Household recycling behaviour in South Africa: Evidence from the 2018 General Household Survey

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Abstract

This paper is an investigation of the determinants of household recycling behaviour in South Africa. Waste generation around the world is growing exponentially. The proportion of South African households who recycle is very low and landfilling is the primary method of waste disposal. This is problematic because landfilling has a negative impact on the environment and human health. Therefore, alternatives to landfilling, like recycling are necessary. Thus, it is important to understand what determines recycling behaviour. A probit regression analysis was carried out using data from the 2018 General Household Survey in order to understand household recycling behaviour. The results of the regression suggest that age, race, province, urban-rural residence, the presence of a radio in the household, and owning a vehicle are significantly correlated with household recycling behaviour ($p<.01$). Additionally, gender, marital status and household income are also significantly correlated with household recycling behaviour. However, the relationship is weaker ($p<.10$). Surprisingly, education, employment, dwelling-type, tenure and the presence of a school child in the household have no effect on recycling participation. These results can help policy-makers understand what factors influence recycling behaviour and help them develop and implement effective policies that optimise recycling activity.

1 Introduction

Economic development, population growth and increased rates of urbanisation around the world has resulted in dramatic increases in waste generation. In many developing countries, the majority of waste generated is landfilled. For example, 90% of the waste generated in South Africa is sent to landfill sites (Statistics South Africa [Stats SA], 2019). However, this method of disposal negatively impacts environmental quality and human health. Furthermore, waste materials are by-products of scarce natural resources. These are often costly to extract and can have secondary-use values which are unable to be recovered

when waste is landfilled. Thus, to conserve resources, reduce reliance on landfills and combat the environmental and health problems associated with traditional waste disposal methods (land-filling, incineration and illegal dumping) there has been a shift by nations toward recycling and other waste-reduction policies (Kipperberg, 2007). Establishing and implementing effective waste management policies and programmes are necessary to address the significant increase in waste being produced by countries around the world.

The Department of Environmental affairs (DEA) is mandated to ensure a safe and healthy environment for all those living in South Africa, this is a constitutional right. Thus, to uphold this right the DEA promulgated the National Environmental Management: Waste Act 59 of 2008 and developed the National Waste Management Strategy (NWMS) in 2010 (Department of Environmental Affairs [DEA], 2020). Recycling has become increasingly important in the integrated waste management system in South Africa. However, up-take is low which is characteristic of many developing nations. For example, in 2018 South Africans consumed 1 876 250 tons of plastic products converted from polymer.[1] However, only 352 000 tons of plastics was recycled into raw material (18.76%) (Plastics SA, 2019).

This paper is an investigation of the determinants of household recycling behaviour in South Africa. This is undertaken by performing a probit regression analysis, using data from the 2018 General Household Survey. Establishing which factors influence household recycling behaviour is important for evaluating the performance of current policies as well as designing future policies. The remainder of the paper is structured in the following manner: Section 2 reviews some of the empirical studies of household recycling. Section 3 presents the methodology used in this paper. The empirical results are reported in section 4 and concluding remarks are provided in Section 5.

2 Literature review

The literature on recycling behaviour can generally be divided into two categories: interventionist and correlational. According to Scott (1999), studies which are concerned with manipulations of specific antecedent and/or consequent conditions are included in the first category (interventionist). [2] On the other hand, studies concerned with identifying variables that differentiate those who recycle from those who do not recycle. Moreover, those examining the relationship between the decision to recycle and its determinants are included in the secondary category (correlational). This paper falls under the second group of studies.

[1] A natural or synthetic chemical compound with large molecules made of many smaller molecules of the same kind.

[2] Porter, Leeming, and Dwyer (1995) provide a thorough review of this behaviour-intervention literature.

2.1 Demographics

Policy makers cannot influence socio-demographic variables. Nevertheless, using certain socio-demographic attributes one can classify a community into areas of varying recycling potential and consequently devise strategies to encourage participation at each level of recycling potential (Lansana, 1992).

Studies on household recycling behaviour have found differing results on the association between recycling behaviour and socio-demographics. The ambiguity in the findings, suggests that no firm hypotheses can be framed about socio-demographic effects (Yangsoo, Hartloff & Meyer, 1999). To get a clearer picture of the inconsistent findings, the sub-sections presented below look in detail at the findings of various studies in terms of demographic characteristics. These include: income, age, gender, education, urban-rural residence, housing tenure, marital status and race.

2.1.1 Income

Vining & Ebreo (1990) compared recyclers and non-recyclers in Champaign and Urbana, two communities located in Illinois.[3] They found a significant association between recycling and higher income levels ($p < 0.05$). This result is supported by Oskamp et al. (1991) and Jenkins et al. (2003).[4] However, the latter study found that household income had a significant and positive effect on the intensity of recycling effort for newspaper only.[5] In addition, Owens, Dickerson & Macintosh (2000) found that recycling efficiency was significantly lower among households with lower levels of income ($0.05 < p < 0.1$). [6] The positive association between income levels and recycling behaviour may be owing to households with higher income levels having better access to information or having relatively more recyclable material than households with lower income levels (Lansana, 1992). Similar to Vining & Ebreo (1990), Lansana (1992) compared recyclers and non-recyclers using four sets of variables.[7] She performed discriminant analysis using data from two communities in Broome County, New York, where a pilot recycling programme had been introduced. [8] However, unlike Vining & Ebreo (1990), Oskamp et. al (1991) and Jenkins et al. (2003),

[3]Recyclers were identified as those respondents who indicated that they had recycled some material within the past year and non-recyclers as those respondents who indicated that they had not done so (Vining & Ebreo, 1990).

[4]Studied the impact of two popular waste programmes (curbside and volume-based pricing) on the rate of recycling of several materials.

[5]Recycling intensity is calculated as a percentage of each material recycled. Materials include: glass bottles, plastic bottles, aluminium, newspaper and yard waste.

[6]Recycling efficiency for each household was calculated as the weight of recyclables divided by the total weight of recyclables and recoverables observed in their recycling and trash containers. RE was assumed to be zero for homes that did not set out a recycling bin.

[7]The sets of variables included: demographic characteristics, knowledge of the local recycling program, perception of programme policies and problems and attitudes toward the environment.

[8]Recyclers were identified as those who participated in the pilot programme during the first 8 months and/or succeeding 12 months of the survey design. Respondents who did not participate at all were classified as non-recyclers(Lansana, 1992).

the findings of the paper suggested that there was no significant difference between recyclers and non-recyclers based on their income level. This finding is supported by: Derksen & Gartrell (1993) who found no significant correlation between recycling participation and higher levels of income; Scott (1999) who found that income did not significantly predict recycling intensity [9] and Budak & Oguz (2008) who found no significant relationship between household income and participation in a pilot recycling programme in Turkey.

