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THE POWER OF NUDGING:

HOW ADAPTATIONS IN REVERSE LOGISTICS SYSTEMS CAN IMPROVE END-CONSUMER RECYCLING BEHAVIOR

ABSTRACT

Purpose

Research shows a recycling behavior gap where end consumers are positive towards recycling, but do not act in accordance with their intentions. Such a gap creates challenges for reverse logistics systems. The purpose of this paper is to investigate how adaptations in reverse logistics systems towards end-consumers-turned-suppliers can improve recycling behavior.

Design/methodology/approach

A framework with three propositions is developed and evaluated empirically using a two-group dependent post-test quasi-experimental design. The empirical setting is recycling of household waste. Three interventions are evaluated: (1) the social norms nudge, (2) the distance nudge, and (3) the availability nudge.

Findings

The results show that nudging improved recycling action behavior for the experimental group. Control group behavior remained constant.

Research limitations/implications

This paper suggests that the end-consumer's role as suppliers needs to be included more actively into reverse logistics systems for products to enter the preferred loops of recycling in the circular economy.

Original/value

A new field of climate psychology is used to explain challenges in reverse logistics systems and nudging is demonstrated as a tool with which to deal with them. The study also shows how quasi experiments can be applied in logistics research.

Keywords: reverse logistics systems, recycling behavior, nudging, household waste, end-consumer, circular economy, experiment

1. INTRODUCTION

One of the goals of the European Union's Green Deal is to create a circular economy (European Commission, 2020). The current global economy has been measured as only 8.6 percent circular (Circle Economy, 2020), which suggests that there is still much work to be done.

The term "circular" refers to keeping products and resources in productive use after first-time use (Kirchherr et al., 2017). Traditionally, products have been said to have life cycles, referring to the linear take-make-waste economy, where products enter markets as new and function until an end-of-life stage. In the circular economy, however, there is a transition into additional life cycles when products and resources enter new loops of use. In this transition, users, or consumers, have an important facilitating role (Anderson and Brodin, 2005). They are expected to perform activities and make efforts to re-enter products and resources into the next life cycle; this is commonly referred to as *re*cycling.

The choices that consumers have when deciding on the next life cycle for products are visualized in the waste hierarchy, which ranges from prevention, reuse, and recycling to landfill (Zero Waste Europe, 2019). For simplicity, we refer to all these alternatives as choices of recycling. Industries and the public sector make these alternatives available through various types of reverse logistics systems. It is common to design preferred loops for products, which requires consumers to take specific actions. While consumers are generally positive toward recycling, there is a gap between recycling intention and action (e.g. Barr, 2006). Consumers do not act in accordance with what they say, and recycling actions do not follow the preferred reverse logistics systems to the extent expected. Hence, products and resources end up in loops other than those intended and productive resources are not utilized to their potential in the circular economy (Korhonen et al., 2018).

To improve such recycling behavior, we argue that it is necessary to study and understand the end-consumer as a supplier in reverse logistics systems (Anderson and Brodin, 2005). Framing the duality, we refer to this role as the "end-consumer-turned-supplier" (ECTS). The ECTS constitutes the "first tier" of the reverse logistics system, which generates volume into the reverse logistics system (Jalil et al., 2016). However, the ECTS does not tend to think of itself as a producer of products to such systems (Zikmund and Stanton, 1971). In addition, the product supplied for recycling is assumed to have a low value and the ECTS is not economically compensated for its recycling effort either (Brodin and Anderson, 2008). Rather, reverse logistics is a service that the end-consumers need to pay for through fees, even though they are considered an important co-producer of value in the reverse logistics system (Halldórsson et al., 2019). In addition, the first mile of the reverse logistics system is characterized by tension because of the need for both quality and efficiency (Halldórsson et al., 2019). Thus, it is a paradox that the ECTS is acting and being treated somewhat distantly to the reverse logistics system, while at the same time filling a critical function.

An intriguing insight into this ECTS recycling behavior comes from a line of research called "climate psychology". This research states that one reason for such a gap is that people simply do not think much about recycling because "when life is crammed, time-demanding to-dos slip downward on our priority lists" (Stoknes, 2015, p.124). Most people have other things to think about than the environment (Stoknes, 2015). Thus, the suggestion is that ECTSs behave distantly towards the reverse logistics system because they do not prioritize recycling activities in a busy everyday schedule. In other words, the ECTS seems to lack a focus towards recycling. When something is not working, the tendency is to increase information (Stoknes, 2015). However, more information does not help people's time schedules, instead it is necessary to alter what they actually do (Stoknes, 2015), and "nudging" is a theory about altering behavior (Thaler and Sunstein, 2009). What people actually do in terms of recycling is largely formed by reverse logistics activities that give rise to a product flow back from the point of use into a system for proper treatment (Fleischmann et al., 2000). Therefore, when the recycling behavior gap exists, it is worth investigating whether the reverse logistics activities is sufficiently adapted to the ECTS. Further, it is interesting to explore nudging as a mechanism to improve activity adaptation and narrow the recycling behavior gap because it seems difficult to catch the ECTS's attention when it comes to recycling.

Figure 1 illustrates the challenge where the ECTS's intention to recycle are greater than their recycling actions, leaving a gap towards the reverse logistics system ideal targets of actions. We refer to this challenge as the recycling behavior gap.

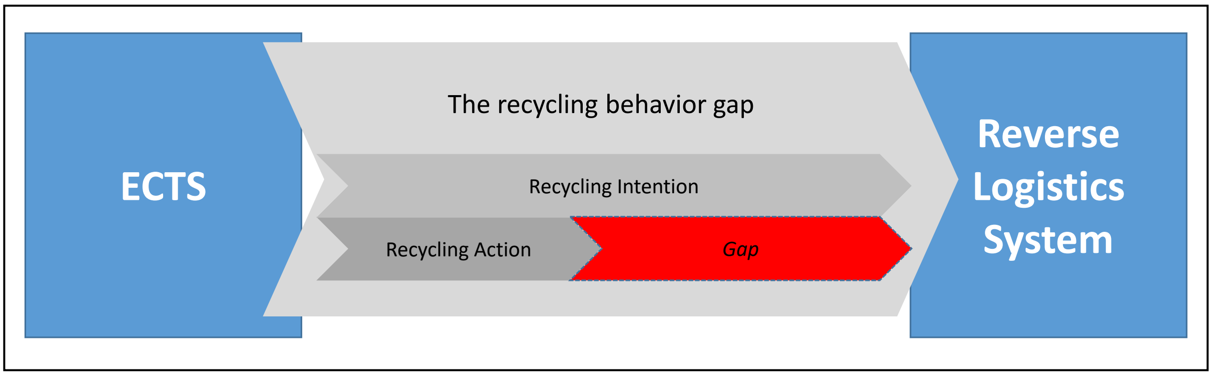

Figure 1: The recycling behavior gap between the ECTS and the reverse logistics system

Applying nudging in a quasi-experimental research design, we find that the recycling behavior gap is substantially narrowed from relatively small adaptations between the ECTS and the reverse logistics system. We contribute with a more detailed understanding of the ECTS role towards the reverse logistics system and show how nudging can be applied to improve recycling behavior. Based on this research, we show how designers and managers of reverse logistics systems could benefit from reevaluating their scope and approaches.

The remainder of this paper has five sections. Section 2 presents the theoretical starting point, concluding with a conceptual framework for empirical testing. Section 3 presents the research design. Section 4 presents the results from the empirical study and Section 5 contains the discussion. Finally, we present limitations and suggest further research.

2. THEORY AND FRAMEWORK

The theoretical argument for this paper develops from climate psychology, and its pragmatic sense of finding solutions "that go with our flow as human beings" (Stoknes, 2015, p.88). For scholars in logistics and the study of flows, it connects to the confidence that closing the loop for the circular economy must be solved with functional and value-creating systems (Guide Jr and Van Wassenhove, 2009). The idea from climate psychology is to make it simple to do the right thing by looking carefully at how choice is presented (Stoknes, 2015). Therefore, nudging has been explored further as a theory for presenting choice (Thaler and Sunstein, 2009). In practice, reverse logistic systems are how recycling loops are presented to the ECTS, and this section looks further into the characteristics of this interface. The section closes with the conceptual framework for the study.

