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Designing Interventions for Behavioral Shifts toward Product Sharing: The Case of Laundry Activities in Japan

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Abstract: This paper presents design approaches to induce behavioral shifts toward product sharing through a case study on laundry activities in Japan. Business models involving provision of temporary access to goods are garnering attention as a way to reduce environmental impacts from the current pattern of consumption. However, the success of such business models is a matter of consumer choice, and there exist hurdles for consumers to forego ownership and transfer to product sharing. To understand the forces that affect consumer behavior involving product sharing and to design effective interventions for behavioral shifts, we conducted in-depth interviews and a web survey. From the results, we specified the decision processes in a behavioral shift between home washing and laundromat use, and generated "implementation of a communal laundromat in an apartment building" as a promising way for consumers to shift toward laundromat use. Based on our calculation, the proposed approach has a potential to reduce environmental impact of a hypothetical community by 1.8% in greenhouse gas emissions and 16% in resource use relative to when only home washing is practiced. Our study provides an example of designing interventions for product sharing through reflecting actual usage patterns and consumer motivations.

Keywords: consumer behavior; laundromat; product service system; sharing economy; life cycle assessment; scenario analysis

1. Introduction

In recent years, business models involving provision of temporary access to goods are garnering attention as a way to transform current patterns of consumption and production toward sustainability [1,2]. Provision of temporary access (thereafter, product sharing) has a potential to reduce environmental impact by producing fewer artifacts relative to individually owning the product [3]. Because of this potential, product sharing takes an integral part in the popular concept on sustainable consumption and production such as sharing economy [4], collaborative consumption [5], and circular economy [6]. With the advent of information and communication technology, product sharing is now supplied with improved accessibility and convenience. However, the success of product sharing is ultimately a matter of individual choice between temporary access and ownership, and there exists hurdles to induce such a behavioral shift.

Inducing behavioral shifts are known to be a great challenge when it comes to sustainable consumption and production. The measures taken by institutions have long focused on alternative

patterns of production because of the complexity of consumer behavior [7,8] and the institutional reticence to engage with issues of consumer behavior and lifestyle [9] The former issue refers to the lack of well-founded understanding of consumer behavior and motivation. The latter refers to the hesitance of institutions to question the way modern society functions: intervening consumer behavior could contradict the sovereignty of consumer choice. Indeed, product sharing has been recognized as a hurdle of consumers [10–12].

In the literature, Matsuo (2005) conveyed that there exists five types of consumer hurdles for engaging in product sharing in general: reduced freedom of product use, reduced convenience, cost, product quality, and anxiety and resistance against sharing products with strangers [11]. With respect to product sharing among peers where the shared product is owned by a peer or jointly owned by a community (i.e., often referred to as collaborative consumption [12]), a number of studies explored consumer motivations to participate [12–15]. Thus far, findings suggest that economic gain and trust play major roles for consumers to participate in peer-to-peer (P2P) sharing [11,15]. However, past studies analyzed the participants of product sharing and those who have never participated in a separate study, where the influential factors in the consumer decision process to engage in product sharing are yet to be clarified. While there is increasing market interest in product sharing with the rise of sharing economy, its penetration requires not only a top-down approach but also consumer acceptance. There is a need to understand the driving forces on consumer behaviors and provide a basis to design interventions for behavioral shifts.

The objective of this research is to design effective interventions for environmental behavioral shifts involving product sharing. Our scope of intervention covers approaches that could be integrated into a policy design concerning consumer behavioral shifts. Regarding design interventions, we analyze consumer behaviors and their associated environmental impact of laundry practices in Japan as a case study. Laundering of clothes is a basic human activity that is initiated by consumers, and the resulting environmental impact is heavily influenced by the consumer behavior. Past studies have reported that load size relative to capacity, washing temperature, and detergent volume to has a decisive influence on the environmental impact of laundry activities [16–18]. Behavioral patterns and prerequisites of laundry practices influence the overall resource consumption by a factor of five [19]. Additionally, laundry can be performed through using a private washing machine or through product sharing such as laundromats. Laundromats are a form of business-to-consumer (B2C) product sharing where a business owns the product. P2P sharing of washing machines has been proposed [20], but is out of scope in this study because it has yet to be introduced to the market. In this paper, we present our design methodology for a behavioral shift based on the analysis of the consumer decision process between home laundry and laundromat use, and the environmental impact assessment of the generated intervention.

2. Materials and Methods

To design interventions for behavioral shifts accounting consumer choice, this research modeled the consumer decision processes involved in the behavioral shifts between home laundry and laundromat use in Japan. We first conducted in-depth interviews with users and non-users of laundromats in Japan to uncover the role and forces that affect the pattern of laundromat use. Secondly, we performed a web survey to specify influential forces involved in the behavioral shifts, and its relation to consumer attributes. Thirdly, we designed an intervention to induce behavioral shifts toward product sharing, and assessed the environmental potential of the intervention through a life cycle assessment (LCA). This section first describes the case study to provide a background on laundry practices in Japan, and explains procedures of each methodology performed.

2.1. Case Study Description: Laundry Practices in Japan

In Japan, one study estimated the yearly number of wash cycles per household as 520, which represents the highest frequency among the 38 counties surveyed [21]. Additionally,

ownership of a washing machine in 2014 was 97% among single-person households and 106.4% among multiple-person households [22]. While washing machines are widely owned by individual households, the laundromat market is currently expanding in Japan: the number of laundromats has increased 1.5-fold between 1997 and 2013 [23]. The case of shifts from individual ownership to product sharing in Japan is quintessential for exploring possible interventions for product sharing in developed countries. The laundry activity in this paper focuses on washing of clothes because washing is done by electric appliances by default in Japan, and clothes are dried naturally by the majority.

2.2. In-Depth Interview

The in-depth interview was performed to uncover consumer perspectives and insights on the pattern of laundry activities, and to develop a consumer decision process model. Specifically, the goal was to identify forces that affect laundromat use. The qualified interviewee is someone who does laundry in their household. The interviewees were mainly recruited by word of mouth. We also recruited laundromat users for this interview in three laundromats in Tokyo. In the end, 31 participants between the age of 20 to 79 were interviewed face-to-face from July to August in 2017. Out of the participants, 10 participants had never used a laundromat, 10 participants used a laundromat less than once a month, 6 participants used a laundromat at least once a month, and 5 participants were regular users of laundromats and owned no washing machine in their household. Each interview took 25 to 50 min to complete.

