The Green Frontier of Mobile Applications in Improving Recycling Consumers' Behavior

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***Abstract*—In this article, we provide a new insight into overcoming resistance to emerging green technologies through mobile app users' environmental engagement. The use of a mobile recycling application is evaluated with regard to its media richness with a sample of 12 539 users in Italy. The research is developed during the COVID-19 pandemic, at a time when users have become more environmentally conscious and aware of plastic pollution. This time period has also seen an increase in the use of mobile applications, which provide social engagement and other benefits. Although it has encouraged new research on recycling behavior and how environmental messages are spread, as far as we know, no research has included a specific technology, such as mobile applications. Through the lens of consumer social media engagement behavior, it has emerged that media richness has a positive correlation with user engagement and recycling behavior. Theoretically, the research offers a novel technological tool worthy of further exploration in the fields of management and engineering. New practical insights are offered in terms of best practices for strengthening the relationships between companies and their clients. As users become more accustomed to social technologies, those technologies may help to establish responsible consumption patterns.**

***Index Terms*—Emerging technologies, mobile applications, social media engagement behavior (EB).**

I. Introduction

THE era of the digital transformation has brought new and disruptive changes that have only been magnified during the COVID-19 pandemic. The pandemic has provoked environmental concerns about the increased rate of plastic pollution, and such concerns have stimulated new uses for emerging technologies that may help to shift consumer behavior toward a greener attitude. This is framed in the global scenario of "zero plastic pollution" envisioned for 2040 [1] in which there is a need for "straightened links between policy–industry–research" [2]. In turn, new research has been focused on consumer or user attitudes toward responsible consumption.

Through the lens of self-determination theory, Deci et al. [3], [4] demonstrated that the integrated extrinsic and intrinsic motivations trigger consumers to purchase organic food as consumers are primarily influenced by ecological welfare and nutritional content [5]. They are prone to making behavioral changes that move toward an ethical self-identity [6], [7]. Such behavior employs a circular process of reducing, reusing, and recycling. Attiq et al. [8] found that consumers reduce food waste if they feel guilty or are made aware of the community and environmental concerns. Therefore, consumers must be encouraged to strive for an "ethical consumerism." For instance, consumers have become more conscious of their personal health, considering organic food to be purer and healthier than industrial food [9]. Consumers are also becoming aware of other forms of waste, such as food waste from both at home and out-of-home dining [10]. Kautish et al. [11] suggested that the development of nature-based campaigns and/or branding helps consumers feel connected to nature, which motivates them to improve their lives as "planet-wide creatures."

Although this movement toward green behavior still seems to be sluggish, there is a clear indication that openness to change has shifted consumers' resistance to green innovations and ethical consumption campaigns to a more favorable stance on the acceptance and adoption of sustainable behavior [12], [13]. In the current times, the combination of the digital transformation and the COVID-19 pandemic has brought new changes, such as an increase in the use of mobile applications. In 2020, the online consumption rate increased proportionally to the growth of the time spent on mobile apps [14]. This has aroused interest from scholars and practitioners about the impact of digital transformation on consumers and companies [15], [16], as well as increasing interest in green innovations [17]. However, as far as we know, the literature has examined consumer behaviors in the sustainability and recycling domain from a psychological and sociological perspective but not from the perspective of the role of technology, such as mobile applications.

Through the lens of consumer social media engagement behavior (CSMEB), the present study examines the behavior of green users of mobile applications in order to challenge previous studies on consumer resistance to the use of emerging

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This work involved human subjects or animals in its research. Approval of all ethical and experimental procedures and protocols was granted by Junker comapany.

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technologies [18], [19], [20]. The study also enriches research on mobile applications [21] and enhances the existing management and engineering literature [22] by examining user behavior in relation to media richness (MR) and engagement of mobile applications. The research context relies on a plastic pollution application diffused in Italy and involves a wide sample of 12 539 users who downloaded and actively used this mobile application in the period of 2019–2020. Italy is considered a suitable setting for this research because of the introduction of new sustainable policies that encourage responsible consumption and production in line with the sustainable development goals of the United Nations. The Italian government has, thus, been pushing green consumer behavior. In more detail, the work uses partial-least square-path modeling (PLS-PM) to investigate the capacity of mobile applications to engage with consumers through their content and interactions—grouped within the concept of MR—and to influence their behavior in favor of recycling. This methodology performs well with a limited pool of theoretical developments [23].

