



# Evaluation of Nudging on Waste Management

A case study

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# Evaluation of Nudging on Waste Management. A Case study.

*Utvärdering av Nudging på avfallshantering. En fallstudie.*

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## Abstract

The interest in sustainability has risen in recent times where several instruments have been put in place to decrease environmental degradation. An up-to-date, as well as a less financially demanding sustainability instrument, is nudging. A nudge is an intervention trying to enhance certain consumer or resident behaviour without affecting economic incentives or forbidding other options. A housing company in Uppsala, Sweden, has introduced nudging in one of their neighbourhoods to increase waste sorting as the area suffered low waste sorting rates before the nudge. This has been done by comparing a yearly survey of tenants' perceptions of their possibility to act environmentally friendly before and after the nudge. To guarantee that the effect is because of the nudge and not any time effect, 12 other areas, chosen on geographical proximity, have been used as a control group. The method consisted of one unconditional Difference-in-Difference and one conditional Difference-in-Difference including control variables. Tenant's perception of their ability to act environmentally friendly was positively affected by the nudge in both the standard DiD-regressions and in the conditional DiD-regression with a 12% respectively 21% positive change. When including control variables in the conditional DiD-regression, several environmental valuations were of positive effect of which the different aspects of environmental behaviour are correlated with the chosen outcome variable and can help explain its variation. The housing company plans to institute more possibilities to waste sort in the future which will likely contribute to a higher conviction of tenants' perception. Insights from this study can help guide future nudge implementation and its effect on tenant perception in neighbourhoods.

*Keywords:* Nudge, Attraction Effect, Default, Framing, Behavioural Economics, Difference-in-Difference, Waste Management, Evaluate Perception

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# Abbreviations

DiD	Difference-in-Difference
EKC	Environmental Kuznets curve
EU	European Union
OLS	Ordinary Least Square
PEA	Pro-Environmental Actions
SLU	Swedish University of Agricultural Sciences
SUTVA	Stable Unit Treatment Value Assumption
UH	Uppsalahem

# 1. Introduction

Environmental awareness at the governmental, as well as societal level, has risen in recent times. An increased willingness to reduce environmental degradation has been recorded in all levels of society (Naturvårdsverket 2021). Several economic instruments have been used to increase pro-environmental behaviour targeting residents in Sweden, such as a curbside food waste collecting system based on fees introduced in 2015 (Svensk Avfallshantering 2020), the can and bottle recycle refund (Pantamera 2022), and the environmental tax on fossil fuels from 1995 (Skatteverket 2022). These policies are used to increase consumers' or residents' environmentally friendly behaviour. Behaviour or habits are important contributors when trying to decrease environmental degradation (Darnton et al 2014). Another example of a habit that is beneficial for the environment is waste sorting. The European Union (EU) aims to reach a "circular economy", defined as 60% of municipal waste and 70% of packaging waste being recycled by 2030 (European Environment Agency 2021). These goals contribute to less environmental degradation, as it saves energy and raw material resources (Svensk Avfallshantering 2020). Food and residual waste are used to renourish our soil and produce biogas as well as electricity. There is a great variation in the member countries' achievements in recycling where several countries are expected to not reach the 60% waste recycling goal by 2030.

On the other hand, Sweden has steadily shown a rising trend in all sorts of recycling. In 2020 the recycling target for packaging was 65% which means that Sweden sets higher requirements than the EU (Svensk Avfallshantering 2020). Likewise, food and residual waste are expected to decrease by 25% by 2025, compared to 2015 (Svensk Avfallshantering 2020). In Sweden, the municipalities are responsible for collecting garbage and recycling (ibid.). Hence, it is the municipalities' responsibility to collect garbage and facilitate waste disposal for residents. However, it is the residents' behaviour when managing their waste, that is determinant in the final level of sorting. Citizens are obliged to recycle and contribute to the public good, but it would be too costly for policymakers to monitor behavioural hazards and further penalize such inaccuracies.

In contrast to recycling cans or reducing fossil fuel use, waste sorting is hard to control without incurring prohibiting monitoring and enforcement costs. Financial instruments are complex to use as there is no direct consumer purchase involved in waste sorting, thus, policymakers must rely on other instruments. Incentives on the tenant level might decrease when they are not solely responsible for potential waste sorting penalties. Therefore, it is of importance to study different measures taken by municipalities and other actors to increase waste sorting as it can bring clarity to the effectiveness.

There is a commonly used alternative to change the environmental behaviour of residents without using economic incentives referred to as nudging. Nudging has been studied in several fields of behavioural and economic science (Hummel & Maedche 2019; Lehner et al 2016; Damgaard & Gravert 2018). According to Thaler and Sunstein (2008) “A nudge... is any aspect of the choice architecture that alters people’s behaviour in a predictable way without forbidding any options or significantly changing their economic incentives.”. I adopt Thaler and Sunstein’s definition of a nudge in this paper.

Studies concerning environmentally friendly nudging in Sweden have been primarily focused on food choices (Kurz 2018; Hebda & Wagner 2015). Earlier studies concerning nudging in waste management based in Sweden have shown various effects depending on the nudge and the studies’ context. In a suburb of Stockholm, long term effects were recorded when distributing leaflets containing descriptive norms (Linder et al 2018). A study based in a rental building complex found that in-house sorting equipment was effective (Bernstad 2015). Also, when introducing a food sorting system in a high-income area, a spillover effect was displayed in other waste recycling (Miliute-Plepiene & Plepys 2015). Partially, the heterogeneity at the population level explains the variation in results (Nainggolan et al 2019). Consequently, this study attempts to study tenants’ self-reported experience of the nudges in one neighbourhood as the tenants are expected to be more homogenous in relevant characteristics.