More recent studies such as Collins, O'Doherty & Snell (2006), Chee & Narayanan (2006), Fiorillio (2013), Oyekale (2015) and Oyekale (2018) have produced less ambiguous results. These studies found a clear positive relationship between income and recycling. Collins, O'Doherty & Snell (2006) used national survey data from the Scottish Household Survey of 2000 and 2001 to empirically investigate household recycling participation. A logit analysis was undertaken and the results reported a significant positive relationship between household income and recycling participation. The authors hypothesised that income is a likely determinant of household recycling for several reasons. Firstly, it is a proxy for an education effect. Secondly, increased income allows for the ability to buy equipment to store recyclables and offers a means to transport materials (i.e. purchase bigger cars). Finally, recycling requires time and effort so the greater the potential loss of earnings and value of leisure time the greater the opportunity cost associated with recycling. Chee & Narayanan (2006) investigated individual recycling behaviour in Penang Malaysia and also performed a logit analysis. They, too found that income is positively related to recycling behaviour. However, unlike Collins, O'Doherty & Snell (2006) no formal sampling methods were adopted to obtain the sample. This can be problematic as there is no guarantee that the sample is representative of the population. Like Collins, O'Doherty & Snell (2006), Fiorillio (2013), Oyekale (2015) and Oyekale (2018) used national survey evidence to investigate recycling behaviour. However, probit analyses were carried out instead of a logit analyses. Fiorillio (2013) investigated the determinants of household recycling in Italy and the probit results showed a positive relationship between household income and household recycling. This finding is supported by Oyekale (2015), who performed a bivariate probit analysis to investigate the payment of waste disposal and recycling in South Africa as well as Oyekale (2018) who used a two-stage probit analysis to investigate household recycling in South Africa. [10]

2.1.2 Age

Using national survey evidence Mohai (1987) found that age is the variable most strongly related to environmental concern. A negative relationship was found implying that younger individuals are more environmentally concerned.

[9] Recycling intensity was measured on a scale that ranged from "always recycled this material" to "never recycled this material", there were 12 eligible materials which could be recycled (Scott, 1999).

[10] Household income was found to be endogenously determined thus, a two-stage probit anlaysis was carried out. An ordinary probit analysis would of yielded biased estimates.

Despite this, environmental consciousness does not necessarily translate into pro-environmental behaviour (see section 2.2.3 of this paper). Vining & Ebreo (1990) found that recyclers were older than non-recyclers ($p<.01$), which was contrary to their hypothesis. Similarly, Lansana (1992) found that recyclers were more likely to be in the age groups of 40 to 64 than non-recyclers were. Albeit, Oskamp et al. (1991) found no significant differences between recyclers and non-recyclers on the basis of age. Derksen & Gartrell (1993) and Jenkins et al. (2003) both found that age had a weak positive effect on recycling. [11] Furthermore, Scott (1999) found that age was the only demographic variable that significantly predicted recycling intensity. Two possible explanations provided for the positive relationship were found. These included: the greater availability of time to recycle when individuals are older and the influence of the Depression and wartime material conservation on older generations.[12] More recent studies such as Fiorillio (2013) and Oyekale (2015) have also found a positive relationship between age and recycling behaviour. Nonetheless, Owens, Dickerson & Macintosh (2000), Budak & Oguz (2008) and Oyekale (2018), found an insignificant relationship between age and recycling behaviour.

2.1.3 Gender

Gender is not an important factor in explaining recycling participation according to Vining & Ebreo (1990), Oskamp et al. (1991), Owens, Dickerson & Macintosh (2000), Meen-Chee & Narayanan (2006), Oyekale (2015), Kirakozian (2016) and Oyekale (2018) .[13] Despite these papers agreeing that gender is insignificant, the sign of the coefficients differed amongst the studies. In some studies the sign suggested men are more likely to recycle than women [14] and in others the sign suggested the reverse. [15] However, as mentioned the coefficients turned out to be statistically insignificant. Contrary to the general consensus, Fiorillio (2013) found gender to be an important predictor of recycling behaviour. The results suggested that being a woman significantly increased the probability of recycling paper, glass, plastic, aluminium and food waste ($p<.01$). Schann & Holzer (1990) also found recycling participation to be higher among women than men.

2.1.4 Education

Vining & Ebreo (1990), Oskamp et al. (1991), Scott (1999) and Budak & Oguz (2008) all found the level of educational attainment to be insignificant in determining recycling behaviour. Nevertheless, Lansana (1992) found that recyclers were more likely to have at least 7-12 years of education than non-recyclers were.

[11] Jenkins et al (2003) found that age had a positive but small impact on recycling intensity for all materials except for glass bottles.

[12] See explanation in Scott (1999).

[13] Oyekale (2018) found that gender is statistically insignificant in all models expect in the unweighted results for the conditional regression on urban households.

[14] See Oyekale (2015) and Kirakozian (2016).

[15] See Meen-Chee & Narayanan (2006) and Oyekale (2018).

Derksen & Gartrell (1993), Owens, Dickerson & Macintosh (2000)[16], Jenkins et al. (2003), Fiorillio (2013) and Oyekale (2015) found a significantly positive relationship between the level of educational attainment and recycling. However, Derksen & Gartrell (1993) and Jenkins et al. (2003) found that educational attainment had a small effect on recycling.[17] Meen-Chee & Narayanan (2006) were forced to drop the education variable owing to multicollinearity between education and income. In spite of that, they suggested that education is important for recycling and hypothesised a positive relationship. However, Oyekale (2018) found that greater levels of educational attainment reduced the probability of recycling for South Africa as a whole and among rural households in South Africa. [18] The author attributes the negative relationship to the fact that poor people often take recycling jobs. Moreover, these people often belong to the most deprived group in society i.e. those with low levels of education.

2.1.5 Urban versus Rural residence

Tremblay & Dunlop (1978) investigated three hypotheses related to rural-urban residence. The results suggested that rural-urban residence is an important variable to consider when examining environmental concern. However, as mentioned earlier environmental concern does not necessarily translate to pro-environmental behaviour e.g. recycling. Derksen & Gartrell (1993) hypothesised that average levels of recycling would be low in areas that provide little support for recycling i.e. rural areas. Thus, the authors expected recycling to be lower in rural areas than in urban areas, which generally have stronger institutionalised support for recycling. The results were in line with their hypothesis as urban-rural residence was found to have a significant but small effect on recycling. Collins, O'Doherty & Snell (2006) found that the probability of recycling was significantly reduced for households living in very remote areas in Scotland compared to households living in the cities ($p<.05$). Similarly, Fiorillio (2013) found that households living in Southern Italy were less likely to recycle than those households living in Northern Italy ($p<.01$). Southern Italy is more rural and less industrialised compared to Northern Italy (Yangsoo, Hartloff & Meyer, 1999). Contrary to the above studies Kirakozian (2016) and Oyekale (2018) found that rural-urban residence is statistically insignificant.

2.1.6 Tenure: Home-owner versus renter

Oskamp et al (1991) and Lansana (1992) found that recyclers were more likely to own their own home (as opposed to rent) than non-recyclers were. In addition, Budak & Oguz (2008) found home ownership to be a significant positive determinant of the household recycling. Thus, home-owners are more likely to

[16]Owens, Dickerson Macintosh (2000) performed a generalised linear model and Wilcoxon procedures.