As a result, there is a positive link among user engagement, MR, and recycling behavior (RB). We affirm the work of scholars who have remarked on the relevance of media content in engaging with environmental concerns [24], [25], and we highlight the use of new emerging technologies, such as mobile applications, to encourage responsible consumption. We also emphasize the view in which the richer the media and the more trustworthy its content, the more effectively it can facilitate consumer engagement and influence consumer behavior [22]. Although users can develop some forms of resistance toward emerging technologies [19], those technologies nowadays seem to be the best way to influence user/consumer intentions and turn them into action. In this research context, mobile applications function as a means to influence consumer behavior to be more sustainable, ecofriendly, and socially responsible. Through emerging technologies of mobile engagement, users become more aware of environmental concerns [13] and develop social bonds with companies that seek to promote green innovations. New practical insights suggest how companies may engage with their consumers in order to foster better emotional and cognitive attitudes toward sustainable products [26]. In conclusion, although the unit of analysis in this study is the individual consumer, it is possible to construct the broader world of startups around the concepts of sustainability and green production [27].

The rest of this article is organized as follows. In Section II, it offers a theoretical background on the current mobile applications situation by looking into the literature of the technology and engineering management society. Following the theoretical framework, in Section III, CSMEB is explicated and debated in line with the concept of MR and RB. On this basis, hypotheses are developed and tested by PLS-PM in Section IV. Section V discusses the results and offers theoretical and managerial implications. Finally, Section VI concludes this article.

II. Theoretical Background

II. Emerging Technologies: Mobile Apps

Increasing engagement with mobile platforms and growing awareness of recycling culture during the pandemic period have shifted consumer behavior away from the resistance to green culture and toward the acceptance and adoption. As noted by Talwar et al. [20], consumer resistance has been investigated in the context of digital and technological innovations [28], including a focus on organic food [12] and new green solutions [17].

Other scholars have pointed out that the propensity for consumer resistance to or boycott of new strategies or products is reduced by the increasingly urgent need to preserve local environments [13]. This has increased the focus on consumer behavior as the waste management industry has not exhibited the capacity to sufficiently reduce plastic pollution [29], [30] (perhaps due to a lack of attention to the externalities of waste) [31], [32]. This concern is not a new one: scholars have long been interested in identifying solutions to reducing pollution through recycling and green innovation [33], [34], with some focused specifically on plastic pollution [1], [35], and others documenting the role of emerging technologies in reducing carbon emissions [36], by driving commercial strategies and exploration activities [37], and influencing RBs [38]. These concerns have pressured many manufacturing companies to be more sustainable in their operations [39]. More recently, attention has shifted onto the preconsumption and postconsumption stages [1], with a focus on "plastic RB" [40]. The focus on consumer behaviors has been explored through the lens of the theory of reasoned action [41], which has been used to analyze waste recycling via consideration of four variables, namely personal attitudes, subjective norms, perceived behavioral control, and perceived moral obligations [42]. The theory of reasoned action was used to explore the gaming market to investigate green attitudes in users [43], [44]. In the scenario of mobile apps, the framework described by Cao et al. [22] on CSMEB seems more appropriate for the analysis in the current study as we aim to understand the role of emerging technologies and consumer behavior in the scenario of "zero plastic pollution."

B. Theoretical Framework: Consumers' Social Media Engagement Behavior

Due to the ubiquity of web-based social media, users are highly motivated and engaged by such communication technologies. This phenomenon is known as consumers' social media engagement behavior (CSMEB) and has been widely explored in the areas of shopping experience [22], [45], [46] and brand performance [47]. Engagement behavior (EB) is influenced by cognitive, affective, and behavioral dimensions that have been further structured into the levels of consuming, contributing, and creating [48].

Consumption is considered a low level of engagement because the social media is used passively, e.g., simply reading or watching. Contribution involves a higher degree of engagement that requires peer–peer or peer-to-content interactions, such as sharing a post with friends. Creating is considered the highest level of engagement because the users are actively generating content by writing a post or publishing a recommendation.