A municipal housing company called Uppsalahem has used nudges in one of their neighbourhoods to increase their tenants’ waste sorting (Freiholtz & Pallin 2021). They have, anecdotally, observed an increased level of waste sorting. In this paper, the effect of Uppsalahem’s nudges is examined more formally. Linder et al (2018) conducted a study on the effect of nudging on waste weights in an urban area using a Difference in Difference (DiD) approach. A similar method to Linder et al (2018) is used in this paper, but instead of the observed waste weights, the tenants’ perceived changes in the waste management are the dependent variable. Accordingly, this paper’s research question is:

- *Has Uppsalahem’s nudge changed tenants’ perception of their ability to sort waste?*

I study the effect of the nudge on tenants’ perception in Bäcklösa through comparing Bäcklösa with 12 other nearby areas, serving as a control group. Specifically, I compare changes in perception in Bäcklösa to changes in perception in the 12 nearby areas that has not undergone any treatment. As the nudge is motivated by the objective of increasing waste sorting, it is expected that tenants’ perception of their ability to act environmentally friendly has increased in Bäcklösa compared to the control group.

Similar studies often focus on the effect of the nudge on the waste weight, here I focus on the perceptions of the tenants in response to the nudge. As the garbage disposal company did not weight waste in correctly, the actual waste sorting is excluded, and a more behavioural and motivational discussion of waste sorting is instead conducted. The result is indeed positive although the effect size of the treatment on how tenants’ perception of their possibility to act environmentally friendly is not significant (p-value = 0.368). Accordingly,

Uppsalahem's observation of the increased effect in waste sorting does align with this paper's result although the effect size cannot be established. In the conditional DiD-regression, where demographics and other perceptions of environmental aspects were included, the treatment effect is positive and significant on a 90% significance level (0.1). The effect size of both DiD-regressions is not as prominent as Uppsalahem's observations. This can indicate that Uppsalahem's nudges did affect tenants' behaviour without influencing tenants' perceived effort or valuation of waste sorting. On the other hand, the causal interpretation of the treatment effect might not be granted if the parallel trend assumption does not hold. The control group, chosen on geographical proximity, might not be a good counterfactual to Bäcklösa, which would affect the plausibility of the coefficients as a causal statement.

The following of this paper consists of a description of the area and its nudges in Section 2. Section 3 firstly, cite earlier work about nudging, secondly, the behavioural findings on waste sorting and lastly describe the studies resembling this paper. Section 4 demonstrates the framework of this study to assess and justify the research question. The Data used is then displayed in Section 5, and further explained in practice in Section 6. Method. The results of the method used are shown in section 7. The results are discussed related to earlier literature and the research question in section 8. Finally, the conclusive remarks are presented.

## 2. Background

The background, firstly, shows the reason for Uppsalahem applying the nudges. Proceeding, the timing, and what sort of implementation has been implemented are described. The theoretical background of these nudges is explained in 2.3, including assumptions that come along with the nudge.

### 2.1 The goal of Uppsalahem's actions

Uppsalahem is a municipal housing association with the mission of distributing and establishing accommodation for Uppsala's residents (Uppsalahem 2022). It is the largest housing association in Uppsala with its 30 000 tenants and works according to Uppsala municipality's sustainability goals (ibid.) The nudging has been conducted in an area called Bäcklösa which consists of 498 newly built rental apartments (Freiholtz & Pallin 2021). The area has been built using sustainable tree materials and with scenic areas within and around the neighbourhood. Rain gardens have been implemented to delay stormwater, as well as various cultivation sites, have been established. There have been underground containers for food and residual waste as well as an environmental house for other waste since the buildings were set up in 2019. Overall, the site would be considered environmentally friendly in terms of infrastructure and design. Nonetheless, a low level of waste disposal at the source has been a recurrent problem since the building was built (ibid.). Reasons for this are, according to Uppsalahem's analysis presented in June 2020, (1) the high ratio of tenants moving in and out of the area, (2) a language barrier since many of the tenants are foreign-born, and (3) a lack of knowledge regarding waste sorting.

To encourage waste sorting in Bäcklösa, nudges have been implemented. In addition, recurrent surveys, interviews, and field visits regarding tenant waste sorting habits have been performed.

### 2.2 Nudge's timing and expected effect

To reach the goal of increasing waste sorting, several nudges have been implemented in Bäcklösa since July 2021 (Freiholtz & Pallin 2021), see Table 1. Additionally, a team of foreign-born women called Femme was assigned the work to be environmental house hosts responsible for cleaning and correcting sorting mistakes in October 2020. The initial supply of sorting options was sufficient in the

environmental house, but the purpose of the different containers was considered vague for tenants. Consequently, Uppsalahem redesigned the environmental house with more colours, explanatory descriptions, and distinct pictures of the environmental house's purpose in July 2021 (see Figure 1). The underground containers for food and residual waste were also considered vague and many of the tenants did not understand the purpose of those. Thus, Uppsalahem conducted the same procedure as with the environmental house using distinct pictures, colours, and a more explanatory description of what waste was to be put in the containers in September 2021 (see Figure 2). Flyers explaining the purpose of waste sorting in both English and Swedish were also handed out and placed around the waste sorting area. In December 2021 Uppsalahem distributed free sorting bags to tenants, matching the design of the respective container in December (ibid.).

Furthermore, Uppsalahem will in the future conduct a sorting school for new tenants and give tenants distinct goals through rewards and feedback (Freiholtz & Pallin 2021). A second environmental house will be built in 2022.

*Table 1*

<b>Time</b>	<b>Nudge</b>
October 2020	The hiring of environmental house hosts
July 2021	Redesigning of environmental house
September 2021	Redesigning of underground containers
October 2021	Informative flyers distributed to tenants
December 2021	Distributing sorting bags to tenants

All nudges implemented during 2021 in time order.

*Figure 1*



From the environmental house, the upper picture is taken before (2020) the nudge whilst the bottom picture is taken after (2021) the nudge.

Figure 2



Underground container for food waste, the left picture is taken after (2021) the nudge whilst the right picture is taken before (2020) the nudge.

