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Frugal by nature or by need? Unpacking long-term smartphone use in Japan and Germany

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ABSTRACT

Understanding consumer behavior is crucial for promoting sustainability in an era of rapid technological advancement and environmental challenges. This study focuses on Japan and Germany. Drawing on data collected through an online survey conducted by a professional web survey company in early 2024, 600 participants were recruited (300 from each country). The analysis employed structural equation modeling (SEM) to examine the relationships between price consciousness, perceived knowledge, emotional attachment, perceived risk, and frugality, as well as their influence on long-term use intentions. The findings reveal that frugality significantly mediates these relationships, with notable cultural distinctions. In Japan, frugality aligns with cultural norms that emphasize resource conservation, thereby amplifying the impact of emotional attachment and perceived knowledge. In Germany, where trust in refurbished products is higher, frugality plays a less pivotal role, with technological reliability and innovation taking precedence. Perceived risks associated with refurbished smartphones negatively impact long-term use intentions in both countries, highlighting the need to address consumer concerns about quality and performance. Practical implications for businesses include designing durable, repairable products, offering extended warranties, and fostering emotional attachment through personalization. Policymakers are encouraged to support repairing infrastructure and enforce regulations ensuring fair access to restore resources. By leveraging SEM to analyze cross-cultural data, this study provides actionable insights for promoting sustainable practices, aligning with global efforts toward a circular economy.

1. Introduction

1.1. Background

In today's rapidly advancing global economy, material prosperity has undoubtedly improved living standards, but it has also exacerbated environmental degradation (Meadows et al., 2004). While often linked to industrial energy use, the roots of environmental harm are equally embedded in individual consumption patterns, values, and everyday choices (Wang et al., 2021). Now essential to modern life, smartphones represent a particularly significant sustainability concern (Paiano et al., 2013). The frequent replacement of mobile phones to meet consumer demand exacerbates environmental challenges by increasing the demand for raw materials, rising energy and water consumption, and, when end-of-life devices are improperly disposed of, causing significant harm to human health and the environment (Gomez et al., 2023). Recent studies indicate that smartphones have surpassed the environmental impact of other electronic devices in their lifecycle due to their rapid replacement cycles and energy-intensive manufacturing (Ercan et al., 2016)

To address these sustainability challenges, governments and international organizations increasingly promote strategies that support resource efficiency and circular economy principles (Kumar et al., 2024; Bracking and Leffel, 2021; Alem and Townsend, 2014; Negi et al., 2025). A central tenet of these strategies is extending product lifespans through design improvements, enhanced repairability, and changes in consumer behavior (Stegmann et al., 2023). From the consumer perspective, frugality, a value-driven tendency to minimize wasteful consumption

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and prioritize long-term use, is receiving renewed attention (Lastovicka et al., 1999). Frugal consumers tend to delay purchases, maintain products for longer periods, and embrace repair and reuse practices, all of which align closely with sustainable consumption goals (Wang et al., 2021; Philp and Nepomuceno, 2020).

Frugality also represents a counter-narrative to materialism and trend-driven consumption, challenging the norms of obsolescence embedded in technology markets (Sheth et al., 2011). However, while frugality is increasingly studied as a pro-environmental behavior, the influence of psychological factors such as risk perception, price sensitivity, and emotional attachment on frugality remains underexplored, particularly in the context of long-term use of smartphones, a product category marked by rapid technological turnover.

1.2. Research gap and research questions

Although prior research has explored the antecedents of frugality (e.g., Goldsmith et al., 2014) and highlighted its environmental relevance, several key gaps remain. First, few studies have explicitly linked frugality to consumers' intentions to prolong smartphone use, a behavior critical for reducing electronic waste and minimizing environmental impact (Herbes et al., 2021). Second, while perceived risk is widely recognized as a barrier to adopting sustainable technologies (e.g., Sheth et al., 2011), little research has assessed how it influences continued product use behavior over time, particularly through indirect pathways such as the mediating role of frugality. This represents a critical omission, given that risk perceptions may deter even environmentally motivated consumers from continuing to use older devices. Third, the roles of consumer attitudes such as price consciousness (Lichtenstein et al., 1993), perceived knowledge, and emotional attachment, as well as their individual contributions to sustainable usage intentions through frugality, remain underexplored. Examining these attitudes in isolation risks overlooking important synergistic or compensatory effects (Riyaz et al., 2024), and a more integrated view can improve predictive accuracy for sustainable consumption behaviors.

To address these gaps, our study draws on Prospect Theory (Kahneman and Tversky, 1979), which explains how individuals evaluate decisions under uncertainty in terms of perceived gains and losses relative to a reference point. This framework is well-suited to consumer decisions about refurbished or long-term smartphone use, where economic and psychological trade-offs are involved. Price consciousness reflects heightened sensitivity to economic gains (e.g., savings from extended use) and avoidance of losses (e.g., the cost of a new phone). Perceived knowledge reduces ambiguity, enabling more accurate gain–loss evaluations, while a lack of knowledge magnifies perceived risk and loss aversion. High perceived risk in replacing a device may lead consumers to frame continued use as loss avoidance, and emotional attachment can shift the reference point so that replacement feels like a loss, reinforcing prolonged use. Linking these constructs through Prospect Theory offers a cohesive explanation of how perceived risks, cognitive evaluations, and emotional responses shape frugality and sustainable usage intentions.

Furthermore, most existing studies rely on data from a single country, limiting their applicability across diverse cultural contexts. Given that environmental values, technology adoption, and consumption norms differ significantly across cultures, cross-cultural research is necessary to distinguish between universal drivers of sustainable behavior and those that are context-specific. This study addresses existing gaps by comparing consumers in Japan and Germany, two economically advanced nations with strong environmental commitments but culturally distinct approaches to frugality and product use. While both countries promote sustainable consumption (OECD, 2023), they differ in how frugality is expressed. In Germany, frugality is often characterized by a strong culture of repair and maintenance, with consumers actively engaging in practices that extend the lifespan of products (Hielscher and Jaeger-Erben, 2019). In contrast, Japanese consumers emphasize craftsmanship, quality, and innovation, favoring durable products but often opting for replacement over repair when newer, higher-quality options become available (Tsukamoto and Yamakawa, 2017). These differing cultural logics offer valuable cross-national insights into how frugality, perceived knowledge, and emotional attachment shape consumer behavior under resource constraints and circular economy objectives (Geissdoerfer et al., 2017).