The three behavioral dimensions are recognized as relevant to an evaluation of engagement and sustainable consumption through the lens of social media [49], [50] and such an evaluation

is further enhanced according to the degree of MR. MR refers to the complexity of a given piece media, expressed in the form of "feedback capability of the medium, the number of channels used, such as emails and face-to-face communication, the source of personal (e.g., relatives and friends) or impersonal (e.g., retailers) information, and finally, language variety, such as verbal and nonverbal (e.g., body language and photo)" [22]. Its complexity is augmented by the use of mobile applications for teaching and learning [51], shopping [52], or enhancing trust [53]. MR, thus, provokes new stimuli that increase the engagement level of consumers [54].

In this vein, we declare the following:

Hp1. The higher the level of EB, the greater the MR.

MR increases the level of engagement by and influence on the user [55]. Consumers appear most inclined to engage with video content based on the increasing number of mobile users who are watching and sharing such content. This research offers interesting insights for marketers in implementing the best strategies for engaging online consumers. Saat and Selamat [56] emphasized the role of MR to convey more information on corporate social responsibility, and Daft and Lengel [57] noted the relevance of the transfer of information by means of MR, claiming that the greater MR allows consumers to understand how those communication technologies are used by companies by creating a mixed "symbolic system" [58]. Nowadays, such richness is achieved through the use of video or other multimedia that enables user interactions [59]. MR offers emotional linkage along with information, as it is not the media itself that makes an impact on consumer behavior but rather its content [55], [60] find that online MR can convert "intention into buying"; consequently, a vibrant product presentation is likely to enhance consumer engagement [61]. Such a presentation is made by embedding the high-quality images, videos, and interactional features that improve a customer's digital shopping experience, allowing customers who may, otherwise, be overwhelmed to streamline their information-seeking process in order to identify and purchase the perfect product. By providing enhanced MR, a company can reach more consumers with a single click [59].

In the context of e-waste, the MR that reveals the unseen product offers a diverse range of characteristics [62]. In recent times, people are more conscious of environmental risks, thanks to a different knowledge flow [63]. Such knowledge is not only expressed in the form of visual content but also in the form of articles, which have an impact on consumer behaviors [24], [64], noted that images enhance "e-waste awareness." Considering the MR theory, a variety of content allows a person to better understand the complex systems involved in recycling and e-waste.

Nanath and Kumar [24] explored this phenomenon by evaluating student attitudes toward sustainability and found that a written article may be more effective than a video, thanks to its structured layout and more effective communication of information. The relevance of content management was also supported by Cheung et al. [25], who explored the context of plastic recycling. However, we do not evaluate the impact of different media contents but rather the full package of MR, which involves diverse content, such as videos, chats, and blogs hosted by a mobile app. In a recent report on "digital 2021," Starri [14] identified a growing trend in recycling influenced by the popularity of mobile apps that offer new content and ways of interacting with others. Because greater awareness of environmental issues, recycling, and e-waste management drives sustainable intention toward action, we maintain that:

Hp2. The more favorable the MR, the greater the likelihood that a user will recycle.

Offering a range of media content increases the enjoyment of and engagement with a particular digital phenomenon. As stated by Nanath and Kumar [24], this is especially true in the case of student RBs. They found that students who felt more engaged with environmental messages that advocated the principles of sustainability were motivated to take an action to preserve their environment. In essence, the spreading of information effectively induces a change in consumer attitudes, and media today makes a great impact on sustainability awareness and attitude. It is not just what we communicate but also how we share it that emotionally engages the audience. Theoretically, the term "engagement" refers to a physical, cognitive, and emotional attachment to a specific situation [65] that gets stronger along with the relationship between consumers and a company [66]. More engaged consumers are more likely to collaborate with a company than resist its innovations. The impact of engagement level has been researched in the fields of marketing, computer science, information systems, among others. Wiebe et al. [67] proposed that users' behaviors can be explained by their sense of engagement, and Scott and Craig-Lees [68] similarly found that engagement induces consumption and, consequently, a more positive feeling toward a product or service. Chan and Li [69] found that online interactions generated social attachment and benefits, and in the specific context of sustainable development that relies on the principles of reduce, reuse, and recycle [69], [70], [71], it has been shown that consumer engagement corresponds with environmentally conscientious behavior, which also relies on social and moral norms [72]. In turn, consumers engage in proenvironmental behavior [73], support e-waste [74], [75], [76], support sustainable energy use [77], [78], [79], and form the intention to buy green products [80]. If people are environmentally engaged, they tend to adopt accordingly the responsible behaviors [78]. E-waste management induces people to prefer more recycled products [81].

