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Article *in* Recycling · July 2022

DOI: 10.3390/recycling7040052

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Factors Influencing Household Waste Separation Behavior: Cases of Russia and Finland

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Abstract: This paper investigates the factors influencing the behavior of individuals in source-separation of municipal solid waste in an immature system for collection of recyclable waste (Saint Petersburg, Russia) and a more mature waste system (selected urban areas, Finland). Online questionnaires were applied to collect data from citizens of Saint Petersburg and the Finnish urban population. The data were examined within an extended theory of planned behavior using structural equation modeling for the identification of factors affecting waste source-separation behavior. The findings indicate that the factors differed significantly in the two waste systems. In Russia, the inconvenience of waste collection limited waste source-separation behavior, while intentions of individuals and information availability had an almost equal positive effect. In Finland, waste source-separation behavior was mostly affected by people's intentions. Based on the findings, recommendations for the development of recycling practices were made for practitioners in Russia and possibly other early-stage systems for the collection of recyclable waste. Limitations of the study pinpointed the possibilities for future research.

Keywords: waste source separation; municipal solid waste; theory of planned behavior; structural equation modeling

Citation: Zaikova, A.; Deviatkin, I.; Havukainen, J.; Horttanainen, M.; Astrup, T.F.; Saunila, M.; Happonen, A. Factors Influencing Household Waste Separation Behavior: Cases of Russia and Finland. *Recycling* **2022**, *7*, 52. https://doi.org/10.3390/recycling7040052

Academic Editor: Elena Cristina Rada

Received: 20 June 2022
Accepted: 27 July 2022
Published: 28 July 2022

1. Introduction

A pathway towards a circular economy and a more sustainable municipal solid waste (MSW) management is now being pursued by many countries. In developed countries and, particularly, in Europe, the efforts to develop MSW management have been performed for years and decades and led to notable progress. According to the policy of the European Union, the current agenda of the EU member states includes increasing the level of MSW for reuse and recycling to 65% by 2035 [1]. While some EU member states have reached recycling rates higher than others, there are countries with waste management systems at development stages considerably earlier than the European front-runners. Among the EU members, in 2019, the lowest recycling rates were recorded in Greece (21%), Cyprus (15%), Romania (11.5%), and Malta (8.9%) [2]. Outside the EU, countries of Southeast and East Europe often rely on landfilling to a much larger extent and have lower recycling rates as well. Particularly, low recycling performance is attributed to post-soviet states such as Russia (7% of MSW recycled), Belarus (19% of MSW recycled), Ukraine (less than 3% of MSW recycled), Moldova, and Georgia [3]. Similar to many other countries in the world,

these Eastern European countries either have already started or will likely increase attention towards the diversion of MSW from landfills in favor of recycling. A clear understanding of the factors limiting a transition towards a circular economy in such less-developed waste management systems may remove barriers and ultimately enhance the transition.

Due to the specific history as well as current economic, political, cultural, and geographical backgrounds of countries, development pathways for MSW management may differ. A great number of factors may affect the chosen strategy and the process of developing waste management and recycling. For instance, available investment funds, institutional structures, allocation of responsibilities in MSW collection and recycling, the efficiency of involved organizations, and so on. In addition, the waste management system itself, as well as the transition towards a circular economy, is extremely complex, involving a wide range of stakeholders and incentives. A crucial part in the transition is played by households as they have to adjust to new daily routines in waste handling and collection. The engagement of households in waste separation activities is also affected by a set of factors, including beliefs and values of individuals, the way waste collection is arranged, its equipment and convenience, incentives provided for source-separation of waste, etc. Factors affecting the behavior of people with regard to source-separation of MSW may vary between countries and regions, as well as the initiatives that are needed to improve waste management.

Within the scope of Europe, there is a considerable amount of research performed on factors influencing participation in source-separation of waste for mature waste management systems. Among other countries, the factors related to source-separation of waste were studied in Sweden [4], Finland [5,6], Germany [7], the United Kingdom [8,9], and Italy [10,11]. However, source-separation behavior and critical factors affecting it have been investigated scarcely in Eastern Europe, where waste separation and recycling practices are less common. In this context, waste handling behavior was studied in Belarus [12] at a time when the separate collection of household waste was only starting to be implemented. Factors affecting waste separation behavior were also researched in Turkey [13], whose MSW recycling performance could be compared to that in Eastern Europe. Comparisons between waste separation behavior representing early-stage and more mature systems for the collection of recyclable waste are also rare. Two studies were found to compare waste source-separation behavior at different development stages in Europe: between Lithuania and Sweden [14] and between Bulgaria and Sweden [15]. Their results showed that the same factors could affect waste source-separation behavior in a different manner, although some factors have a similar effect at different stages of MSW system development. For example, satisfaction with local facilities for waste collection negatively affected waste source-separation behavior in Bulgaria and had no influence on the behavior of respondents in Sweden [15]. By contrast, attitudes toward source-separation of waste and recognized moral obligation to recycle waste were significant factors regardless of the maturity of the system for collection of recyclable waste [14,15]. While Sweden, Lithuania, and Bulgaria are EU members, little is known about waste source-separation behavior of people in less developed waste systems outside direct influence of waste strategies and regulation in EU. The former Soviet states, and in particular Russia, are thus prominent examples of European countries with less developed waste collection and management systems.