The interview questions consisted of three parts: general information, current pattern of laundry activities, and perspectives on laundry activities at a laundromat. General information asked for demographic information, and ownership of washing machines and dryers. Questions on the frequency and the contents of laundry activities such as the use of washing machine, dryer, and laundromats followed. The next section asked about their experience with a laundromat such as how long they have been using laundromats, and the reasons for and the overall experience of the laundromat use. For those who have never used a laundromat, we asked about their impression of laundromats. The first two sections were structured interview, and the third section was a semi-structured interview.

Based on the analysis of consumer perspectives on laundry activities, we formulated a consumer decision model inspired by the Engel-Blackwell-Miniard (EBM) model [24]. The EBM model is a well-accepted analytical model that allows marketing researchers to map and explore the key elements involved in the consumer decision process. In this study, we referred to the stages involved in the decision processes in the EBM model to map triggers and consumer decisions in the process from home laundry to laundromat use.

2.3. Web Survey

We conducted a web survey to identify decisive conditions and factors in behavioral shifts modeled from the interviews, and to analyze its relation to consumer attributes. The qualified respondents were residents of Japan between the age of 20 to 69 who launder clothes by themselves. Based on the interview results, we defined three segments by the frequency of laundromat use: use a laundromat less than once a month (HL), use a laundromat more than once a month (PL), and do all laundry at a laundromat (EL). After screening 21,806 initial responses, we received 613 responses, where the sample size of each segment is shown in Table 1. The web survey was distributed by a marketing research company and was conducted from 28th to 30th November in 2017.

Table 1. Summary of segments in the web survey.

	Home Laundry (HL)	**Partial Laundromat User (PL)**	**Exclusive Laundromat User (EL)**
n	206	256	151
Frequency of laundromat use	Less than once a month	More than once a month	Always

The web survey was composed of three sections: general information, current pattern of laundry activities, and perspectives on behavioral shifts involving laundromats. For those who use laundromats regularly (i.e., PL and EL), questions regarding occasions and reasons for laundromat use, and perspectives on their future lifestyle were also inquired. Survey questions are described in the following paragraphs, and a summary is shown in Appendix A Table A1.

- General information

This section asked for basic demographic information. Regarding the family size, type of household members (i.e., number of seniors and number of children), and employment status of the respondent were inquired.

- Current pattern of laundry activities

In this section, we asked for the ownership of washing machines, frequency of laundry, and average size of one load in their household. For those who use laundromats, we also asked for the frequency of use, the average size of one load of laundry at laundromat, and the average expenses paid per laundry. The mode of transport and time required to reach the laundromats was also enquired.

- Perspectives on the behavioral shifts toward laundromat use

This section contained a series of questions regarding conditions required to exclusively use laundromats for clothes washing, where each question corresponded to a trigger and decision process modeled from the interview results. Through analyzing the survey responses of consumer segments, we generalized the trigger and identified defining factors in each decision process.

The survey results were analyzed through statistical test and cross tabulation based on the three segments. The differences among the demographic attributes of segments were tested statistically using Chi-squared test where $p < 0.05$ was considered significant. On the questions with ordinal data (i.e., level of potential to shift), numbers were designated to each answer (i.e., -2 = I cannot shift; -1 = I probably cannot shift; 0 = I am neutral; 1 = I probably can shift; 2 = I can shift), and arithmetic mean was computed.

2.4. Design and Assessment of Interventions for Behavioral Shift

Based on the results of the influential forces that affect consumer choices in the decision processes, we designed an intervention to induce behavioral shifts toward laundromat use. The environmental potential of the proposed intervention was assessed using an LCA, which accounted for the number of households that would undergo a behavioral shift according to our survey results.

2.5. Environmental Impact of Laundry Activities

We computed the environmental impact of per-household laundry activities to analyze the environmental potential of the proposed intervention. The environmental impact was computed through an LCA following the ISO 14040: 2006 procedure [25]. The goal of this LCA was to identify environmental hotspots of laundry activities at home, at laundromat, and upon intervention. The functional unit was one year of laundry activities per household. A household size was defined as three people, and the geographic specificity was set in Japan. Laundry activities generally consist of washing and drying, and we focused on washing process and assumed drying to be done by natural drying. Washing of clothes assumed to be completed using a washing machine only. We assumed each household launders once a day at home with 4.5 kg of clothes based on our survey results, where the mode of laundry frequency of home washing machines was more than seven times a week. Raw material extraction, manufacturing, use, disposal, and recycling processes were considered in this LCA, as shown in Figure 1. The details of material composition of each category (i.e., washing machine, detergent, and detergent packaging) are summarized in Table A2 of Appendix A. In the recycling

process, steel from washing machines and plastics (polyethylene and polypropylene) from detergent bottles were recycled at the rate of 95 wt. % and 40 wt. %, respectively [26]. The environmental impacts from disposal and recycling were allocated to the yearly use of washing machines by considering the lifetime and recycling rate of products. We also assumed that the detergent contents are the same at home and at a laundromat. The assumptions, and data sources are summarized in Table 2. The majority of the life cycle inventory data referred to Japanese inventory data: Inventory Database for Environmental Analysis (IDEA version 2.1.3) [27].

Two environmental impact categories were selected for impact assessment in this study: greenhouse gas emissions (GHG) and resource use of steel. We chose GHG in this study to assess the energy efficiency of washing process of home and the industrial appliances. The GHG was computed with respect to the global warming potential of carbon dioxide defined by IPCC 100-year in 2007 [28]. To illustrate the changes in resource use from product sharing to individually owning them, we computed resource use of steel, which composes 62 wt. % of a top-loader washing machine [29]. The resource use simply reflects the weight of steel consumed per functional unit. The recycling rate mentioned earlier is considered in the computation.

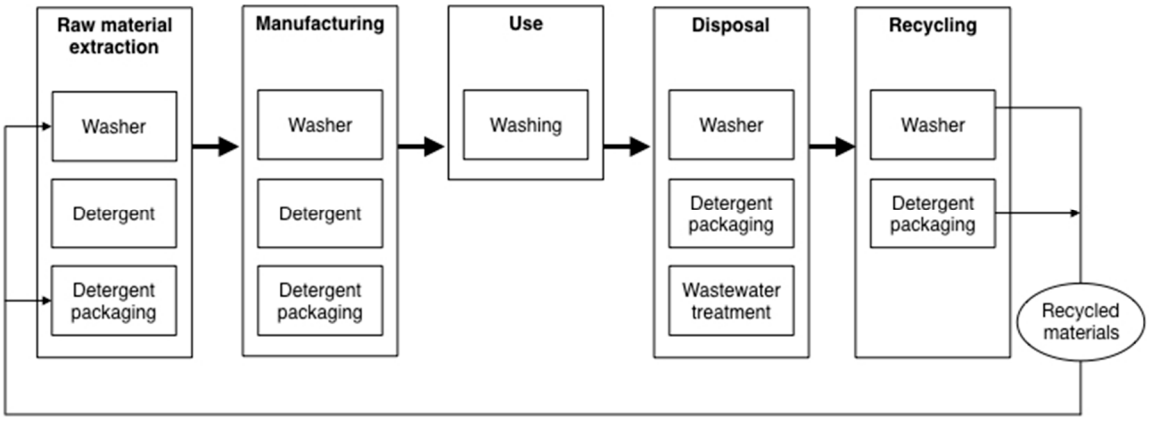

Figure 1. System boundary of this LCA.