[17]Jenkins et al.(2003) found a significant and positive effect for all materials except for plastic bottles and yard waste.

[18]The effect of education on recycling behaviour was insignificant among urban households in South Africa.

recycle than renters (Lansana, 1992). However, Owens, Dickerson & Macintosh (2000) found that recycling efficiency did not differ significantly between levels of home-ownership (own versus rent).

2.1.7 Marital status

Fiorillio (2013) included four dummy variables for marital status in the regression model. The dummies included: married, divorced, widowed and single (reference group). Being married was found to be statistically significant and positive in all models; at the 1% level of significance for paper, glass and plastic and at the 5% level of significance for aluminium and food waste. The divorced dummy had a negative sign in all models. It was found to be significant at the 5% level of significance for paper and at the 10% level for glass and aluminium. It was insignificant for plastic and food waste. Additionally, Oyekale (2018) found that being married was statistically significant ($p<.01$) and positive in the combined data and urban household data. [19] Thus, this suggested that being married increased the probability of recycling in South Africa as a whole and in urban households within South Africa.

2.1.8 Race

According to Schultz, Oskamp & Mainieri (1995) the relationship between ethnicity and recycling has not received much research attention. Notwithstanding, there are a few studies which have investigated the influence that race has on recycling behaviour. Owens, Dickerson & Macintosh (2000) found that recycling efficiency did not differ significantly by race. Thus, African Americans and Caucasians were equally as likely to recycle. Furthermore, Oyekale (2015) found that households who had household heads' with Indian origin were more likely to recycle than those without. Oyekale (2018) includes dummies for the four race groups in South Africa: Coloured, White, Indian and African (reference group). Results showed that Coloured, White and Indian in the combined model and urban model were positive and statistically significant ($p<.01$). Having a White household head was the only race variable that was statistically significant ($p<.01$) in the rural model. Thus, overall the results suggested that the probability of recycling was lower among households with African household heads compared to household heads who belonged to the other race groups. In addition, Meen-Chee & Narayanan (2006) included dummy race variables for Malay, Chinese and Indian individuals (reference group). The results revealed that Chinese individuals were more likely and Malay individuals were less likely to recycle than Indian individuals.

[19] In the weighted results of the rural model the married dummy is insignificant and positive.

2.2 Knowledge, perceptions, attitudes and social influence

2.2.1 Programme knowledge

Studies have also examined the impact of knowledge on recycling behaviour. According to Vining & Ebreo (1990), it is highly likely that recyclers and non-recyclers differ in what they know about recycling and how they acquired that knowledge.

Their findings suggested recyclers were better informed overall about recycling than non-recyclers. Recyclers' knowledge about locally recyclable materials was generally more accurate, and they were familiar with more local programmes and sources of information than non-recyclers ($p<.05$). [20] Lansana (1992) also found recyclers to be better informed than non-recyclers in terms of the planning operations of the recycling programme. Oskamp et al. (1991) found that conservation knowledge was significantly higher among curbside-recyclers than non-recyclers and results of a multivariate regression revealed conservation knowledge to be a significant predictor of recycling. Oskamp et al. (1991) examined the effect of general conservation knowledge on curbside recycling whereas Gamba & Oskamp (1994) looked at specific knowledge about the materials that were recyclable and found that it predicted curbside recycling. This is supported by Lansana (1993) who found that a person's knowledge of the local recycling program, particularly where to recycle and what types of materials are eligible, is an important factor influencing recycling participation. The author suggested that household awareness of the recycling programme is crucial because it alleviates some of the economic concerns that residents express towards recycling. The greater the awareness about the programme and its associated environmental benefits, the less likely the residents will complain about the time involved and the inconveniences or lack of knowledge about the number of items to separate from their garbage. Meen-Chee & Narayanan (2006),Vicente & Reis (2008), Budak & Oguz (2008) all agreed that those who were better informed had a greater propensity to participate in recycling than those who were not so well informed. Budak & Oguz (2008) found knowledge to be the most statistically significant factor in determining whether a household will participate in recycling or not ($p<.001$). However, Scott (1999) found that knowledge pertaining to the recycling programme in the study did not significantly predict recycling behaviour despite finding that those who had read the waste calendar [21] recycled a significantly greater number of materials than those that did not ($p<.01$)

[20] Recyclers reported that they had heard about recycling from more sources than non-recyclers ($p<.05$).

[21] Provided information on several waste diversion programmess including what materials were collected, recycling techniques and when special collections occurred.

2.2.2 Policy perceptions

Researchers have examined households perception of programme policies in terms of the time, effort, storage space and other requirements imposed by participation (Lansana, 1992). Vining & Ebreo (1990) found that non-recyclers believed that nuisance and household inconvenience were more important reasons for not recycling than did recyclers. Non-recyclers also thought that economic incentives and rewards were more important than recyclers thought. Several collection methods have been examined, such as curbside recycling, drop-off recycling and buy-back centres. Accessibility and convenience to the participating households were found to be critical factors in selecting these methods. The situational context (convenience of the programme) is critical for recycling participation (Scott,1999). Lansana (1992) found that many households did not favour the use of drop-off sites as collection points, rather curb-side strategies were preferred. Scott (1999) also found a preference toward curbside recycling. 48% of respondents said that they would recycle less if the curbside recycling programme were to be cancelled and replaced by a system of neighbourhood drop-off depots. Jenkins, et al. (2003) found that the curbside recycling programme had a bigger effect on recycling behaviour than the drop-off programmes. Kipperberg (2006) found that the availability of curbside recycling and drop-off recycling in Norway both had a positive effect on recycling behaviour but for different types of recyclable materials. [22] In addition, the effects of voluntary or mandatory policies on recycling behaviour have been investigated. Lansana (1992) found that recyclers preferred mandatory recycling programmes and suggested the preference could be because such a policy acts as a commitment device; it ensures everyone in the community recycles. Nevertheless, Jenkins et al.(2003) found that mandatory as opposed to voluntary recycling programmes had an insignificant effect on recycling behaviour.

2.2.3 Environmental attitudes

Research has also focused on attitudes as determinants of recycling activity with a particular focus on the link between environmental attitudes and behaviour. Environmental attitudes have been described as the individual's beliefs, values, and feelings with regards to particular aspects of the environment or issues related to it (Lansana, 1992). Pro-environmental attitudes tend to show a low positive relationship to specific actual behaviours (Yangsoo, Hartloff & Meyer,1999). In other words, there can be large disparities in expressed attitudes and actual behaviour. Vining & Ebreo (1990), Lansana (1992) and Scott (1999) found that non-recyclers were no different than recyclers in the strength of their belief that protecting the environment was an important reason to recycle. This is supported by Oskamp et al. (1991) and Gamba & Oskamp (1994) who found that general environmental attitudes or behaviours did not predict participation in the local curbside recycling programmes they

[22] Curbside recycling had a positive effect on paper, plastics, and food waste recycling intensities and the availability of drop-recycling affected glass recycling.

were investigating. Although Oskamp et al. (1991) found that general pro-environmental attitudes did not predict curbside recycling behaviour they did find that attitudes specific to recycling did. They suggested that it cannot be assumed that environmentally concerned citizens will be more likely to recycle because there are many discrete and separate patterns of environmentally conscious attitudes and behaviours. On the other hand, Derksen & Gartrell (1993) hypothesised that concern for the environment should have an effect on recycling but only among urban households with access to a regular recycling programme. Individuals who have access to the programme and who express high levels of concern should recycle more. The results of their study were in line with their hypothesis. Environmental concern alone was not a significant predictor of recycling. However, the interaction of environmental concern with the presence of a recycling programme was. Thus, individual attitudes towards the environment affect recycling behaviour only in communities with easy access to a structured recycling programme. Contrary to the findings of Vining & Ebreo (1990), Lansana (1992), Scott (1999), Oskamp et al. (1991) and Gamba & Oskamp; Meen-Chee & Narayanan (2006) Vicente & Reis (2008), Fiorillio (2013) and Kirakozian (2016) all found that environmental attitude/concern does in fact matter for recycling behaviour.