In order to increase recycling and support the transition toward more circular waste management systems, an improved understanding of the key motivators and barriers for households and individuals in waste source-separation behavior is needed. This study aims to identify and evaluate critical factors influencing the behavior of people in source-separation of MSW in the context of an early-stage system for collection of recyclable waste and a developed system. For that, the case of Russia is studied to represent an underdeveloped waste collection scheme, and the case of Finland is used as a benchmark for a more developed EU waste system. The study compares the identified factors for the two cases and, on this basis, provides recommendations for how to improve waste separation at the source and, consequently, boost the transition towards a circular economy.

2. Materials and Methods

2.1. Case Selection and Description

System for separate collection of MSW in Finland serves as a case of a well-established system, while Russian case is an example of an underdeveloped system. In order to draw a comparison with regard to waste source-separation behavior, urban population was studied in both cases. Saint Petersburg was chosen to represent the Russian case, and multiple towns in Finland were involved in the study as a Finnish case.

In Finland, separate collection of waste has been implemented for over 30 years. Nowadays, municipal waste management system is predominantly based on source separation of waste, and only two mechanical-biological treatment facilities operate in the country [16]. An approach to the waste collection service can vary in different areas and for different housing types in Finland. In urban areas, blocks of flats are provided with separate bins for biowaste, paper, cardboard, glass, metal, and mixed waste within a door-to-door system (meaning that waste bins are provided nearby residential buildings). Separate collection of plastics is optional by law. Remote and sparsely populated areas are often provided with a mixed waste bin only on a door-to-door basis. Additionally to a door-to-door scheme, regional collection points for various waste fractions are available for residents in Finland. Regional collection points and municipal waste management centers are organized by the Finnish producer responsibility organization RINKI and municipalities. Collection of plastic and glass bottles and metal cans is organized also using reverse vending machines. Hazardous household waste is collected separately at domestic hazardous waste collection points, municipal waste management centers, and touring collection vehicles. When it comes to pricing of MSW collection services, waste fee usually includes fixed and variable parts; the variable part depends on waste bin volume and collection interval [16]. According to Finnish waste legislation, the pricing must promote separate collection of waste; however, as stated by Ukkonen and Sahimaa [16], provision of an additional waste bin often increases the total waste fee paid by households. The waste collection system developed in Finland allowed recycling 42% of municipal solid waste in 2020 [17], while the recycling rate is aimed to reach 65% by 2035. In order to reach recycling targets, Finnish waste collection system is being further improved. Source-separation is planned to be extended so that all residential buildings with at least five apartments will be obliged to separate biowaste, plastic, paper, cardboard, metal, glass, and mixed waste, while source-separation of biowaste will become obligatory for all real estates by 2024 [18]. The regulation covers all settlements with a population over 10,000 inhabitants. Moreover, source-separation of textile will be introduced by 2023 [18]. To reach better recycling performance, attempts to engage more Finns into MSW source-separation are being made using, e.g., gamification [19]. At the same time, convenience of waste collection is also improved in some places, e.g., by organizing self-service waste reception points with full guidance provided via a mobile application [20].

In Russia, waste separation practices were lost after the Soviet Union's collapse in 1991 and, at present, are only starting to reappear. Saint Petersburg, being the second largest city and the cultural capital of Russia, may be considered one of the leaders in the development of waste source separation. Source-separation of waste is not yet a common practice in the city but is rather sporadic. Before January 2022, when a single organization—a regional waste management operator—was put in charge of MSW management in the city, MSW collection was run by private companies independently. Similarly to the present time, a one-bin collection system was predominant, although containers for separate collection are provided for a very limited number of households (by some waste management companies). Some bins for separate collection of waste may be installed in public places by small businesses which collect and stock specific waste fractions before selling them to recyclers. Moreover, waste collection events run by activists exist. Separate collection of hazardous household waste is handled by the city administration and is free of charge for residents. Price for MSW collection is defined by the apartment area or number of residents in a household and, therefore, does not promote waste reduction and waste separation.

For a long time, source separation of waste has not been clearly targeted by the city administration; instead, the increase in mixed waste sorting capacity was primarily planned within the currently ongoing waste management reform [21]. In the present days, as the national policy in waste management promotes the development of source-separation of MSW, its implementation is expected during the waste reform [22].

2.2. Conceptual Framework

Waste separation behavior has been researched using several theoretical frameworks. According to Raghu and Rodrigues [23], the most widely used theoretical approaches are the norm activation theory [24] and particularly the theory of planned behavior (TPB) [25]. Developed as an extension of the theory of reasoned action [26], the theory of planned behavior was designed to explain human behavior in specific contexts. It provides a framework for a systematic investigation of factors influencing behavior of individuals. The concept has been successfully applied not only to the investigation of waste separation behavior [27–31] but to various other matters as well, e.g., adoption of new technologies [32], entrepreneurial behavior [33], etc. The original TPB states that behavior of an individual is affected by behavioral intention, which in turn depends jointly on attitude towards the behavior, subjective norms, and perceived behavioral control. This framework was also extended in a number of studies to account for other factors specific to waste source separation. Modified theoretical models examined the impact of motivation, self-identity, past experience, environmental awareness, situational and other factors on intentions and behavior of individuals [34–36].