Table 2. Assumptions in the LCA of HL and laundromat.

Reference Flows	Unit	Value	Assumptions	Value	Assumptions
			Home laundry		**Laundromat**
Frequency of laundry	Load/year	365	Based our survey, 53% of home washing machines wash more than 7 loads per week	182.5	Assumes half of the frequency of HL
Weight of clothes to wash	Kg/load	4.5	Clothes from daily use. Computed from the average daily laundry weight of 1.5 kg per capita [30]	9.0	The assumptions are consistent with the HL
Washing machine	Machine	1	Washing machine is a top-loader with a capacity of 9 kg [1] with a weight of 39 kg [31]. Lifetime of a washing machine assumes 3832.5 loads [2]	1	Washing machine is an industrial front-loader with a capacity of 9 kg with a weight of 127 kg. Lifetime of an industrial washing machine assumes 10,000 loads [6]
Detergent [32]	Kg/load	0.049	Liquid detergent	0.082	Liquid detergent
Water	L/load	82.4	Estimated from detergent manufacturer's estimation [33]	95	Estimated from industrial washing machine catalogue [34]
Electricity	kWh/load	0.044	Estimated from detergent manufacturer's estimation [33]	0.25	Estimated from industrial washing machine catalogue [34]

[1] 54.9% of home washing machines use top-loader washing machine with a capacity larger than 6 kg and less than 10 kg.; [2] computed based on the lifetime of a home washing machine reported as 7 years [35] multiplied by 1.5 load per day [36].

3. Results

3.1. Consumer Decision Processes in a Behavioral Shift toward Laundromat Use

The interview results are representative of neither Japan nor Tokyo population because of the sample size. They rather provide a general understanding of consumer perspectives on washing machine ownership and key elements that are claimed to explain the behavioral shift between HL and laundromat use. The interview results are summarized in the following two key findings. Based on these findings, we formulated a behavioral shift model with a case of HL to laundromat use by adopting the EBM model (Figure 2).

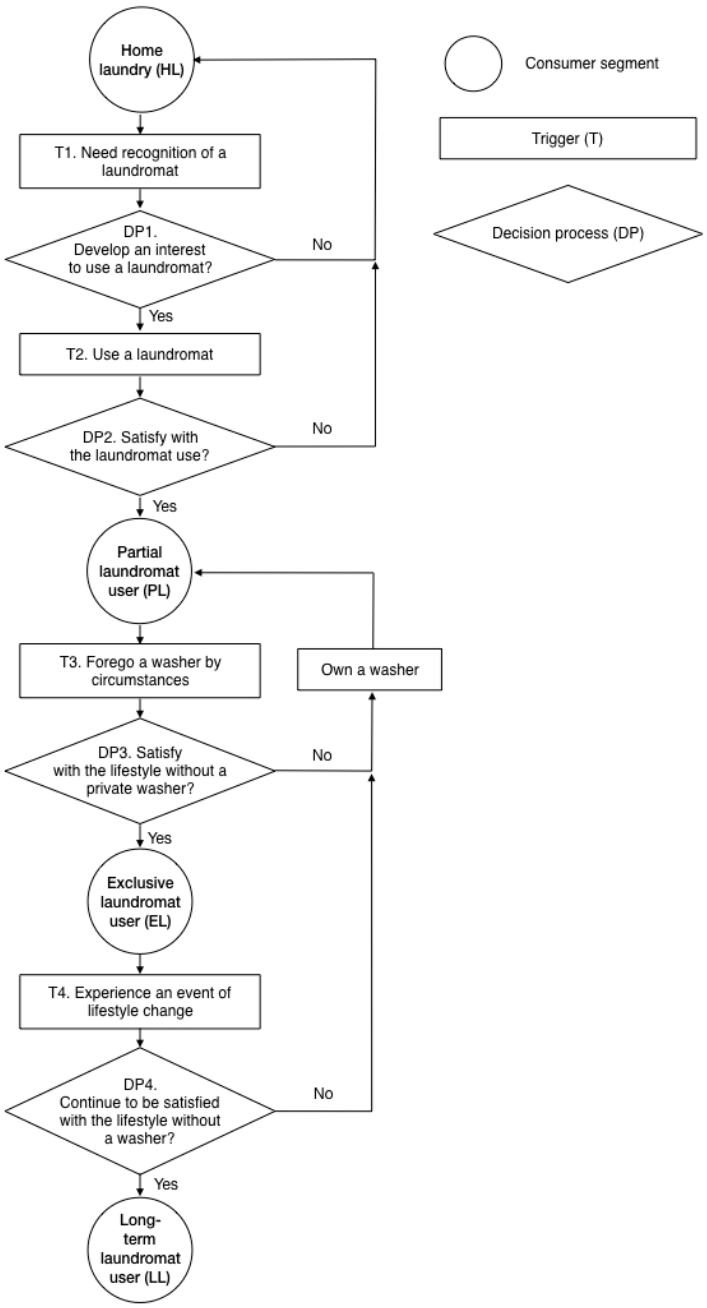

Figure 2. Consumer decision model of the behavioral shift from home washing to laundromat use.

1. Ownership of washing machines was considered essential by the majority. However, a few respondents expressed that owning a washing machine is not necessary if conditions are met.

Regardless of the status of washing machine ownership, 21 respondents stated that owning a washing machine in their household is essential for their lifestyle. If their washing machine breaks down, they said, "I'd purchase a new washing machine immediately." They may use a laundromat out of necessity, but it would only be a temporary use.

On the contrary, seven respondents expressed that a private washing machine is not necessary under certain conditions. Out of the seven respondents, six respondents are of the young generation (20 to 39 years-old) who live away from their family members. While all respondents grew up in an environment with a washing machine in their household, the young generation in urban areas appeared to perceive that ownership of a washing machine is no longer a necessity in their lifestyle. One respondent stated a preference for laundromats over HL because "I can complete washing and drying in shorter time than that of laundry at home" and that as long as the laundromat is nearby the respondent's housing, it is not necessary to own a washing machine. Accessibility to the laundromat, the cost of washing and drying, and the quality of laundry were the most frequently raised condition to be met for a lifestyle without a private washing machine. These conditions resonate with past studies, where the cost and trust in product quality were raised as consumer hurdles in product sharing [8,9]. Two respondents in the interview did not state clear preference on private washing machine ownership.