2.2.4 Social influence

Social influence is another factor that has been examined by researches as potentially influencing recycling activity. According to Vining, Linn & Burdge (1992), social influence is defined as family members, neighbours or friends support for recycling. They suggested pressure to recycle can result from family members', neighbours' and friends' perceptions about an individual's or household's behaviour. In a more positive sense, social facilitation may occur when friends, family members or neighbours encourage particular behaviour in this case recycling behaviour. Conversely, lack of support from members of one's household may increase pressure not to recycle.

Vining & Ebreo (1989) found that social pressure was reported to be the least important reason for recycling in a study of a small community with a curbside recycling programme. However, other studies contradicted this finding. Some of these studies include Oskamp et al. (1991), Hornik et al. (1995), Vicente & Reis (2008) and Kirakozian (2016). Oskamp et al. (1991) and Hornik et. al (1995) found that recycling by friends and neighbours is a strong predictor of recycling behaviour. Suggesting that peer influence (pressure or support) is an important consideration in some people's decision to recycle and encourages recycling behaviour (Scott, 1999). Vicente & Reis (2008) found that attitudes about social and personal norms have the strongest positive effect on recycling participation. This means that when citizens feel a strong obligation to recycle or feel bad if they do not co-operate with recycling or when they are convinced that recycling is a task for everyone (friends, family members and neighbours) the propensity to co-operate with recycling is higher. Interestingly, Kirakozian (2016) found that social influence has a significant and negative effect on recy-

cling. Meaning that neighbours negatively influence recycling behaviour. This is quite strange as one would assume that social influence has a positive impact on people's recycling behaviours. [23]

2.3 Household characteristics

2.3.1 Household size

Vining & Ebreo (1990), Scott (1999), Owens, Dickerson & Macintosh (2000) and Budak & Oguz, (2008) found that household size does not significantly determine recycling behaviour. Contrary to the studies above, Jenkins et al. (2003) found that household size had a significant and positive effect on recycling efforts for glass bottles and yard waste.

2.3.2 Type of dwelling: Single-family versus multi-family

Jenkins et al. (2003) found that residents of single-family dwellings are substantially more likely to recycle larger quantities of their yard waste than residents of multi-family dwellings. Moreover, Derksen & Gartrell (1993) found that single family dwellings recycle about 1/3 more of an item than residents in multi-family dwellings. They results suggested that living in a single-family dwelling was the strongest predictor of participation in the curbside recycling programme they were investigating. Similarly, Oskamp et al, (1991) found that the most important variable determining recycling participation was the demographic characteristic of living in a single-family house. The results revealed that separate house dwellers were more likely to recycle than residents of condos, apartments or mobile homes. A possible explanation is that single-family dwellings have more storage space for recyclable materials. Budak & Oguz (2008) found that living in a an apartment building where custodial service was available was a significant determinant of household recycling participation.

[23] See page 1493 for a possible explanation for the negative relationship that was found.

3 Methadology

3.1 Data

The dataset used in this paper is generated from the 2018 General Household Survey (GHS) and was obtained from DataFirst.[24] The GHS is an annual household survey produced by Statistics South Africa. The target population of the survey consists of all private households in all nine provinces of South Africa and residents in workers' hostels.[25] The GHS measures the living circumstances of South African households and includes both household and individual characteristics.[26]

Section 1 to 5 of the questionnaire covers specific characteristics of each person in the household whereas section 5 to 10 of the questionnaire covers general information regarding the household. As a result a person and household dataset was produced from the questionnaire. The person dataset has 71 137 observations and contains variables at the individual level. The household dataset has 20 908 observations and contains variables at the household level. The two data files also contain some derived variables. Although this paper is evaluating household recycling and thus carrying out the investigation at the household level, the person and household datasets have been merged to form one cross-sectional dataset. This allows individual characteristics (such as gender, age and education) of the household members in particular the household head to be included in the study. Information pertaining to waste management and refuse removal which comes from section 5 of the questionnaire is the primary focus of this paper.

To describe and analyse the complex sample survey data (ssd), clustering, weights and stratification have been taken into account.[27] This allows the results reported in the descriptive statistics section and empirical section of this paper to be interpreted as nationally representative. Thus, this paper is able to comment specifically on the recycling behaviour of South African households.

According to StatsSA (2018), the GHS uses a Master Sample (MS) frame developed in 2013 as a general purpose sampling frame.[28] The sample for the GHS is based on a stratified two-stage design with probability proportional to size (PPS) sampling of primary sampling units (PSUs) in the first stage, and sampling of dwelling units (DUs) with systematic sampling in the second stage.

[24] DataFirst is a research data service based at the University of Cape Town (UCT) that provides open access to data from South Africa and other African countries.

[25] The survey does not cover other collective living quarters such as students' hostels, old-age homes, hospitals, prisons and military barracks, and is therefore only representative of non-institutionalised and non-military persons or households in South Africa (Stats SA, 2018).

[26] The GHS collects data on education, health, and social development, housing, access to services and facilities, food security, and agriculture (Stats SA, 2018).

[27] The PSU, person_wgt and stratum variables contained in the dataset are used as the cluster, weight and strata respectively. The PSU variable is the primary sampling unit, house_wgt are weights applied to each person in the household and the Stratum variable is based on province, metropolitan area and geography type (Stats SA, 2018).

[28] The master sample is based on information collected during the 2011 Census conducted by StatsSA.

After allocating the sample to the provinces, the sample was further stratified by geography (primary stratification), and by population attributes using Census 2011 data (secondary stratification)[29].

3.1.1 Descriptive statistics

[30]

Table 1 below presents descriptive statistics for the variables hypothesised to influence household recycling. Column (1) reports the overall mean values for South African households, column (2) reports the mean values for South African households who recycle and column (3) reports the mean values for South African households who do not recycle.[31] In addition, a mean comparison test (ttest) is performed to determine whether the difference between the two groups (households who recycle versus households who do not recycle) are statistically significant. Column 4 reports the difference between the two groups (column (2)-(3)) and whether the difference is statistically significant at the 1%(*), 5%(**) or 10%(***) level of significance. The t-statistic is reported in column (5).