According to TPB, individual behavior is influenced by behavioral intention, which indicates how much effort people are willing to make to perform the behavior [25]. Attitude towards the behavior is the extent of having a favorable or unfavorable assessment of the behavior in question, and subjective norms are understood as the perception of social pressure related to performing the behavior [25]. Thus, the person's evaluation of waste source-separation and the perception of social pressure towards separating waste are studied in this paper. Perceived behavioral control is another factor included in TPB, which captures the perception of a person's difficulty or ease in performing the behavior. Hypotheses about the interconnection of these factors in the context of waste source-separation are formulated as follows.

Hypothesis 1 (H1). *Intention to waste source-separation positively affects the individual behavior in waste source-separation.*

Hypothesis 2 (H2). *Attitude towards waste source-separation positively affects behavioral intentions.*

Hypothesis 3 (H3). *Subjective norms positively affect behavioral intentions.*

Hypothesis 4 (H4). *Perceived behavioral control positively affects behavioral intentions.*

A number of TPB-based studies adopted additional factors relevant to waste source-separation behavior. Among them, the factor which reflects constraints to perform the behavior (lack of time, resources, the convenience of waste collection, etc.) While perceived behavioral control is meant to reflect the perception of these factors, it is often an insignificant factor in recycling-related studies [37]. As a consequence, more specific factors which can limit waste source-separation behavior are commonly used in such studies [28,38,39]. In this paper, a specific factor, "inconvenience of waste collection system", was designed to measure the presence and ease of accessing waste containers as well as the time and space needed for waste separation in households. The effect of the factor is relevant to behavior of individuals rather than their intentions since waste collection system is not yet fully in place in Saint Petersburg. Therefore, the following hypothesis is tested for both studied cases:

Hypothesis 5 (H5). *Inconvenience of waste collection system negatively affects waste separation behavior.*

Similarly, this study investigates the effect of the availability of information provided to promote waste source-separation practices. The knowledge needed to perform waste separation can affect both intentions and behavior of a person, thus, the relevant hypotheses are:

Hypothesis 6 (H6). *Availability of information positively affects waste separation behavior.*

Hypothesis 7 (H7). *Availability of information positively affects behavioral intentions.*

Economic incentives are expected to predict individual intention to waste sorting and are measured similarly to [40,41]. The factor is meant to capture the importance of monetary benefits for an individual in performing waste sorting.

Hypothesis 8 (H8). *Economic incentives to waste sorting positively affect behavioral intentions.*

Several studies found distrust of waste collection system to be another factor that influenced waste separation behavior [14,42] and investigated it within TPB-based studies, e.g., [11,43]. Distrust of the system captures a lack of the person's belief that separated waste is handled properly and ultimately recycled but not disposed of at a landfill. It is generally expected that people are less likely to be intended to engage in waste separation behavior if the distrust of the system is present. Therefore, the relevant hypothesis studied in this paper is:

Hypothesis 9 (H9). *Distrust of waste collection system negatively affects behavioral intentions.*

The theoretical framework created for this study is given in Figure 1.

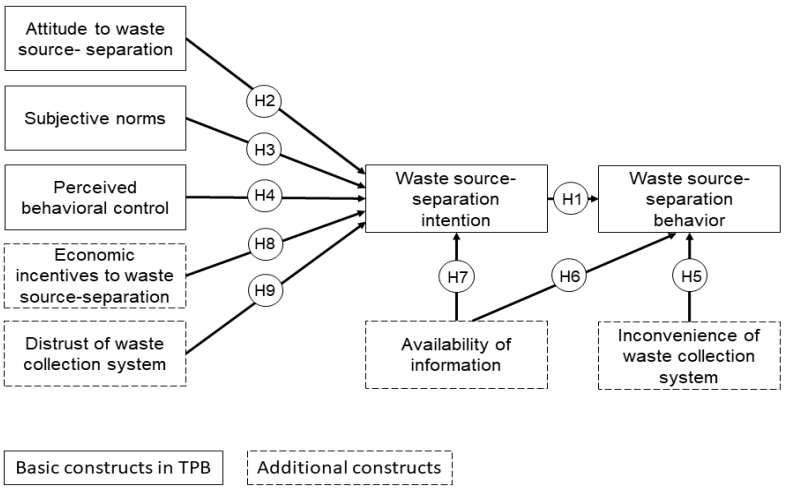

Figure 1. Extended theory of planned behavior.

2.3. Survey Design and Data Collection

The questionnaire was designed so that the first section contained demographic characteristics of respondents (age, gender, education, and income) and other background data (living area, type of housing, etc.); the second section provided questions related to the core topic of the research. Each factor considered by this study was measured using 2 to 5 survey items; all items used are reported in Supplementary Materials. For each item, respondents gave their answers on a five-point Likert scale (e.g., I disagree (1)–I agree (5)), which allows measuring unobservable constructs [44]. The survey was carefully translated into Russian

and Finnish languages with the help of experts in waste management. Two pilot tests were conducted using sample sizes of 15 and 35 respondents. Based on the results, the wording of some of the items was modified to ensure clarity and readability. The anonymity and confidentiality of the responses were ensured to avoid social desirability bias.

In order to access the population in Saint Petersburg and Finnish urban population, an online method of data collection was used. Online data collection was preferred as a more cost-efficient and less time-consuming option and due to restrictions on travel and social gathering related to the ongoing COVID-19 pandemic. In both Russia and Finland, the links to online questionnaires were distributed using multiple local groups on social media (communities of cities, districts, or neighborhood areas), webpages, and social media profiles of waste collection companies in those locations, as well as the webpage of research-related AWERE project which initiated this study [45]. The data collection period started in July 2021 and ended in October 2021.