2. There exists four triggers and four decision processes between the behavioral shift from home washing to laundromat use.

We identified that consumers of home washing undergo four types of triggers (T) and four decision processes (DPs) before they exclusively use a laundromat. Here we define "trigger" as an incidence that provides an opportunity for consumers to consider a behavioral shift toward laundromat use. The triggers were grouped into four types: (T1) Recognize the need for laundromat use, (T2) Use a laundromat, (T3) Forego a washing machine by circumstances, and (T4) Experience the event of lifestyle change. Upon experiencing a trigger, consumers are subjected to make a decision on whether to move toward a behavioral shift, which we call decision processes: (DP1) Develop an interest in using a laundromat, (DP2) Satisfy with the laundromat use, (DP3) Satisfy their lifestyle without a private washing machine, and (DP4) Continue to be satisfied with the lifestyle without a private washing machine. When consumers decide to continue in each decision process, their behaviors shift toward EL use. With a rejection at a DP, their laundry pattern moves toward home washing.

The triggers and DPs are depicted as rectangles and diamonds, respectively, in Figure 2. The consumers in distinct stages are illustrated as circles: home laundry (HL), partial laundromat user (PL), exclusive laundromat user (EL), and long-term laundromat user (LL). The last segment, LL, is a consumer who intends to continue a lifestyle without a washing machine in the long term. The segments in the questionnaire survey were formulated according to this consumer grouping, as previously described in Table 1.

3.2. Determinants of the Four DPs

From the survey results, we identified the contents of four triggers and variables influencing each decision process. We first summarize the demographic profile of the survey respondents, then discuss the contents and variables in each trigger-decision process combination in order.

3.2.1. Demographic Profile of the Survey Respondents

The demographic attributes with a statistical significance based on Chi-square test ($p < 0.05$) among the segments were gender ($p = 0.06 \times 10^{-9}$), age ($p = 0.002$), employment ($p = 0.01 \times 10^{-3}$), and population size of the area of residence ($p = 0.012$). Our sample is not representative of Japan because we set qualifications to obtain sufficient samples in each segment. As shown in Table 3,

gender distribution showed more female than male for HL, and more male than female for EL. The employment status implies that the large group of HL are homemakers. More than half of PL and EL work full time. With respect to age distribution, PL represents younger population than that of EL and HL. There were more family households in HL and PL, while single-person households were prominent among EL population. There were more EL living in an apartment, while that of HL and PL were in a detached house.

Table 3. Summary of demographic attributes and use patterns of survey respondents.

	Home Laundry (HL)	Partial Laundromat User (PL)	Exclusive Laundromat User (EL)
Total	206	256	151
Gender			
Male	70	143	105
Female	136	113	46
Age			
20–29	12	16	10
30–39	55	94	30
40–49	67	85	55
50–59	48	41	47
60–69	24	20	9
Employment			
Employed, full-time	72	127	66
Self-employment	9	22	15
Contract worker	8	8	9
Employed, part-time	41	36	22
Homemaker	61	41	17
Unemployed	10	16	12
Students and others	5	6	10
Housing type			
Detached house	72	108	28
Apartment/Condo	122	133	111
Others (Shared housing, dormitory)	12	15	12
Household structure			
Single-person	59	81	101
Couple	24	13	6
With children	109	141	34
Three generations	9	16	5
Others	5	5	5
Frequency of laundry at home			
More than 7 times per week	109	107	-
4 to 6 times per week	41	53	-
1 to 3 times per week	50	70	-
1 to 3 times per month	4	12	
Less than once or none	2	13	-
Frequency of laundromat use			
More than 7 times per week	-	20	11
4 to 6 times per week	-	15	6
1 to 3 times per week	-	37	54
1 to 3 times per month	-	48	28
Less than once or none	-	58	44

3.2.2. T1 and DP1: Need Recognition and Factors Influencing the Interest in a Laundromat

We found that there are largely two types of triggers that led to need recognition for laundromat use (T1): circumstantial and increased accessibility. The most frequently answered choices for the question, *What triggered you to use a laundromat?* were "in the event of lifestyle changes" and "there was a new laundromat in the neighborhood" for PL and EL, respectively (Figure 3). The 40% of PL and 33% of EL began using laundromats because there was a new laundromat in the neighborhood; increasing visibility and accessibility of a laundromat is effective for consumers to consider its use. Additionally, more than one-fourth of the respondents recognized the need for laundromat use through

circumstantial factors such as the event of lifestyle changes and breakdown of their washing machines. This result indicates that accustomed use of a laundromat is a result of circumstances. According to our interview, lifestyle-changing events include moving and birth of a child. One interviewee reported that he did not have time to purchase a washing machine at the time of moving into a new place, and he has been using laundromat since then. He has yet to consider purchasing a washing machine because laundromat use fits into his current lifestyle. The birth of a child was mentioned by two respondents, where both addressed that being able to wash and dry laundry in a more time-efficient manner is helpful when handling a large volume of laundry.

Additionally, the difference in the pattern of responses between PL and EL showed a statistical significance ($\chi^2 = 3.967$, degree of freedom = 1, $p = 0.046$), which suggests that distinct events of need recognition leads to partial use and exclusive use of laundromats. In other words, the most frequently answered choice of PL implies that visibility of laundromats in the neighborhood of the consumers is effective for consumers to consider laundromat use, but that of EL suggests that circumstantial factors play roles for consumers to become an exclusive laundromat user.

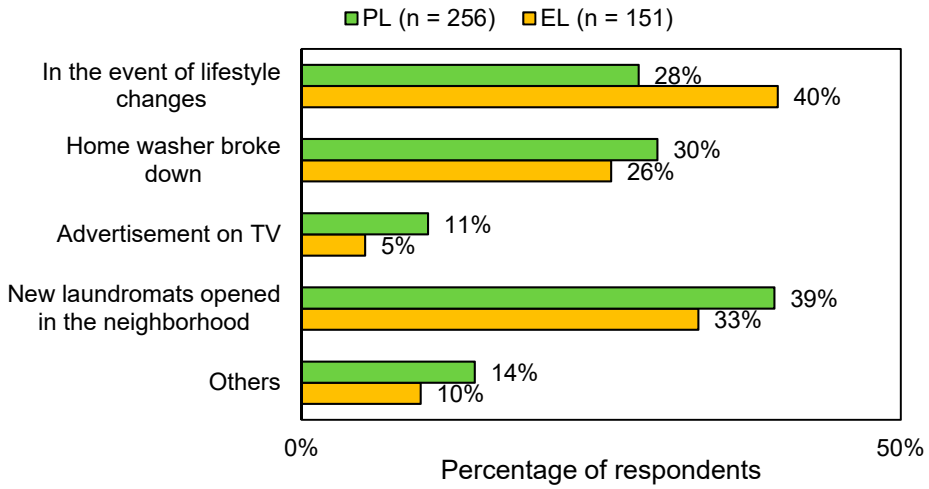

Figure 3. Cross tabulation of the event of need recognition with a laundromat.