Table 1:Descriptive Statistics

Variable	(1) Total	(2) Recycle	(3) Do not recycle	(4) Difference	(5) t-stat
Recycle (y)	0.1792	-	-	-	-
	(0.0049)	-	-	-	-
Female	0.416	0.375	0.426	-0.0512***	-4.84
	(0.0038)	(0.0097)	(0.0042)	(0.0106)	
Age	45.72	47.86	45.29	2.572***	7.05
	(0.134)	(0.3350)	(0.1459)	(0.3649)	
African	0.809	0.631	0.847	-0.216***	-15.43
	(0.0035)	(0.0128)	(0.0026)	(0.0140)	
Coloured	0.0714	0.0965	0.0665	0.0300***	3.70
	(0.0022)	(0.0071)	(0.0038)	(0.0081)	
Indian or Asian	0.0243	0.0303	0.0232	0.00712	1.54
	(0.0017)	(0.0042)	(0.0018)	(0.0046)	
White	0.0949	0.242	0.0632	0.179***	15.52
	(0.0029)	(0.0110)	(0.0027)	(0.0115)	
Mean edu<7	0.373	0.296	0.389	-0.0932***	-8.96

[29]See Stats SA (2018) for a detailed explanation of the survey's sampling procedures.
[30]See appendix for variable description
[31]Mean values for binary variables are interpreted as percentages.

Table 1 continued

Variable	(1) Total	(2) Recycle	(3) Do not recycle	(4) Difference	(5) t-stat
	(0.0039)	(0.0093)	(0.0043)	(0.0104)	
7< Mean edu<12	0.528	0.533	0.527	0.00559	0.51
	(0.0041)	(0.0100)	(0.0045)	(0.0110)	
Mean edu >12	0.0991	0.171	0.0835	0.0876***	8.73
	(0.0028)	(0.0095)	(0.0028)	(0.0100)	
Mean employed	0.430	0.461	0.421	0.0393***	4.34
	(0.0035)	(0.0082)	(0.0039)	(0.0091)	
Married	0.460	0.548	0.441	0.107***	10.06
	(0.0040)	(0.0098)	(0.0043)	(0.0106)	
Western Cape	0.113	0.219	0.0909	0.128***	11.04
	(0.0024)	(0.0104)	(0.0028)	(0.0116)	
Eastern Cape	0.101	0.0768	0.107	-0.0300***	-3.92
	(0.0018)	(0.0063)	(0.0024)	(0.0076)	
Northern Cape	0.0205	0.0131	0.0225	-0.00936***	-3.48
	(0.0006)	(0.0022)	(0.0008)	(0.0027)	
Free State	0.0541	0.0456	0.0560	-0.0105	-1.42
	(0.0012)	(0.0062)	(0.0017)	(0.0074)	
Kwa-Zulu Natal	0.174	0.0696	0.196	-0.127***	14.44
	(0.0027)	(0.0071)	(0.0035)	(0.0088)	
North West	0.0726	0.0794	0.0715	0.00787	0.94
	(0.0016)	(0.0072)	(0.0022)	(0.0084)	
Gauteng	0.293	0.407	0.266	0.142***	8.23
	(0.0037)	(0.0147)	(0.0048)	(0.0172)	
Mpumalanga	0.0773	0.0734	0.0786	-0.00521	-0.64
	(0.0014)	(0.0067)	(0.0021)	(0.0081)	
Limpopo	0.0947	0.0157	0.112	-0.0960***	-26.26
	(0.0017)	(0.0024)	(0.0022)	(0.0037)	
Urban	0.699	0.849	0.666	0.184***	15.87
	(0.0038)	(0.0098)	(0.0046)	(0.0116)	
Single-family dwelling	0.820	0.831	0.818	0.0131	1.20

Table 1 continued

Variable	(1) Total	(2) Recycle	(3) Do not recycle	(4) Difference	(5) t-stat
	(0.0043)	(0.0100)	(0.0047)	(0.0109)	
Informal single-family dwelling	0.132	0.110	0.137	-0.0275***	-3.07
	(0.0036)	(0.0078)	(0.0041)	(0.0089)	
Multi-family dwelling	0.0475	0.0589	0.0445	0.0144*	1.90
	(0.0029)	(0.0073)	(0.0030)	(0.0076)	
Home-owner	0.632	0.571	0.648	-0.0776***	-5.09
	(0.0056)	(0.0139)	(0.0061)	(0.152)	
Household income	10726.0	15642.1	9673.1	5969.0***	15.57
	(112.34)	(354.54)	(119.01)	(383.45)	
Household size	3.235	3.182	3.249	-0.0673	-1.46
	(0.0184)	(0.0415)	(0.0205)	(0.0463)	
Presence of school child	0.448	0.409	0.458	-0.0494***	-4.38
	(0.0041)	(0.0103)	(0.0045)		(0.0113)
Cell-phone	0.966	0.971	0.964	0.00716**	2.22
	(0.0013)	(0.0028)	(0.0015)	(0.0032)	
Tv	0.822	0.889	0.807	0.0820***	10.14
	(0.0036)	(0.0072)	(0.0040)	(0.0081)	
Subscription	0.447	0.561	0.423	0.139***	10.53
	(0.0046)	(0.0122)	(0.0050)	(0.0132)	
Computer	0.215	0.389	0.177	0.212***	17.25
	(0.0037)	(0.0113)	(0.0039)	(0.0123)	
Radio	0.526	0.622	0.505	0.116***	8.25
	(0.0056)	(0.0132)	(0.0060)	(0.0141)	
Vehicle	0.306	0.495	0.266	0.228***	17.14
	(0.0040)	(0.0120)	(0.0044)	(0.0133)	
No/irregular refuse removal	0.272	0.212	0.285	-0.0731***	-5.83
	(0.0061)	(0.0110)	(0.0125)	(0.0125)	
Litter	0.347	0.280	0.361	-0.0808***	-5.93
	(0.0066)	(0.0122)	(0.0074)	(0.0136)	
Water pollution	0.155	0.105	0.166	-0.0609***	-6.76

Table 1 continued

Variable	(1) Total	(2) Recycle	(3) Do not recycle	(4) Difference	(5) t-stat
	(0.0051)	(0.0079)	(0.0057)	(0.0090)	
Air pollution	0.189	0.167	0.194	-0.0263**	-2.42
	(0.0057)	(0.0098)	(0.0063)	(0.0109)	
Land degradation	0.327	0.288	0.337	-0.0490***	-3.51
	(0.0064)	(0.0124)	(0.0072)	(0.0140)	
Noise pollution	0.142	0.120	0.145	-0.0254**	-2.77
	(0.0049)	(0.0082)	(0.0055)	(0.0092)	

(author's calculations based on 2018 GHS)

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

The results in table 1 reveal that only 17.92% of households living in South Africa recycle and 82.08% of households do not not recycle. 41.60% of household heads in South Africa are women and 58.4% are men. The proportion of household heads who are women is significantly less (p<.01) among households that recycle (37.50%) compared to households who do not recycle (42.60%). On average household heads are 45.72 years of age. Among households that recycle the average age is 47.86 years of age compared to 45.26 years of age among households that do not recycle. Thus, recyclers are slightly older than those that do not recycle and this difference is statistically significant (p<.01).