Conducting a factor analysis requires the sample size to exceed the number of analyzed variables at least five times [46]. Accordingly, each of the two samples should contain at least 160 valid responses. Population of Saint Petersburg and urban population of Finland constitute approximately 5.4 million and 4.7 million, respectively. Based on these numbers, sample sizes required to reach representativeness of samples were estimated to amount to 385 in both cases. This number was derived assuming that for both samples, the population proportion equals 50% to produce the maximum sample size, as suggested by Bartlett et al. [47], while the margin of error equals 5% and the confidence level equals 95%, as common in social sciences [48]. Therefore, the sample size of 385 in each of the two cases was determined to be sufficient to represent the populations and to conduct factor analysis. A total of 593 responses from Russia and 474 responses from Finland were collected. The responses which contained missing data or did not fit the geographical scope of the study (meaning those coming from rural areas in Finland and outside Saint Petersburg in Russia) were removed from the datasets. Settlements with a population of fewer than 15,000 inhabitants were considered rural according to Statistics Finland [49]. After that, 490 and 410 observations from Russia and Finland, respectively, were eventually available for data analysis.

Table 1 represents the results of the descriptive statistical analysis for the study after missing data and responses falling outside of the scope were eliminated. In Table 1, the demographic characteristics of obtained samples are compared to the most recent data on the population of Saint Petersburg and the population of Finland. Because the questionnaire was aimed at the population aged over 18 and the data for current population profile is only available for 0–19 age group, it is not possible to estimate the representativeness of 18–19 age group in samples. The population aged over 60 is underrepresented in both Russia (6.4%) and Finland (11.1%). In both cases, females appeared to be more active in answering the survey constituting over 70% of respondents. Moreover, the respondents of the questionnaire appear to be more educated and have a higher income than the actual population. These are the limitations of the study, which are also highlighted in the conclusion section.

Table 1. Descriptive statistical analysis of obtained samples.

Descriptive Characteristic	Russia		Finland	
	Survey Result (n = 490)	Population Profile	Survey Result (n = 410)	Population Profile
Age				
≤19	2.4%	18.9%	1.2%	20.9%
20–29	22.8%	12.5%	22.1%	12.0%
30–39	35.4%	18.2%	24.0%	13.0%
40–49	22.2%	14.1%	23.3%	12.0%
50–59	10.8%	13.2%	18.3%	12.9%
≥60	6.4%	23.1%	11.1%	29.2%

Table 1. *Cont.*

Descriptive Characteristic	Russia		Finland	
	Survey Result (*n* = 490)	**Population Profile**	**Survey Result (*n* = 410)**	**Population Profile**
Gender				
Male	22.4%	55.0%	26.4%	51.0%
Female	77.6%	45.0%	71.2%	49.0%
Not reported	0.0%		2.4%	
Education				
School	1.2%	19.9%	1.2%	26.2%
College	9.2%	30.5%	32.2%	32.3%
Higher education	89.6%	49.4%	65.6%	41.7%
Other	0.0%	0.2%	1.0%	
Income (1000 RUB per month/1000 EUR per year)				
0–14/0–9.9	8.4% [1]	9.4%	11.3%	31.2%
14–27/10–29.9	11.8% [1]	24.1%	27.2%	36.9%
27–45/30–49.9	15.0% [1]	27.1%	37.7%	21.5%
45–60/50–69.9	11.0% [1]	13.9%	13.5%	6.2%
≥60/≥70	18.8% [1]	25.5%	10.3%	4.2%

[1] Percentage does not add up to 100% because the policy of some companies distributing the questionnaire link did not allow to collect income data.

2.4. Data Analysis

In order to prove the adequacy of the collected data for further analysis, the data were first examined via validity and reliability tests. Russian and Finnish datasets were analyzed separately. Negatively worded items were recoded so that high scores on Likert scale indicate the same type of response on all items. Cronbach's alpha [50] is commonly used as a measure of scale reliability in behavioral sciences and tests the internal consistency of items within a group. Lower scores of Cronbach's alpha indicate lower internal consistency. Additionally, composite reliability (CR) was used to measure the reliability of the scales. For both indicators, values equal to and above 0.7 were considered acceptable [51,52]. Construct validity was tested to ensure that the scores on the measure used are indicative of the theoretical construct, or in other words, that the constructs measure what they are meant to measure. Validity of the constructs was considered acceptable when average variance extracted (AVE) was not less than 0.5 [53] and factor loadings for each item were greater than 0.4 [54]. Cronbach's alpha was calculated using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Values for factor loadings of items were extracted as standardized regression weights using IBM SPSS Amos version 26.0 (IBM Corp., Chicago, IL, USA); CR and AVE were calculated using factor loadings.

