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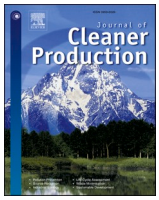

Perception and social acceptance of 5G technology for sustainability development

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ABSTRACT

This research was carried out to enable a better understanding of the attitudes of Hungarian consumers and future users towards 5G technology. The development of 5G technology supports social, economic and environmental sustainability together. Among other things, innovative communities, economic progress and a reduction of the carbon footprint can be positive outcomes of 5G. For example 5G benefits the environment in two ways: it helps telecom operators reduce their energy usage, thus lowering their environmental impact, and it provides tools that telecom companies can use to assist others in reducing their environmental footprint. The Partial Least Squares (PLS) regression method was used to establish the correlations between the five factor groups. Research indicates a prevalent skepticism among Hungarian consumers toward 5G technology, characterized by apprehensions regarding health risks and a lack of perceived competitive advantages or inherent business benefits to adopting 5G. This hesitancy must be countered by transparently addressing health concerns, debunking myths, and building a foundational trust in 5G technologies through comprehensive educational and awareness-raising initiatives, aligning technological advancements with consumer confidence and acceptance. 5G must be demystified so that consumers will come to trust the technology and embrace its adoption. Due to the similar technological conditions and historical backgrounds of the Central European Countries (CEC), the results of this research will prove useful to policymakers throughout the region.

1. Introduction

5G networks offer more advanced capabilities compared to older generations. This improved connectivity enables the development of new sustainability services that individuals, businesses, and governments can use to reduce their carbon footprint and achieve sustainability goals. The Massachusetts Institute of Technology (MIT), in collaboration with Ericsson, has investigated the role of 5G and other mobile infrastructures in achieving carbon neutrality. The white paper, published in the MIT Technology Review series on the latest technologies and their commercial, social and policy implications, argues that 5G will enable the most polluting industries to go digital and reduce their carbon footprint by up to 50% by 2030. The report also highlights the key role of digital transformation based on mobile communications to increase production efficiency and support sustainability, and the importance of data-driven carbon neutrality (MIT Technology Review, 2021).

5G quality connectivity can improve digital services in local areas and play a key role in supporting sustainable economic recovery and social cohesion. In smart communities, 5G technology will help modernise socio-economic drivers in many sectors, in particular health, education, public administration and transport, making them more efficient and resilient. By delivering faster data speeds, low latency, wider coverage and greater network reliability, 5G technology is also expected to boost the uptake of Internet of Things (IoT) systems, which have huge potential to add value to physical objects when connected to cloud-based solutions (European Commission, 2023).

Perception and acceptance of 5G technology vary greatly by country, with 5G's incorporation into daily life in Asian countries contrasting the skepticism and reluctance demonstrated by Hungarian consumers. In today's digital age, the mobile market is constantly evolving. Even before the introduction of high-speed, full-featured fifth-generation (5G) mobile communications, 1G networks had changed our world radically, leading to the creation of new industries and reshaping society (Dunnewijk and Hultén, 2007; Jehadessan, 2005; Maeng et al., 2020; Rappaport, 1996). The second generation of mobile networks (2G) promoted voice communications, while the third generation (3G)

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brought wireless internet (Korhonen, 2003; Maeng et al., 2020; Siau and Shen, 2003). The fourth generation (4G) has provided a variety of high-speed mobile services, such as e-finance, e-shopping, and new forms of entertainment (Arshad et al., 2010; Govil and Govil, 2007; Maeng et al., 2020). With each generation of innovation, consumer preferences, and expectations have risen accordingly.

Continuous development, improvement, and technological innovation are also having a major impact on the mobile market. This impact is not limited to foreign and international markets and is challenging businesses and consumers at a national level. Businesses and consumers must adapt to these changes and their ability to do so promptly should be evaluated. An examination of international market and technological trends, such as the rise of 5G in Asia, is essential but leaves many questions regarding local conditions in CEC (Central European Countries). The purpose of this research is to investigate consumer attitudes throughout the CEC, using Hungary as an example. For historical and economic reasons, the mobile market and consumer economies have developed very similarly through the CEC, which share many traits—cultural and otherwise—which the researchers believe will make results herein regionally applicable.