80.90% of household heads are African, 7.14% are Coloured, 2.43% are Indian or Asian and 9.49% are White. There is a higher percentage of household heads who are non-African among households that recycle compared to those that do not recycle (p<.01). For example among households that recycle 63.10% of household heads are African whereas 84.70% are African among households that do not recycle. The proportion of White and Coloured household heads is significantly (p<.01) higher among households that recycle (24.20% and 9.65% respectively) compared to those that do not (6.32% and 6.65% respectively). The proportion of Indian or Asian household heads does not differ significantly across the two groups (p>.10).

The majority of South African households (52.8%) average years of education is greater than 7 and less than 12. 37.30% of households have an average which is less than 7 years and only 9.91% have an average which is greater than 12. This pattern holds for recyclers and non-recyclers. In addition, there is a significantly higher(p<.01) percentage of households whose average years of education is greater than 12 among households that recycle (17.10%) compared to those that do not (8.35%). An average between 7 and 12 years of education does not differentiate recyclers from non-recyclers.

On average the mean number of people employed in a household is 43.00% ,

for households that recycle it is 46.10% and 42.10% for households that do not recycle. Thus, on average households that do not recycle have less household members in employment than households that do recycle. 46.00% of South African household heads are married. In contrast, for households who recycle 54.80% of household heads are married whereas 44.10% are married among households who do not recycle. Thus, a greater proportion of recyclers are married compared to non-recyclers ($p<.01$).

The majority of South African households reside in Gauteng (29.30%), followed by Kwa-Zulu Natal (KZN) (17.40%) and then by the Western Cape (11.3%). Only 2.05% of households live in the Northern Cape. The majority of households that recycle as well as those that do not recycle reside in Gauteng. However the proportion is significantly ($p<.01$) greater among households that recycle compared to those that do not (40.70% and 26.6%, respectively). The Western Cape is the province with the second highest percentage of households residing in it among households that recycle (21.90%) whereas KZN has the second highest percentage of households residing in it among households that do not recycle (19.6%). The difference for each province across the two groups is statistically significant, except for the Free State and North West province.

69.90% of South Africans households live in urban areas. In addition, 84.90% of households that recycle live urban areas compared to 66.60% of households who do not recycle. Thus, there is a significantly ($p<.01$) higher proportion of households living in urban areas among recyclers than non-recyclers. 82% of households are single-family dwellings, 13.20% are informal single-family dwellings (shacks) and 4.75% are multi-family dwellings. Among households that recycle 83.10% are single-family dwellings, 11.00% are informal single-family dwellings and 5.89% are multi-family dwellings. Among households that do not recycle 81.80% are single-family dwellings, 13.70% are informal single-family dwellings and 4.45% are multi-family dwellings. The difference in the percentage for informal single-family dwellings and multi-family dwellings is statistically significant at the 1% and 10% level of significance respectively. The difference for single-family dwelling is not significant. A greater percentage of households are owned among non-recycling households than recycling households (64.8% versus 57.1%)

The average household income for South African households is R10 726. It is R15 642 for recycling households and R9 673 for non-recycling households. Thus, households who recycle have a household income that is R5 690 greater than those who do not recycle and this difference is significant ($p<.01$). The average household size is 3.24 and does not differ significantly across recycling households and non-recycling households. 48.8% of households have one or more school-going children compared to 40.90% for recycling households and 45.8% for non-recycling households.

A high percentage of households across all 3 groups have a cellular telephone in the house (96.60%, 97.10% and 96.40% respectively). The percentage of households with a cell-phone, tv, subscription, computer and radio is significantly higher among recycling households than non-recycling households. 38.90% of households that recycle have a computer compared to 17.7% of house-

hold that do not recycle. In addition 62.20% of recycling households have a radio compared to 50.50% for non-recycling households. 49.50% of recycling households have at least one vehicle whereas only 26.60% of non-recycling households have a vehicle.

The majority of South African households experience the environmental problem, of littering in their community (34.70%), followed by land degradation (32.70%) and no or irregular refuse removal (27.2%). A similar pattern holds for recycling and non-recycling households. The proportion of environmental problems experienced is greater for all problems among non-recycling households than recycling households. A possible explanation is that households that recycle are already engaging in one pro-environmental behaviour and are likely to be participating in other pro-environmental behaviours e.g. anti-littering or anti-pollution behaviour. Thus, they are less inclined to experience environmental problems in their community. However, among the non-recycling households, it is likely that they are not participating in other environmental behaviour and thus these households experience more environmental problems. Communities are usually similar thus if one household is not engaging in pro-environmental behaviour other households are not either. Therefore the community is more inclined to experience environmental problems.

Overall, the majority of the differences between recyclers and non-recyclers are significant. However, the ttest does not control for the other variables. Thus, caution must be taken and it cannot be assumed that the significant variables are automatically predictors of recycling behaviour. This can only be determined after running the regression model.

3.2 Estimated model

3.2.1 Generalised linear model

When the dependent variable is binary like in this study, the linear probability model is problematic because predicted values are not constrained to be between 0 and 1. Thus, Ordinary Least Squares (OLS) would not be a suitable model to consider in this scenario. Generalising the linear probability model can be a way to deal with this problem. The generalised linear model, models the probability as a function, $G(\mathbf{x}\beta)$, where $0 < G(\mathbf{x}\beta) < 1$. The generalised linear model takes the form:

$$\Pr(y=1|x) = G(\beta 0 + \beta 1 x1 + ... + \beta k xk) = G(\mathbf{x}\beta) \quad (1)$$

where y is a binary variable equal to 1 if the household recycles and 0 otherwise. G is a non linear function , $\mathbf{x} = (1, x1, x2, .., xk)$ is a $1 \times (k+1)$ vector of regressors hypothesised to to influence the probability of recycling, $\beta = (\beta 0, \beta 1, \beta 2, ..., \beta k)$ is a $(k+1)$ vector of coefficients. It is important to mention that some variables identified in the literature as key determinants of recycling behaviour, like pro-environmental behaviour have unfortunately not been included in the model.

This is owing to the limitations of the 2018 GHS dataset which simply did not capture these variables. Thus, it is likely that omitted variable bias is present in the results presented in section 4 and caution should be taken.

3.2.2 Standard normal cumulative distribution function (Probit model)

In this paper $G(x\beta)$ is the standard normal CDF which takes the form:

$$=p(x)\equiv \mathbf{G}(\mathbf{x}\beta) = \Phi(\mathbf{x}\beta) = \int_{-\infty}^{x\beta} = \frac{1}{\sqrt{2\pi}} e^{\frac{-z^2}{2}} dz = \int_{-\infty}^{x\beta} \phi(z)dz \quad (2)$$

where Φ is the CDF of the standard normal distribution. This case is referred to as a probit model. This model is used to carry out the investigation and is preferred to OLS.