2.1. *Nudging to influence recycling behavior*

Nudging builds on psychology and behavioral economics (Stoknes, 2015). A nudge may be defined as "any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives" (Thaler and Sunstein, 2009, p.6). Nudges are not mandates, and for something to count as a nudge the intervention must also be easy and cheap to avoid. For example, placing fruit and vegetables at eye level in a grocery shop counts as a nudge towards healthy eating, but banning unhealthy food does not (Thaler and Sunstein, 2009). Nudging is about making small changes in choice architecture that have a large impact and benefit people (Thaler and Sunstein, 2009). Thus, choice does not depend solely on factors such as price and technical information (Stoknes, 2015).

There are several ways to nudge. One method involves making desired choices the default option, such as organ donation consent (Johnson and Goldstein, 2003) or double-sided printing (Egebark and Ekström, 2016). Another way to nudge is through social influence, which appeals to people's tendency to conform to what others are doing (Thaler and Sunstein, 2009). Peer pressure also plays a role in exerting social influence because people take their social cues about what is considered acceptable behavior from others. "Choice architects can [therefore] make major improvements to the lives of others by designing user-friendly environments" (Thaler and Sunstein, 2009, p.12). Stoknes (2015) illustrated several ways to present choices, include bundling of services, size of containers, availability of equipment, and making relevant information available. Thus, nudging can be applied in a variety of ways, and it is necessary to carefully identify how to do so to get the desired behavioral impact (Zhang and Wang, 2020).

The characteristics of a situation and groups are what determine suitable nudges (Zhang and Wang, 2020). Therefore, it is necessary to understand the recycling behavior gap further. Recycling behavior is defined as "the action performed by the individual when he decides to recycle a particular product after he has stopped using it" (Phulwani et al., 2020, p.355). Since we are discussing a gap, it is relevant to focus on the drivers and barriers of recycling behavior (Kollmuss and Agyeman, 2002). These types of classifications are typically divided into many categories (Concari et al., 2020), such as personal or situational factors (Jalil et al., 2016), demographic, external, or internal factors (Kollmuss and Agyeman, 2002), or socio-demographic and psychological, technical-organizational or study-specific factors (Miafodzyeva and Brandt, 2013). The classification itself is not key, but the common division is between the characteristics of individual behavior and contextual factors. Following this division, we continue by looking into the characteristics of the ECTS on one hand and the reverse logistics systems on the other.

2.1.1. *ECTS Characteristics*

Individual constraints are often linked to demographic characteristics, and the role of socio-demographics is one of the earliest focus areas in the literature about recycling behavior (Hornik et al., 1995). However, findings on the role of socio-demographic characteristics (such as age, income, level of education, and gender) have been contradictory (Shrum et al., 1994, Rousta et al., 2015, Monnot et al., 2014). When synthesized, there is no strong evidence that demographics predict recycling behavior (Miafodzyeva and Brandt, 2013). In addition, when individuals incorporate recycling into their habits over time, socio-demographic factors seem to correlate less with recycling behavior (Hornik et al., 1995, Del Cimmuto et al., 2014). Thus, demographic characteristics should be limited to descriptive use to explain recycling behavior.

Housing is one characteristic that seems to affect recycling behavior (e.g. Jalil et al., 2016). Constraints include the type (for example, detached house or flat), size, and number of people making up a household, and influence sorting activity and convenience of recycling (Bernstad, 2014). Convenience can be the availability of adequate equipment for sorting behavior (Bernstad, 2014), as well as the perception of space available to carry out the sorting activity (for example, storage space). Urban areas, where families live in small flats with limited space for storing waste and low perceived convenience of recycling, could lead to poorer recycling behavior (Ando and Gosselin, 2005). If the ECTSs perceive that they are not able to find an appropriate way to sort, store, and deliver products for recycling, it increases the risk of deviance.

In conjunction with housing, motivation and knowledge have been found to affect recycling behavior, as individual values have an indirect and positive effect on recycling behavior (McCarty and Shrum, 1994, Knussen *et al.*, 2004). The source of motivation may be internal or external. External motivation is affected by social norms, which are “sets of beliefs about the behavior of others” (Schultz, 1999, p.26). External motivation may become internal motivation if social norms are internalized to individual values and attitudes. Together with internal motivation factors, a lack of knowledge about what, where, and how to sort waste can also be an important barrier to recycling action (Schultz, 1999, Barr, 2007). However, even if the most commonly used intervention to improve recycling behavior is “dissemination of information” (Schultz et al., 1995), results are mixed and most studies have shown weak effects (Schultz, 1999). The implied assumption – that if people become more knowledgeable about recycling, they will recycle more – does not hold. Rather, it is better to influence motivation (Schultz, 1999).

2.1.2. Reverse logistics system characteristics

Typically, new products are “distributed to” the consumer, but “collected from” the consumer at end-of-life, reversing traditional forward supply chain activities (Barnes, 1982). A key discussion on reverse logistics system has been to clarify the processes and activities that make up the flows in the system (Agrawal et al., 2015). The collection function is characterized as the start of the reverse process (Jahre, 1995). In order to know how to collect products, the initial design activity for reverse logistics systems are inevitably tied to the purpose decision (Fleischmann et al., 2001). The purpose decision is visualized by and detailed in the waste hierarchy (Carter and Ellram, 1998), and the choice of recovery option is considered a strategic decision (Thierry *et al.*, 1995). Depending on the recovery option, collection calls for different sets of activities, and additional variation is also generated from specific contexts (Fleischmann and Krikke, 2000). Reverse logistics systems can also be identified as multipurpose when the first step of the reverse process evaluates what to do with the product (Govindan and Soleimani, 2017). In addition, the reverse logistics system is characterized by inherent supply uncertainty, where the timing, quantity, and quality of returned products is unknown before being collected (Fleischmann et al., 2000). Thus, the start of the reverse logistics system is characterized by a high degree of variability in decision-making, both from the ECTS and the system perspective. An insight from this is that the collection function, which initiates the reverse logistics system, is particularly important.

Collection denotes “all activities rendering used products available and moving them to some point where further treatment is taken care of” (Fleischmann et al., 2000, p.657). The collection function reverses the traditional distribution activities of accumulation, bringing together product flows from heterogenous sources to homogenous supply sorted for recycling (Barnes, 1982). However, as the incentives to act as a commercial intermediary are lacking for the ECTS in the reverse logistics system (Barnes, 1982), the collection function must compensate for this. Service is a factor that facilitates the collection function; for example, curbside and bring schemes (Jahre, 1995). The difference between these systems is the distance of the delivery and the degree to which an ECTS has items picked up closer to their home or must walk or travel further to recycle. Curbside collection is shown to increase the sorting activities (Dahlen and Lagerkvist, 2010) because the distance for the ECTS is reduced (Rousta et al., 2015). Shorter distance is more convenient (Rousta et al., 2017). Providing a sorting possibility to the ECTS is viewed as a valued service, because the ECTSs get a green external image and are concerned about the effectiveness of others (Czajkowski et al., 2014). Therefore, an adapted service level in the collection function is expected to have an impact on recycling behavior.

2.2. Framework

The characteristics of the ECTS and reverse logistics systems provide an understanding of how the recycling behavior gap could be influenced, from which we formulate three propositions on how to apply nudging to the recycling activities taking place between the ECTS and the reverse logistics system. Figure 2 shows the conceptual framework, and the propositions are elaborated below.