The most critical lesson to draw from this research is that consumers in the CEC are less open to 5G than are those in Asian countries. This is because CEC consumers have little information about 5G, fear for their health, and do not see the benefits of 5G. The best remedy for these problems is effective consumer education. Asian consumers are much more open to 5G than CEC country consumers. In Asian countries the perception of privacy had a notably adverse impact on people's attitudes toward 5G technology, whereas the speed of 5G had a notably positive effect. Additionally, there were positive associations between people's attitudes toward 5G and factors such as ubiquity, subjective norms, word-of-mouth recommendations, and their willingness to pay for 5G services.

2. Theoretical framework

5G technology brings a significant breakthrough in modern communication, creating many new opportunities in terms of economic, social and environmental sustainability. 5G systems use more advanced technology and more energy-efficient hardware solutions, which reduces energy demand and greenhouse gas emissions. By improving spectral efficiency (Akyildiz et al., 2016), less infrastructure is required and this provides further energy reduction benefits. At the same time, the investments required for infrastructure developments and data traffic associated with 5G technology can lead to increasing electronic waste and energy loss. It is important to keep environmental sustainability in mind during the development of new technologies and to look for solutions that minimize harmful effects (Rene et al., 2021). Criticism of 5G technology may also arise in relation to health issues, as it operates at a higher frequency than previous generation networks. Some people are concerned about possible radiation and see the development of 5G networks as panic. Others, however, say the scientific evidence does not support this concern and believe that the benefits of 5G technology far outweigh the potential risks. The debate is still ongoing and it is important to continuously monitor the results of the research, as well as ensure the appropriate regulation and precautionary measures to ensure that 5G networks operate safely and efficiently (Chiaraviglio et al., 2020). In addition, 5G technology supports the faster spread of digitization, which brings many sustainability benefits. Telecommuting, smart cities and the Internet of Things (IoT) enable people, communities and businesses to reduce physical movement and resource consumption (Akyildiz et al., 2016; Yu et al., 2017). 5G technology supports social sustainability by providing access to digital services in rural and excluded areas, bridging the digital divide and improving social equality (Fahn and Yan, 2021). Furthermore, 5G networks will break down distance barriers, enabling distance learning, telehealth care, and global collaboration, which will improve quality of life and reduce inequality. Overall, 5G technology contributes to the promotion of economic, environmental and social sustainability by reducing energy demand, supporting the availability of digital services and improving living conditions for society (Fahn and Yan, 2021).

The following chapters present the literature background of 5G technology, with particular attention to its appearance and acceptance. Therefore, the research focuses mainly on consumer attitudes and the acceptance of 5G technology. Exploring consumer attitudes is essential to understanding the extent to which people will accept 5G and whether the technology can really be used as a tool for sustainable development.

2.1. Mobile communication

Today, people, systems, and machines rely on mobile communication technology. For example, the mobile (e.g. smartphone) internet and the IoT (Internet of Things) are two major drivers of the seemingly ineluctable development of the telecommunications industry (Kalem et al., 2021; Liu et al., 2018). Since 2020, a huge increase in the prevalence of IoT devices (sensors, actuators, cameras, etc.) has advanced the need for better mobile data access (Alliance, 2015). This is likely to continue, and the growth in mobile data traffic necessitates the examination of network development plans (Rickards, 2002). Increasing mobile data consumption and the growth in the number of connected devices around the world will require higher data capacity, significantly faster connection speeds, and lower latency (Benseny et al., 2019; Kalem et al., 2021). With each new iteration in software design, application bandwidth requirements increase, and future applications are expected to have much higher performance requirements than current LTE (Long Term Evolution) networks can achieve. The continued spread of smart devices and growth of mobile data traffic, as well as new market drivers, are advancing at an ever-faster pace, accelerating the need to transition to 5G. More mobile network operators and other major stakeholders in the industry are planning to invest in 5G technology. According to research by Ericsson, a major telecommunications company based in Sweden, 5G will reach 40 percent coverage of the world's population and 1.5 billion subscriptions by 2024. As a result, 5G is projected to be the fastest-growing generation in the history of mobile globally (Ericsson, 2019). The International Telecommunication Union has identified advanced mobile broadband, machine-to-machine communication, and highly reliable, low-latency communication as the three main pillars of 5G (Kalem et al., 2021; Liu et al., 2018). Long-term economic development is shaped by developments in infrastructure, particularly changes in networks connecting people and businesses in different locations (Andersson and Andersson, 2008). 5G will be a critical part of this evolving infrastructure.