The theoretical model, which was suggested by the study and refined during reliability and validity tests, was further assessed through structural equation modeling (SEM). As a statistical analysis technique, SEM combines factor analysis and regression or path analysis; SEM has been used extensively in behavioral research [55]. In this study, SEM was performed in IBM SPSS Amos (version 26.0) software using the maximum likelihood estimation method. In order to assess whether the collected data fit the proposed theoretical model, the following model fit criteria were used: relative chi-square (CMIN/df), the goodness-of-fit index (GFI), the comparative fit index (CFI), the adjusted goodness-of-fit index (AGFI), the incremental fit index (IFI), the normed fit index (NFI), and root-mean-square error of approximation (RMSEA). Relative chi-square can be considered acceptable when it falls within a range of 2–5 according to Paswan [56] or less than 3 according to Kline [57]. GFI, CFI, AGFI, IFI, and NFI values close to 0.9 and larger indicate a good fit between the hypothetical model and the sample data [58–60]. RMSEA value demonstrates a close fit of the data when it ranges from 0.05 to 0.08 [58], and model fit improves as

RMSEA decreases. When sufficient model fit was ensured, path coefficients [61] were used to examine the possible causal relationship between factors in SEM.

3. Results

The results for Cronbach's alpha calculated for each studied construct are given in Table 2. The results are acceptable for all constructs except perceived behavioral control (PCB). To ensure that a lower alpha score was not caused by short scales used to measure PCB, the Spearman–Brown coefficient was calculated as the most appropriate reliability index for a two-item scale [62]. However, in this case, PCB showed poor reliability of scales as well (0.46) and, therefore, had to be excluded from the measurement model.

Table 2. Cronbach's alpha for Russian and Finnish datasets.

Factor	Factor Code	Russia	Finland
Waste source-separation behavior	BEH	0.75	0.70
Waste source-separation intentions	INT	0.95	0.76
Attitude towards waste source-separation	ATT	0.89	0.83
Subjective norms	SN	0.77	0.75
Perceived behavioral control	PCB	0.60	0.46
Inconvenience of waste collection system	SYST	0.82	0.86
Availability of information	INF	0.90	0.78
Economic incentives	ECON	0.82	0.72
Distrust of waste collection system	DISTR	0.72	0.80

Factor loadings, CR, and AVE scores were first calculated for the measurement model that includes all items used in the questionnaire (see Supplementary Materials). Due to low factor loadings of items SYST4 and SYST5 (items related to time and space needed for waste source separation) coupled with the low AVE of a construct in the Russian dataset, SYST4 and SYST5 were deleted from the model for both datasets in order to keep measurement models identical for the studied cases. Factor loadings, CR, and AVE scores of the final measurement model are presented in Table 3. Nearly all loadings exceed 0.6, indicating an adequate contribution to measuring the constructs. Factor loadings of items ATT4 (in the Finnish dataset) and DISTR3 (in the Russian dataset) are only approaching the threshold value of 0.4; however, they are kept in the model, providing that other testing criteria are met. Lastly, the AVE of a construct measuring economic incentives (ECON) in the Finnish dataset falls slightly below 0.5, yet, according to Fornell and Larcker [54], it can be considered acceptable as the CR value of the construct is satisfactory.

Table 3. Descriptive statistics and the results of the measurement model assessment (items corresponding to items' codes are given in Supplementary Materials).

Item Code	Russia					Finland				
	Mean	St. Dev.	Factor Loading	CR	AVE	Mean	St. Dev.	Factor Loading	CR	AVE
BEH1	3.85	1.37	0.69	0.76	0.62	4.62	0.69	0.66	0.71	0.55
BEH2	4.33	1.19	0.88			4.81	0.61	0.82		
INT1	4.73	0.79	0.97	0.95	0.90	4.70	0.64	0.80	0.77	0.63
INT2	4.73	0.81	0.93			4.84	0.52	0.79		
ATT1	4.76	0.59	0.75	0.87	0.64	4.73	0.55	0.81	0.81	0.54
ATT2	4.79	0.64	0.95			4.75	0.54	0.89		
ATT3	4.77	0.69	0.89			4.70	0.62	0.75		
ATT4	4.82	0.69	0.55			4.85	0.60	0.38		
SN1	2.82	1.44	0.69	0.79	0.55	3.98	1.11	0.61	0.76	0.52
SN2	2.26	1.15	0.86			3.58	1.17	0.82		
SN3	2.81	1.31	0.67			3.97	0.95	0.73		
SYST1	3.77	1.11	0.80	0.83	0.63	3.66	1.49	0.79	0.87	0.69
SYST2	3.75	1.10	0.90			3.76	1.36	0.96		
SYST3	3.62	1.25	0.66			3.34	1.45	0.73		

Table 3. *Cont.*

Item Code	Russia					Finland				
	Mean	St. Dev.	Factor Loading	CR	AVE	Mean	St. Dev.	Factor Loading	CR	AVE
INF1	3.58	1.45	0.87	0.90	0.70	4.54	0.78	0.85	0.80	0.51
INF2	3.71	1.41	0.92			4.61	0.73	0.76		
INF3	4.04	1.23	0.75			4.70	0.59	0.71		
INF4	3.78	1.39	0.80			4.49	0.89	0.50		
ECON1	2.02	1.17	0.73	0.82	0.61	2.70	1.24	0.58	0.73	0.48
ECON2	3.05	1.30	0.76			3.65	1.15	0.84		
ECON3	2.82	1.35	0.85			4.08	0.98	0.64		
DISTR1	3.50	1.28	0.71	0.74	0.51	2.85	1.32	0.79	0.80	0.58
DISTR2	3.20	1.36	0.94			2.32	1.26	0.86		
DISTR3	4.62	0.89	0.39			3.89	1.28	0.61		

Model fit indices obtained for the two datasets are reported in Table 4. It can be stated that sample data fit the model well, even though few indices are slightly lower than the recommended cut-off values.