## 2.3 Description of implemented nudges

According to Thaler and Sunstein's (2008) terminology, several nudges have been used. These nudges have in common that they all utilize tenants' cognitive process in trying to alter certain behaviour. In psychology, the Dual Process Model is a theory of how people process different choices (Kahneman 2011). The theory includes the automatic system 1, and the more logical system, 2. System 1 includes easier choices where shortcuts connected to earlier experiences and habit induces less effort to act, whereas system 2 involves more valuation and thinking to reach a rational decision. Due to system 1 relying on habitual or fast thinking, such as waste sorting, it is easier to adjust such choices with practical changes or nudges. The description of system 1 is argued to explain why people are not always rational in their behaviour (ibid.).

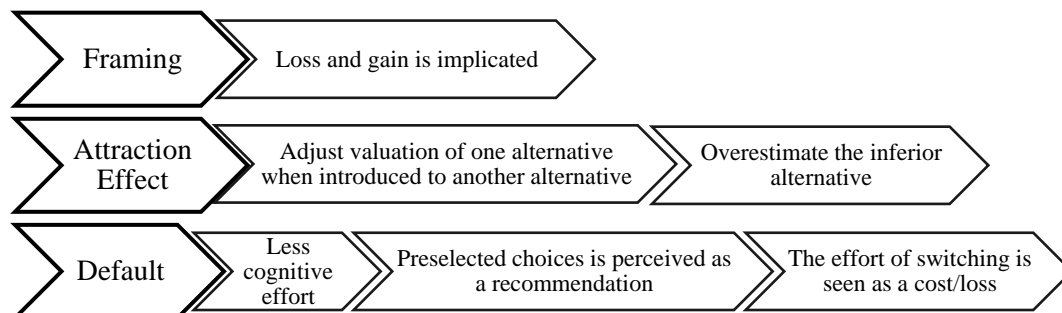
The process of redesigning the underground containers and the environmental house relates to framing (Thaler & Sunstein 2008). Framing uses the effect of presenting an action or good as more appealing in terms of individual gains. For example, by using explanatory positively phrased texts about why it is necessary to waste sort, as well as using bright colours, the nudge can influence the tenants' behaviour towards Uppsalahem's preferred garbage disposal action. This is due to Uppsalahem emphasizing the gains of waste sorting.

When advertising information and the benefits of waste sorting the behaviour becomes more attractive than the option of not sorting waste, connected to the attraction effect (ibid). People's comparison ability is limited when performing fast choices. The introduction of an inferior alternative is easily overestimated by individuals in comparison to the former alternative. For that reason, the benefits exposed to the tenants could be perceived as overly important in contrast to not sorting their waste.

By giving tenants sorting bags with colours matching the containers, Uppsalahem creates a shortcut in the cognitive effort which transfer the alternative of waste sorting closer to a default act (ibid.). When tenants need to make an active choice, it is more likely to opt-out as a choice is perceived as a cost and an effort. When tenants are given the waste sorting equipment, their choice of investing in such is preselected by their tenant association. Additionally, waste sorting is interpreted as a recommendation from Uppsalahem, enhancing the pressure of what is the proper choice of action.

The nudges used by Uppsalahem, and what these nudges utilize in tenants' habitual thinking is summarized in Figure 3.

*Figure 3*



The nudges and their effect on tenants (Thaler and Sunstein 2008).

## 3. Literature Review

The following section is structured as follows: The first subsection consists of important contributions of literature concerning nudging. The second part refers to the behavioural aspects of waste management and its potential utilization when performing nudges. Thirdly, studies resembling this study are presented with methods and results.

### 3.1 Literature on nudging

The psychology behind choice gained great attention during the '70s when people's rational decision-making began to impugn (Thaler 2016). Tversky and Kahneman (1981) contributed to this debate by using experimental designs where subjects were assigned to choose between two programs when trying to reduce the spread of a deadly disease. These programs had the same probability of saving lives, but the framing of these programs differed. This resulted in most respondents choosing the alternative program framed with more appealing wording. Similar experimental designs were conducted by the authors exposing several behavioural aspects affecting individuals' final decisions (Tversky & Kahneman 1973; 1974; 1991). Thaler and Sunstein (2008) later introduced the concept of nudging where these behavioural aspects were exploited to alter behaviour (2008). Framing, as explained in Tversky and Kahneman (1981), became a nudging alternative to alter certain behaviour. Kurz (2018) examined a second nudge called the attraction effect when promoting a vegetarian diet. The experiment constituted of two restaurants where the treated restaurant made the vegetarian dish more visible on the menu. This led to a 6% increase in sales for the vegetarian dish. A third nudge called default was studied to increase organ donations (Johnson & Goldstein 2003). The article argues that the default or the pre-filled choice can affect individuals' choice as it is assumed to be the authorities' recommendation, it is effortless to agree on, and the inaction becomes a status quo where a change of choice involves a trade-off at an individual level. And so, if the status quo or default assumes that individuals want to donate organs, the donation rate will increase (ibid.). Habits are dependent on the automatic mind in which nudges can adjust such fast cognition (Darnton et al 2011). The automatic mind can explain why individuals set sub-optimal choices or do not act according to their intention. Policies or nudges should be designed to impose the optimal choice and bring individuals' behaviour closer to their intention. If so, the behaviour change is considered a "good habit" which will make the individual feel good about themselves and repeat the behaviour.

Changes in habits are more receptive when other life changes occur. It is also seen that a good intention before facilitating change yield a larger effect (ibid.)

The nudges used in this study are according to Thalers and Sunstein's terminology (1) Framing, (2) Attraction effect, and (3) Default (2008). These nudges affect individuals' choices differently dependent on the cognitive influence. As follows, it is essential to acknowledge the behavioural motivation for an individual's change in pro-environmental actions (PEA).