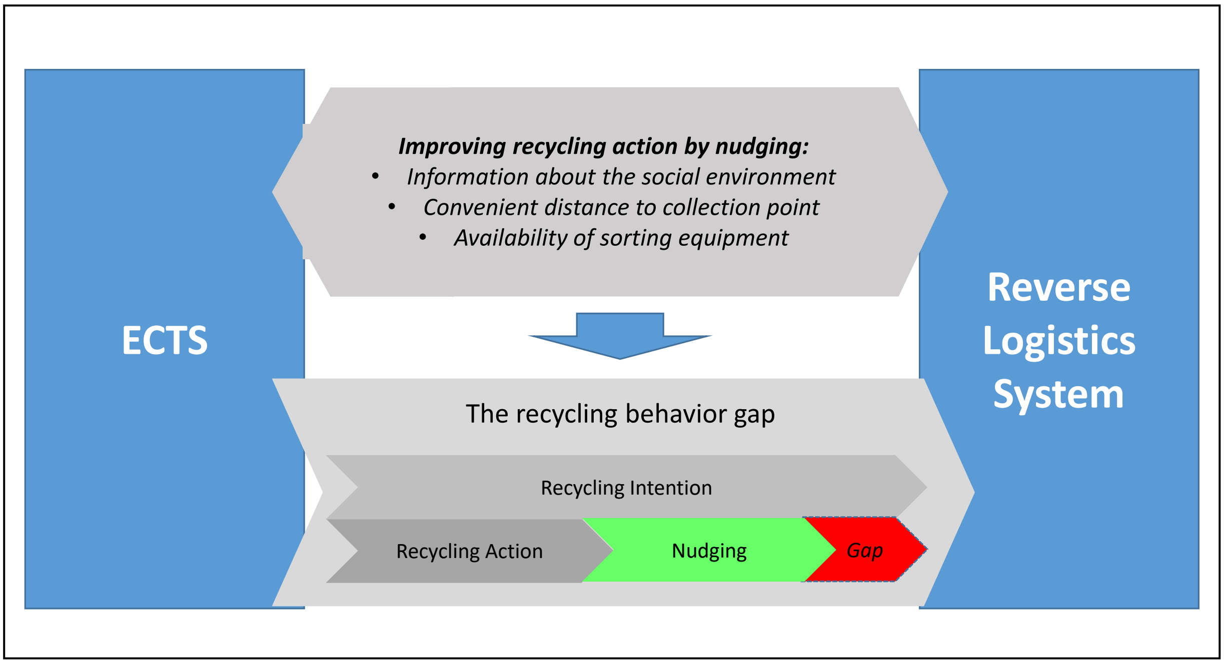

Figure 2: The conceptual framework: Applying nudging to narrow the recycling behavior gap

The literature indicates that ECTSs are more likely to sort out their products for recycling if they have information about others in their social environment doing the same, that is, activation of social norms (Miafodzyeva and Brandt, 2013). A combination of descriptive norms (describing the prevalence of a certain behavior) and injunctive norms (convey social approval) is needed because this will avoid the boomerang effect, whereby a normative message has the opposite effect to what was intended (Schultz et al., 2007). Normative feedback has been found to be effective in improving recycling participation. Therefore, sharing information about recycling behavior of others is a way of nudging towards the ECTS. Thus, we formulate the following proposition:

Proposition 1: Information about positive recycling action in the ECTS's social environment is likely to narrow the recycling behavior gap.

Further, the literature indicates that ECTSs are likely to increase their recycling action levels if they experience the reverse logistics systems as more convenient (Bernstad, 2014). Such a characteristic is mirrored by shorter distance to the collection point (Rousta et al., 2015), or increased service level in the collection function (Jahre, 1995). Therefore, adjusting the location of collection point is a way of nudging towards the ECTS, and we formulate the following proposition:

Proposition 2: A convenient distance to collection points for the ECTS is likely to narrow the recycling behavior gap.

The collection point is a second step in the reverse logistics system. First, the ECTSs need to accumulate products (Barnes, 1982). The literature shows that it is more likely that the ECTSs will accumulate products for the relevant recycling loop if they possess necessary sorting equipment (Monnot et al., 2014). Availability of sorting equipment nudges towards the ECTS, and we formulate the following proposition:

Proposition 3: Availability of sorting equipment for the ECTS is likely to narrow the recycling behavior gap

3. RESEARCH DESIGN AND METHODOLOGY

A quasi-experimental design was chosen for the study. Most research examining recycling behavior has used self-assessment surveys, and has observed intended behavior rather than objectively what is done (e.g. Knussen et al., 2004, Meneses and Palacio, 2005). Therefore, a quasi-experimental field-study design will measure action, and an opportunity to provide knowledge about how to narrow the recycling behavior gap.

The chosen empirical setting was the collection of household waste in Oslo, Norway, where the recycling behavior gap is present. In 2019, the proportion of people with positive or neutral recycling intentions was high, at 97 percent (Renovasjonsetaten, 2019b), but recycling action, measured by collection rate, was only 38 percent (Renovasjonsetaten, 2019a). Recycling has been mandatory since 2012, but the recycling rate has only improved by about one percentage point since then.

Households sort food waste into green bags, clean plastic packaging into blue bags, and residual waste into white (or different colored) bags, which are co-collected from the same curbside bin for optical sorting at a facility. Paper and cardboard are also part of the curbside scheme and collected in a separate bin. Glass and metal are defined as a bring scheme and collected from pick-up points that should be within an average walking distance of 300m. As a main rule, other waste fractions must be delivered at recycling stations.

In cooperation with the Agency for Waste Management (AWM) in Oslo, a housing cooperative was identified as a suitable site to carry out the quasi-experiment. The housing cooperative in the sample consisted of 17 four-story buildings with 328 households of similar size and layout (approximately 1000 people). This choice provided sufficient households in both the experimental and control group. The households were equally exposed to the collection system, such that the experimental treatment would differentiate an effect between the two groups.

The quasi-experimental design used an untreated control group along with dependent pre-test and post-test samples (Shadish *et al.*, 2002). Ninety-six households were selected for the experimental group, and 80 for the control group (53 percent of cooperative households). The waste from the collection points for each of the groups was analyzed before and after an intervention (experimental treatment) for the experimental group. Finally, all households received a questionnaire designed to measure recycling intention, distributed last to avoid confounding effects by warning the households about the experiment ahead of time. Table 1 shows the research design.

Table 1: The quasi-experimental set-up

	Pre-test	Intervention	Post-test 1	Post-test 2
Experimental group	Pick analysis	*Intervention*	Pick analysis	Questionnaire
Control group	Pick analysis	*No intervention*	Pick analysis	Questionnaire

The layout of the housing cooperative and location of collection points is visualized in Figure 3, which shows that the experimental group and control group are located on opposite ends of the housing cooperative. The dots show the collection points. This grouping was made to minimize the risk of cross-contamination between samples; that is, the groups would most likely not use each other's collection points as the distance between them made that impractical.

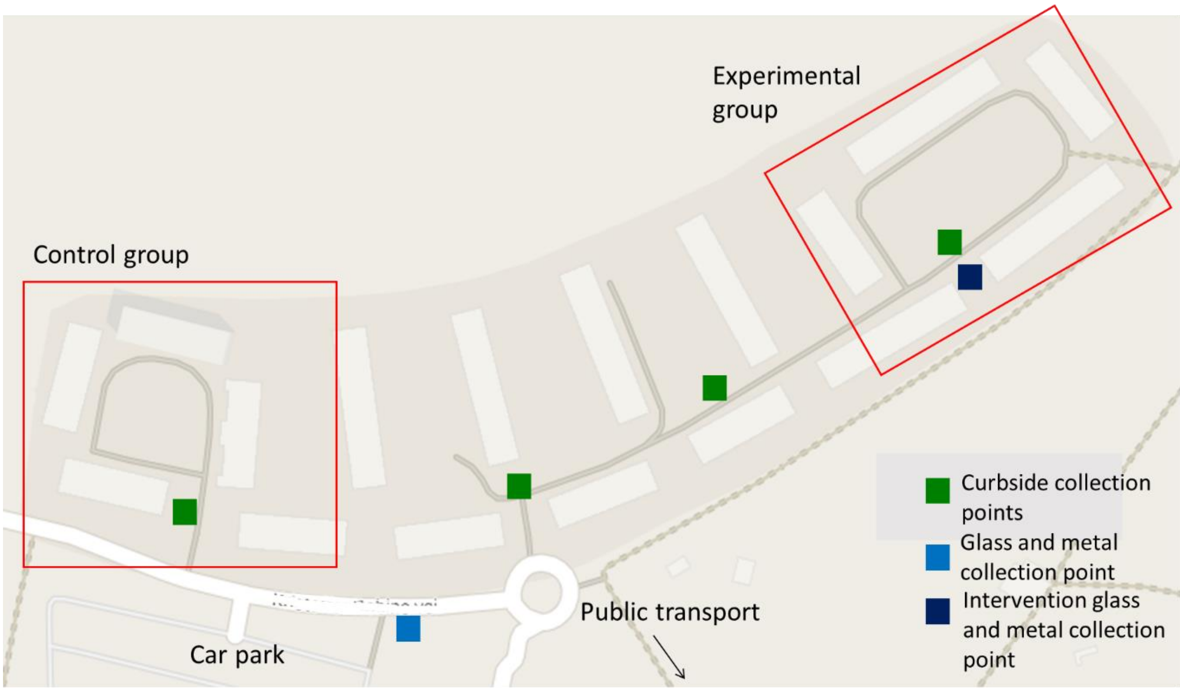

Figure 3: Map of the housing cooperative where quasi-experiment was set.