First, Japan and Germany were chosen because both countries demonstrate distinct, culturally embedded approaches to frugality shaped by their historical and socio-economic contexts. In Japan, the concept of *mottainai,* which expresses regret over wasting something valuable, embodies a deeply rooted cultural norm that promotes mindful consumption and environmental stewardship (World Economic Forum, 2019). A 2009 survey found that 57 percent of Japanese respondents considered themselves environmentally conscious, and 84 percent preferred to purchase environmentally friendly consumer products (McKinsey Quarterly, 2010). Furthermore, over one-third of Japanese consumers had reduced their spending. At the same time, 53 percent reported preferring to "spend time to save money" rather than "spend money to save time," reflecting a widespread frugal orientation driven by cultural values and economic awareness. In contrast, Germany's frugality is closely linked to historical experiences with economic instability and national efforts to promote fiscal discipline. German consumers have long been characterized by price sensitivity and a strong value-for-money mindset (Witschi et al., 2021). These contrasting yet deeply ingrained approaches to frugality make Japan and Germany ideal for cross-cultural analysis of consumer behavior in sustainability and circular economy contexts.

Second, Germany has been at the forefront of the circular economy in Europe and exhibits high levels of environmental awareness and policy integration (Stahel, 2016). On the other hand, Japanese consumers are known for their appreciation of product quality and long-term use, especially within a cultural context that values *mottainai* (Evers et al., 2018).

This study investigates the following research questions in the contexts of Japan and Germany.

- **RQ1:** How does frugality influence consumers' intentions to extend the use of smartphones in Japan and Germany?
- **RQ2:** How does perceived risk affect the intention to use smartphones over the long term, and does this relationship differ between Japanese and German consumers?
- **RQ3:** How do price consciousness, perceived knowledge, and emotional attachment interact with frugality to shape long-term smartphone usage intentions in Japan and Germany?

By addressing these questions, the study contributes to the literature in three key ways: (1) it advances theoretical understanding of frugality as a mediating mechanism in sustainable technology consumption, (2) it incorporates a range of psychological and behavioral drivers into a comprehensive analytical model, and (3) it provides comparative empirical insights from Japan and Germany, two nations with contrasting cultural values but comparable economic and environmental ambitions.

The remainder of this paper is structured as follows: Section 2 reviews the relevant literature and develops the hypotheses. Section 3 outlines the research methodology. Section 4 presents the empirical results. Section 5 discusses the findings and their implications. Section 6 offers practical recommendations for stakeholders. Section 7 concludes with limitations and directions for future research.

2. Literature review and hypothesis development

2.1. Theoretical background

Our conceptual framework was primarily informed by the work of

Wang et al. (2021), who examined the role of frugality in shaping green purchase intention, identifying it as a key personal value that influences sustainable behavior. Their study also demonstrated the mediating role of motivation to save in the relationship between frugality and environmentally conscious purchasing behavior. Inspired by this approach, we extended the idea of frugality as a mediating construct to a different, yet related, behavior: long-term smartphone use. In addition, our framework is shaped by prior findings from our earlier work (Chun et al., 2023), which indicated that price consciousness does not directly lead to sustainable consumer behavior. Instead, we observed that an intervening variable (mediator) was frequently necessary to translate these psychological factors into concrete behavioral intentions. The mediation between price consciousness and purchase intention has also been observed in other studies, where attitude serves as a mediator (Jin and Kang, 2011). Emotional attachment was used as a mediator in Thomson et al. (2005) and Jussila et al. (2015). This study hypothesizes that frugality serves as the key mediator, linking consumer attitudes (e.g., price consciousness, perceived knowledge, emotional attachment) to the intention to extend smartphone usage, a sustainable behavior aligned with the goals of the circular economy. Thus, our conceptual model builds upon and integrates prior theoretical perspectives from Prospect Theory (Kahneman and Tversky, 1979) and empirical findings by Wang et al. (2021), while offering a novel contribution by applying the mediation role of frugality in the context of long-term product use across two cultural settings.

2.1.1. Long-term use and the circular economy

The long-term use of consumer goods, especially smartphones, is a key strategy in achieving the objectives of the circular economy, which emphasizes reducing waste, extending product life cycles, and improving material efficiency (European Parliament, 2024). By promoting maintenance, repair, reuse, and remanufacturing, the circular economy helps minimize resource depletion and environmental impact.

Smartphones require significant amounts of energy and rare earth minerals to produce and are among the fastest-growing categories of e-waste (Cordella et al., 2021). Extending their lifespan reduces both material input and waste output. Moreover, promoting long-term use supports the principle of slowing resource loops, as described by Stahel (2016), helping consumers avoid premature replacement. The refurbished smartphone market plays a crucial role in this effort, offering access to lower-cost, lower-impact devices (Nasiri and Shokouhyar, 2021).

This study examines the psychological and behavioral factors influencing the long-term intention to use smartphones, focusing on **frugality**, **risk perception**, **price consciousness**, **perceived knowledge**, and **emotional attachment**. Among the many potential factors influencing such behavior, we selected *frugality*, *price consciousness*, *perceived knowledge of refurbished smartphones*, and *emotional attachment* because they directly capture key economic, cognitive, and emotional dimensions relevant to long-term product use, especially for high-involvement goods like smartphones.