3.2.3. T2 and DP2: Use Experience with a Laundromat

To identify factors that leads consumers to become accustomed to laundromat use, we asked the reasons for regular use of laundromat to PL and EL respondents. As a result, the frequently answered reasons for PL were related to convenience and efficiency, whereas that of EL were related to their living conditions. The difference in the responses between PL and EL again exhibited statistical difference ($\chi^2 = 45.26$, degree of freedom = 1, $p = 1.72 \times 10^{-11}$). This distinction is well illustrated in Figure 4: PL recognized being able to do a large load, taking less time and effort to complete, and having a better finish as reasons for laundromat use, while EL raised space and cost issue of owning a washing machine. Because the large population of PL are young homemakers with families living in a detached house, efficiency of laundry activities was identified as a critical element in their lifestyle.

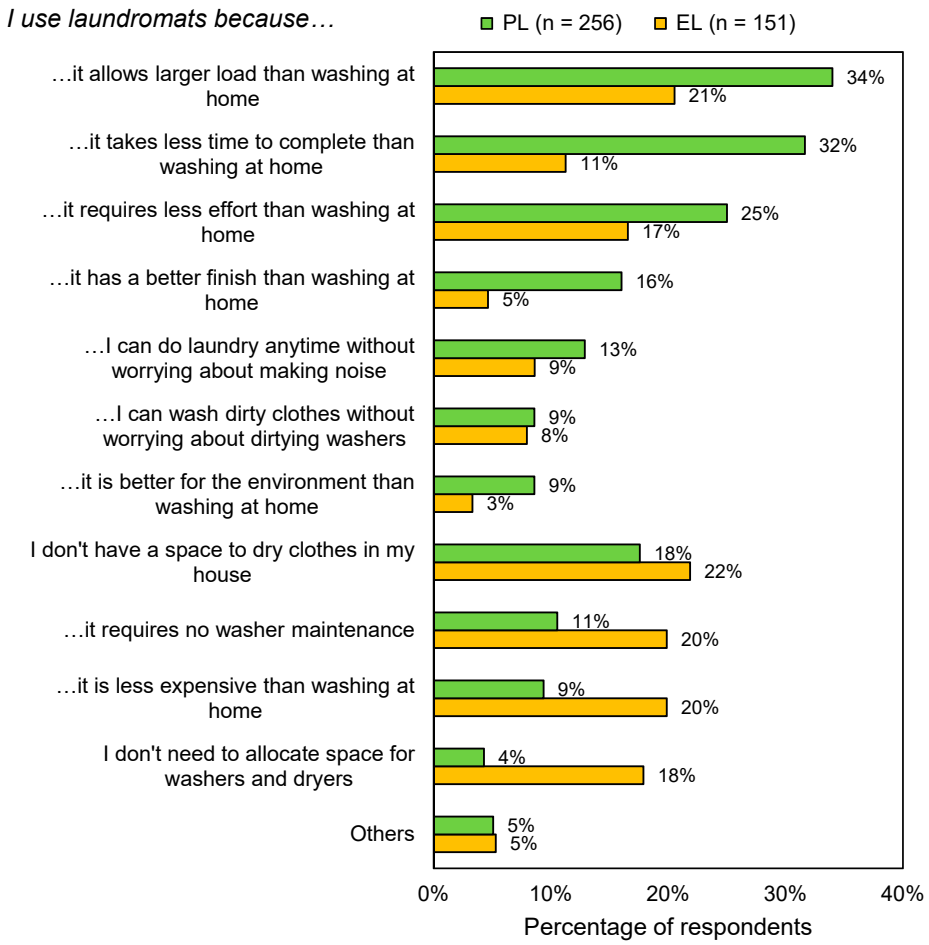

Figure 4. Cross tabulation of the reasons for laundromat use.

3.2.4. T3 and DP3: Lifestyle without a Private Washing Machine

Upon abandoning a washing machine because of circumstances, consumers are subject to decide whether to replace a washing machine. We asked two questions to identify influential factors in this decision process (DP3). First, we asked for the willingness to forego washing machine ownership if a specific type of laundromat was located near their neighborhood with an ideal cost to perform laundry: *For each laundromat described below, if such a laundromat was located in your ideal location with ideal price setting, would you be able to shift to a lifestyle without a private washing machine?* The responses were collected in five levels (−2 = I cannot shift; −1 = I probably cannot shift; 0 = I am neutral; 1 = I probably can shift; 2 = I can shift). For those who currently have a lifestyle without a private washing machine (i.e., EL), we asked if they would be able to continue their current lifestyle if such laundromats existed. The numerical value designated in each level was regarded as an indicator of potential to shift to laundromat use. Each of the eight type of laundromat contains specific characteristic that helps identify necessary characteristics for a behavioral shift. These characteristics are described in Table A1 in Appendix A.

Figure 5 shows the average level of willingness to shift for the eight types of laundromat for each segment. Out of the eight laundromats we proposed, all segments agreed on average that five types of laundromats had a potential to drive consumers to forego a washing machine. "3. Have fluff and fold service" was the only laundromat that would not make a behavioral shift possible by any segment. Laundromats that sell fashionable and laundromat-branded goods were recognized as favorable for EL but not favorable by HL and PL. When the mode of responses was analyzed among each segment, PL with "1. Built within the apartment housing" was the only option where the mode was "I probably

can shift" and the mode of all others was "I am neutral". This result implies that accessibility plays a crucial role in laundromat use, and features of laundromats presented in our survey were inadequate for consumers to consider a behavioral shift toward product sharing.

Secondly, we asked for the reasons why they think lifestyle without a private washing machine is undesirable for those who chose "I cannot shift" or "I probably cannot shift" in any of the eight laundromats. For EL whose lifestyle is already without a washing machine, we asked for the reasons why they would not be able to continue the current lifestyle without a private washing machine. The results in Table 4 show that the most frequently chosen reason was the financial reason in all segments: "Laundromat seems more expensive than washing at home." Cost of product sharing is a hurdle that again resonates with the past studies [8,9]. Indeed, we identified that cost was the most prominent consumer hurdle for product sharing with respect to laundromat. Moreover, the average willingness to pay (WTP) per load (i.e., 1 load was defined as 10 kg of clothes) for each segment was 201 yen, 259 yen, and 266 yen for HL, PL, and EL, respectively. These WTP are cheaper than that of market price (i.e., the smallest washing machine, 7 kg, requires 300 yen), but the difference in WTP among the segment indicates that HL respondents are likely unaware of the market price of laundromats. HL respondents also considers washing at home to be inexpensive compare to laundromats.