2.2. The 5G network in Hungary

Hungary has superior 4G and 4G + mobile networks. This position can be transformed into a competitive advantage in the next phase of digital transformation by taking the lead in 5G mobile developments. The aim of the Hungarian 5G Coalition (5 GK), initiated by the Digital Prosperity Programme, is to make Hungary one of the European centers of 5G development and a regional frontrunner in the development and testing of 5G-based applications (Vodafone, 2021). In 2020, the level of consumer knowledge of about 5G in Hungary was assessed. Researchers surveyed 4000 Internet users over the age of 16. Less than half (42 percent) of Hungarian consumers had seen *the term* 5G in print or online, and 46 percent of respondents were unfamiliar with 5G *as a concept* and did not know the meaning of the term. Moreover, 13 percent of respondents had not heard of 5G at all, even in passing (Statista, 2021b). Young people, men, graduates, people in good financial situations, and those who are familiar with using the internet are more informed than average about 5G. Yet not all information is equally accurate or correct. Two-thirds of those who have at least heard of 5G say they have heard something about the possible health effects of the new mobile network,

which is not to suggest that they necessarily agree with these assertions. Buyer intentions are significantly influenced by health awareness and expectations related to well-being (Parashar et al., 2023; Rana and Paul, 2017). Among those who are somewhat familiar with 5G, the majority of internet users indicated that do not require a faster network because they feel that 4G is sufficient for them. There are equal proportions of respondents who welcome the new technology for its ability to enable machine-to-machine communication and those who do not support 5G because of the environmental burden. A third of respondents fear that the new technology could have harmful health effects (ARIOSZ, Research). In a survey conducted in March 2021, 3573 consumers were asked about their views on 5G. According to the survey, 29 percent of people aged 16 and over in Hungary had a negative opinion about 5G, 35 percent had a positive opinion and 36 percent of respondents had neutral feelings about the technology. Furthermore, one-third of respondents feared that the new technology could have dangerous health effects due to radiation. These results suggest that there still is uncertainty among people in Hungary, but that the proportion of positive attitudes towards this technological change is higher than the share of negative attitudes (Statista, 2021a).

2.3. Consumer preferences

The economic environment is affected by all consumer goods purchased by individuals to fulfill their daily requirements (Drábik et al., 2020). In examining consumer preferences for 5G networks, this investigation identifies customer delay as a crucially important variable affecting the adoption of 5G networks. Besides describing global trends in consumer attitudes, it additionally discusses access-based product service systems based on 5G technology in terms of consumer attitudes and the customer acceptance model. Most of the research on 5G technology has been conducted in Asia. That is unsurprising given the technological development in parts of Asia and the existence of some already-constructed 5G networks there. For example, Korean consumers were the first to experience 5G services when the fifth-generation mobile network became available on 3 April 2019. Other countries followed, with many of them launching 5G networks to consumers in 2020. In reviewing consumer preferences, global consumer perceptions of and knowledge about 5G technology are especially noteworthy. Research shows that, overall, consumers who are aware of 5G intend to use its services within two years of deployment (Ericsson, 2018). However, the difference between awareness and take-up varies markedly from country to country. China and the United States lead the way in consumer awareness and the willingness to adopt 5G. Despite lacking knowledge about 5G, consumers in Argentina and Mexico see it as a way to overcome existing wireless technologies' shortcomings in terms of speed and reliability. In Latin America, 68 percent of smartphone users plan to use 5G within two years of launch, and the global average for adoption within two years is 53 percent. Shah et al. (2023) investigated Chinese consumers' attitudes towards 5G and found that the focus should be on developing personalised products and services that meet consumers' needs, which can increase consumer value and trust. They also point out that consumer purchase intention for 5G technology is indirectly influenced by product affordability. The results will help to better understand the safety and guidance features that also influence purchase intentions. Finally, the research also points to the need for companies to adopt different marketing practices in order to maximise consumer opportunities (Sach et al. 2023). Similar results were obtained in a study conducted in Serbia. The survey conducted in this study revealed high expectations among respondents for 5G and its innovation capacity. The significant general interest in personal smart lifestyle services represents important information and business opportunities for operators to design and develop new offerings for the residential segment. Confidence in technology was identified as a particularly important factor for user adoption. The results suggest that interest in personalised services and 5G awareness also have a significant impact on behavioral intentions, supporting the need for citizen education and active involvement in this area. Recommendations include educating end-users, gradually building trust and new services, as well as encouraging early adopters and loyalty programmes, all of which contribute to encouraging the use of 5G-based services (Stojanović et al., 2023). A similar study to the present one was conducted in Hungary with a sample of 504 respondents aged 14–76 years. The research focused more on individual preferences for 5G, with the following results. Currently, the social acceptance of 5G is not yet achieved and there are significant negative sentiments associated with it, especially in social groups that are generally less receptive to new technologies. Interest in 5G technology is primarily shown by younger men living in metropolitan areas, while perceptions are more negative among women, older people and those with less technological experience. One way to reduce negative attitudes is through interactive education, including the opportunity to try out 5G-based services. The research showed that information sources play a crucial role in shaping attitudes towards 5G; information from trusted sources triggers positive emotions, while information from other, less credible sources triggers negative emotions. The results suggest that offline presentations and discussions, where participants can try out the technology in person, may be important to promote the social acceptance of 5G (Korbuly and Szabó, 2021).