Therefore, we affirm that:

Hp3. The higher the level of user engagement, the greater the likelihood that a user will recycle.

III. Methodology

A. Research Context

Since the first quarter of 2020, the COVID-19 emergency has generated the most disruptive global shock in the past 100 years and has accounted for the emergence of both positive and negative technologies and environmental effects due to lockdowns. Pandemic restrictions have brought decreases in pollution in those geographical areas that hit particularly hard

by the coronavirus, such as China, Spain, and Italy. Lockdown policies have induced transport limitations and have consequently generated a positive impact of up to 30% on average air pollution [82]. However, regarding plastic pollution, the global overview shows that, in the last 70 years, the growth in the annual production of plastics in terms of polymer resin and fiber has increased exponentially, reaching a ratio of about 1 ton of plastic for every world citizen. Segmentation by industry shows that the packaging sector is the highest contributor to plastic waste, as it uses the most plastic components and generates the shortest product lifecycle. In Europe, Germany is the highest producer in terms of annual plastic waste, followed by the United Kingdom, Spain, France, and Italy [31]. These polymer products are extensively used in people's daily lives and represent an important material for food protection and preservation, especially for maintaining food quality and integrity and, therefore, the reduction of food waste. These factors make it a global priority for private and public sectors to focus on waste management or e-waste recycling systems and their continuous improvement [30], [39], [83]. In fact, several governments and industries have put programs in place to improve the sustainable management of waste while also supporting recycling and disposal activities [84]. This background indicates a tendency for companies and consumers to adopt green behaviors and attitudes by engaging with emerging technologies, which we explore in the particular context of the MR of a mobile application.

According to Cao et al. [22], MR is formed not just by email and face-to-face communication but also through web-based social media. We, therefore, include mobile apps as a form of MR. The mobile app is considered one of the most-used communication platforms in the modern age [85], and mobile communication technologies have improved daily conversation and information exchanges in organizational environments [86] and among consumers [87]. Mobile devices have also enhanced MR, thereby directing the media choices of brand marketers and retailers seeking to promote their products and services [54].

In this context, the mobile app Junker was founded by the company Giunko in Italy to engage consumers and encourage them to adopt environmentally sustainable and socially responsible behavior. It aims to achieve the important goals of the circular economy package released in 2015 and has just recently received the Ecohitech Award 2021 in Italy. Junker demonstrates the use of mobile communication technologies in allowing citizens to actively participate in the objectives of the circular economy and teaches users how to behave in the process of recycling goods. In addition, it also facilitates the communication between governments and citizens. Although Junker aims to engage with users throughout Europe, its maximum visibility and usage are currently centered in Italy [88]. Since its launch in 2016, the Junker app has engaged with more than 1.3 million people in 800 municipalities, and it lists 1.6 million goods in its database. The app will refer to the guidelines of a user's city and show the user how to properly dispose any product included in its database. It also allows users to suggest new products and indicate flaws in the listed information. In response to its many features and services, the app has registered 40 million visits and 30 million barcode scanners per day. The richness of this app relies on images, texts, barcodes, quizzes, and blogs.

B. Sample

The empirical analysis for this study was conducted by using the Junker app database, composed of a population of 52 134 users based in Italy. Users from across the country were randomly contacted via the mobile application and invited to complete an online survey. As aforementioned, 12 539 users fully completed the survey.

The sample was composed of 59.77% women and 40.23% men. Their ages ranged from 16 to over 65 years old, with a highest engagement rate found in the age range of 45–64 years old. The use of Junker was quite frequent; most respondents used the app approximately two to three times per week, and most users reported mainly employing Junker to scan a barcode on an item and find out how to recycle that product. The application offers other media content, such as interactions via Facebook or other social media and Instagram quizzes, but these features were less commonly used. Despite that, users showed a greater interest in blog articles on the topic of recycling and conservation (as was noted by Nanath and Kumar [24]).

C. Data Collection and Analysis

The data were collected by means of a survey composed of 21 closed-ended questions that were sent to all users (a total number of 52 134) through the mobile app with 12 539 users fully completing the questionnaire. The data were collected from July 2020 to August 2020. The questions were measured based on a five-point Likert scale, and the data were analyzed by partial-least square path modeling (PLS-PM).