The sample housing cooperative is located in Oslo's Stovner district and is demographically representative of the district (Oslo Kommune, n.d.). Median household income levels were below the median for Oslo (632,000 NOK per year vs. 702,000 NOK), as well as higher-education levels (≥ 4 years, 24 percent vs. 49 percent). There was a mixture of one-person households, families with and without children, and retired persons. Approximately 50 percent have an immigrant background (vs. 33 percent in Oslo). Self-reported recycling behavior was in line with that of Oslo (Respons Analyse, 2015).

3.1. *The experimental treatment*

The choice of nudges follows the suggested propositions, and the nudges are designed as interventions to the experimental group, as listed and discussed below:

1. Informational letter containing a nudge to activate social norms that target food waste recycling action (referred to below as “the social norm nudge”)
2. A nudge through reduced distance to a glass and metal collection point (referred to below as “the distance nudge”)
3. A nudge through access to free sorting equipment (waste bags for food, plastic, and residual waste, and reusable glass and metal bag) (referred to below as “the availability nudge”)

The first intervention was a social norm nudge, constituting a letter with information about neighbor behavior, to affect motivation through the activation of social norms. The letter covered food waste as the fraction to target because it was an area with improvement potential, according to previous waste analyses (Mepex Consult AS, 2015). The advice is to align a descriptive and injunctive norm and convey a message that confirms the preferred behavior (Cialdini, 2003). For our study, the following statements were combined:

- *Did you know that eight out of 10 of your neighbors separate their food waste into green bags?* **(Descriptive norm)**
- *Food waste is an important resource that is used to produce biogas and bio fertilizer. Even if you only have a small amount of food waste, it is important to use a green bag*. **(Injunctive norm)**

The second intervention involved reducing the distance to a collection point, moving the glass and metal container together with the bins for the plastics, food, residual, and paper waste. The glass and metal fraction was chosen because a large share was found in the residual waste during previous waste analyses (Mepex Consult AS, 2015), meaning that the consumer does not sort it correctly. It is a waste type with sorting potential. In addition, broken glass and metal often tear other waste bags and ruin already-sorted waste. The distance to the glass and metal collection point was held constant for the control group (120 m) and reduced for the experimental group (from 230 m to 6 m).

The third intervention concerned access to sorting equipment. All experimental group participants received green bags for food and reusable bags for glass and metal. In addition, blue bags for plastic waste and red bags for residual waste were distributed to minimize contamination; previous analyses have revealed a certain degree of residual waste contamination in blue and green bags (Mepex Consult AS, 2015). All materials were distributed through doorstepping.

Table 2 summarizes the study variables. The dimensions relate to the nudges that are evaluated and the measures show how data are collected. The recycling action behavior dimension is measured by the recycling rate, which is a measure used as a stated goal of European and Norwegian governments and is a reported key performance indicator for the AWM in Oslo. The recycling rate measures the actual waste being recycled. This result can then be deducted from the perceived recycling intention level that the ECTS report, giving a final size of the recycling behavior gap.

Table 2: Study variables

Dimension	Measurement
Recycling action behavior	Recycling rate measured as weight of sorted fraction as a percentage of total waste weight (denoted “wt. %”, weight-percentage) (Eurostat, 2020)
Activation of social norms	Willingness to sort different fractions, measured through self-reported recycling behavior (Barr, 2007). Observation of food waste in residual waste and green bags.
Convenient distance to collection point	Measure glass and metal in residual waste and fill rate of new collection point
Access to equipment	Count number of red bags used, and contaminated blue and green bags

3.2. Data collection

Two main sources of primary data were necessary for the quasi-experiment: Data from a pick analysis (waste composition analysis) to evaluate recycling action, and data from a questionnaire to evaluate intentions.

A pick analysis involves sorting waste manually into separate fractions. In this study, waste was sorted into 12 fractions: usable food waste; non-usable food waste; recyclable plastic; paper and cardboard; textiles; gardening waste; glass and metal; plastic bags used for waste disposal; bulky waste (other glass and metal, polystyrene, wood, other plastic); hazardous waste; electrical and electronic (EE) waste; and residual waste. A pick analysis gives the exact data for how consumers sorted their waste, measured by weight in tons and kilos. To do the data collection, the researchers received training in and used the same pick analyses method as used for Oslo (Mepex Consult AS, 2015).

To ensure a representative sample of waste, experiment timing was chosen to coincide with “normal” weeks to prevent any bias in waste production (such as holidays). For both test groups, waste was collected from the same containers at the same time on both occasions. This was verified by one of the researchers who participated in collection. Table 3 provides an overview of the experimental timeline.

Table 3: Overview of data collection with the experiment timeline

Week	Experiment timeline						
	Mon	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**
1			Pre-test pick analysis				
2			**Intervention**				
3	Week 3 to allow for intervention to be absorbed						
	Picked up unclaimed materials left at door			Scheduled collection outside experiment			
4			Post-test pick analysis				

The postal questionnaire, designed to control for ECTS characteristics and investigate recycling intention, consisted of 11 questions about self-reported recycling behavior (that is, recycling intention) and 11 demographic questions. The control variables are listed in Table 4 below.

In addition, two constructs were tapped into to assess the effect of the social norm nudge about food waste: Whether respondents believed their neighbors were better at sorting their waste, and how much food waste they believed their neighbor was sorting. The questionnaire was distributed two weeks after the post-test pick analysis was completed.

Table 4: Control variables

Dimension	**Measurement**
Recycling intention behavior	Self-reported recycling behavior (Barr, 2007); asking *how often* and *how willing* the respondents were to recycle 10 items listed in the standard sorting guide distributed in Oslo.
Demo-graphics	Age, income, education, ethnic background, etc. (Respons Analyse, 2015).
Housing	Type, size, number of residents in household (Stoknes, 2015)
Knowledge	What households think happen to waste they sort (Milford et al., 2015).
Pick-up frequency	Number of pick-ups per week per fraction

3.3. Research quality

Causality is hard to prove due to the empirical setting of quasi-experiments, but internal validity can be improved with careful research design (Shadish *et al.*, 2002). One issue is the lack of random sampling. Measures are taken to prevent selection bias. First, the pre-test pick analysis was conducted to identify pre-test differences and create a baseline for the recycling behavior of the experimental and control group. Second, demographic characteristics were assessed through the questionnaire. Third, risk of cross-contamination was minimized by selecting a housing cooperative with a favorable location of collection points. Still, many threats towards validity cannot be prevented by design features alone, as it is impossible to control every variable in real life (Shadish et al., 2002). However, measures taken in this study mitigate such threats, such as keeping information and interaction during doorstepping brief with the experimental group, having a pre-test pick analysis to compare with, and conducting all the pick analysis for both groups at the same time. These measures address selection maturation, instrumentation, and history (Shadish et al., 2002).

When internal validity improves, this may involve lowering the external validity (Shadish et al., 2002). Measures taken to improve external validity included the authors reviewing existing literature to provide reasoning, which resulted in the framework and propositions. The use of official statistics showed face validity between the city, district, and housing cooperative. Construct validity is strengthened through operationalization underpinned by the literature, as measures have been used in prior studies. The researcher–participant interaction was limited in general, and any information provided was standardized across groups. The doorstepping hit rate and response rate were analyzed to reveal possible bias in the results.

To ensure reliability, the pick analysis was conducted using the same methods and fractions as the annual waste composition analysis of Oslo. Post-test pick analysis took place shortly after the intervention to limit the possible external sources of response variation. All researchers conducted the post-coding of responses to open-ended questions from the questionnaire to ensure construct validity.