Table 4. The model fit results for Russian and Finnish datasets.

Dataset	CMIN/df	GFI	CFI	RMSEA	AGFI	IFI	NFI
Russia	2.246	0.920	0.956	0.050	0.895	0.957	0.924
Finland	2.093	0.914	0.934	0.052	0.887	0.935	0.882

Estimation results for both datasets are presented in Figure 2. First, it is evident that not all hypotheses are supported by the collected data, and the results differ for Russia and Finland. In the case of Russia, only six hypothesized relationships between factors are statistically significant. Waste sorting intention of Russian people is found to be positively influenced by their attitude to waste separation, availability of information, and subjective norms; hence, hypotheses H2, H3, and H7 are supported. In turn, waste separation behavior is shown to be positively influenced by the waste separation intention and availability of information while negatively influenced by the inconvenience of the waste collection system, as predicted by hypotheses H1, H5, and H6.

Analysis of the Finnish dataset resulted in only four hypotheses supported (Figure 2). Within the proposed theoretical model, only attitude to waste separation and availability of information has an effect on waste separation intentions for Finns. Furthermore, waste separation behavior is shown to be influenced by Finn's intention to sort waste and the availability of information but not by the inconvenience of the waste collection system. Even though the relevance of economic incentives and distrust of the waste collection system with regard to waste separation intention is not supported by the data in both studied cases, the signs of obtained path coefficients correspond to hypothesized directions of relationships between factors.

The ranking of path coefficients given in Figure 2 can pinpoint those factors which have the most considerable influence over the dependent variables. For example, the ultimate result—source-separation of waste—appears to be closely tied with waste source-separation intention, especially for Finns, as the path coefficient is the highest for the intention-behavior path. For Russians, waste separation behavior is influenced most considerably by both the intentions and availability of information, as corresponding path coefficients are the highest. Behavioral intentions, in turn, are mostly dependent on attitude towards waste source-separation in Russia and on the availability of information in Finland, meaning that these factors play the biggest role in determining waste source-separation intentions and, therefore, can leverage people's intentions most efficiently.