Frugality was selected as a central construct because it encompasses financial prudence and a value-driven mindset that encourages product longevity, qualities critical for sustainable smartphone use (Belk, 1988; Thøgersen, 2018). While other psychological constructs, such as environmental concern or materialism, may be relevant, frugality more precisely captures the cost-avoidant, utility-maximizing orientation directly tied to product retention and reuse. *Price consciousness* was chosen over broader economic status variables (e.g., income) because it reflects consumers' behavioral tendencies rather than static socioeconomic indicators. Research indicates that price-conscious individuals frequently adopt frugal consumption patterns (Shoham et al., 2017), rendering this construct a more actionable predictor of sustainable smartphone use. We included *perceived knowledge of refurbished smartphones* because knowledge enables consumers to overcome doubts about product reliability and make informed decisions (Ballantine and Creery, 2010). Compared to general product knowledge or technology adoption factors, perceived knowledge of refurbished devices is more context-specific and highly relevant to the reuse and extended-use behavior we study. Finally, *emotional attachment* was selected to capture the psychological bond users form with their devices, influencing maintenance behavior and the desire to prolong usage (Dolan, 2023). Although other constructs like habit or satisfaction might also predict long-term use, emotional attachment explains why users may resist upgrading and sustain relationships with their current devices instead. These variables were chosen not arbitrarily, but because they represent core dimensions, economic (frugality, price consciousness), cognitive (knowledge), and emotional (attachment), that are theoretically grounded, empirically supported, and contextually relevant for examining long-term smartphone use in both sustainable consumption and cross-national settings.

2.2. Hypothesis development

2.2.1. The relationship between frugality and the intention of long-term use of smartphones

Frugality is a personal value or lifestyle orientation characterized by restrained acquisition and resourceful use of goods and services (Lastovicka et al., 1999). Frugal individuals seek to minimize unnecessary consumption and derive satisfaction from maximizing the utility of existing products (Pepper et al., 2009). This attitude aligns with sustainable consumption principles: repair, maintenance, and continued use.

From the perspective of Prospect Theory (Kahneman and Tversky, 1979), frugality reflects a decision-making approach that seeks to avoid perceived losses (e.g., spending on unnecessary upgrades) and maximize perceived gains (e.g., extracting more value from existing devices). Frugal consumers are likely to frame continued use of functional smartphones as both an economic and psychological gain, reinforcing circular consumption patterns.

Recent studies reinforce the significance of frugality in sustainability contexts. For example, Wang et al. (2023) conducted a meta-analysis that demonstrated a positive association between frugality and sustainable consumption behaviors, including the practice of product longevity. Similarly, Awais et al. (2020) found that frugality is a key driver of sustainable consumption behavior across product categories.

H1. Frugality is positively related to the intention of long-term use of smartphones.

2.2.2. The relationship between perceived risk and the intention of long-term use of smartphones

Perceived risk includes uncertainty regarding a product's functional performance, durability, and trustworthiness (Stone & Grønhaug, 1993). For smartphones, especially refurbished or older models, concerns about early failure or lack of support may drive premature replacement (Jimenez-Parra et al., 2014). These risks may undermine even frugal intentions, particularly when users feel that repair or continued use is not worth the potential trouble.

From a Prospect Theory standpoint, high perceived risk increases loss aversion, making potential failures loom larger than potential gains from keeping the device. This negative framing may shift consumer decisions toward replacement rather than continued use, despite possible economic benefits.

Empirical evidence supports this relationship: perceived risk has been shown to significantly deter product adoption and continued use in technology contexts (Lu et al., 2005; Kim et al., 2015; Pelaez et al., 2017). Van Weelden, Mugge, and Bakker (2016) similarly found that perceived risk was a significant barrier to the continued use and repair of products in the electronics sector.

H2. Perceived risk is negatively related to the intention of long-term use of smartphones.

2.2.3. The mediating role of frugality in the relationship between price consciousness and the intention of long-term use of smartphones

Price consciousness refers to the tendency to prioritize low prices and perceived value when making purchase decisions (Lichtenstein et al., 1993). In the electronics sector, price-conscious consumers often choose refurbished smartphones to obtain desired functionality at a lower cost (Matsumoto et al., 2018a). While their initial motivation may be savings, the desire to maximize utility, especially when combined with frugality, can lead to longer product retention (Shoham and Brenčič, 2004).

Prospect theory offers a useful lens to understand this behavior: framing prices, emphasizing potential losses (or avoided losses through frugal choices), and anchoring decisions to reference points can shape how consumers express price consciousness and frugality (Orhun and Palazzolo, 2019). Lastovicka et al. (1999) also highlight the link between avoiding unnecessary spending and loss aversion, a core principle of prospect theory. Price sensitivity's role in shaping consumer decisions is also supported by prior work in mobile commerce (Natarajan et al., 2017). For price-conscious consumers, the "loss" of overpaying for a new phone can feel particularly acute. In contrast, the "gain" of saving money by extending the use of their current device can feel especially rewarding. This reinforces the likelihood that price consciousness and frugality are connected. As we have established the relationship between frugality and the intention to use smartphones long term, we propose the following hypothesis.

H3a. The effect of price consciousness on the intention of long-term use of smartphones is mediated by frugality.

2.2.4. The mediating role of frugality in the relationship between perceived knowledge and the intention of long-term use of smartphones

Perceived knowledge, a consumer's subjective assessment of their understanding of a product, can reduce perceived uncertainty and influence behavior (Brucks, 1985). In the refurbished smartphone market, greater perceived knowledge is associated with more informed expectations, less concern about quality, and a higher likelihood of product acceptance (Wang and Hazen, 2016).

According to Prospect Theory, ambiguity heightens perceived risk and loss aversion. When consumers are well-informed, they can more accurately weigh potential gains, such as cost savings, against possible losses, such as performance issues, when deciding whether to retain or replace a device (Tversky and Kahneman, 1992). This clarity supports longer device use and fosters frugal behavior, as consumers view extended use as a feasible, gain-maximizing strategy (Nasiri and Shokouhyar, 2021). Given the established link between frugality and the intention to use smartphones long term, we propose the following hypothesis.

H3b. The effect of perceived knowledge on the intention of long-term use of smartphones is mediated by frugality.

2.2.5. The mediating role of frugality in the relationship between emotional attachment and the intention of long-term use of smartphones

Emotional attachment involves the affective bond between a user and a product, often formed through daily interaction, personalization, or stored memories (Thomson et al., 2005; Vincent, 2005). In the case of smartphones, users often develop attachment due to sentimental or habitual factors, making it harder to discard the device even when it ages (Sung and Choi, 2014).