During analysis, possible bias was reduced by looking at the change within the respective waste fractions, rather than the change in the share of overall amount of waste (for example, change within the food waste fraction, not change in food waste as a percentage of overall waste). This allowed investigation of the change in recycling behavior over time between the two groups, as this result would not be affected by pre-test differences (see Figure 4).

4. RESULTS

A total of 1335 metric tons of household waste, divided across four samples, was collected for analysis. After removing blue and green bags for later analysis, this left 946 tons of residual waste for the more detailed waste composition pick analysis. Margins of errors for pick analyses like these are set at a range of ± ≤ 2 percent discrepancy after analysis (Mepex Consult AS, 2015). The errors in this study were within this margin. Figure 4 summarizes the result of the pick analyses.

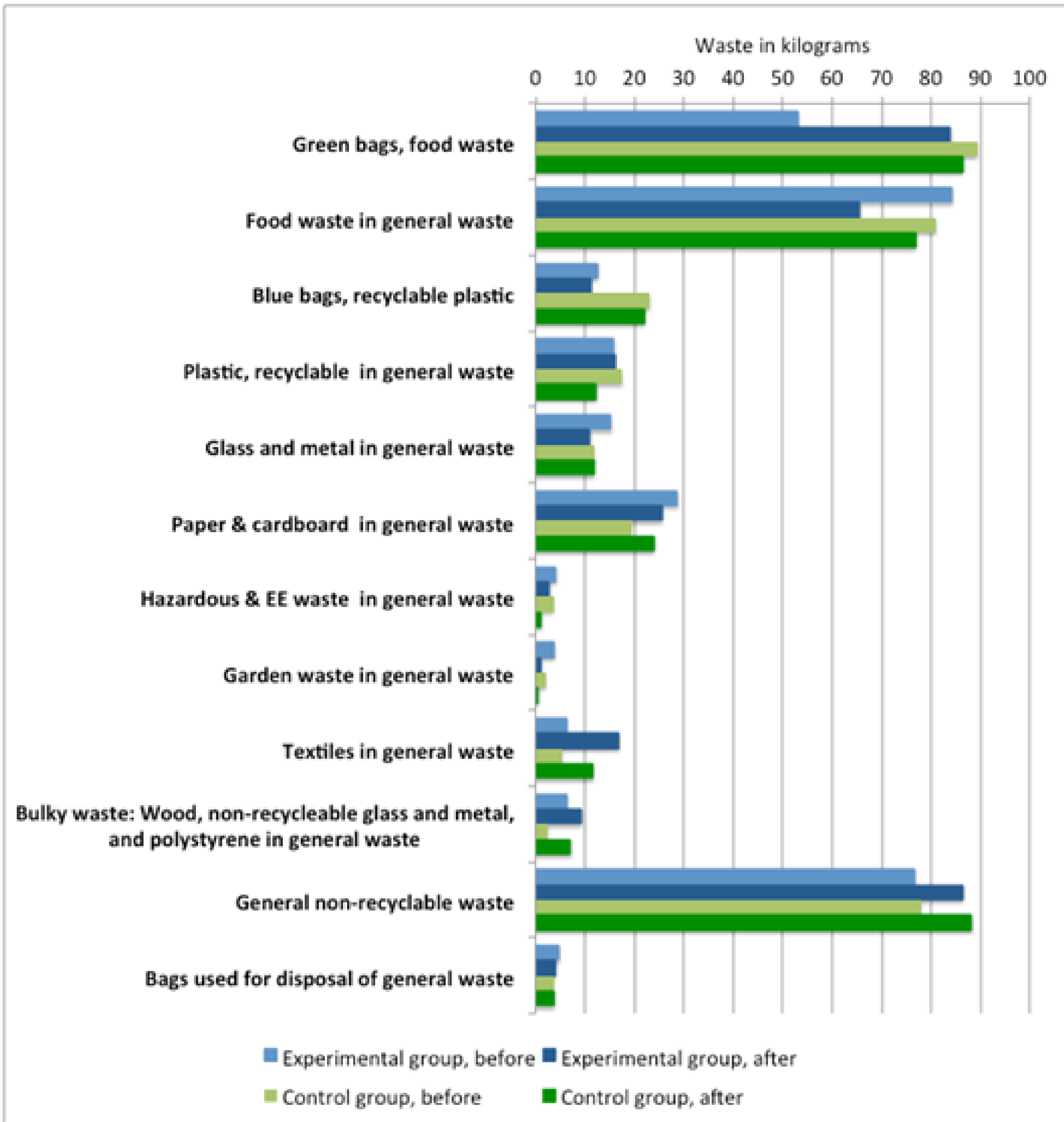

Figure 4: Change in waste fractions over time between and across experimental (blue) and control (green) groups.

4.1. Results from observed recycling behavior (action)

This section reports the results from the nudging interventions. Our focus is on food, and glass and metal waste because these types have been identified as problem areas due to cross-contamination. The results show that all the three evaluated nudges have an effect in narrowing the recycling behavior gap.

4.1.1. The social norm nudge

The social norm nudge is evaluated with an informational letter that target food waste. Figure 5 shows the results from the pick analysis for food waste.

The experimental group recycling action behavior has improved, as 17 percent more food waste (56 percent) was sorted into green bags after intervention. This increase was also without contamination in the green bags (20 percent pre-test to 39 percent post-test), meaning that sorting quality improved. The results showed that the control group sorted approximately the same levels in the pre- and post-test results, with only a 1 percent point difference (52 and 53 percent sorted food waste, respectively).

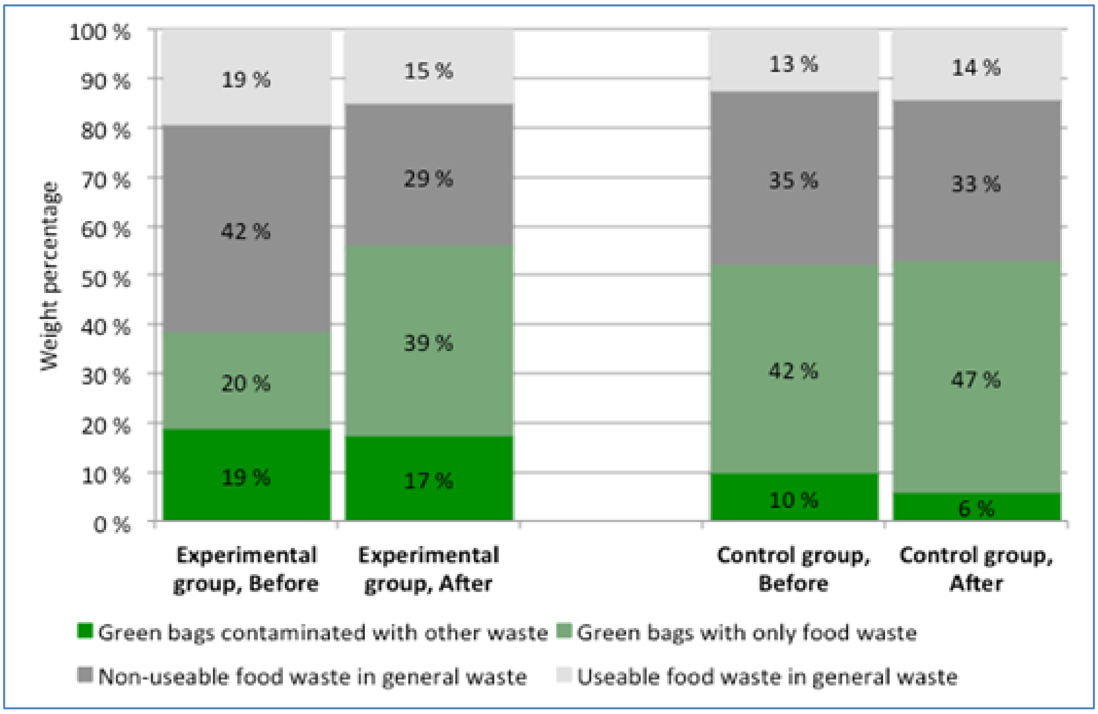

Figure 5: Sorted food waste for the experimental and control groups before and after intervention. Waste sorted by origin, percentage of total food waste.