This method is considered suitable when the research model seeks to expand an existing study and enhance less developed theories [23], [89], [90], as it allows the evaluation of the relationship among variables. PLS-SEM can be performed using non- normally distributed data because it uses a bootstrapping approach, that is, "a nonparametric technique that allows examining the statistical significance of different PLS-SEM results" [91]. It has been employed in different domains, such as consumer behavior, e-business, marketing, and strategic management [92], [93], [94], [95], [96]. PLS-SEM was employed to evaluate the correlation among EB, MR, and RB.

D. Measures and Items

EB is composed of creation behavior (EB1), contribution behavior (EB2), and consumption behavior [22], [49]. It is an independent variable that is assessed in relation to MR and RB.

MR is a mix of different types of content that can facilitate cognitive, emotional, and social bonding. This occurs through 'feedback (MR1), communication tools (MR2), and message cues (MR3)' [22 (p. 839); [97] along with social media referral (MR4)]. This variable assumes the position of a dependent or independent variable; in other words, it is exogenous.

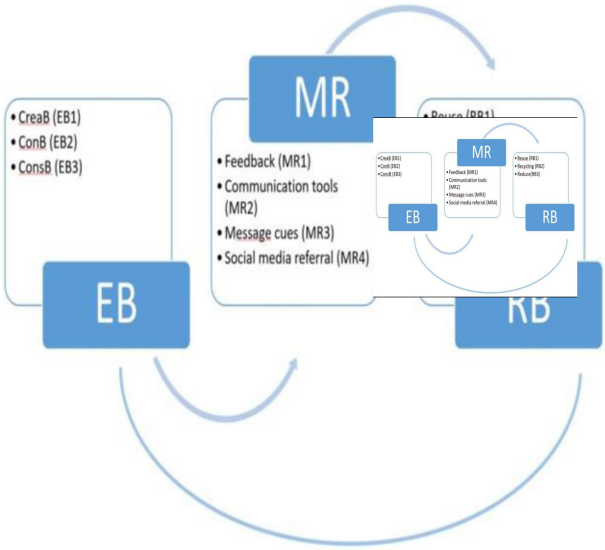

Fig. 1. Research model.

RB is comprised of reuse (RB1), recycling (RB2), and reduction (RB3) behavior [70], [71], [98]. It is a dependent variable that is evaluated in relation to MR and EB.

The correlation of all these variables is presented in the research design, as shown in Fig. 1.

IV. Results

A. Common Method Bias

Considering Podsakoff et al.'s [99] work, common method bias was assessed. The items were validated by sending out the survey to a small number of users ($N = 30$). As result, no language problems or misunderstandings emerged. The users' identities were anonymous to reduce judgment apprehension. Finally, a statistical check was completed by running a confirmatory factor analysis (CFA) as a more sophisticated technique. CFA was used to measure the dimensionality of the research design. We consider three measures of EB, MR, and RB in relation to ten items (as shown in Fig. 1). The results show a good fit as follows: $CMIN/DF = 2.32$, $CFI = 0.82$, $IFI = 0.879$, $TLI = 0.887$, $SRMR = 0.039$, and RMSEA $= 0.061$. This is also supported by Hu and Bentler [100] and Jöreskog and Sörbom [101].

The empirical analysis developed by PLS-SEM is structured in two stages. The first one is the measurement model to assess the reliability of the research design. The second stage is the structural model used to test the hypotheses.

B. Measurement Model Testing

According to the previous studies, the measurement model is useful in estimating the validity and reliability of the research design [102]. The reliability was calculated by Cronbach's Alpha (CA) to assess the internal consistency between measures and items. If CA exceeds 0.5, the measurement model can be accepted. Convergent validity was calculated by the average variance extracted (AVE) and the factor loading (FL), which also should exceed the value of 0.5 [23], [103], as shown in Table I.

TABLE I
CA Test

Measures	Items	FL	CA	AVE
EB	EB 1	0.834	0.594	0.523
	EB 2	0.754		
	EB 3	0.900		
MR	MR 1	0.824	0.623	0.682
	MR 2	0.721		
	MR 3	0.639		
RB	RB 1	0.651	0.583	0.643
	RB 2	0.837		
	RB 3	0.921		

C. Structural Model Testing

The structural model testing allows the estimation of the positive correlation between the three measures: EB, MR, and RB. Before calculating the correlations, it is necessary to assess the collinearity between those measures/variables to avoid any issue in the evaluation of the path coefficient. In this case, the variance inflation factor (VIF) was calculated, offering a value less than 3 (see Table II) [89], [102].