Within Prospect Theory, emotional attachment shifts the consumer's reference point. Replacing a beloved device is perceived not as a neutral act but as a psychological loss, which individuals are motivated to avoid (Thaler, 1980). This framing can reinforce frugality by increasing the perceived value, both economic and emotional, of continued possession. Research indicates that emotional attachment can act as a psychological barrier to product disposal and encourage consumers to maintain functionality (Toh et al., 2019; Sohn et al., 2022). Emotional bonds to products or consumption experiences can increase willingness to extend product use, reduce waste, and act in resource-conscious ways (Ni, 2021). Mannion and Nolan (2020) further argue that smartphones serve as emotional anchors in the digital age, which may increase the likelihood of prolonged use. Accordingly, we propose the following hypothesis.

H3c. The effect of emotional attachment on the intention of long-term use of smartphones is mediated by frugality.

2.2.6. Research model

FIg.1 illustrates the conceptual model of this study, outlining the hypothesized relationships among the key variables.

3. Methods

3.1. Data collection

In early 2024, a professional web survey company administered an online questionnaire to 600 participants, evenly divided between Japan (n = 300) and Germany (n = 300). Recruitment followed purposive sampling, targeting individuals who met two specific eligibility criteria: they were currently using a mobile phone or smartphone, and they had personally been involved in selecting their current device. Screening questions at the beginning of the survey verified these criteria, and respondents who answered "No" to the first question or "Not involved" to the second were excluded.

The questionnaire began with the screening items, followed by demographic questions and an explanation of smartphone options. Participants were then introduced to a hypothetical purchase scenario involving refurbished smartphones. These were described as professionally cleaned, repaired, and data-erased by a third-party refurbish manufacturer, with a battery retaining at least 80 % of its original performance (but not replaced), a price set at $250, and a warranty for product replacement within a specified period.

The survey was fully anonymous, and all participants provided informed consent before proceeding. Clear instructions ensured that respondents understood the task, and confidentiality was maintained throughout. Responses were compiled for subsequent analysis to compare preferences and purchase intentions across demographic segments and national contexts.

Table 1 presents the demographic profile of the sample, which achieved an equal gender distribution and proportional representation across age categories and residential areas in each country.

3.2. Scales of measurement

Respondents' perceptions were measured using 18 questions on a seven-point Likert scale across four key constructs: frugality (three items), perceived knowledge of refurbished smartphones (three items), perceived risk (three items), emotional attachment (three items), and price consciousness (four items). These constructs were based on a literature review (Lastovicka et al., 1999; Jimenez-Parra et al., 2014; Wang et al., 2013; Lichtenstein et al., 1993) and industry consultation. Each latent variable was measured using three or four items, meeting the recommended number for constructs in CFA or SEM, which facilitates model identification and the assessment of convergent and discriminant validity (Kenny and McCoach, 2003). We used existing, validated scales to measure all constructs. These scales have been applied in prior studies conducted in Japan and Germany. Frugality was measured with Lastovicka et al.'s (1999) scale, perceived knowledge and risk with Wang et al.'s (2013), and price consciousness with Lichtenstein et al.'s (1993). Two items for long-term smartphone use intention were developed for this study. The questionnaire was pretested with 110 U.S. university students before broader administration. We consulted with local business professionals in each country to ensure accurate and culturally

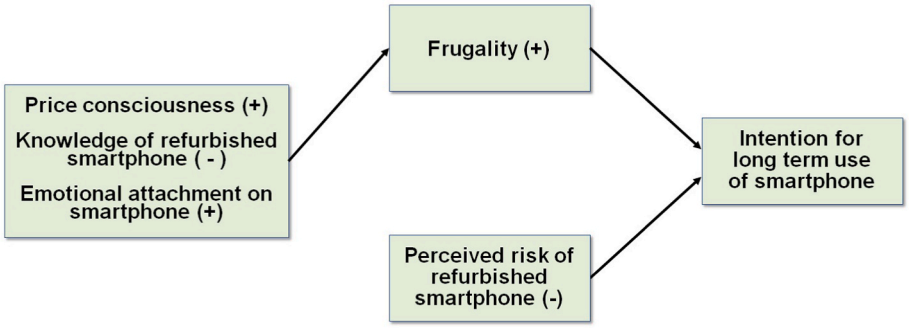

Fig. 1. Research model.

Table 1
Summary of demographic statistics of respondents.

		Japan		Germany	
Measure	Categories	Frequency	Percent (%)	Frequency	Percent (%)
Gender	Male	150	50.0	150	50.0
	Female	150	50.0	150	50.0
Age	18–29	60	20.0	60	20.0
	30–39	60	20.0	60	20.0
	40–49	60	20.0	60	20.0
	50–59	60	20.0	60	20.0
	≥60	60	20.0	60	20.0
Family income	<2M	30	10.0	42	14.0
	2M–3.99M	54	18.0	81	27.0
	4M–5.99M	60	20.0	74	24.7
	6M–7.99M	38	12.7	44	14.7
	8M–9.99M	30	10.0	27	9.0
	>10M	31	10.0	22	7.3
	Don't know	57	19.0	10	3.3
Residence	Large cities	78	26.0	57	19.0
	Regional cities	89	29.7	99	33.0
	Suburban	52	17.3	49	16.3
	Rural area	74	24.7	93	31.0
	Other	7	2.3	2	7.0

Note: Family income is expressed ¥ for Japan and € for Germany.

appropriate translation of the survey items. Their input allowed us to refine the wording to provide clarity and relevance across diverse consumer segments. For example, "frugality" was carefully translated into Japanese as *setsuyaku*, a word that reflects economic restraint and lifestyle simplicity.

3.3. Survey administration

Participants were shown two smartphone options: a latest-model device and a refurbished device. Detailed information on each option's features and price was provided. They then completed a questionnaire measuring price consciousness, perceived risk, frugality, product knowledge, attachment, and intention for long-term use, using a 7-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree." The survey was conducted electronically. Demographic factors showed no significant impact on the model.