For PL and HL, foregoing a washing machine is improbable because private washing machine is a basic requirement in their lifestyle. The results in Table 4 supports that incidental reasons such as the event of lifestyle changes triggers foregoing a washing machine. Also, lack of freedom to do laundry anytime was concerned by the three segments. Enhancing accessibility and opening the laundromat for 24 h could potentially resolve this issue.

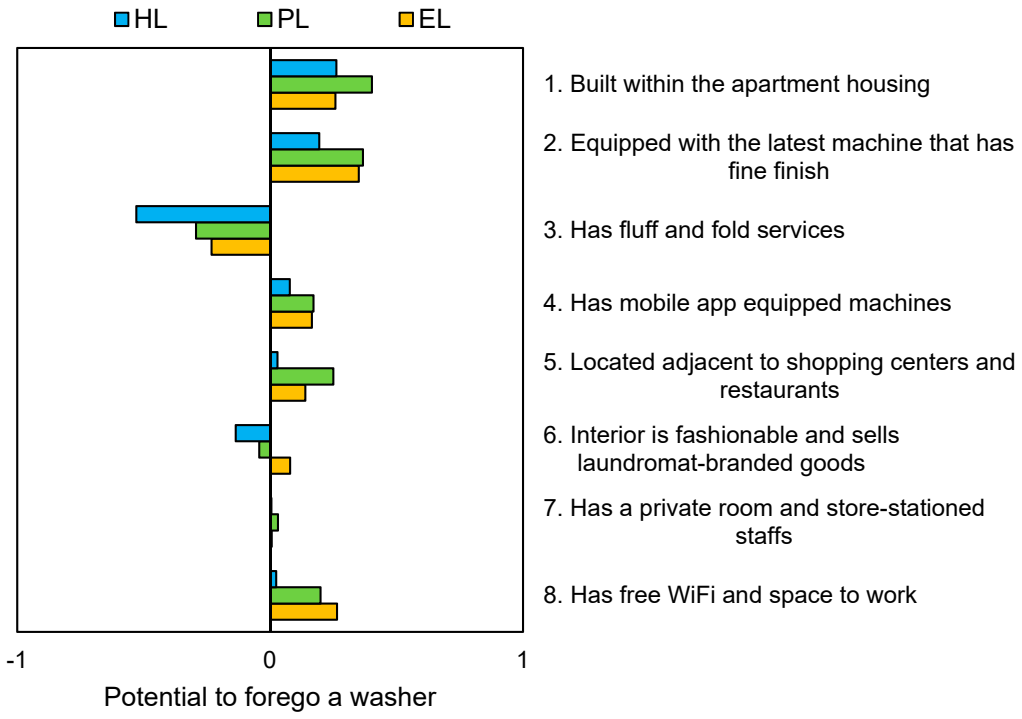

Figure 5. Potential to shift to a lifestyle without a private washing machine, if a specific laundromat existed.

Table 4. Top five reasons for not being able to forego a private washing machine.

	Home Laundry (HL)	Partial Laundromat User (PL)	Exclusive Laundromat User (EL)
1	Laundromat seems more expensive than washing at home (59%)	Laundromat seems more expensive than washing at home (58%)	Laundromat seems more expensive than washing at home (36%)
2	HL is sufficient (39%)	Lack of freedom to do laundry anytime (32%)	Lack of freedom to do laundry anytime (21%)
3	HL is a basic requirement in my lifestyle (39%)	HL is a basic requirement in my lifestyle (26%)	Laundromat seems dirty (19%)
4	Lack of freedom to do laundry anytime (36%)	Laundromat requires more effort (25%)	I don't want to share the laundry space with others (17%)
5	I don't want to share washing machines and/or dryers (33%)	Home laundry is sufficient (25%)	Laundromat requires more effort (15%)

3.2.5. T4 and DP4: The Event of Lifestyle Changes and Their Influence on Laundromat Use

Consumers may forego a washing machine for a period, but they could acquire a private washing machine in the event of lifestyle changes. We analyzed the decision processes at DP4 through asking the respondents' intent upon experiencing a lifestyle-changing event: *In the event of each lifestyle changes listed below, would you be able to shift to a lifestyle without a private washing machine?* The responses were again collected in five levels, and the potential to shift was quantified in the same manner as DP3. As Figure 6 shows, HL responded that any event of lifestyle change would not trigger them to pursue a lifestyle without a private washing machine. This result was consistent with the results in Table 4, where 39% of HL consider home laundry as a basic requirement in their lifestyle. For PL, income increase was the only event with a potential to forego a washing machine. Those who already has a lifestyle without a private washing machine, EL, they responded that they would continue the current lifestyle if they had more time, more income, and if they were younger. These results imply that even if consumers currently have a lifestyle without a private washing machine, they have a high potential to return to owning a washing machine in the event of lifestyle changes.

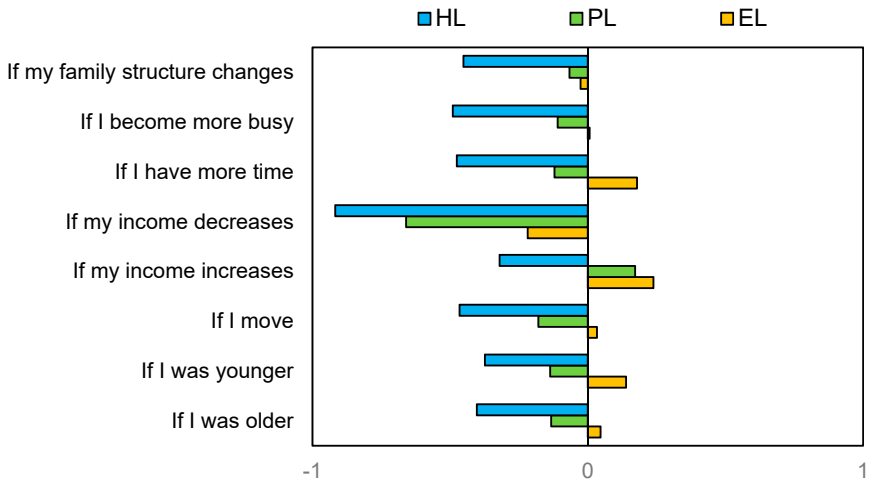

Figure 6. Potential to shift to a lifestyle without a private washing machine, upon the event of lifestyle changes.