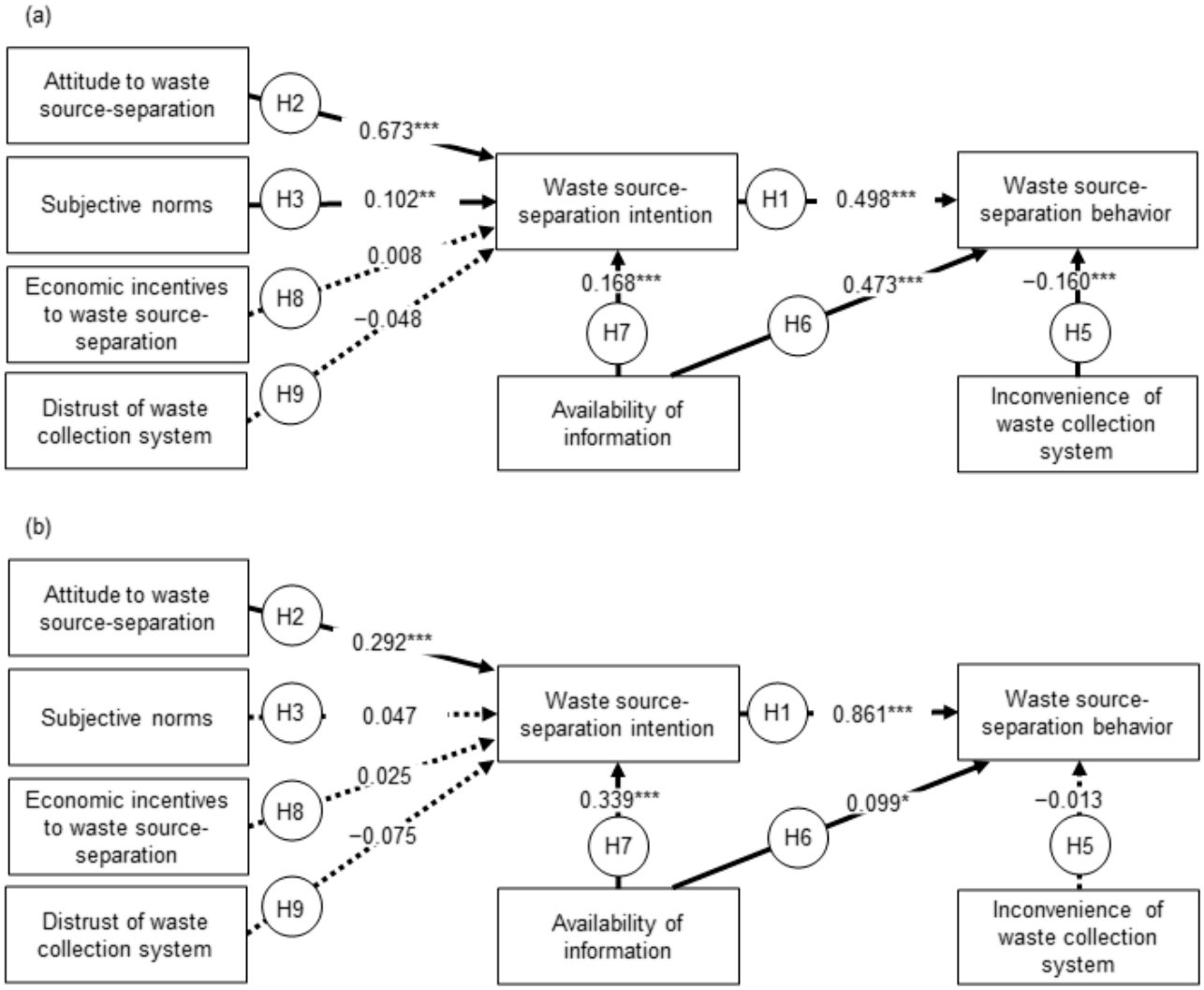

Figure 2. The estimated structural equation model: (**a**) Russian case, (**b**) Finnish case. Coefficients are standardized regression weights (path coefficients). * Significant at $p < 0.1$; ** Significant at $p < 0.01$; *** Significant at $p < 0.001$. Solid arrows represent supported hypotheses; dotted arrows represent unsupported hypotheses.

4. Discussion

The extended TPB framework used in this study allowed us to identify factors affecting waste source-separation behavior for an early-stage system for collection of recyclable waste in Saint Petersburg, Russia, and a mature system in Finland. Relationships between the behavior and influencing factors, however, differed in the two cases. The differences in influencing factors and possible reasons for that are discussed further.

4.1. Inconvenience of Waste Collection System

The ubiquity and convenience of the waste collection system is a factor that makes a key distinction between the studied cases. The results of SEM proved that the inconvenience of waste collection is a barrier for individuals to separate waste in Saint Petersburg, where the system for separate collection of waste is underdeveloped and scattered. In Finland, where different waste containers are provided in close vicinity to residential buildings and some public spaces, waste separation behavior is not predicted by the inconvenience of the system. Mean scores for items used to measure the inconvenience of the waste collection are relatively close in Russia and Finland, meaning that Finnish and Russian respondents would be affected by the obstacle in a similar manner. However, in reality, the

waste separation behavior of Finns scored high. Thus, the absence of a causal relationship between behavior and system inconvenience in Finland stems from the fact that a well-established provision of waste containers is always in place. In other studies, a significant influence on the inconvenience of waste collection is found for immature waste collection systems [14,43,63] as well as for mature ones [38].

4.2. Availability of Information

Regardless of the maturity of the system for recyclable waste collection, the availability of information is found to be an important predictor of waste source-separation intention and behavior. Information support was proven to influence both waste separation intention and behavior also by Zhang et al. [64] in the context of underdeveloped waste source-separation practices. In the present study, mean scores for items relevant to the availability of information (Table 3) clearly show that in Finland, the information is communicated substantially better than in Russia. Indeed, in Finland, the needed information is provided for residents next to each waste container, and detailed guidance and support can be reached from the websites of waste management companies. Furthermore, the possibilities for disposal of recyclable waste are well communicated by parties responsible for waste collection. The extent of information availability in a mature waste collection system can be seen as a benchmark and an exemplar for developing waste source separation in Russia.

4.3. Intention to Collect Waste Separately

The intention to separate waste appeared to be central for waste source-separation behavior in both studied cases. It is, in fact, the only factor affecting the behavior in the original TPB. In the extended theoretical frameworks, which include other factors affecting the behavior, the intention of an individual was a key predictor of waste separation behavior as well [38]. The results of SEM reveal that intention to separate waste affects the behavior of Finns almost solely. This may be explained by the fact that the waste source-separation practice was established for a long time in Finland. By now, the widely known and successful practice of waste source separation has reached the point in which the intention is the only thing needed to perform the behavior. Therefore, waste separation should be promoted mainly by improving the intention to separate MSW, which, in turn, is determined by other factors.

4.4. Attitude to Waste Source Separation

Attitude to waste separation is a considerable predictor of the intention, as shown in the estimation results. The results are consistent with the results by Zhang et al. [31] and Ma et al. [65]. The positive effect of attitude is significantly larger in Russia (0.673) than in Finland (0.292). Thus, improving attitudes of people in Russia, e.g., via public educational campaigns, is expected to increase the intentions more efficiently compared to Finland. Mean scores for items measuring the attitude to waste source-separation show that respondents in Finland and Russia favor source-separation of waste equally, and both populations recognize waste source-separation and recycling as beneficial practices. The impact of such an attitude may be higher in Russia due to this reason: more Russian respondents who engage in waste source-separation are mainly motivated by their beliefs about recycling rather than the convenience of waste collection, as proper collection facilities are scarce. Meanwhile, in Finland, source-separation of waste is a common practice that does not require extra motivation.

4.5. Subjective Norms

The influence of subjective norms, or public opinion, may seem to be ambiguous if estimation results are examined in contrast to the items' mean scores. For the Russian dataset, SEM results suggest that subjective norms determine waste source-separation intention to some extent: H3 is supported, and the path coefficient equals 0.102. At the same time, mean scores indicate that Russians tend to disagree that they are expected by

their family, neighbors, and society to engage in source-separation of waste. The results for Finland are the opposite of those from Saint Petersburg. According to mean scores for the relevant items, Finns mostly agree that they are expected to separate waste, but the relationship between this belief and waste source-separation intention is not statistically significant. Such results can be interpreted as follows: in Saint Petersburg, there is a potential to improve waste source-separation intention to some extent by increasing subjective norms. In Finland, other factors may interfere with the formation of waste source-separation intention so that subjective norms do not cause the intention to appear.