The mean scores varied between Japan and Germany, reflecting cultural or market differences. Germans scored higher on price consciousness (mean = 5.189 vs. 4.343), knowledge (mean = 4.059 vs. 2.853), and frugality (mean = 5.466 vs. 5.074), while Japanese participants scored slightly higher on perceived risk (mean = 4.053 vs. 3.888) and attachment (mean = 4.464 vs. 4.743). Long-term use intention was similar, with Japanese participants scoring 5.280 and Germans 5.385. Descriptive statistics for all constructs are summarized in Table 2.

A total of 300 participants participated in the study in each country, comprising 150 males and 150 females. The participants were further categorized into age groups, with 60 individuals in each country's age brackets: 18–29, 30–39, 40–49, 50–59, and 60 and older.

Table 2
Descriptive statistics of constructs.

	Japan		Germany	
	Mean	s.d.	Mean	s.d.
PCONS	4.343	1.134	5.189	1.595
KNOW	2.853	1.502	4.059	1.763
PRISK	4.053	1.224	3.888	1.718
FRUGAL	5.074	1.168	5.466	1.349
EATTACH	4.464	1.284	4.743	1.464
LTUSE	5.280	1.517	5.385	1.642

Note: PCONS: Price consciousness; KNOW: Knowledge of refurbished smartphones.
PRISK: Perceived risk of refurbished smartphones; FRUGAL: Frugality.
EATTACH: Emotional attachment to the smartphone.
LTUSE: Intention to use the smartphone for a long-time.

4. Results

4.1. Testing measurement model

Composite reliability and Cronbach's α demonstrated the scale's internal consistency; all constructs ranged above .8. Convergent validity was examined because the indicator's estimated coefficient was significant on its posited underlying construct factor. We used three criteria (Fornell and Larcker, 1981) to evaluate convergent validity: factor loadings should be greater than .5; the internal reliabilities (measured by Cronbach's α) should be greater than .8; and all constructs' average variance extracted (AVE) should meet at least .5.

The results summarized in Table 3 demonstrate that they meet the criteria for convergent validity. The AVEs for each construct were greater than their shared variance with any other construct, thus satisfying the criteria for the discriminant validity (Fornell and Larcker, 1981) of the measurement model in this study.

To assess the potential presence of Common Method Bias (CMB), Harman's single-factor test was conducted using factor analysis in SPSS. The number of factors to extract was fixed at one, and no rotation was applied. The results indicated that the single factor accounted for 26.249 % of the total variance, which is below the threshold of 50 % commonly suggested as indicative of substantial CMB (Podsakoff and Organ, 1986; Podsakoff et al., 2003). Therefore, it can be concluded that CMB was not a serious concern in this study.

4.2. Analysis by structural equation modeling

We analyzed the data using AMOS version 28, a statistical tool for Structural Equation Modeling (SEM).

Table 3
Convergent and Discriminant validity.

	Composite Reliability (Cronbach's α)	PCONS	KNOW	PRISK	FRUGAL	EATTACH	LTUSE
PCONS	.92(.90)	**0.69**					
KNOW	.92(.92)	.07	**0.79**				
PRISK	.88(.88)	.00	.01	**0.70**			
FRUGAL	.83(.83)	.25	.00	.01	**0.63**		
EATTACH	.80(.80)	.02	.06	.05	.04	**0.58**	
LTUSE	.88(.88)	.07	.02	.00	.27	.02	**0.79**

Figures (in bold) in diagonal elements are AVEs. Other figures are square of the correlation.

4.2.1. Group comparison

We compared relationships between constructs across Japan and Germany: FRUGAL to PCONS, FRUGAL to KNOW, FRUGAL to EATTACH, LTUSE to FRUGAL, LTUSE to PRISK, LTUSE to EATTACH, LTUSE to KNOW, and LTUSE to PCONS. Parameter constraints were applied to test differences. A chi-square (χ^2) value ≥ 3.84 (df = 1) indicated a less than 5 % chance of deviation due to randomness.

The models showed a significant difference in the strength of the relationship between PCONS and FRUGAL (p = .02). No significant differences were found between LTUSE and EATTACH ($\chi^2 = 1.352$, p = .245) or LTUSE and PCONS ($\chi^2 = .703$, p = .402). However, the directional influences differed. For LTUSE and EATTACH, the estimate was .107 for Japan and −.002 for Germany. For LTUSE and PCONS, the values were −.063 for Japan and .023 for Germany. While conceptually significant, the overall model comparison (with all paths constrained) revealed no significant difference between the two countries (Df = 8, χ^2 = 15.277, p = .054).

4.2.2. Direct effects in the model

We examined the structural relationships and computed the R^2 statistic to determine the variance explained by the predictors. For LTUSE, R^2 was .25 (Japan) and .40 (Germany); for FRUGAL, it was .20 (Japan) and .32 (Germany), exceeding the benchmark of .1 (Falk and Miller, 1992).

The relative chi-square for the model was 2.12 ($\chi^2(254) = 539.393$), within the acceptable range (<5, Schumacker and Lomax, 2004). Fit indices indicated a good model fit: CFI = .953; TLI = .943; RMSEA = .043. Table 4 summarizes the direct effects.

The SEM examined relationships among FRUGAL, PCONS, KNOW, EATTACH, PRISK, and LTUSE across both countries.

4.2.3. Long-term use, frugality, and risk

LTUSE was strongly influenced by FRUGAL in both Japan (estimate = .658, SE = .110, p < .001) and Germany (estimate = .644, SE = .089, p < .001) (H1 was supported.). LTUSE had a negative association with PRISK in Japan (estimate = −.153, SE = .070, p = .028) but not in Germany (estimate = −.037, SE = .053, p = .489) (H2 was supported in Japan, not in Germany).

4.2.4. Other direct relationships

The following direct relationships were not hypothesized in the study but are reported here. Frugality (FRUGAL) was positively associated with price consciousness (PCONS) in Japan (estimate = .279, SE = .057, p < .001) and Germany (estimate = .464, SE = .052, p < .001). FRUGAL showed a negative association with knowledge of refurbished smartphones (KNOW) in Japan (estimate = −.130, SE = .039, p < .001) but no significant association in Germany (estimate = −.011, SE = .047, p = .817). FRUGAL was positively associated with emotional attachment (EATTACH) in Japan (estimate = .168, SE = .044, p < .001) but not significantly associated in Germany (estimate = .083, SE = .062, p = .185).