3.3. Designing an Intervention and Its Environmental Potential

From the results of the interview and survey, we designed an intervention with the highest potential for home washing machines to shift toward EL use. Accessibility to a laundromat was repeatedly noted as a key role in laundromat use. In addition, among the eight laundromats presented in Figure 5, those built within an apartment building was the only type with mode of "I can probably

shift" with PL. Respectively, we generated "implementation of a communal laundry room in each apartment building" as an effective intervention to encourage product sharing.

Under the assumption that one household washes every other day with the laundromat, and one washing machine is used for 12 loads per day, we set a scenario that 24 households in an apartment building are to share 1 washing machine. Because one load (9 kg) of washing generally takes about 30 min to complete, we chose 12 loads as the maximum number of loads possible assuming efficient switch between one user to another. Additionally, in the survey, 42% of HL responded their willingness to forego washing machines and use laundromats if there was a laundromat in an apartment building. We applied this statistic and computed the environmental impact of laundry activities of a baseline case (i.e., all residents own and use home washing machines), a laundromat case (i.e., all residents forego washing machines and use laundromat in the apartment), and a behavioral shift case (i.e., 42% of the residents forego washing machines and use the laundromats). As a result, the behavioral shift case has smaller GHG emissions and resource use by 1.8% and 16%, respectively, when compared to the baseline case (Figure 7 and Table 5). The major GHG contributor in laundry activity is the manufacturing of detergents and electricity use in the washing machine operation. The energy efficiency was also found to be comparable between home washing machines and laundromat washing machines. These two influential processes are constant per load of washing upon product sharing; thus, the GHG reduction potential of laundromats is limited. Indeed, our GHG result aligns with that of a study comparing annual energy consumption of communal laundry room and home washing machine [37]. Resource use on the contrary, can be directly benefitted from product sharing. If the washing machines can be shared with a greater number of households, the resource use per load of washing could also be reduced further.

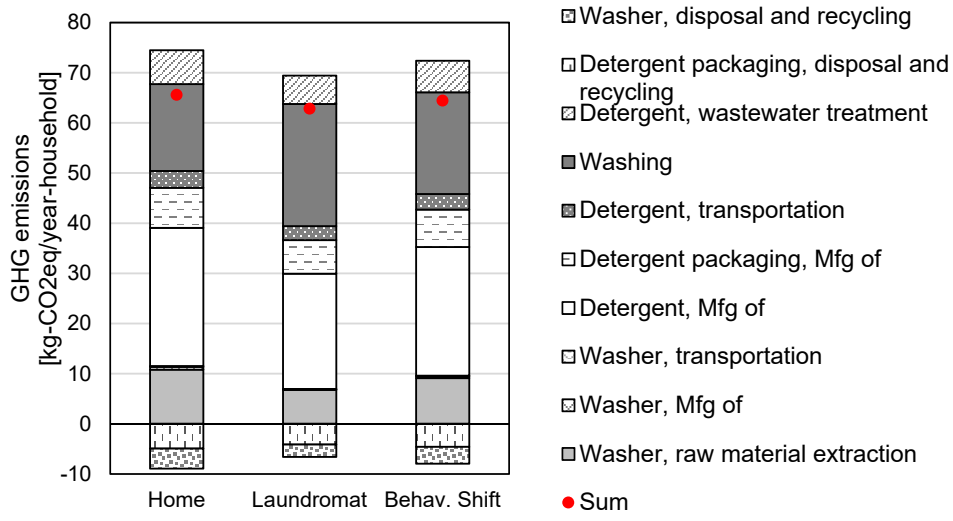

Figure 7. GHG emissions of baseline case (Home), laundromat case (Laundromat), and behavioral shift case (Behav. Shift).

Table 5. Numerical results of the environmental impact assessment.

Environmental Impact	Unit	Home	Laundromat	Behav. Shift Scenario
GHG emissions	$kgCO_2$-eq/year-household	65.6	62.8	64.4
Resource use	kg steel/year-household	1.97	1.23	1.66

4. Discussion

To induce a behavioral shift in laundry activities toward laundromats for consumers owning private washing machines, we proposed "implementation of a communal laundry room in apartment

buildings" as a promising intervention. While one study conveyed that utility, trust, cost savings, and familiarity were found to be essential in collaborative consumption [15], our conclusion conveys that utility in a form of accessibility to the product is the key element for consumers to forego their ownership. We also provided an example of consumer decision model in the behavioral shift between individual ownership to product sharing. This model sets a basis to investigate behavioral shifts with sharing of other products. As we envisioned our methodology to be beneficial for policy design, we first discuss policy infrastructures and other requirements to realize our proposed intervention to be effective. Secondly, we discuss limitations raised from the assumptions in our study.

Implementation of our proposed intervention expects consumer acceptance, and reduction of GHG and resource use; however, several policy infrastructures and environmental requirements are recommended for the intervention to be effective. We generated a list of policy infrastructures based on our survey results, which found to resonate with the five types of consumer hurdles for product sharing by Matsuo (2005). First, the communal laundry room should be open for 24 hours because all segments mentioned "Lack of freedom to do laundry anytime" as one vital reason for not being able to forego a private washing machine (Table 4). This factor would also reduce the perceived hurdle for product sharing: reduced freedom of product use. Secondly, the laundry room use should be restricted to residents to minimize traffic and maximize privacy while sharing washing machines. This rule would minimize the anxiety and resistance against sharing products with strangers. Restricting the access is also likely to help maintain the cleanliness of the facility, which was mentioned as the most important factor in laundromat use by all segments. To ensure cleanliness, setting up stringent health standards by the Health and Medical Bureau is recommended because the current standards required by laundromats is more flexible than dry cleaners in Japan [38]. Additionally, the installed equipment should allow large loads and process washing in a time-efficient manner. These functions could be coupled with another type of laundromat with a relatively high potential for a behavioral shift in Figure 5: Equipped with the latest machine that has a fine finish. It is indeed possible to combine multiple types of laundromats inquired in our survey to increase consumer acceptance. These two characteristics were found important for consumers to continue using the laundromats (Figure 4).

Furthermore, we generated our intervention and drew conclusions on its effectiveness based on several assumptions, which also led to limitation of our study. First assumption is the treatment of consumer preference as consumer acceptance in the survey analysis. The survey responses are mere reflectance of consumer preference, and whether the respondents would actually enact according to how they responded is uncertain. To make causal inferences between consumer preference and consumer acceptance, experimentation is necessary [39]. Secondly, we disregarded social norms involved in washing machine ownership. As the washing machine was widely advertised as one of "The Three Sacred Treasures of Home Appliances (Sansyu-no-jiingi)" after World War II, washing machine ownership has been a sign of affluence in Japan for the past half century. While laundromat markets are newly developing in Japan, the influence of social norms on the laundromat use has yet to be considered in this study. Thirdly, we assumed laundry patterns remain the same between home washing and laundromat, but it may not be the case in reality. Often consumers use a drying machine after washing at a laundromat, which has a significant energy use [40]. On the one hand, laundromat can increase environmental impact, while on the other, consumers may do a larger load of laundry with a communal laundromat to save money because financial reasons were critical among all segments (Table 4). A larger load of laundry would result in a smaller environmental impact per load.