Two questions from the questionnaire were asked to evaluate whether the nudge (the informational letter claiming that "Eight out of 10 of your neighbors recycle their food waste.") was the likely cause of the increase in food waste recycling action behavior observed in the experimental group. The first question measured perceived diligence of neighbors, and the second measured the perceived quantity recycled. In the experimental group, 91 percent of respondents believe their neighbors recycle half or more of their waste (vs. 71 percent for control group). The results are similar in terms of diligence, showing that a higher share of experimental group respondents believe in their neighbors recycling behavior. The results confirmed that most respondents in both groups, believe their neighbors recycle about the same amount of waste as them, regardless of how much waste they believe their neighbors recycle.

Based on these results, it can be argued that using a social norm nudge to improve food waste recycling had the expected effect and the quasi-experiment did manage to activate a social norm regarding recycling.

4.1.2. The distance nudge

The distance nudge is evaluated by reducing the (walking) distance to the collection point for glass and metal waste. Figure 6 shows the results from the pick analysis for glass and metal waste.

After the intervention, recycling action behavior for glass and metal waste improved for the experimental group, as 29 percent (-4.39 kg) less glass and metal was observed in residual waste in the post-test pick analysis. In comparison, the results were a 2 percent reduction (-0.19 kg) in residual waste for the control group.

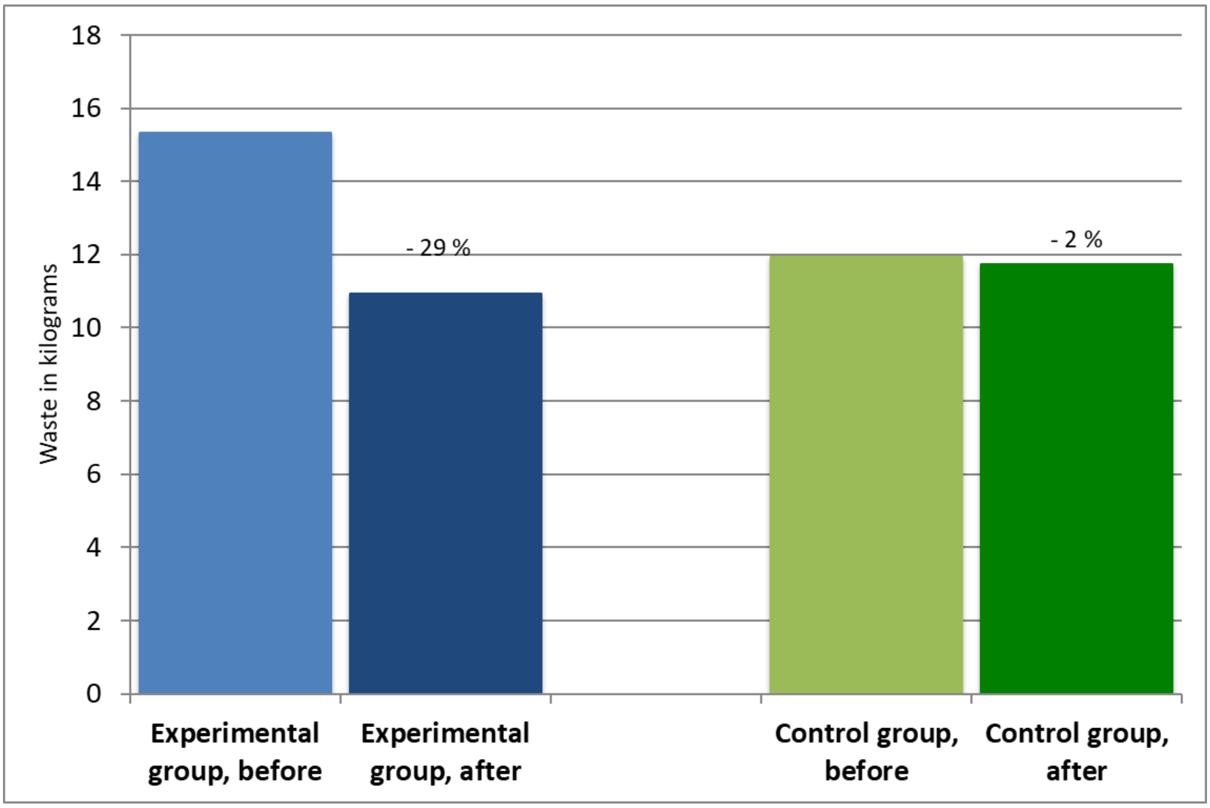

Figure 6: Share of glass and metal waste in the residual waste for the experimental and control group.

To evaluate whether these results show an actual change in recycling behavior, rather than seasonal change, the respondents were asked to rate their sorted quantity of glass and metal waste over the last six weeks in the questionnaire. Forty-four percent of experimental group respondents reported that they had sorted *more* or *much more* glass and metal waste (see Figure 7). No such patterns were identified for the control group. This identified a change in perceived behavior since the start of the intervention. Thus, there is an improvement in glass and metal self-reported recycling behavior for the experimental group, supporting the result of an actual change.

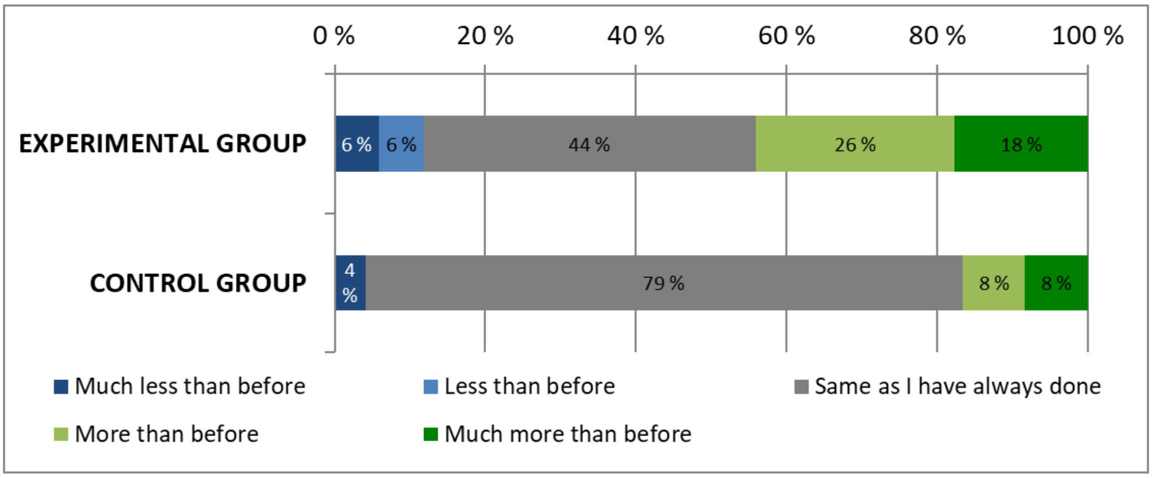

Figure 7: Perceived change in glass and metal recycling behavior after a six-week period.

Sensor data from the new container also showed a steady fill rate, which indicates that it was in regular use over time. The AWM also made the container permanent due to its frequent and continued use after the experiment period was over, which confirms the results and change in recycling action behavior.

In conclusion, it can be argued that the distance nudge had the expected effect, and the quasi-experiment did manage to improve the recycling behavior for glass and metal waste.

4.1.3. The availability nudge

The availability nudge was evaluated by handing out sorting equipment (bags). The results were evaluated by looking at how contamination of bags changed after we knew that the ECTS had bags available for sorting the relevant waste types. Figure 8 shows the results for the green bag for food waste.

The data suggest that the quality of green bags improved for the experimental group, with a 10 percent decrease in the number of contaminated green bags. The control group behavior remained constant.