4 Empirical results

Table 2 below reports the results of the probit regression. The coefficients for the independent variables are reported in column (1) with the standard errors in parentheses. The average marginal effect (AME) is reported in column (2). When running a probit regression model, the coefficients do not have a straight forward interpretation as in other regression models. Thus, only the sign of the coefficient can be interpreted and is useful. A positive sign means that there is a greater probability of recycling whereas a negative sign means that there is a lower probability of recycling. The magnitude of the coefficients are not useful and thus the average marginal effects are reported in order to determine the change in the probability of recycling when there is change in the explanatory variables. The average marginal effect (AME) reports the change in y when x changes from 0 to 1 (binary) or when there is a small change in x (continuous). Significance is reported at the 1% (***), 5% (**) or 10%(*) level of significance. Multicollinearity and heteroskedasticity is not a concern. The mean VIF is equal to 1.78 and tests failed to reject the null hypothesis of homoskedasticity. All results reported below are interpreted on average and holding all else constant (ceteris paribus).

Table 2: Probit results

Variable	(1) Coefficient		(2) Marginal effect
Female	0.0715*	(0.0395)	0.0166*
Age	0.00305**	(0.0012)	0.000708**
Coloured	0.0625	(0.0777)	0.0145
Indian or Asian	0.375***	(0.1161)	0.0871***
White	0.582***	(0.0677)	0.135***
<7 Mean edu < 12	-0.0343	(0.0348)	-0.00797
Mean edu >12	0.0533	(0.0666)	0.0124
Employed	-0.0359	(0.0679)	-0.00832
Married	0.0663*	(0.0379)	0.0154*
Western Cape	0.138**	(0.0678)	0.0321**
Eastern Cape	-0.354***	(0.0783)	-0.0822***
Northern Cape	-0.506***	(0.1170)	-0.117***
Free State	-0.360***	(0.1130)	-0.0837***
Kwa-Zulu Natal	-0.804***	(0.0780)	-0.187***
North West	-0.109	(0.0873)	-0.0254
Mpumalanga	-0.236***	(0.0906)	-0.0548***
Limpopo	-1.046***	(0.0940)	-0.243***
Urban	0.161***	(0.0603)	0.0373***
Single-family dwelling	0.0744	(0.0993)	0.0173
Informal single-family dwelling	-0.0455	(0.1088)	-0.0106
Home-owner	-0.0114	(0.0431)	-0.00265
Household income (ln)	0.0348*	(0.0190)	0.00807*
Household size	-0.0000137	(0.0092)	-0.00000317
Presence of school child	0.0166	(0.0413)	0.00386
Cell	-0.0827	(0.0897)	-0.0192
Tv	-0.0493	(0.0535)	-0.0114
Subscription	0.0517	(0.0372)	0.0120
Radio	0.211***	(0.0363)	0.0489***
Vehicle	0.121***	(0.0414)	0.0281***
No/irregular refuse removal	0.0526	(0.0458)	0.0122
Litter	-0.0582	(0.0451)	-0.0135
Water pollution	-0.133**	(0.0579)	-0.0309**
Air pollution	0.0160	(0.0534)	0.00373
Land degradation	0.0982*	(0.0503)	0.0228*
Noise pollution	0.0312	(0.0535)	0.00724
_cons	-1.490***	(0.2048)	
N	14931		14931

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

The results reveal that gender is positive and significant at the 10% level of

significance. This finding is in line with Fiorillio (2013) and Schann & Holzer (1990) and is contrary to many of the studies which found that gender is not important in explaining recycling participation. The AME suggests that households that have women as household heads are 1.66% points more likely to recycle than households that have men as household heads. Age is significant and positive ($p<.05$) however, the effect is small. The probability of a household recycling increases by 0.07% for a small change in the age of the household. The coefficients of the race dummies are all positive. This means that households with non-African household heads are more likely to recycle than households with African household heads. However, only the Indian or Asian and White race dummies are significant ($p<.01$). Thus, the probability of a household recycling increases by 8.75% points if the household head is Indian or Asian and increases by 13.5% points if the household head is White. The probability of a household recycling increases by 1.54% points if the household head is married as opposed to not being married.

Studies have suggested that higher levels of educational attainment leads to greater recycling participation amongst households. However, the results of this study reveal that households' average years of education is not a significant predictor of recycling behaviour. Furthermore, average years of education between 7 and 12 has a negative sign whereas an average greater than 12 has a positive sign. Thus, those falling in the middle category recycle less than households with the lowest average years of education (mean edu<7) and those in the highest category recycle more. The average number of people employed in the household has a negative sign which is as expected. Recycling requires times and if household members are employed their time to recycle is very limited. Those who are unemployed have more time. There is a weak ($p<.10$) positive relationship between marital status and household recycling participation.

All provinces besides the Western Cape have negative coefficients. Thus, this suggests that households outside of the Western Cape are less likely to recycle than households residing in Gauteng (reference group). Whereas households living in the Western Cape are 3.21% more likely to recycle than households living in Gauteng. Households residing in Limpopo have the greatest change in probability, they are 24.3% points less likely to recycle than households living in Gauteng. This is closely followed by households living in KZN that are 18.70% points less likely to recycle than households living in Gauteng. It can be expected that rural areas are associated with lower probability of recycling activity since they are less likely to feature a higher density of recycling infrastructure (Collins, O'Doherty & Snell, 2006:137). The results suggest that this could be the case as the probability of recycling is 3.73% points higher for households residing in urban areas compared to households residing in rural areas ($p<.01$).

The negative sign on multi-family dwelling is expected given the literature. It was found that single-family dwellings were more likely to recycle than multi-family dwellings. Surprisingly, it is statistically insignificant. On the other hand informal single-family dwellings are more likely to recycle than single-family dwellings. However, it too is statistically insignificant. The sign on home-owner is contrary to expectation. Many studies found home-owners to be more likely

to recycle than renters. In spite of this, the results in this study show that the opposite holds true. It is not significant which surprising as well. A 1% change in household income results in a 0.0001% point change in the probability of recycling (p<.10), this is a very small effect.[32] Household size as well as the presence of a school-going child is insignificant. This is contrary to expectation as it was hypothesised that bigger households would recycle more as there would be more recyclable material. It was also hypothesised that the presence of a child in the household that attends school could also possibly increase the probability of recycling. Scott (1999) and Collins, O'Doherty & Snell (2006) included number of children in the household as a regressor. However, these studies found it to be statistically insignificant. The hypothesis in this paper was that it is not only about the number of children in the household but whether those children are attending school. Many schools have recycling initiatives in place. Participating in recycling activities at school can spill-over to home life too.

