvement and continuous collaboration, this system cannot exist. This article explores the importance of consumer motivation to participate in the IRSPWM by ensuring that the recyclable materials are available for the recycling industries. By using a combination of multivariate statistical methods, this study shows the importance of providing consumer convenience in order to gain greater involvement in reverse logistics systems for recycling. On the whole, the research supports the conceptual model of customer service (Figure 1). As in the traditional forward logistics systems, customer service in the reverse logistics system for recycling comprises hard and soft levels (hypotheses 2 and 3). As hypothesized, both levels explain consumer involvement (hypothesis 1), with the hard level representing the most important predictor (hypothesis 4). This study has theoretical contributions and managerial implications. Previous studies in forward logistics identify the elements that form the customer service construct and explore the importance of providing an adequate level of customer service. The first theoretical contribution of this article lies in exploring this issue in the specific context of reverse logistics for recycling. The EFA and CFA that this study employs show that the hard level of customer service in the reverse logistics chain also corresponds to the basic service, which, in this case, means easy access to specific disposal recipients for recyclable materials. These analyses also show that other customer service elements form the soft level. These findings support those found in the forward logistics research. The second theoretical contribution of this study concerns a comprehensive analysis of a service based on convenience in order to enhance recycling behavior. In fact, existing literature in the field of environmental social psychology addresses some customer service elements individually (Table 2). This study focuses on the various elements as a whole, combining them into a single analysis, and adding new elements (hygiene, security at the disposal sites and the existence of support and claim services), revealing to be significant factors. Overall, this study substantiates that consumers are sensitive to several customer service elements and that their evaluation of this service determines the current self-reported recycling behavior and the frequency of involvement. These results have managerial implications. The first one is that meeting customer service demands in terms of customer service requirements must be a priority in planning this type of reverse logistics networks. This is not difficult to carry out because the customer service elements of the reverse logistics system for household packaging are manageable variables. Therefore, their evaluation reveals opportunities and insight to improve the effectiveness of the customer service concept and, as a consequence, increase consumer involvement in the system. The study also observes the customer service levels by taking into account their relative importance in fostering consumer involvement: the hard level is relatively more important than the soft level. This finding also has managerial implications since it helps prioritize the overall logistics needs for a more effective selective-collection system. Although the overall organization and performance of the Portuguese reverse logistics system for recycling requires global improvement, an important priority us defining the location of the eco-points in terms of easier and more convenient population access. In establishing this, focus should turn to aspects such as available support and claim service, more recycling awareness campaigns, and general disposal conditions (cleaning, maintenance, safety, etc). Reverse logistics systems with centralized the disposal facilities (as is the case with the eco-points in Portugal) are more inconvenient because consumers must transport and deposit recyclable materials at drop-off points. However, these systems are also less expensive than the curbside alternative. In curbside schemes, collection is door-to-door, which increases convenience but also collection costs and ultimately the overall cost of the system. A less expensive collection option is to maintain eco-points and invest in more convenient locations. However, considering the relative importance of the hard customer service level as the main determinant of consumer involvement, the possibility of providing curbside collection, at least temporarily and in a few municipalities, should be considered. As this study shows, shortening the distance that consumers have to travel to reach the collection points is the best way to obtain greater involvement. The improvement of the quality and quantity of the collected materials may compensate the additional collection

costs of curbside collection. This is as aspect that clearly deserves further investigation. As this study demonstrates, the soft level also explains consumer involvement in the reverse logistics system. Systems based on eco-points reduce the monetary separation costs because consumers do not receive financial compensation for their sorting and discarding activities. Given that the current system demands significant efforts on the part of consumers, this may reduce their willingness to recycle. A more convenient alternative would be not to expect consumers to separate recyclables, that is, to allow them to discard all the recyclable materials into a single recipient and assign the responsibility of the separation process to Material Recovery Facilities. Although such a strategy can reduce the system's complexity from the consumer perspective this substantially increases separation costs and, thus, the total cost of the system. A similar problem would incur if the improvement of customer service implies a change to a commingled collection system (in contrast to multi-material collection) or the implementation of a more frequent collection system. These strategies are likely to improve the soft level of customer service in terms of reducing the perceived sorting complexity and solving the (lack of) maintenance and design appeal of disposal recipients. The potential of these strategies and their effects on separation and transportation costs is also a future research avenue. An additional alternative and intermediate strategy that can improve the soft level of customer service is to maintain the current multi-material collection based at the eco-points and promote marketing campaigns to increase consumer awareness for greater involvement. Campaigns can also demystify exaggerated negative expectations about the recycling system. Implementing curbside collection, on a larger scale, is also a solution for reducing the sorting complexity, since information exchange is possible on a one-to-one basis. However, and as referred, the implementation of such a collection system requires a detailed cost-benefits analysis. On the whole, this study clarifies the need to address all customer service elements. An important limitation, however, is the fact that the sample is small and drawn from a single city and, as a consequence, the generalization of the conclusions needs additional research. Furthermore, the improvement of customer service brings challenges whose overcoming requires additional research. Entities that manage the system must weight the need of increasing consumers' involvement without compromising the system's economic viability. Therefore, an important challenge that such a reverse logistics system needs to overcome is to find the best way to minimize the strategic costs of the collection system without affecting consumer service performance. Another challenge that arises in the reverse logistics systems for recycling is to guarantee that the market absorbs the recycled materials. The quality of collected packaging residues affects the performance of the system because most soiled materials either cannot be further recycled or may lead to increased reprocessing costs. In this sense, additional support should be given to research that promotes the development of new products using recycled materials and also marketing campaigns that aim to increase consumer awareness in using such materials.

Location of disposal containers	
Frequency of waste collection	
Distance to the disposal recipients	
Cleaning and maintenance of disposal recipients	
Local safety	
Emptying regularity	
Available information	
Support and claim service	
System adequacy to lifestyle	
Number and type of suitable waste materials	

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