The data from Europe is particularly striking and contrasts the aforementioned, with European users preferring to wait for the technology to mature. Only 39 percent of the European consumers surveyed said they would use 5G within two years of its launch. For example, Finnish consumers prove to be rather cautious and consequently are unlikely to take advantage of the services offered by the technology within three years of deployment (Ericsson, 2018).

Consumers associate 5G networks primarily with internet connectivity. Hence, their expectations for mobile services are crucial. Within mobile services, their expectations for data traffic are remarkably high. More than one-quarter (26%) of consumers expect much faster data traffic from 5G. According to 13 percent of them, 5G is faster than Wi-Fi, has much better outdoor and indoor coverage, and offers lower prices. Moreover, 4–6 percent of survey respondents also expect fewer delays, higher quality video streaming, or longer battery life for devices (Ericsson, 2018).

2.4. Consumer acceptance-model and global trends in the use of 5G technology

Consumer acceptance can be measured in several ways, using different models. These models are designed to help researchers understand the factors that influence the efficient use of technology. Of these models, the Technology Acceptance Model (TAM) is the most popular and most commonly used in studies of computer and internet technologies. Developed by Davis (1989), TAM measures individuals' willingness and intention to use technology based on three elements: perceived usefulness, perceived ease of use, and behavioral intention to use (Kaur et al. 2018). Mobile providers worldwide contend with various challenges (Benedek et al., 2014).

Venkatesh et al. (2003) argued that a single model would not be sufficient to explain technology use, and therefore the issue needs to be examined in a multidimensional way. He developed the Unified Theory of Acceptance and Use of Technology (UTAUT). This model divides the intention to use technology into the four components of "performance expectancy, effort expectancy, supportive conditions, and social influence" and combines eight elements into a single theory. These include:

1. Social cognitive theory
2. Innovation diffusion theory
3. A technology acceptance model
4. A combined technology acceptance model
5. A theory of planned behavior
6. A motivational model

7. A model of PC utilization
8. A theory of reasoned action (Sezer and Yilmaz, 2019).

A survey In Ireland in 2020 looked at the adoption of 5G networks. There, 5 percent of respondents currently are using 5G and another 24 percent of them intend to switch as soon as it becomes available. Compared to 2019, however, enthusiasm for 5G has eased in that country. The percentage of respondents who would switch to a 5G network if they "started to hear good things about it" has fallen by 12 percent in a year (Deloitte, 2021).

Potential risks comprise one of the biggest 5G-related issues for consumers. However, several studies have shown such fears to be unfounded. The research accordingly shows that a clear majority of people disagree with the statement that there are health risks associated with 5G. Even in Europe, where considerably more respondents than in Ireland report fearing the health effects of 5G, only 36 percent and 34 percent in Austria and Belgium (respectively) thought this to be a concern (Deloitte, 2021).

3. Methodology

A quantitative online questionnaire was fielded to collect the participants' views of 5G technologies and services. The goal of the research was to assess their perceptions of 5G, their willingness to use services, and changing consumer preferences by way of self-completed questionnaires. Self-completed questionnaires can reach a large number of people in a relatively short time (Chapman et al., 2005). The first draft of the questionnaire was based on past studies and literature. The statements to be evaluated by participants were adopted from earlier research. The validated scales were adapted from three studies, namely "Consumer's intention to purchase 5G: Do environmental awareness, environmental knowledge, and health consciousness attitude matter?" (Shah et al., 2021b), and "Elaborating on the consumer's intention behavior gap regarding 5G technology: The moderating role of the product market-creation ability" (Shah & Zhongjun, 2021). Some additional statements were taken from the "Ericsson Consumer and Industry Insight Report January 2018" (Ericsson, 2018; Shah and Zhongjun, 2021; Shah et al., 2021a). The variables were measured using a five-point Likert scale, and the questionnaire was divided into three main parts: attitude statements about 5G technologies, 5G awareness, and demographic characteristics.