LTUSE was positively associated with EATTACH in Japan (estimate = .107, SE = .061, p = .080) but not in Germany (estimate = −.002, SE = .064, p = .969). KNOW was positively associated with LTUSE in Germany (estimate = .140, SE = .049, p < .001) but not in Japan (estimate = .078, SE = .054, p = .149). PCONS and LTUSE were not significantly associated in Japan (estimate = −.063, SE = .078, p = .418) or Germany (estimate = .023, SE = .063, p = .716).

4.2.5. Indirect effects in the model

To examine mediation, we applied the bootstrap confidence interval test method. Table 5 summarizes these results. We rejected the null hypothesis (i.e., no indirect effect) if zero was not included in the confidence interval's bounds. Bootstrap analyses were conducted with 2000 resamples at α = .05.

In Japan, the indirect effect of PCONS on LTUSE via FRUGAL was supported, with a confidence interval of .1–.303 (p = .001) (H3a is supported in Japan). The effect of KNOW on LTUSE through FRUGAL was also significant, with bounds of −.162 and −.029 (p = .002). Due to the negative relationship between KNOW and FRUGAL, this indirect effect was negative (H3b was supported in Japan). FRUGAL fully mediated the path between EATTACH and LTUSE, with bounds of .049–.186 (p = .001) (H3c is supported in Japan). These effects were confirmed as mediations since direct paths from PCONS, KNOW, and

Table 4
Results of direct effects in the structural equation model.

			JAPAN			GERMANY			Group Comparison		
			Estimate	SE	p	Estimate	SE	p	Df	CMIN (χ^2)	p
FRUGAL	<—	PCONS	.279	.057	***	.464	.052	***	1	5.384	.02*
FRUGAL	<—	KNOW	−.130	.039	***	−.011	.047	.817	1	3.525	.060
FRUGAL	<—	EATTACH	.168	.044	***	.083	.062	.185	1	1.131	.288
LTUSE	<—	FRUGAL	.658	.110	***	.644	.089	***	1	.009	.922
LTUSE	<—	PRISK	−.153	.070	.028*	−.037	.053	.489	1	1.664	.197
LTUSE	<—	EATTACH	.107	.061	.080	−.002	.064	.969	1	1.352	.245
LTUSE	<—	KNOW	.078	.054	.149	.140	.049	***	1	.666	.415
LTUSE	<—	PCONS	−.063	.078	.418	.023	.063	.716	1	.703	.402

*** Sig. at <.001; ** Sig. at <.003; * Sig. at <.05.
All estimate is unstandardized.
FRUGAL: Frugality; PCONS: Price consciousness; EATTACH: Emotional attachment to the smartphone; KNOW: Knowledge of refurbished smartphones; PRISK: Perceived risk of refurbished smartphones; LTUSE: Intention to use the smartphone for a long-time.

Table 5
Results of mediations: Japan and Germany.

	Japan				Germany			
Parameter	Estimate	Lower	Upper	P	Estimate	Lower	Upper	P
Med1 (PCONS - > FRUGAL - > LTUSE)	.184	.100	.303	.001***	.299	.187	.455	.001***
Med2 (KNOW - > FRUGAL - > LTUSE)	−.085	−.162	−.029	.002**	−.007	−.068	.063	.869
Med3 (EATTACH - > FRUGAL- > LTUSE)	.110	.049	.186	.001***	.053	−.034	.181	.256

*** Sig. at <.001; ** Sig. at <.003; * Sig. at <.05.
Med1 shows interaction between PCONS and LTUSE, FRUGAL serving as a mediator between them.
Med2 shows interaction between KNOW and LTUSE, FRUGAL serving as a mediator between them.
Med3 shows interaction between EATTACH and LTUSE, FRUGAL serving as a mediator between them.
FRUGAL: Frugality; PCONS: Price consciousness; EATTACH: Attachment to the smartphone; KNOW: Knowledge of refurbished smartphones; PRISK: Perceived risk of refurbished smartphones; LTUSE: Intention to use the smartphone for a long-time.

EATTACH to LTUSE were not significant (see Table 5).

In Germany, the indirect effect of PCONS on LTUSE via FRUGAL was supported, with bounds of .187–.455 (p = .001) (H3a is supported in Germany). However, no support was found for the indirect effect of KNOW on LTUSE (bounds of −.068 to .063, p = .869) (H3b is not supported in Germany), and FRUGAL did not mediate the relationship between EATTACH and LTUSE (bounds of −.034 to .181, p = .256) (H3c is not supported in Germany).

5. Discussion

5.1. Findings

This study confirms that **frugality significantly influences the intention to extend smartphone use**, but cultural context shapes how this influence unfolds. In both Japan and Germany, frugal consumers tend to maximize the utility of their smartphones by avoiding frequent replacements, a behavior consistent with prior findings linking frugality with sustainability-oriented actions. However, the intensity and implications of this behavior vary across countries.

In **Japan**, frugality is deeply embedded in cultural norms that promote minimalism and resource efficiency, thereby strengthening its influence on long-term usage behavior, including product repair (McQueen et al., 2022). Japanese consumers who score high in frugality are more likely to take care of their devices, avoid unnecessary upgrades, and engage in maintenance or repair practices that prolong the product's lifespan. While frugality also predicts long-term use in Germany, its impact may be less dominant because German consumers heavily value product performance, innovation, and trust in quality over cost-avoidance (James, 2025).

Perceived risk consistently has a negative impact on long-term use intentions in both countries, particularly with regard to refurbished smartphones. This aligns with recent studies showing that perceived quality and performance risks remain a major barrier to adopting secondhand or remanufactured electronics (Chinen et al., 2021; Wahjudi et al., 2018). In Japan, where consumers tend to be highly quality-sensitive (McKinsey Quarterly, 2010; Matsumoto et al., 2017), even frugal individuals may hesitate to extend use if risk perceptions remain high. In contrast, German consumers display a comparatively higher baseline trust in refurbished products, which moderates the influence of perceived risk on behavior.