To test the hypotheses, a path analysis was conducted that demonstrated a positive correlation among all variables. As shown in Table III, EB has a positive impact on MR, and MR has a positive impact on RB, which is also positively affected by EB.

V. Discussion

This research primarily investigates the relationships among EB, RB, and MR with the aim of providing theoretical and practical insights toward empowering consumers to participate in the reduction of plastic pollution. From a theoretical standpoint, this study provides a research model that supports the positive

TABLE II
COLLINEARITY RESULTS

Measures/variables	VIF
EB	1.380
MR	1.420
RB	1.509

TABLE III
PATH ANALYSIS

	Path	T-Value	Path Coefficient
Hp.1	EB –MR	4.6	0.0000
Hp.2	EB-RB	6.2	0.0000
Hp.3	MR – RB	7.1	0.0000

correlation between the three hypotheses based on three key latent variables, namely EB–RB–MR. Our results indicate that the three constructs proposed for the research model in this study each influence one another in such a way that the higher levels of EB and MR correspond to a higher level of RB. This outcome constitutes a fundamental theoretical contribution of this study to the CSMEB in the field of resources, conservation, and recycling. As Lau et al. [1] suggested, such engagement in reducing plastic pollution can occur during both the pre- and postconsumption stages.

The significance of HP1—*the higher the level of EB, the greater the MR*—affirms the active role of users in the consumption journey. To feel more engaged, consumers should seek both, to passively consume less and to actively participate more, either by interacting with the content in some way or by creating new knowledge products [48]. Such engagement is reached by providing a high level of MR that enables better interaction with other users and even with companies or institutions [22]. This direct significance of EB and MR reinforces the conclusions of Maity et al.'s [54] study, which found that MR generated new stimuli that could enhance the degree of engagement. For instance, mobile applications are becoming more common and are increasingly used not only in online shopping [104] but also in teaching and learning [51]. Mobile applications are also used to influence "plastic RBs" [40].

As shown by the significance of HP2—*the more favorable the MR, the greater the likelihood that a user will recycle*—users are gaining awareness of green culture and are adopting sustainable behavior in response to media content. MR transfers knowledge on corporate social responsibility and it improves the link between consumers and companies [56]. This leads to a relationship between engagement and RB that is positive, which tests HP3—*the higher the EB, the greater the likelihood that a user will recycle.* This hypothesis underpins sustainable development goal based on the principles of reduce, reuse, and recycle [70], [71]. It also illustrates the need to disseminate social and moral norms that will encourage proenvironmental behavior [72], [73] and green consumption [80]. Such a tendency toward sustainability, which embraces green culture, is taking place on an organizational and national level as well [74], [75], [76]. Developing a culture of environmental friendliness increases sustainable attitudes and behaviors [78] and drives companies to meet the demand for green products [81].

A. Theoretical Implications

The present research expands the Technology and Engineering Management Society literature through its focus on green behavior from a range of perspective.

The first perspective is technology-based. Although previous studies have primarily focused on the psychological and sociological view of green consumer behaviors [4], [6], [8], [9], [10], we have shown that even technologies, such as mobile apps, may encourage ethical consumerism. Second, our research indicates the need to spread information and increase knowledge about relevant green behaviors. This supports previous studies that have demonstrated that nutritional content influences consumer orientations toward a green attitude when it comes to choosing sustainable foods [5]. The third perspective pertains to the role of technologies in enriching information for consumers and leads naturally into the fourth, which stresses the importance of the preconsumption stage [1]. As a result, it is significant that MR encourages consumers to take a more active role in sustainability initiatives since as consumers embrace a green culture, companies may gather more data on their behavior [56] and develop nature-based campaigns or brandings in order to better appeal to those consumers [11]. The fifth implication regards the use of technologies in overcoming resistance to green behavior and transforming intention into action. Such technologies can also be the driver of participation in the circular economy of reduce, reuse, and recycle [7], [70], [71] by encouraging consumers to recycle more often. The final perspective links technologies and consumer RBs and supports the increase of time spent on mobile apps [14]. Consumers appear increasingly inclined to embrace digital transformation and changes in response to environmental concerns, reducing the likelihood of resistance to the adoption of relevant emerging technologies [18], [19], [20].