The literature has revealed that knowledge about recycling is important to increase household recycling participation. Knowledge can come from various sources. The presence of a cell-phone, tv, radio or whether the household has a subscription for MNET, DSTV or top TV was included to capture the effect of knowledge. Surprisingly, the presence of a cell-phone or tv has a negative sign and is statistically insignificant. However, the probability of recycling is 4.89% higher for households who have radios compared to those who do not. As expected households who have a vehicle are more likely to recycle (p<.01). This finding is consistent with Collins, O'Doherty & Snell (2006). The results indicate that households who have a vehicle are more likely to recycle by 2.81% points. A possible explanation for the positive relationship is that recycling requires time and effort. Households who do not have curb-side recycling programmes will have to go to drop-off recycling points or buy-back centres. If these are not located in close proximity to the household, households can be deterred from recycling. Even if they are in close proximity, if households have a significant amount of recyclable material, not having a vehicle could mean having to make multiple trips which could be an inconvenience to the household. However, if a household has a vehicle they are more likely to recycle because they able to transport the recyclable material in the vehicle and drive to the drop-off points or buy-back centres instead of having to find an alternative means of transportation. Only two environmental problems are statistically significant: water pollution and land degradation.

5 Conclusions

Recycling is important as it helps address substantial environmental and health concerns. These concerns are related to the presence of landfill sites and other harmful methods of waste disposal such as incineration and illegal dumping. In

[32] A level-log interpretation was used for household income. This means a 1% increase in x leads to a ($\beta 1/100$) unit (percentage point) change in y.

addition, it helps conserve scarce natural resources by exploiting the secondary-use values associated with certain waste products. Despite the clear benefits of recycling, up-take remains low, especially in developing nations. Thus, it is important for policy-makers to understand what factors influence recycling behaviour in order to develop and implement effective policies that optimise recycling activity.

This study has provided a snapshot of the various factors that influence household recycling behaviour in South Africa. A probit model of estimation was undertaken using national survey data (GHS 2018) in order to explain the probability of household recycling participation. The results of the probit estimation have shown a range of variables that are significant determinants of household recycling behaviour. Additionally, there are a few variables which surprisingly do not influence recycling behaviour.

Some factors identified to be important in determining recycling behaviour are unlikely to be influenced by public policy (socio-demographic variables). However, they can be used to identify certain groups of households. Once identified, these groups can be categorised in terms of their respective level of recycling activity and can be targeted accordingly. This is helpful as it allows policy makers to develop customised recycling policies and strategies. These are likely to yield improved results than if households are targeted in general. Policy makers will be tasked with determining which groups to focus on. They need to determine whether they focus on households that have low recycling participation or on households that are already inclined to the idea of recycling. This decision will depend on which group will yield the maximum desired outcome.

Overall, the results of the study suggest that households that have women as household heads are more likely to recycle than those with men as household heads. Having an older household head increases the probability of household recycling. Married and non-African household heads are more likely to recycle than non-married and African household heads, respectively. African individuals make up the majority of the population in South Africa thus, developing and implementing interventions targeted at African households can improve recycling participation substantially.

Gauteng and the Western Cape have the highest percentage of households that recycle (40.74% and 21.90% respectively). The results suggest that households residing in Western Cape are more likely to recycle than households residing in Gauteng. Whereas households outside of the Western Cape are less likely to recycle than those living in Gauteng. In addition, urban-rural residence matters. Households residing in urban areas are more likely to recycle than those residing in rural areas. Thus, properly evaluating the distribution and efficiency of waste recycling facilities across South Africa can significantly improve recycling participation amongst households in South Africa.

There is a weak relationship between household recycling and income. In addition, the presence of a radio in the household increases recycling participation. The presence of a radio in the household was the only significant factor out of the other information sources evaluated. Thus, improving the dissemination of recycling information across all sources can improve recycling participation.

Owning a vehicle also increases the probability of recycling. Thus, improving access to recycling facilities for those without a car can lead to a large increase in the probability of recycling. For example, ensuring that drop-off recycling points and buy-back centres are conveniently located. In addition, increased car ownership is not a favourable option as it harms the environment and negates the pro-environmental benefits of recycling. Thus, there should be a greater effort towards implementing curb-side recycling programmes in neighbourhoods across South Africa which eliminate the need to drive to recycling centres.

Finally, it is important to be cautious when drawing inferences from the results presented in this paper as some key variables identified in the literature were not included in the model. The 2018 GHS dataset unfortunately did not include data on certain variables identified in the literature as key determinants of recycling behaviour. This is a notable limitation of this paper. Nevertheless, the 2018 GHS dataset was the best available dataset to use to model household recycling behaviour in South Africa. The paper still provides valuable insights despite the above mentioned shortcoming. If possible, future contributions toward household recycling behaviour should try and use a dataset that includes the full scope of variables identified in the literature. Presently, such a dataset does not exist and the GHS should include a more detailed questionnaire on recycling behaviour to ensure that this type of behaviour can be modelled correctly.

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Appendix

Table A1: Variable description

Variable	(1) Description
Recycle	1= Household recycles, 0 otherwise
Female	Gender of household head, 1=female, 0 otherwise
Age	Age of household head (years)
	Race of household head
African	African=1, 0 otherwise (reference group)
Coloured	Coloured=1, 0 otherwise
Indian or Asian	Inidan or Asian=1, 0 otherwise
White	White=1, 0 otherwise
	Households average years of education
Mean edu<7	Mean edu<7=1, 0 otherwise (reference group)
7<Mean edu<12	7<Mean edu<12=1, 0 otherwise
Mean edu> 12	Mean edu> 12=1 , 0 otherwise
Employed	Average number of people employed in household (continuous)
Married	Marital status of household head,1= Married,0 otherwise
	Province in which household resides
Western Cape	Western Cape=1, 0 otherwise
Eastern Cape	Eastern Cape=1, 0 otherwise
Free State	Free State=1, otherwise
Kwa-Zulu Natal	Kwa-Zulu Natal=1, 0 otherwise
North West	North West=1, 0 otherwise
Mpumalanga	Mpumalanga =1, 0 otherwise
Gauteng	Gauteng=1, 0 otherwise (reference group)
Limpopo	Limpopo= 1, 0 otherwise
Urban	Geography type, Urban=1, 0 otherwise
	Dwelling type
Single-family dwelling	Single-family dwelling=1, 0 otherwise
Informal single-family dwelling	Informal single-family dwelling=1, 0 otherwise
Multi-family dwelling	Multi-family dwelling=1, 0 otherwise (reference group)
	Tenure
Home-owner	Home-owner=1, 0 otherwise

Table A1 continued

Variable	(1) Description
Household income(ln)	Natural log of household income (continuous)
Household size	Number of people living in household
Presence of school child in household	Yes=1, 0 otherwise
	Information sources
Cell	Yes=1, 0 otherwise
Tv	Yes=1, 0 otherwise
Subscription (Mnet, Dstv, Toptv)	Yes=1, 0 otherwise
Radio	Yes=1, 0 otherwise
Vehicle	Yes=1, 0 otherwise
	Environmental problem in community
No/irregular refuse removal	Yes=1, 0 otherwise
Litter	Yes=1, 0 otherwise
Water pollution	Yes=1, 0 otherwise
Air pollution	Yes=1, 0 otherwise
Land degradation	Yes=1, 0 otherwise
Noise pollution	Yes=1, 0 otherwise