Importantly, **frugality acts as a key mediator** between price consciousness and long-term use, as recent literature suggests that frugality is more than a cost-saving motive—it reflects a long-term value orientation. In Japan, price-conscious consumers often channel their motives through frugality, emphasizing durability and quality over short-term savings. This supports the findings of Shoham and Brenčič (2004), who suggested that sustainable behaviors among price-conscious consumers are more likely when frugality is present as an internalized value. In Germany, price consciousness influences behavior more directly, with less reliance on frugality as an intermediary.

With **perceived knowledge**, our findings align with recent evidence that consumer knowledge reduces perceived uncertainty and enhances confidence in making sustainable product choices (Wang and Hazen, 2016; Matsumoto et al., 2018a, 2018b). In Japan, increased awareness of refurbished smartphones helps reduce skepticism, lowering the psychological barrier to long-term use and diminishing the need for frugality as a precautionary measure. In Germany, however, where consumers already perceive refurbished products as trustworthy, additional knowledge does not substantially affect frugality or usage intentions.

The role of **emotional attachment** in promoting frugal behavior and long-term use is particularly notable in Japan. Japanese consumers' cultural inclination to value and maintain possessions amplifies this effect. In contrast, German consumers, who are more focused on performance and functionality, demonstrate a lower reliance on emotional attachment as a driver of frugality or extended use.

Overall, the findings contribute to a growing body of literature emphasizing the **importance of frugality as a context-dependent construct**. It operates as a trait and a value influenced by cultural norms, emotional bonds, and perceived competence. These results suggest that promoting long-term smartphone use requires culturally tailored strategies. In Japan, messaging that appeals to emotional attachment, resource conservation, and knowledge-building may be more effective. In Germany, strategies might better focus on reinforcing the reliability and performance of refurbished products to reduce risk perceptions.

5.2. Theoretical implications

This study contributes to the growing body of literature at the intersection of sustainability, consumer behavior, and cultural psychology by clarifying the context-dependent role of frugality as both a trait and a behavioral mediator in long-term smartphone use. Our findings extend existing theory on frugality (e.g., Lastovicka et al., 1999; Shoham and Brenčič, 2004) by demonstrating that its influence on sustainable consumption is not universal but culturally contingent. In Japan, frugality is closely tied to deeper cultural norms, such as minimalism and *mottainai*, which reinforce its expression through behaviors like repair, maintenance, and extended use. In contrast, in Germany, where consumer behavior is more performance-oriented, frugality is less strongly tied to emotional or cultural values and functions more as a pragmatic financial orientation. These distinctions enhance our understanding of frugality beyond its general association with resource conservation, suggesting that local cultural scripts shape its manifestations. Importantly, our study also integrates insights from Prospect Theory (Kahneman and Tversky, 1979). This theoretical lens helps explain why frugality may serve different psychological functions across cultures. In Japan, frugality aligns with a loss-avoidant mindset rooted in a cultural aversion to waste, making behaviors like repair and extended use feel like moral or emotional gains. In Germany, the same behaviors may be framed more as cost-saving measures, with decisions weighed primarily

against financial losses. By framing long-term use decisions as risk-averse or loss-avoidant strategies, Prospect Theory provides a psychological explanation for the cultural variability in how frugality is activated and expressed. The study further offers a theoretical model in which frugality mediates the effects of price consciousness, emotional attachment, and perceived knowledge on long-term use intentions. Prior studies have often treated these variables in isolation, but our results suggest that frugality acts as an integrating mechanism, converting abstract values or motives (e.g., cost sensitivity, product attachment) into tangible behavioral outcomes. This finding supports and extends value–behavior link models (e.g., Stern et al., 1999) by incorporating frugality as a culturally variable mediator that bridges internal dispositions and sustainability-related behaviors.

The study highlights the distinct impact of perceived knowledge on shaping frugality and long-term use. While perceived knowledge is often assumed to directly increase pro-environmental behavior (Wang and Hazen, 2016), our data show that its effect depends on baseline consumer trust. In Germany, where refurbished products are already accepted, additional knowledge has diminishing returns; in Japan, however, increased knowledge reduces reliance on frugality as a risk-avoidance mechanism. This nuance contributes to knowledge-attitude-behavior frameworks (e.g., Ajzen, 1991) and complements *Prospect Theory* by suggesting that increased certainty (via knowledge) can shift decision-making from intuitive, risk-averse heuristics (like frugality) toward more rationalized assessments of product value and longevity.

5.3. Practical implications

This study provides actionable insights for businesses and policymakers committed to achieving sustainability and circular economy goals, grounded in empirical findings from Japan and Germany. Specifically, the discovery that frugality mediates the relationship between price consciousness, product knowledge, and emotional attachment on long-term smartphone use provides valuable direction for stakeholders in the refurbished smartphone market.

For businesses, frugality emerges as a dual-edged trait: it can both encourage long-term use and suppress it, depending on consumers' perceived knowledge of refurbished products. Companies can segment their customer base by frugality levels and knowledge, utilizing customer data and surveys to develop differentiated strategies. For highly frugal customers, cost-saving messages emphasizing the total cost of ownership over a five-year horizon may encourage long-term use. Our finding that knowledgeable consumers in Japan become less frugal, and hence less likely to extend device use, suggests the need for strategies that assure product quality. Offering high-end refurbished devices with performance guarantees equivalent to those of new models, under the "Refurbished Premium" branding, could appeal to this group. This responds to prior research by Wang et al. (2021), which cautions that high frugality can reduce green purchase intentions if quality concerns persist.

Importantly, the differing effects observed between Japan and Germany highlight the need for market-specific strategies. In Germany, where knowledge and emotional attachment did not significantly influence long-term use through frugality, firms should prioritize transparency and trust-building over appeals to emotional connection. Rovanto and Finne (2023) emphasize that circular economy strategies must be culturally adaptive, reflecting local consumer mindsets and motivations. Our results support this approach, underscoring the limitations of a uniform global messaging strategy.