## 3.2 Waste management choices

Barr (2007) investigated PEAs using a survey-based method examining three different PEAs: waste reduction, reuse, and recycling. He found that the three PEAs' underlying motivations varied. The action is the sum of environmental values, psychological variables, and situational variables, which affected behavioural intention, having a bilateral relationship with the actual behaviour. Recycling was motivated by normative behaviour or where situational variables had an increasing effect (ibid.). Hence, simplifying recycling would enhance recycling. Wang et al (2020) studied drivers of waste sorting and the discrepancy between waste sorting intention and waste sorting behaviour. Using a survey investigating six attributes, the authors found that attitudes, subjective norms, perceived behavioural control, personal moral norms, and waste sorting knowledge directly influenced the resident's intention of waste sorting, which included an effect on the waste sorting behaviour. Foremost, the knowledge of waste sorting aligned with the resident resulted in a smaller discrepancy between action and incentive. The size of the discrepancy was dependent on external accessibility and subjective as well as personal moral norms. In contrast to Barr (2007), Wang et al (2020) did discover a change in waste recycling caused by knowledge.

Recycling knowledge and waste sorting convenience were further encouraged by Miliute-Plepiene and Plepys (2015) after performing a survey- and waste weight-based case study in Vellinge, Sweden. The area introduced a separate food waste collection system in 2012 which had a spillover effect on general waste sorting due to the increased knowledge and accessibility. Conjointly, they suggested that as Vellinge is a higher-income area, the waste sorting level potentially was related to income following the theory of the environmental Kuznets curve (EKC). EKC describes how when an economy reaches a certain level of income, the environmental degradation begins to decrease (Grossman & Krueger 1991)

Social pressure or expectation can influence green consumerism (Nyborg et al 2006). Social pressure can appear in different designs: information proposing the neighbourhood norm, implementation of systems or recommendations indicating expectations from the household agency etc. Yet, it can also enhance unsustainable consumerism if considered the social norm (ibid)

Motivation is diverse on an individual level in which demographics, such as income, are one of the important contributors. Therefore, investigating waste sorting on a national level is too indulgent and makes area-specific studies the most appropriate when examining changes in behaviour when exposed to nudges. It is consequently of importance to assess those smaller areas that are exposed to the same social norm.

### 3.3 Nudges and waste management in Sweden

The convenience of food recycling was pointed out as the greatest driver of sustainable waste management in Bernstad's (2014) study based in a rental apartment area in Sweden. The method consisted of a comparison of food weights before and after two separate groups in the same area were treated. Area (a) received written information about recycling food waste and area (b) got an installation of separate food waste systems in each household where solely area (b) got a significant increase in food waste sorting. Except for the lower threshold of sorting due to convenience, Bernstad (2014) argue that a social norm is imposed when introducing a food waste system. Potentially, tenants receive the in-house food system as an expectation from the household company influencing tenants' motivation for food recycling.

Flygansvær et al (2021) studied the effect of social norms, distance to garbage disposal, and availability by implementing nudges specific to enhance these variables. They found that all treatments influenced the amount of total recycling as the treatment group did increase respective waste recycling when being exposed to the treatments. The authors contend that an individual's intention and behaviour of waste sorting do not coincide. Whereas, individuals' intention, or will, is harder to change compared to the convenience nudges, referred to as the reversed logistical system. Thus, simplifying the behavioural aspects increases the end-consumer recycling behaviour.

A study based in a suburban area in Hökarängen, Sweden, used DiD to measure the effect of a leaflet motivating waste sourcing that was handed out to half of the area (Linder et al 2018). The leaflet contained information based on descriptive norms and relatable information on environmental benefits which have been argued to have a greater effect on PEA (Cialdini 2003; McKenzie-Mohr et al 2013). Descriptive norms imply that people adjust their behaviour depending on the beliefs of their peers. After receiving the leaflet, a significant effect on recycled food was observed 8 months after the treatment. However, some limitations concerning the validity of their result were present which the garbage disposal company changed during the period studied, where omitted observations took place in the transition phase, and, also, they could not guarantee that the waste weight observed was only from the residents in the experiment as there was no lock on the waste sorting houses (ibid.).

The result of the Swedish-based papers studying convenience, displayed a joint result of convenience, or availability, increasing residents' waste sorting behaviour. Peer pressure or social norms were, similarly, increasing waste sorting. Bernstad (2014) found that general information about waste sorting benefits did not increase waste sorting. This could imply that the Swedish knowledge of waste sorting's environmental effect is already sufficient, or, that individuals care more about social pressure and facilitation of waste sorting than the environmental benefits. Altogether, more focus should be accessed on the end-consumer recycling system or/and societal encouragement, rather than delivering general recycling knowledge.

## 4. Framework

In the framework, the key concept of earlier literature is laid out. It is withal explained how earlier findings can be applied in this study connected to the research question: *Has Uppsalahem's nudges changed tenants' perception of their ability to sort waste?*

### 4.1 Key concepts from earlier literature and its application in this paper

Demographics and preconditions of areas undergoing nudges are possibly influencing factors (Miliute-Plepiene & Plepys 2015), which means that different studies, even though using similar approaches, can derive different results. Furthermore, the sort of nudge can influence areas differently. For example, Linder et al's (2018) study was based in a suburb of Stockholm with condominium rights whereas Uppsalahem's nudge is used in a rental building neighbourhood with other nudges than the suburb of Stockholm. Linder et al's result cannot be transferred to this study as it has neither received the same treatment nor have the same context. Similarly, the result of this study cannot be transferred to an area with other characteristics and/or treatment. However, the result can inspire and guide other housing associations to explore the possibility of implementing nudges.

Uppsalahem's approach to implementing nudges mirrors earlier studies (Barr 2007; Ordoñez et al 2015; Sewak et al 2021). The review of waste management interventions stretching from 1995 to 2020 by Sewak et al (2021) highlighted that structural changes, such as in-house waste sorting equipment or sorting stations close to the property, have the greatest impact on recycling. Interventions should accordingly be customized depending on the users' practical needs. Uppsalahem has implemented such structural change, namely the in-house sorting bags in addition to the environmental house and the underground containers.