The PLS method was chosen to test the hypotheses. The method was applied for attitudinal analysis by Shah et al. (2021b). The PLS method has been accepted and used by researchers for decades to investigate relationships between latent variables (Henseler et al., 2009), but its use in Hungary has only really started to spread in the last decade (Kazár, 2014). The advantages of the method include the fact that it can be used for variables with non-normal distributions and low sample sizes (Hair et al., 2012; Henseler, 2010). Furthermore, it is important that the latent factors can be constructed simultaneously among the variables included in the procedure and their relationships can be tested using a regression model. We worked with predefined (and already validated) factors drawn from existing research, giving us the ability to thoroughly investigate the relationships between these factors (Kovács and Bodnár, 2016). The use of structural equation modeling in latent variable modeling, PLS in particular, is considered a useful and practical technique and is well-suited to the present research (Kazár, 2014).

3.1. Pilot study

Before fielding the questionnaire, a pilot survey was conducted to test the clarity and usefulness of the questionnaire items. At the beginning of the pilot questionnaire, a short paragraph was provided to explain the goal of the study. The pilot study contained 39 items of measurement adopted from existing literature. The pre-test was administered to 39 respondents, 17 men, and 22 women. In terms of age, 35 people belong to the birth group 1996–2010 and 4 people to the birth group 1982–1995. The scales in the questionnaire were originally in English but were translated into Hungarian and adapted as necessary. With the help of the pilot survey's participants, several changes to the questionnaire were implemented.

The target group of the research was young Hungarian consumers, and the focus of the research was on the attitudes of this target group towards 5G. The study investigated the relationships between the external and internal factors identified during the setting up of the research model. The external factors are business and environment, the internal factors are values and health, and purchase and preferences.

The hypotheses of this research are based entirely on the literature review. The relationship between business and 5G technology and consumer value systems also relates to access-based product-service systems. Hence, its relevance is revisited for several factors.

Fig. 1 illustrates the design of the main factors examined. It makes use of scales validated in previous research (Shah & Zhongjun, 2021; Shah et al., 2021b). The present study also retained the main factor groupings from those earlier investigations: Perceived Benefits (PB), Perceived Sacrifices, Product Market Creation Ability, Environment Awareness, Environmental Knowledge, Perceived Values (PV), Health Consciousness Attitude, Adoption Intention, Consumer Purchase Behavior, Consumer Purchase Intention, and Consumer Preferences. The perceived benefits factor is external because it can provide benefits outside the consumer's control, e.g. the ability to build a business faster or to start a business that would not be possible without the 5G. The question in this case is whether the consumer sees these benefits. Perceived values are internal factors, so, it can be interpreted as internal motivation. The question is how much does it become an intrinsic value to the consumer if the 5G opportunity is given?

Subsequently, the validated groups were categorized into main factors based on their content and the purpose of the study. The internal factors are the main factors over which the consumer has (to some extent) influence: Values, Health, Purchase, and Preferences. The external factors are the main groups of factors over which the consumer has almost no influence: Business and Environment. The PLS method was used similarly by Sharifi et al. in a study published in 2022. The labeling was designed to reflect the content of the main factor groups and to fit the 5G applications identified in the literature.