4.6. Economic Incentives and Distrust of Waste Collection System

Economic incentives were not found to influence waste source-separation intention in both cases. In Russia, this may be because the respondents had sufficient motivation for the separation of MSW regardless of the possible economic incentives. This can be further justified by the fact that pay-as-you-throw systems are not implemented in Russia, and deposit-refund systems are not common. In Finland, no effect of economic incentives may be connected to high standards of living, which allow people to be more concerned with their environmental issues rather than economic stability. Moreover, the results might have been affected by a larger share of Finnish respondents with higher income. The importance of economic incentives was not established also by Miliute-Plepiene et al. [14], who compared the situation of a developing system for the collection of recyclable waste in Lithuania and a mature one in Sweden. Likewise, no statistically significant relationship was observed between distrust of the waste collection system and the intention to separate waste at the source. Mean scores, however, suggest that the distrust of the waste collection system exists in Saint Petersburg but not in Finnish urban areas covered by the survey. Therefore, there is an indication that the collection of recyclable waste in Saint Petersburg should be more transparent, and the fate of collected recyclables should be communicated to people better to eliminate the distrust. However, from the estimation results in this study, it cannot be claimed that earned trust should strengthen the intention to separate waste. In other studies on waste source-separation behavior, distrust is usually measured from a more general perspective. In the study conducted by Vassanadumrongdee and Kittipongvises [43], which used similar items to capture the distrust of the waste collection system in Bangkok, Thailand, the influence of distrust on behavioral intention was significant.

5. Conclusions

This study, for the first time, applied an extended theory of planned behavior and structural equation modeling to analyze factors affecting waste source-separation behavior in a less-developed system for collection of recyclable MSW in Saint Petersburg, Russia, and in a waste management system with well-established source-separation practices in Finland. At the same time, the study contributed to very limited research comparing two cases within the same structural model. The results revealed that the influencing factors of waste source-separation behavior were distinctly different in the two cases. In a more mature waste system in Finland, the analysis showed that the main factor influencing people's behavior was their intention to separate waste, provided that the information needed to perform the behavior was sufficient. Although the Russian households demonstrated similarly high intentions to separate waste as in Finland, the lack of information and proper collection facilities limited waste source-separation. The intentions of Russians to engage in source-separation of MSW were strongly affected by their attitude towards waste source-separation and less affected by subjective norms. Regardless of the waste system's maturity, economic incentives and distrust of the waste collection system appeared to be insignificant in predicting waste source-separation behavior. Based on these findings, developing a convenient system for separate collection of recyclable waste and providing guidance on waste source-separation are key measures to improve waste source-separation in Saint Petersburg. Furthermore, extensive educational campaigns covering wider audiences are expected to be effective in engaging more residents in waste source-separation. These

recommendations can be useful for local governments and businesses involved in the waste collection also in other cities in Russia and possibly other post-soviet countries, although further generalization across early-stage waste systems is limited due to differences in the educational and cultural background of the population.

The study has several limitations that must be noted when drawing conclusions. First, the analysis was made based on self-reported behavior, so some level of bias in favor of better performance is possible. Moreover, online data collection eliminates certain socio-demographic groups from the sample, as only those with internet access can be potential respondents. The demographic profile of respondents showed that the middle-aged, female, and well-educated parts of the population were somewhat overrepresented. Additionally, as answering an online questionnaire is voluntary, an online method of data collection could also cause more pro-environmental individuals to answer the questionnaire, especially in Russia, where the waste management is a recognized problem in society and is currently being addressed by the waste reform. This also makes the results prone to bias. The above-mentioned limitations of the study can be addressed in future research. Furthermore, this paper mostly focused on factors that can be influenced by actors in the MSW management system and omitted possible cultural differences between respondents in the two countries. As the findings indicate, a certain distinction in factors affecting MSW source-separation behavior at different levels of maturity of the system for collection of recyclable waste, further research could investigate the matter for identical or comparable cultures but still contrasting MSW source-separation practices. Regardless of all limitations, the findings clearly suggested measures that would engage more individuals in MSW source separation and support a transition toward a more mature system for the collection of recyclable waste.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/recycling7040052/s1, Table S1: Items and latent factors measured.

Author Contributions: Conceptualization, A.Z., I.D., J.H., M.H. and A.H.; methodology, A.Z. and M.S.; formal analysis, A.Z.; investigation, A.Z., I.D. and A.H.; resources, A.H.; writing—original draft preparation, A.Z.; writing—review and editing, J.H., M.H., T.F.A., M.S. and A.H.; visualization, A.Z.; supervision, I.D., J.H., M.H. and T.F.A.; project administration, M.H. and A.H. All authors have read and agreed to the published version of the manuscript.

Funding: The study was conducted as a part of AWARE (Against Waste: Activate Research and Education for increased environmental awareness) project (KS1913) within CBC Programme co-funded by the European Union.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: Authors would like to thank waste management company PKF Petro-Vast OOO and other organizations in Finland and Russia for their support in data collection. Authors would like to thank Nadia Bystriakova, Svetlana Tereshchenko, Ekaterina Rakovskaya, Nataliya Zanko (Saint Petersburg Forest Technical University), Elena Freidkina (Saint Petersburg State University of Industrial Technologies and Design) for their contribution to conceptualization of this study.

Conflicts of Interest: The authors declare no conflict of interest.

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