Moreover, it is of importance that landlords or responsible associations understand which sort of facilitation measures specific tenant groups need through bilateral communication (Ordoñez et al 2015). Housing companies can exploit this understanding on the tenant level to increase waste sorting (ibid.). Given that housing companies, such as Uppsalahem, affect several households' waste management, the impact of these waste sorting rates has an additional significance from an environmental standpoint. Uppsalahem has examined residents' needs and complemented them with respective nudges, as described in 2. Background.

Social interventions such as norms, peer pressure, or an environmental interest are also of influence. When peer pressure increases, the PEAs can be

enhanced through the dissemination of norms (Zheng et al 2020). As the households of Uppsalahem are clustered in neighbourhoods, the peer pressure increases, possibly amplifying PEA. Several nudges have involved the social norms, (1) the Femme group organizing the environmental house, (2) the handed-out information about waste management benefits, and (3) the in-house sorting system, all of which demonstrate the expectations and, again, the norms from Uppsalahem.

## 4.2 Objective of the research question

PEAs, or in this case waste sorting, contribute to the public good and there is both national and international set goals on increasing waste recycling (European Environment Agency 2021; Svensk Avfallshantering 2020). When evaluating nudges and tenants' perception of those nudges' effect, it can bring clarity to what is efficient and how subjects interpret such implementation. The interpretation of nudges can change their final behaviour due to the added social pressure (Wang et al 2022; Barr 2007) but also have spillover effects on other PEAs (Miliute-Plepiene & Plepys 2015; Nyborg et al 2006). Earlier studies have used actual waste weights as measured outcomes using different methods (Linder et al 2018; Bernstad 2015; Flygansvær et al 2021). In this paper, the individual perception of the nudges is examined.

## 4.3 Methodological approach

Bäcklösa's level of waste sorting was lower than the average of nearby neighbourhoods before the treatment for reasons mentioned in Section 2 (Freiholtz & Pallin 2021). Along these lines, the implementation of nudges is not random and cannot be treated as a natural experiment (Kahn-Lang & Lang 2020). Bäcklösa might be different from nearby neighbourhoods in meaningful ways. According to Uppsalahem, Bäcklösa suffered low waste sorting due to the high relocation ratio, a language barrier as many of the tenants is foreign-born and, had insufficient knowledge about waste sorting. Another difference in the context is that Bäcklösa has only one environmental house distributed with a high number of tenants (485), which is less than the comparison group.

To manage these differences, I compare the treated unit before and after the treatment. This yields the treatment effect and other time changing effects. The control group that has not undergone treatment is capturing all time changing factors. Through subtracting the before and after of the control group from the before and after of the treatment group, the treatment effect is measured under suitable assumptions discussed below. The nudges have been designed according to earlier documentation of the tenant's requirements. Therefore, the influence of these is assumed to be positive.

## 4.4 Control for main differences between Bäcklösa and the control group

In Bäcklösa a relatively high number of tenants move in and out every year which could imply that residents possibly do not feel engaged in neighbourhood norms or feel the responsibility to waste sort. The high relocation ratio can affect demographical changes, so it is of importance to add such controls in the DiD-regression. This is because the change in attitude could be based on demographic change rather than the nudge. The demographical variables included in this analysis are gender, household income and household size. These could be prognostic of the outcome. Females have been reported to take more responsibility for environmental degradation (Swim et al 2019) which can be of important influence. The household income can impact the variation of the outcome as it is related to the education level which has been shown to cause increases in PEAs (Meyer 2015). Moreover, the household size can impose time constraints on the garbage management in which unsorted waste demands less time and effort.

The language barrier affects the low waste sorting rate by not being able to understand the Swedish description of the respective container's source. The number of Swedish-speaking tenants is not observed in the surveys. One of the nudges includes distributing information about waste sorting in Swedish and English in the area, as well as adding pictures on the respective source, the effect is assumed to be that all tenant now has access to waste sorting information whilst an unknown number of non-Swedish speakers did not have access before the treatment. According to the municipality demographical mapping, Bäcklösa was in both 2020 and 2021 a foreign-born dense area (Persson & Nedomys 2021).

The insufficient knowledge about waste sorting includes both the environmental benefits and the tenant's ability to choose the right sorting container. This is controlled using the two control variables on tenants' perception of (1) their possibility to sort at source, and (2) Uppsalahem's effort to contribute to sustainable development as control variables. These are closely linked to the research question and this paper's main interest in measuring the change in perception of tenants' ability to act environmentally friendly.

## 5. Data

The Data section display which sources were used to collect this paper's data and further how the data is used to assess the method. The threats and limitations of the data are thereupon to be presented.

### 5.1 Overview of collected data

Through contact with Uppsalahem and their survey suppliers, the data gathered consists of the following.

- Demographics of individuals from 13 areas including the treated area (Aktivbo).
- The disaggregated answers from the monthly survey of the same 13 areas (Aktivbo).
- The contexts of the 13 neighbourhoods such as the number of tenants and waste disposal stations.

The survey questions used are found in Appendix 1. All of which, include the answers from 2020 to 2021. In total 544 surveys were collected in 2020 and 792 households responded in 2021.

The area exposed to the nudges, Bäcklösa, is the treatment area with its 498 households (Uppsalahem 2021). A total of 2 223 households are included in the untreated areas. These areas have been selected on a geographical basis under the assumption that geographical proximity increases the probability of demographic similarities. Moreover, Uppsala municipality presents a yearly socio-economic report in which they cluster different areas depending on their demographics (Persson & Nedomys 2021). The cluster is dependent on the six variables: household income, percentage of unemployed, percentage of unhealth, level of degree, economic aid, and the percentage of economically vulnerable under the age of 20. Bäcklösa, along with the control group is clustered into the most or second-worst socio-economic regions which is consistent with the geographical assumption. The following is a Table 2 of the selected areas and some of their properties gathered from Uppsalahem's contractor (2020).