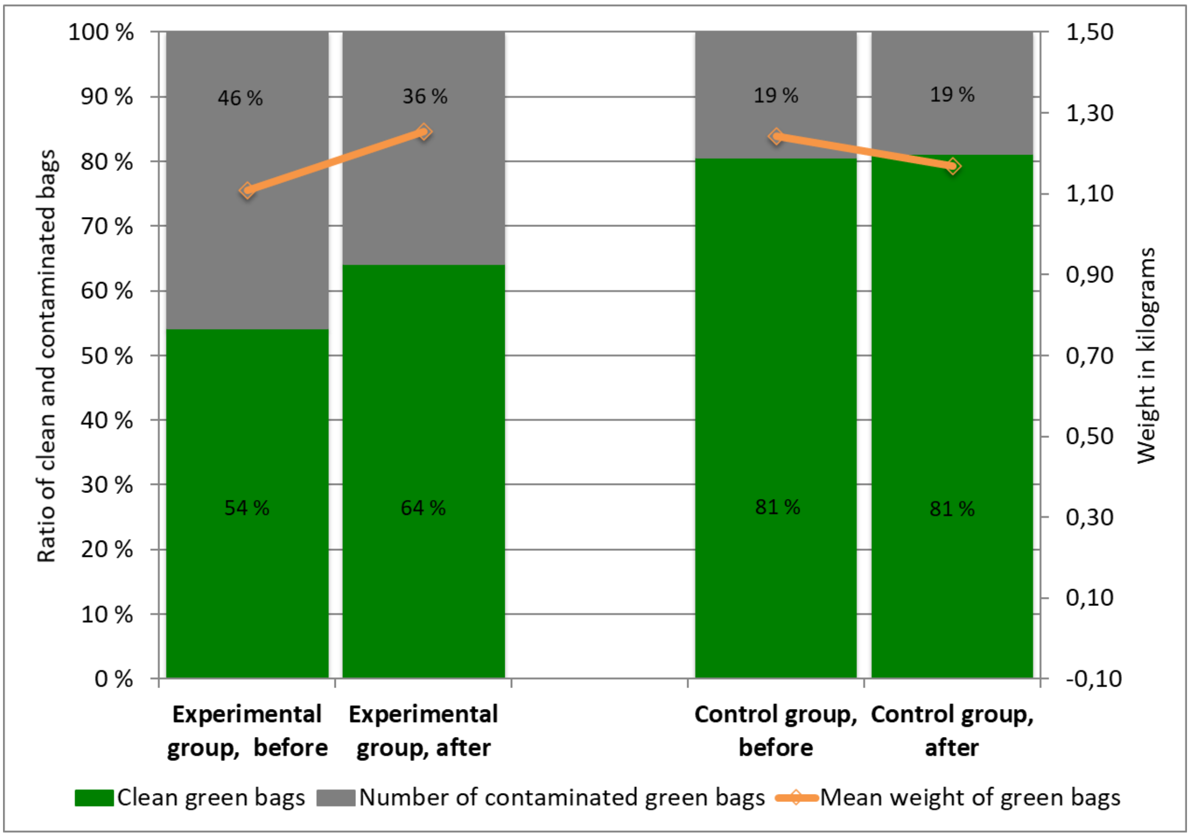

Figure 8: The ratio of correctly sorted and mean weight of green bags for the experimental and control group. Food waste sorted by origin and number of green bags.

The mean weight of green bags for the experimental group also increased from 1.11 kg to 1.25 kg (13 percent increase). By comparison, the mean weight of green bags for the control group decreased by 6 percent, from 1.24 kg to 1.17 kg. Food waste is the heaviest fraction, which indicates that experimental group green bags contain more food waste and less contamination from other fractions, suggesting that the quality of green bags improved.

It is not possible to know how much of the increase in food waste recycling rate was caused by the social norm nudge or by access to waste bags, but the fact that the positive change also occurred for blue bags (plastic waste) suggests that overall recycling action behavior has improved. More importantly, the post-test pick analysis showed an improvement through a decrease in the number of green bags used for residual waste bags.

The glass and metal bag was intended to influence user convenience and nudge the ECTS into recycling (more) glass and metal. Sensor data show a lag in the fill rate, which is probably explained by the bag's large size and that it takes a while to fill it.

These results show that the different types of bags are most likely taken in use and that availability of equipment matters and nudged respondents to improve their recycling action behavior.

4.2. Results from self-reported recycling behavior (intentions)

This section outlines the results from the questionnaire and provides an understanding of the housing cooperative's intended recycling behavior. The overall response rate was 33 percent.

The examination focused on relative frequency to uncover trends, rather than statistical conclusions, due to use of categorical variables, the relatively small sample size, and low response rate. The researchers scrutinized the data for bias in demographics but found no visible differences between the experimental and control groups.

Results show that overall system satisfaction is high *(very satisfied* or *satisfied)*, and slightly higher for the experimental group (94 percent) than the control group (79 percent). None of the respondents in either group reported being dissatisfied. Similar overall results were reported for the waste accumulation solutions at their homes; both the experimental (76 percent) and the control group (75 percent) reported being *very satisfied* or *satisfied*.

The results for self-reported intention to recycle food waste and glass and metal waste are similar, but since glass and metal waste are reported in absolute volume only, we continue the discussion with a focus on food waste. To increase reliability, we included two questions on food waste, see Figure 9. The wording with "dinner leftovers" was chosen to make it more specific for the respondents to relate to.

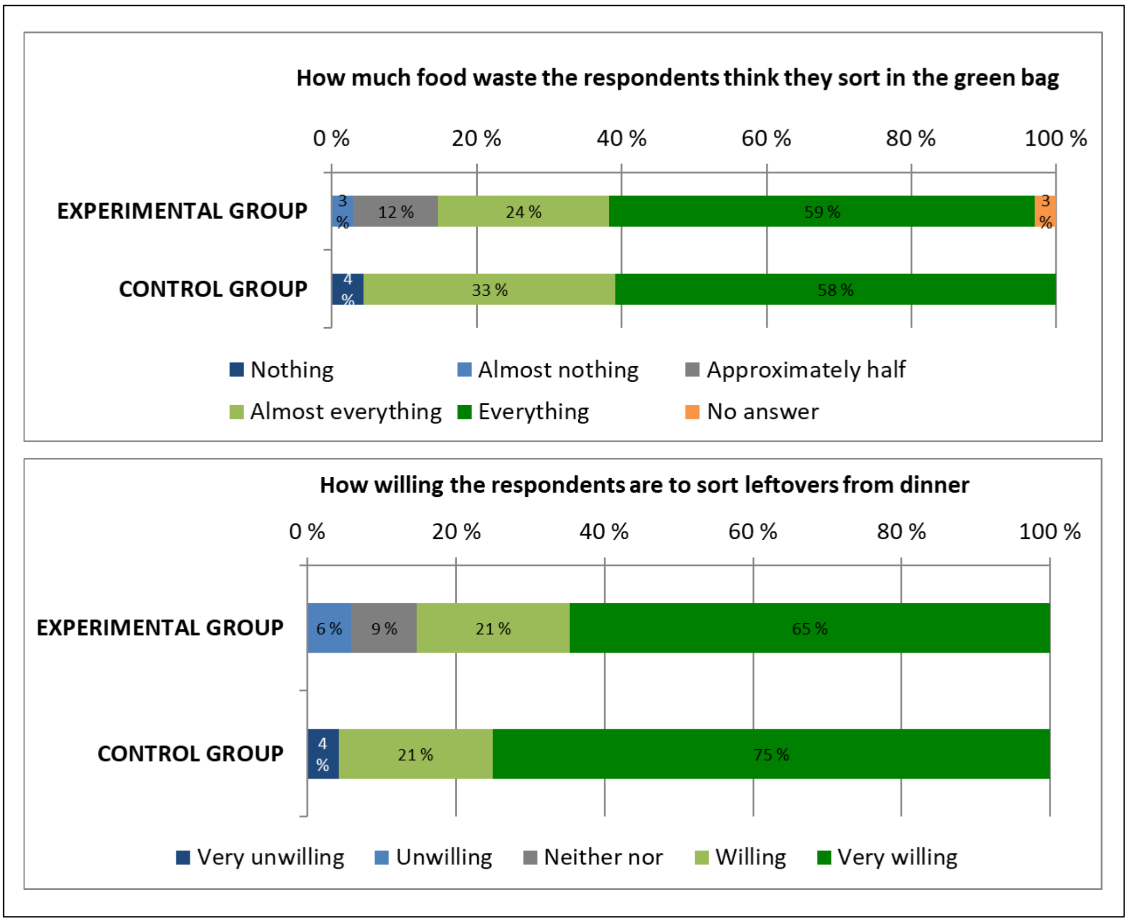

Figure 9: Self-reported intentional food waste recycling behavior

As expected, the self-reported intentions to recycle food waste were high. Eighty-three percent of respondents in the experimental group reported that *almost everything* or *everything* of their food waste is sorted into green bags, versus 92 percent in the control group, and almost 60 percent of respondents in both groups claimed they sort all their food waste into green bags.