Another key implication relates to perceived risk, which negatively influenced long-term use in Japan. Businesses should actively reduce this risk through extended warranties, third-party quality certifications, or educational campaigns. The success of Fairphone provides a useful model: its educational initiatives and modular design have helped reshape consumer expectations around durability and repairability. Cordella et al. (2021) argue that increasing reliability through mechanical robustness and longer software support can reduce premature replacement, aligning directly with our findings. A similar strategy could also be useful in other markets, where product lifespan is a consumer concern.

Emotional attachment, found to be positively related to frugality in Japan, can also be leveraged. Businesses can design campaigns and product features that encourage personalization and long-term emotional investment. Customization options, aesthetic upgrades, and storytelling around longevity and sustainability could enhance attachment, reinforcing long-term use behavior among frugal consumers.

Apple's business model offers both cautionary and instructive lessons. Its rapid product cycles and repair limitations contribute to premature obsolescence and consumer turnover. Although Apple introduced its Self-Service Repair program in 2022, user feedback suggests that ongoing barriers persist in terms of usability and cost. Apple could extend software support and enhance modularity to align with long-term sustainability goals. It could also introduce pre-owned modular models with subscription-based upgrade paths, enabling longer device to use while appealing to high-end markets. These changes would reduce environmental impact and open new customer segments in emerging markets.

Fairphone exemplifies how a company can operationalize such principles. Its focus on modular design, long-term support, and consumer education has led to measurable growth across more than 40 countries, with nearly 100,000 units sold in 2021. Fairphone's strategy aligns with Cordella et al. (2021), who advocate for modularity and ease of disassembly to facilitate effective repair. It also aligns with Albert (2019), who promotes "ecologically sustainable frugal innovation." Fairphone's success demonstrates the viability of business models that appeal to frugal yet environmentally conscious consumers by shifting the narrative from disposability to durability.

For resellers and repair businesses, the implications are equally relevant. Our findings suggest that reducing perceived risk and increasing product transparency can improve consumer intentions toward long-term use. These businesses could implement standardized condition grading systems and offer trial periods or guarantees to mitigate concerns. Targeting less knowledgeable consumers through high-quality refurbished offerings and service assurances can help build trust. Moreover, cost-effective maintenance and repair services should be promoted as financially sound alternatives to new purchases, especially for frugal buyers.

Policymakers also play a central role in enabling long-term use of smartphones. Identifying and engaging frugal consumers through public messaging and partnerships with companies like Fairphone can amplify sustainability efforts. Regulatory measures like tax incentives for durable and repairable devices could encourage businesses to invest in product longevity. Legal developments such as California's Right to Repair Act (California Legislative Information, 2023), which mandates greater access to repair tools and information, represent steps in the right direction and should be emulated in other regions. Furthermore, governments must hold companies accountable for practices that restrict repairability or shorten product lifespans, such as software locks or proprietary tools. Promoting repair infrastructure, mandating longevity benchmarks, and ensuring fair access to repair resources can significantly reduce e-waste and increase participation in the circular economy.

Stakeholders can implement differentiated and evidence-based strategies to foster longer smartphone usage by addressing frugality, risk perception, and knowledge disparities. These strategies align with our findings and advance broader environmental and economic sustainability goals.

6. Conclusions

This study examines the effects of frugality (as a mediation variable),

perceived risk (exogenous variable), knowledge (exogenous variable), and emotional attachment (exogenous variable) on the intention for long-term smartphone use (endogenous variable) in Japan and Germany. Frugality emerged as a key mediator, influencing the relationships between price-consciousness, perceived knowledge, and emotional attachment, particularly in Japan. In Germany, frugality's effects were less prominent, as consumer behavior was more influenced by confidence in the quality and reliability of refurbished smartphones.

The research offers several insights. First, frugality strongly correlates with long-term use intentions, reflecting a desire to maximize value and minimize expenses. Second, perceived risk discourages long-term use, as concerns over quality and reliability deter consumers from retaining devices. Third, frugality mediates the relationship between price-consciousness and long-term use, with frugal consumers prioritizing durability over immediate cost savings. Finally, the mediation of frugality between knowledge and emotional attachment differs culturally, highlighting the need for localized strategies to promote sustainable consumption. These findings present opportunities for businesses to engage frugal consumers by emphasizing product longevity, addressing perceived risks, and fostering emotional connections. Tailoring approaches to different markets, such as Japan and Germany, allows companies to align with specific consumer behaviors. Policymakers can also promote sustainability through initiatives supporting repairability, extended lifespans, and consumer education.

This study has limitations. First, we used **stratified quota sampling** to ensure that our sample represented diverse consumer groups in both Japan and Germany. Quotas were based on age and gender to reflect the demographic composition of smartphone users in each country. This approach improves data quality by capturing group responses with potentially distinct behavioral patterns. However, we acknowledge that while quota sampling ensures demographic representativeness, it may limit the generalizability of results to broader populations beyond smartphone users. Specifically, within each stratified group (e.g., males aged 20–29), participants were selected using a convenience sampling method via an online research panel. Although not purely random, this method is commonly used in cross-cultural consumer research and allows us to collect data efficiently while maintaining demographic balance. We acknowledge this limitation and have controlled for key demographic variables in our models to mitigate potential biases. While this approach does not support probability-based inference, our use of structural equation modeling focuses on examining theoretical relationships rather than making population-level predictions. Second, its cross-sectional design restricts causal inferences; longitudinal studies could better capture changes in attitudes and behaviors. Focusing on Japan and Germany limits generalizability, and future research should include more cultural contexts. Self-reported data may introduce bias, and validating findings with objective measures like tracking usage patterns would enhance reliability. Expanding research to other product categories could reveal whether these relationships hold across various consumer electronics.

By examining the role of frugality in shaping long-term use intentions, this study provides actionable insights for businesses and policymakers to foster sustainability. Addressing these findings and limitations can support a circular economy and a more sustainable future for the smartphone industry.

CRediT authorship contribution statement

Kenichiro Chinen: Validation, Project administration, Methodology, Data curation, Conceptualization. **Daniel Wu:** Writing – original draft, Investigation, Conceptualization. **Mitsutaka Matsumoto:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization. **Nina Le Nguyen:** Writing – original draft, Investigation. **Ai T. Chinen:** Writing – original draft, Formal analysis.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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