*Table 2*

Area	Households	Residual waste disposals	Food waste disposals	Relocation rate %
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Östra Bäcklösa	485	8	8	22,27
Nya Aug Söderman	26			23,08
Solisten	111	2	2	5,41
Rangström	333	10	3	9,91
Oscar Arpi	190	4	2	8,95
Jenny Lind	258	3	2	11,24
Flöjten	68	2	1	4,41
Dirigenten	124	4	2	12,1
Stenhammar Blomdahl	329	12	6	9,12
August Jämna	186	7	4	11,29
August Udda	194	4	1	9,79
Peterson Udda	272	6	4	8,46
Peterson Jämna	132	7	3	6,82

## 5.2 Methodological application

Uppsalahem included several questions in their survey distributed in 2020 and 2021. In the survey sent out in 2020, 544 households responded whilst in 2021, 792 households responded to the survey. The survey was randomly assigned to tenants and thus, it is not the same sample nor individuals necessarily answering the survey between years. The survey included 28 sections divided into different topics with sub-questions. The questions included as variables in this paper's econometric model are found in Table 3. Several questions were possible to connect to the research question such as the tenants' view of (1) waste management in the area, (2) their possibility to sort at source, (3) their possibility to act environmentally friendly, and (4) their experienced effort from Uppsalahem in contributing to sustainable development. As Uppsalahem implemented the nudges focusing on increasing knowledge on the benefits of waste sorting, connected to environmentally friendly behaviour, along with increasing the ability to sort by source, the (3) possibility to act environmentally friendly is relevant when measuring tenant's experienced possibility to sort at source and their increased environmental knowledge due to the nudges. Thus, the dependent variable is (3) *the tenants' possibility to act environmentally friendly*. The dependent variable takes one of 4 values, where 1 indicates a bad possibility to act environmentally friendly, 2, a not so good possibility., 3, a good possibility., and 4 indicates a very good possibility to act environmentally friendly.

Table 3

Variable	Obs	Mean	Std. Dev.	Min	Max
Neighbour Contact	1,171	2.93	.88	1	4
UH's Waste Management	1,266	2.77	.95	1	4
Possibility to Sort at Source	1,254	3.23	.81	1	4
UH's Cleaning of Environmental House	1,232	2.75	.90	1	4

Possibility to Act Environmentally Friendly	1,143	3.04	.79	1	4
UH's Effort to Contribute Sustainable	1,098	3.06	.79	1	4
Household Size	1,130	2.24	1.3	1	5
Household Income	1,119	15 219	12 573	0	40 000
Gender	1,073	.50	.50	0	1
Area	1,336	.19	.39	0	1

Properties of variables collected from the survey used in this paper's econometric model.

### 5.3 Limitations

As the apartment complex of Bäcklösa was built in 2019 and therefore also the survey, there are no feasible way to control pre-trends or the parallel trend assumption. The geographical proximity assumption, nor the added control variables, can statistically verify that the parallel trend assumption holds. I can only argue that the similarities between nearby areas ought to increase the probability of pre-trends. The control group is followingly not of certainty the best fit when comparing waste weight between years with Bäcklösa.

Uppsalahem has designed the survey in which the length and order of the questions might affect the tenant's answers. The survey is long and time-consuming which can affect the tenant's patience when answering accurately.

As described in the Framework, the intention of tenants is foremost investigated in this paper. Ideally, the discrepancy, if any, between intention and behaviour could have been measured if the waste weights of the 13 areas were included. The discrepancy is of interest as the main goal of Uppsalahem's nudge is to increase waste sorting in which the actual waste weights are of interest. On-field visits, the municipality has observed a great improvement in source sorting since 2019. Unfortunately, the contractor responsible for the garbage disposal has not weighted the waste correctly, consequently, reporting inaccurate observations.

Threats of inaccurate observations have been shown when measuring the effect on waste weights (Linder et al 2018; Flygansvær et al 2021; Bernstad 2014). When several actors have been involved in the garbage disposal process the risk of inaccurate measurements increases. Likewise, the change in perception can suffer measurement errors due to memory biases, changes in demographics or inaccurate answers from respondents.

## 6. Method

My goal is to study how Uppsalahem's nudges have changed tenants' perception of their ability to sort waste and act environmentally friendly. Uppsalahem began the yearly survey in 2019 and continued with this until the present. This makes it possible to compare the survey answers before and after the nudges and onwards measure the perceived effect at the tenant level. To ensure that a potential change in waste management behaviour is due to the nudge and not affected by any time effect; 12 other areas are used as a control group, chosen on geographical proximity.

### 6.1 Difference-in-Difference

The nudge is specific for Bäcklösa as only tenants living in the area have been treated in which there are no spillover effect or Stable Unit Treatment Value Assumption (SUTVA) violations between neighbourhoods. SUTVA is a key assumption containing that the potential outcome for any unit does not vary with the treatments assigned to other units (Angrist et al 2009). Likewise, each unit should not include different versions of each treatment level generating different potential outcomes (ibid.). This is adopted as only Uppsalahem's govern areas are included in this paper in which other treatments would have been recorded. A binary variable is created, taking the value of 1 if it is the treatment area and 0 if it is untreated. Further, the treatment period is during 2021 which is indicated through a second binary variable taking the value of 1 if 2021 and otherwise, 0. The regression is estimated using Ordinary Least Squares (OLS) including an interaction term indicating the effect on the possibility to act environmentally friendly when living in the treatment area during the treatment period. Below is the DiD-regression:

$$y = \beta_0 + \beta_1 T + \beta_2 S + \beta_3 (T \cdot S) + \varepsilon$$

where  $y$  is the outcome variable and thus, the perception of tenants' possibility to act environmentally friendly.  $T$  is a dummy variable for the period equal to 1 if  $t = 1$  or after the treatment in July 2021.  $S$  is a dummy variable equal to 1 when  $s = 1$  or if the area has undergone treatment. The interaction term  $(T \cdot S)$  is a dummy variable equal to 1 when  $t = 1$  and  $s = 1$ , thus, in period 1 when Bäcklösa is treated.  $\varepsilon$  is the error term.