5. Conclusions

In this study, we designed an intervention to induce behavioral shifts toward product sharing from individual ownership that reflect consumer behaviors and acceptance with a case of laundry activities in Japan. In the process of intervention design, we formulated a consumer decision model from HL to laundromat use, where we identified four triggers and DPs in the behavioral

shift. This model sets a basis for understanding the behavioral shift between ownership to product sharing. Accessibility to laundromat was a prevalent factor for consumers to recognize the need, use a laundromat, and continue to use laundromats. We generated "implementation of a communal laundry room in apartment buildings" as a promising intervention to induce behavioral shifts, where it has a potential to reduce GHG and resource use with respect to home washing only by 1.8% and 16%, respectively, in a community of households. While we limited our study to treat consumer preference as consumer choice, our design approaches provide an example of ways to identify decisive factors in product sharing and integrate consumer acceptance in policy intervention.

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

Appendix

Table A1. Summary of survey questions.

Section	Type of Questions	Respondents		
		HL	**PL**	**EL**
1. General information	Age; gender; employment status; household income; size of household; type of household members; housing type; location of residence	○	○	○
2. Current pattern of laundry activities	2.1 Home washing a. Type of washing machine and dryer owned b. Frequency of laundry and type of washing machine used c. Average size of one load 2.2 Washing at laundromat a. Frequency and size of washing machine and dryer used b. Average size of one load c. Mode of transport	○	○	○
3. Perspectives on behavioral shifts involving laundromat use	3.1 (T1 and DP1) Need recognition and factors influencing the interest in a laundromat: *What triggered you to use a laundromat? Please select one or more from the list.* ☐ In the event of lifestyle changed ☐ My home washing machine broke down ☐ I saw advertisement on a television ☐ I learned that new laundromats opened in my neighborhood ☐ Others		○	○
	3.2 (T2 and DP2) Use experience with a laundromat: *What are the reasons for you to continue using a laundromat? Please select your reason(s) from the list.* I use laundromat because . . . ☐ It allows larger load than washing at home ☐ It takes less time to complete than washing at home ☐ It requires less effort than washing at home ☐ It has a better finish than washing at home ☐ I can do laundry anytime without worrying about making noise ☐ I can wash dirty clothes without worrying about dirtying washing machines ☐ It is better for the environment than washing at home ☐ I don't have space to dry clothes in my house ☐ It requires no washing machine maintenance ☐ It is less expensive than washing at home ☐ I do not need to allocate space for washing machines and dryers ☐ Others		○	○

Table A1. *Cont.*

3.3 (T3 and DP3) Lifestyle without a private washing machine (1): *For each laundromat described below, if such laundromat was located in your ideal location with ideal price setting, would you be able to shift to a lifestyle without a private washing machine?*
(Characteristic of the laundromat)

1. Built within the apartment housing (Accessibility)
2. Equipped with the latest machine that has fine finish (Quality of the product shared)
3. Has fluff and fold services (Additional service for efficiency)
4. Has mobile app equipped machines (Efficiency)
5. Located adjacent to shopping centers and restaurants (Accessibility)
6. Interior is fashionable and sells laundromat-branded goods (Additional service)
7. Has a private room for customers and store-stationed staffs (Privacy and additional service)
8. Has free Wi-Fi and space to work (Efficiency)

3.4 (T3 and DP3) Lifestyle without a private washing machine (2): *For those who selected "I am neutral", "I probably cannot shift" or "I cannot shift", what are the reasons for not being able to shift? Choose from one or more from the list below.*

- ☐ Laundromat seems more expensive than washing at home
- ☐ Home laundry is sufficient
- ☐ Home laundry is a basic requirement in my lifestyle
- ☐ Lack of freedom to do laundry anytime
- ☐ I don't want to share washing machines and/or dryers
- ☐ Laundromat seems dirty ○ ○ ○
- ☐ I don't want to do accumulate laundry and do a large load at once
- ☐ Laundromat requires more effort
- ☐ I don't want to share the laundry space with others
- ☐ I cannot imagine my current lifestyle with laundromats
- ☐ It takes more time to complete laundry
- ☐ It's worse for the environment compare to washing at home
- ☐ I am concerned of pollens and allergies
- ☐ The finish is not as good as washing at home
- ☐ I am particular about how I do laundry
- ☐ I don't have many clothes
- ☐ Others

3.5 *How much are you willing to pay per load (10 kg of clothes) for you to shift to a lifestyle without a private washing machine? Select one from the list below*

- ○ Less than 50 yen
- ○ Less than 100 yen
- ○ Less than 200 yen
- ○ Less than 300 yen
- ○ Less than 400 yen
- ○ I am willing to pay over 400 yen
- ○ I cannot shift regardless of the cost of laundromat

Table A1. *Cont.*

3.6 (T4 and DP4) The event of lifestyle changes and their influence on laundromat use: *In the event of each lifestyle change listed below, would you be able to shift to a lifestyle without a private washing machine? Select one or more from the list below* ☐ If my family structure changes ☐ If I become more busy ☐ If I have more time ☐ If my income decreases ☐ If my income increases ☐ If I move ☐ If I was younger ☐ If I was older	○	○	○	

Table A2. Summary of material composition of products.

Product	Stage	Material/Resource	Value	Unit	Data source
Washing machine	Raw material extraction	Fe (Zn-plated) Fe Cu Al Polypropylene Polystyrene Polyvinylchloride Acrylonitrile butadiene styrene	26.5 26.5 3 1 7.4 7.4 7.4 7.4	% of washing machine weight	[26,29] Material manufacturing taken from IDEA [18]
	Manufacturing	Electricity Heavy oil City gas Transportation	8.87 0.46 0.27	kWh/washing machine kg/washing machine m^3/washing machine	[29]
Detergent	Raw material extraction	"Manufacturing of synthetic laundry detergent"	1.34	$kgCO_2$/kg-detergent	[27]
Detergent packaging	Raw material extraction	Polyethylene (Bottle) Polypropylene (Cap) Polyethylene (Pouch)	9.73×10^{-2} 3.99×10^{-2} 2.09×10^{-2}	Kg/kg-detergent	Primary data taken from the detergent product of Lion corporation

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