B. Managerial Implications

There are several implications that can be gleaned from this research, many particularly relevant to managerial considerations. First, we think that this study provides useful information to policymakers, industry leaders, and the research community in response to the need for immediate action toward the "zero plastic pollution scenario by 2040" [1]. Our study shows that the

consumers are ready and willing to adopt green behaviors but may need to be educated in doing so. This calls for the dissemination of a new green educational program that can facilitate the shift from resistance to acceptance of sustainability initiatives.

Second, our study provides useful recommendations to national and local institutions and, in particular, to smart city leaders with regard to the usefulness of emerging technologies and mobile apps to engage with citizens in order to address plastic pollution. Considering the role of cities in reaching the sustainability goals of UN 2030, it will be necessary for municipality leaders to improve their policies and leverage public–private collaboration in their territories as well as engage their constituents through different technologies, mediums, and communication strategies. Overall, institutions need to enrich media content to be more effective. The correlation between MR and EB can be leveraged as a win–win dynamic between local governments and consumers, united by a common interest in a reduction in plastic pollution and an increase in sustainability and recycling culture. Public policies may also be used to develop new models for waste management through experimental activities. This has resulted in the development of a "city lab approach," which relies on openness and the adoption of new advanced technologies in those areas, which are categorized as smart cities.

The third practical implication is aimed at industry leaders in the sectors identified as the biggest producers of plastic waste, namely the packaging industry and other industries that rely on fast-moving consumer goods. In order to offset their necessary production of plastic, they can develop nature-based campaigns by using mobile apps that creatively stimulate consumers and encourage them to employ the circular process of reducing, reusing, and recycling. In turn, such companies can promote "sustainable industrialization" in accordance with the United Nations' sustainable development goals. This is also embraced at the macrolevel of the circular economy as it empowers businesses to proactively contribute to the behavioral change of consumers. In addition, the success story of the Junker app, which grew exponentially in Italy during the COVID-19 pandemic, may create an opportunity for entrepreneurs and managers to scout emerging startups and explore how they could collaborate on new solutions in terms of consumer engagement driven by emerging digital and communication technologies.

Because the empirical analysis was performed with a large sample of 12 539 respondents in Italy, we can highlight the growth in the use of social media content and the average time spent per day on mobile devices, which have increased, since 2020, mainly due to the lockdowns and the effects of social distancing implemented in response to the coronavirus. Along with the insights from this research, this growth trend identifies an area of potential discovery for the manufacturing industry toward the research and development of sustainable new materials for single-use products and personal protection equipment to be reinforced with consumer's conscious green behavior. This point would also be compliant with sustainable development goal 12 based on responsible consumption and production.

Finally, through empirical analysis, innovators and startups can become more committed to a plastic-free world and feel inspired to develop more sustainable products. In the near future, we can expect that emerging technologies, such as artificial intelligence, will be able to accelerate the role of those mobile apps in enhancing RB purchases.

VI. Conclusion

In this article, the limitations we acknowledge offered a set of potential research challenges for the future. First, our empirical research was developed based on the self-report data on Italian consumers. This choice was made because Italy has been heavily impacted by the COVID-19 crisis and represents a large consumer market in Europe and, as such, is among the top producers of plastic pollution in the region. A possible extension of this research could explore other European territories, such as Germany, Spain, and France.

Second, the consumer sociodemographic range considered in this study was drawn from a survey sample of the userbase of the Junker mobile app. Considering the emerging values of the younger generation and culture toward a sustainable future, it would be interesting to focus on generation Z consumers (born between 1995 and 2010).

The third limitation of this study is related to a generic consideration of social media on consumer engagement and behavior, with a lack of focus on emerging social media and mobile app usage patterns and impacts on young consumers' behavior. It may be interesting to explore research questions, such as how new social media mobile apps, such as Clubhouse (audio social network) or Twitch (gaming and streaming), relate to attitudes among generation Z consumers toward reduced plastic use and more frequent recycling.

Above all, we enforced the original contribution of this article that stresses the concept of "zero plastic pollution by 2040" [1] and clearly points to the power of mobile applications in shifting consumer behavior and, consequently, company behavior toward "more recycling and less pollution." Therefore, a particular interest was aimed at "Internet of behaviors" as technology-enabled transformations with environmental and social impacts. With this background, this study offered an interesting scenario for policymakers and industry leaders in terms of opportunities to leverage the current Internet of behavior's trend, combining emerging technologies with prominent buying groups of consumers.

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