Further, a conditional DiD-regression will be executed including control variables as explained in Section 4. This is to control for variation in the outcome variable caused by other factors than the interaction term, time or area effects.

Following this paper's hypothesis, the interaction term coefficient is expected to be positive for Bäcklösa after period 1, which is the only area experiencing the nudging. Hence,  $\beta_3 > 0$ .

## 7. Results

This section displays the statistical results of the standard DiD-regression and, the conditional DiD-regression including all control variables.

### 7.1 Unconditional DiD-regression

The unconditional DiD-regression includes the dummy variables for the treatment period, treatment time and the interaction term of these, thus the treatment effect. The collected answers include both 2020 and 2021 survey answers.

Table 4

Variable	Coefficient	Robust Standard Error
Year	0.121**	0.052
Area	-.005	0.119
DiD	0.126	0.140
N	1,143	

Note: Robust standard errors in parentheses \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

The total number of observations is 1,143. The only significant independent variable is Year (p-value = 0.02) which is expected to increase the possibility to act environmentally friendly by 0.121 on the tenant level. The Area, although not significant (p-value = 0.97), has no or very small impact on the outcome variable. The interaction term, the effect of the nudge, has a positive effect on tenants' possibility to act environmentally friendly but is not significant (p-value 0.37).

### 7.2 Conditional DiD-Regression

The conditional regression includes the same variables as the standard DiD-regression. Additionally, the main demographics and tenants' valuation of the environmentally friendly possibilities they perceive they have, are included. The collected answers include both 2020 and 2021 survey answers.

Table 5

Possibility to Act Environmentally Friendly	Coefficient	Robust Standard Error
Time	.042	.043
Area	-.017	.106
DiD	.21*	.127

Neighbour contact	.075***	.029
UH's Waste Management	.018	.035
Possibility to Sort at Source	.22***	.041
UH's Cleaning of Environmental House	.077*	.038
UH's Effort to Contribute to sustainable	.456***	.056
Gender	.05	.042
Household size	-.024*	0.136
Household income	-5.93	1.560
_cons	.451***	.134
<i>N</i>		809

*Note: Robust standard errors in parentheses \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .*

Including the control variables in the DiD-regression did yield a 90% significance on the interaction term (p-value = 0.1). The two other environmental valuations had further an influence on the dependent variable which also is an environmental valuation (p-value = 0.00, 0.00). Neighbour contact did also have a significant effect (p-value = 0.01) as well as Uppsalahem's cleaning of the environmental house (p-value = 0.04). Of the demographical control variables, Household income and Gender were not of significance (p-value = 0.70, 0.24). The Household size had a small negative significant effect on the outcome variable (p-value = 0.08) on a 90% significance level.

## 8. Discussion and Concluding Remarks

The discussion evaluates the results as well as potential errors in the data and method. Followingly, this study's contribution to the literature and recommendations for future studies is presented.

### 8.1 Interpretation of the result

The effect of the variables in the standard DiD-regression yielded no significant effect on the treatment variable (0.368). The effect size displayed that the treatment had a 12,6% increase in the perception of tenants' possibility to act environmentally friendly.

The conditional DiD-regression displayed a 21% positive effect of the treatment term on tenants' possibility to act environmentally friendly. The treatment interaction term only had a significant effect size in the regression including control variables (0.1). This implies that the control variables explain elements of the variation in the outcome variable. Foremost, the environmental valuations had the greatest impact in explaining the change in the outcome variable. As the outcome variable is also an environmental evaluation these are likely correlated. The demographical variables did not have any major significant effect on the outcome variable. This implies that this paper's included areas chosen on geographical proximity were similar in demographical characteristics. Characteristics are an important factor when performing DiD-regressions as they are possibly correlated with the prior differences in the areas.

This thesis hypothesised that  $\beta_3$ , the coefficient of the DiD-interaction term, is positive. The coefficient is insignificant in the standard DiD-regression, but displays a positive effect on the outcome variable, meaning that the nudge has the desired effect according to Uppsalahem's goal. However, this positive effect cannot be established on a 90% significance level and is interpreted with uncertainty. In the conditional DiD-regression, the treatment term has a greater positive effect size than in the standard DiD-regression and is significant on a 90% level. Therefore, the result of the DiD-regressions is consistent with Uppsalahem's observations. In the conditional regression, it is prominent that other environmental valuations impacted the outcome variable which could help identify other changing factors due to the nudges.

The nudges have likely had a positive effect on tenants' possibility to act environmentally friendly, including waste sorting and their enhanced knowledge regarding PEAs.

This could not be established without control variables nor on a 99% significance level. There are several potential reasons for this. Firstly, the outcome variable is the answer to the grading alternative: *my possibility to act environmentally friendly*. This formulation is the most consistent available variable aligning with the research question, as explained in subsection 5.2 Methodological application. Accordingly, the tenants do not seem to recognize how much the nudges have affected their possibilities. As the survey is sent out one year apart, people might forget how the implemented changes has affected them influencing the respondent's answer. Additionally, Uppsalahem reports that 22% of tenants move in and move out every year of which 22 % do not have any baseline scenario to compare with. Thus, about 1/5 of tenants has an unknown background of their perceived possibility to act environmentally friendly which could influence their perception when answering the survey. This is not recognized when using control variables in the DiD-regression, as the demographics did not change.

Secondly, As the data is based on self-reports, the risk of self-image preservation is excluded by asking tenants about their ability to sort waste rather than their approximate level of waste sorting. On the other hand, the outcome variable becomes subjective and is not easily interpreted. A question more straightforward, asking directly about tenants' behaviour would potentially have been more desirable in this paper.