Equally, the willingness to sort dinner leftovers was high, at 86 and 96 percent for the experimental and control groups, respectively.

From these results we can see a gap between recycling intention and action. For the control group the measure is 96 vs 53 percent. This is a valid comparison for the control group because they have not been exposed to any interventions, however the results for the experimental group are most likely influenced. Still, the recycling behavior gap for the experimental group can be interpreted as having narrowed. The fact that the intention results are lower compared to the control group could indicate that the respondents have adjusted their score based on the experience from the experiment, but there is still a gap between their intentions and actions.

5. DISCUSSION

Recycling behavior has been widely studied in the literature (Phulwani et al., 2020), and an intention action gap has been repeatedly confirmed (e.g. Barr, 2006), so too in our study. We have seen that the recycling behavior gap can be explained by the fact that ECTS is not really too concerned with recycling (Stoknes, 2015) and do not really view themselves as a supplier in the commercial sense (Zikmund and Stanton, 1971). Rather, it can be argued that recycling is viewed as "a necessary evil", something that one must do, even if reluctantly. We contribute to literature by demonstrating how it is possible to get major effects on end consumer recycling behavior and narrow the recycling behavior gap, by making relatively small adaptations in reverse logistics systems. The line of reasoning comes from the nudging and choice architecture (Thaler and Sunstein, 2009). The insights we draw from this is that the way the reverse logistics system is presented to the ECTS has a direct effect on the recycling action levels. Basically, it is easier to adapt reverse logistics systems than to adapt people's will. We provide insights into three specific adaptations, which we have labeled the social norm nudge, the distance nudge, and the availability nudge. Next, we will discuss the theoretical and managerial implications from our study.

5.1. Theoretical implications

Reverse logistics, like logistics in general, is about managing flows, which is prevalent in this frequently used definition of reverse logistics: "The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal" (Rogers and Tibben-Lembke, 2001). We explain the effects that we see in our study with the ability of the adaptations to make the reverse flows even more effective.

First, the social norm nudge is linked to the flow of information. In the present study, the ECTS was presented with information about neighbors' recycling behavior. The recycling behavioral literature argues that relevant information activates social norms and increases the ECTSs' motivation to recycle, and hence improve recycling action (Miafodzyeva and Brandt, 2013). Taking the ECTS "supplier" role in perspective and reflecting on this situation from a commercial point of view, we argue that information about the neighbor recycling levels is parallel to market information. It sets a standard for performance and what "the supplier" should expect from his or her own "business", almost like a benchmark. Following such an argument, neighbors could be viewed as immediate competition, for which it would be motivational for the ECTS to match, and even beat. Therefore, in a reverse logistics perspective, such "market information" improves the information flow in the reverse logistics systems, and the actors, including the ECTS, are in a better position to make improved decisions and recycling actions.

The literature confirms that information sharing has a positive effect on reverse logistics performance (Olorunniwo and Li, 2010), and that lack of information flows is a barrier for reverse logistics system operations (Jayasinghe et al., 2019).

Second, the distance and availability nudges are linked to the product flows. We have learned from the behavioral literature that “a closer point means less effort” (Miafodzyeva and Brandt, 2013 p.225), and hence improves the recycling behavior (Perrin and Barton, 2001). In reverse logistics this is parallel to curbside schemes, which have an increased service level compared to bring schemes (Jahre, 1995). The design feature of the reverse logistics system makes the product flows more convenient to manage for the ECTS when they have access to sorting equipment (Bernstad, 2014) and a reduced distance to collection points (Rousta et al., 2015). An additional insight from our study is the effect of co-location of collection points which are corresponding to waste fractions sorted at ECTSs homes. Consumers tend to apply different waste accumulation strategies depending on their routine for taking out waste (Monnot et al., 2014). Therefore, when the ECTS have access to equipment for the four waste types, and the same four waste types are co-located at the delivery (collection) point, it makes the product flow more effective and the recycling effort more simplified (Stoknes, 2015). When people take out waste, they need to walk to only one location, not two, which in practice gives the ECTS one less thing to think about, reducing the planning from two to one destination. Basically, a bring scheme is presented as it was a curbside collection scheme (Jahre, 1995). Adapting service levels in the reverse logistics system (for example, through curbside schemes) is expected to generate more quantity and better quality of the recycled products (Dahlén et al., 2007), and hence improved recycling action. In fact, our results show that the ECTS find it more convenient not to sort and recycle waste to the preferred loop when reverse logistics activities are not well adapted to their behavior.

5.2. Managerial implications

The area of climate psychology contributes to insights into how ECTSs most likely do not think much about recycling (Stoknes, 2015). Managers of reverse logistics systems need to take this information into consideration when managing such systems. Rather than aiming at increasing general information to try to enlighten, train, and increase ECTSs’ knowledge, the focus should address system adaptations (through for example nudging). Observation of ECTS behavioral patterns and presenting them with a reverse logistics system that is fine-tuned to what they actually do is likely to result in improved recycling action behavior.

The targets for recycling levels are increasing, as governments set more ambitious goals towards the circular economy (European Commission, 2020). Therefore, measures like reverse logistics systems must contribute to the performance, and managers need to be able to close any loss in efficiency due to maladaptation between the participating actors. In particular, managers need to include the end-consumer-turned-supplier as part of their planning and system design, as this actor has a crucial role in the new business logic of the circular economy. Factors such as getting sorting equipment delivered at the doorstep, co-location of collection points, and sharing performance information are shown as adaptation possibilities.

5.3. Limitations and further research

The cost levels also need to be evaluated when considering the adaptations that we suggest in this paper. This is a limitation of our study. Implementation of reverse logistics systems must also be cost-efficient (Rogers and Tibben-Lembke, 2001). However, we argue that it is necessary to investigate into types of adaptations and evaluate their effect before discussing cost. When we know what works, it is possible to also find ways to minimize cost.

A second limitation to our study is the parallel implementation of the interventions. Therefore, we cannot be certain that the effects are not influencing each other. However, each of the interventions do address separate waste types, like the informational letter addressing food, the distance change focusing on glass and metal, and the door delivery of bags addressing contamination. While we obtained positive results in all these waste types, the possibility that implementing one intervention separately may not give the same effect must be taken into consideration.

The quasi-experiment is set in one housing complex, with two pick-up points. In practice, this is a relatively limited empirical observation. However, the housing complex consists of 320 apartments and has been identified by the AWM employees as a representative selection. Eighty percent of Oslo residents live in housing complexes; thus, the majority of people live like the households in the selection for this study. Still, a more representative study is relevant for future research.

A corresponding concern is the sample size. Even after examining waste from 176 households, the co-collection made it impossible to isolate every individual's waste and carry out statistical testing. Statistical testing would allow for statistical conclusion validity, which would strengthen the internal validity even further (Shadish, Cook, and Campbell, 2002). Therefore, the presented results need to be interpreted within this limitation. It would, however, be an interesting study to get data on recycling action behavior from individual households.

Another limitation is the time between the interventions and the post-test pick analysis. It is probably too short to say anything about long-term effects. To evaluate potential persisting changes in recycling behavior, a new pick analysis would have to be performed at later points in time. Therefore, studies to investigate into long term effects are suggested for future research.

6. CONCLUSION

The study aimed to sharpen the lens regarding the ECTS as having a dual role between consumption and recycling because all practicalities in attitudes, habits, and everyday routines in sum provide product flows that are vital for closing the recycling loops and transforming towards the circular economy (Korhonen et al., 2018).

A framework and set of propositions for understanding how ECTS and reverse logistic system characteristics affect the recycling behavior gap was developed and evaluated through a quasi-experimental design. The study was empirically set in a household waste recycling context. The present study demonstrates the power of nudging and how the recycling behavior gap is narrowed with well-adapted interventions.

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