Thirdly, as argued by Flygansvær et al (2021), it is difficult to change individuals' valuation of waste sorting in comparison to changing their behaviour. Adding tools, such as the in-house sorting system facilitates the effort of sorting without demanding as much personal motivation. It is possible that the reported effect on nudges does not coincide with this study's result due to tenants' not recognizing their change in behaviour or the possibility to act environmentally friendly due to their mitigating effort caused by the nudges.

Fourthly and lastly, I cannot statistically confirm the parallel trend assumption. Without any information of previous years' trends or levels it is currently impossible to verify that the chosen control group is a suitable counterfactual to Bäcklösa. It is likely that the parallel trend assumption is violated as the effect size of the unconditional DiD-regression imply that other factors explain the change in the outcome variable.

Albeit the data used in this paper is very limited, there is good reason to believe that the nudges have affected waste sorting and increased their knowledge about waste sorting, although the tenants' perception of their possibility to act environmentally friendly could not be established. This is because the nudges are consistent with earlier findings and implementations. Uppsalahem has facilitated source sorting by handing out sorting bags and more clearly defined which source is to be sorted in the respective container. Likewise, they have handed out information about the environmental benefits of waste sorting. Several studies argue that such implementations enhance PEAs (Wang et al 2020; Sewak et al 2021). The group of females assigned to clean and correct sorting mistakes, and the indirect message of Uppsalahem's expectations on their tenants through information and in-house sorting bags all increase the social pressure (Flygansvær et al 2021; Nyborg et al 2006).

Furthermore, Uppsalahem plans on introducing more projects such as building a second environmental house and a "Living in a Uppsalahem household"- school.

The environmental house increases the facilitation of waste sorting with a shorter distance to the waste station. The school is implemented so that newly moved in tenants get the chance to increase their knowledge regarding Uppsalahem's values including the expectations of tenants' waste sorting. The school induces an additional aspect of behavioural motivation, namely the social norm or peer pressure which has been reported to have a great effect in earlier literature (Sewak et al 2021; Zheng et al 2020; Linder et al 2018; Wang et al 2020). The social norm is embedded in closely built areas and enhanced by being urged by Uppsalahem to waste sort through their nudges. Additionally, social norms can be enhanced through neighbours attending the same school and developing a personal relationship with other tenants and are directly exposed to the Uppsalahem's expectations. It is also argued that habits, such as waste sorting, are easier to change whilst undergoing life changes, such as moving to a new apartment (Darnton et al 2011).

## 8.2 Conclusion

The research question of this study is: *Has Uppsalahem's nudge changed tenants' perception of their ability to sort waste?* The finding is that tenants' perceptions did increase (12.6%) in the standard DiD-regression, but the effect size cannot be established on a 90% significance level. When adding other environmental valuations of the tenants, the nudges' effect size increase (21%) and is significant at a 90% level. According to Uppsalahem's anecdotal observations, their actual waste sorting has increased. Uppsalahem's observations align with this study's result and tenants' perception of their possibility to act environmentally friendly.

The result cannot be interpreted with certainty of either effect size nor the variance in of the included variables. This can either mean that tenants do not recognize their behavioural change with an operative discrepancy between intention and behaviour or, that the gathered survey answers were unable to create serviceable data.

This paper contributes to the literature through insight in tenants' perception of nudges aiming of increasing pro environmental actions and how its results can differ dependent on the studies' location, context, and applied method. Perception is a hard variable to measure, although important to integrate when aiming for improvement in pro environmental actions on individual level and moreover the public good. To further evaluate the effect of nudges, waste weights should be included to measure the behavioural changes.

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## Popular science summary

Intresset för hållbarhet har ökat på senare tid där flera styrmedel har införts för att minska miljöförstöringen. Ett mindre finansiellt krävande styrmedel som används mer och mer är nudging. En nudge är ett instrument som försöker främja visst beteende hos invånare utan att påverka deras ekonomiska incitament eller genom att förbjuda andra alternativ. Ett bostadsbolag i Uppsala har infört nudging i ett av sina kvarter eftersom det var få av hyresgästerna som sopsorterade med målet att öka sopsorteringen. Under bostadsbolagets fältbesök har de observerat en ökad nivå av sopsortering till följd av nudgen, men det finns ingen tillgänglig data för att verifiera denna förändring. I denna uppsats utvärderas i stället hyresgästers uppfattning av förändringen som skett sedan nudgen. Detta har genomförts genom att jämföra hyresgästers årliga enkätsvar före och efter nudgen. Den variabel vald för att mäta effekten av nudgen är "möjligheten att agera miljövänligt" eftersom den både mäter hyresgästers uppfattade sopsortering-möjlighet, samt förståelsen för varför man ska sopsortera. 12 andra närliggande områden har använts som kontrollgrupp att jämföra med området som genomgått nudgen. Resultatet visade en positiv effekt av nudgen på hyresgästers uppfattade möjlighet att agera miljövänligt. Resultatet överensstämde således med bostadsbolagets oregistrerade observationer även om effektstorleken inte kan fastställas på grund av insignifikanta resultat och bristfällig data. Bostadsbolaget planerar att införa fler möjligheter att avfallssortera i framtiden, vilket sannolikt kommer att bidra till en högre övertygelse om dess effekt hos hyresgäster. Insikter från denna studie kan hjälpa till att vägleda framtida nudge-implementering och dess effekt på hyresgästernas uppfattning i närområden.

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# Appendix 1

Uppsalahem Survey						
UHs waste management?		Bad	Not so good	Good	Very good	
Possibility to sort by source?		Bad	Not so good	Good	Very good	
UH's cleaning of the environmental house?		Bad	Not so good	Good	Very good	
Your possibility to act environmentally friendly?		Bad	Not so good	Good	Very good	
UHs effort to contribute to sustainability?		Bad	Not so good	Good	Very good	
Neighbour contact?		Bad	Not so good	Good	Very good	
Household size?	1	2	3	4	5+	
Household income? (sek)	0 - 9 999	10 000 – 19 000	20 000 – 29 000	30 000 – 39 000	40 000+	No answer
Gender?	Male	Female	Other			No answer

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