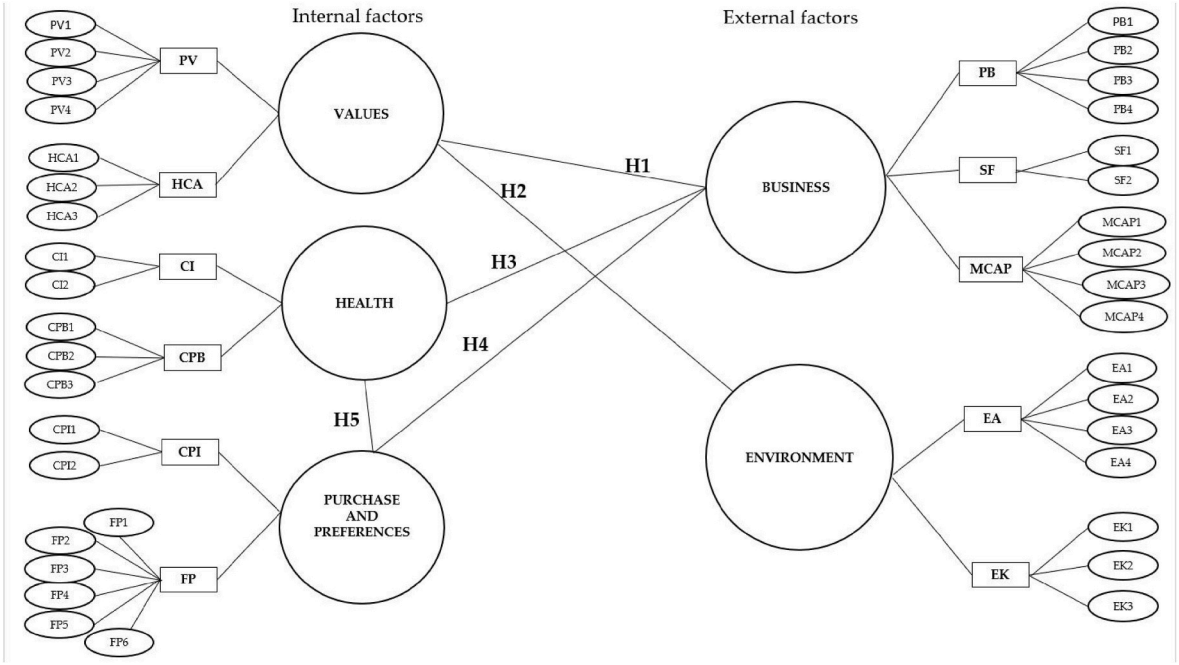
Thus, we have established a framework for evaluating our hypotheses so that we may determine which, if any, main factor groups are related. The PLS method was used to test the hypotheses, i.e. to measure the relationship.

Deployment and take-up of 5G have significant impacts on economic development and the profitability of small and medium-sized enterprises (Elayoubi et al., 2017; Grigorescu and Mocanu, 2020). Additionally, corporate values permeate the functioning of enterprises, their decision-making mechanisms, and economic and technical processes (Attanasio et al., 2022; Baltuttis et al., 2022). It is assumed that the values of the respondents about 5G and the business processes generated by 5G have an impact on each other. Hence, the first null hypothesis is:

H01. Values of 5G for acceptance is unrelated to Business.

Literature research has confirmed that issues of consumer values and the vulnerability of our natural environment play a prominent role in our daily lives and at the global economic level (Madan et al., 2022). The impact of values on the environment has been investigated in several studies, and values influence the environmental factor (Bogner, 2018; Miao et al., 2022; Bogner, 2018). Moreover, the relationship between the environment and a person's values age dependent. The relationship between environmental behavior and values can be identified as early as childhood (Boeve-de Pauw and Van Petegem, 2013). Based on these findings, the second hypothesis explores the relationship between values and natural environment in the case of 5G.

H02. Values of 5G for acceptance is unrelated to Environment.



Source: own processing

Fig. 1. Research model.
Source: own processing.

In many cases, technological developments in health care have been shown to have an economic stimulus effect. The widespread use of 5G will enable rapid diagnostics, efficient data analysis, and thus rapid healthcare action. The best example of this speed is the COVID-19 pandemic, where 5G has played a significant role in data analytics and information sharing, enabling rapid healthcare actions, with indirect impacts on Business (Guo et al., 2021; Qiu, 2021; Siriwardhana et al., 2021). Hence, the third hypothesis is:

H03. Health (benefits from the acceptance of) 5G is unrelated to Business.

Previous research has studied the impact of the Purchase and Preferences factors on shopping habits. For example, consumer preferences influence purchase preferences between different organic packaging materials (Notaro et al., 2022) and brand perception (Ndlovu and Heeralal, 2022). A positive effect between preferences and digitalization has been demonstrated for Indian SMEs (Ali et al., 2022). To illustrate the relationship between values, preferences, and household environmentally conscious business solutions, P2P (peer-to-peer) models have been investigated in Germany (Karami and Madlener, 2022). Accordingly, the fourth hypothesis is:

H04. Purchase and Preferences for 5G for acceptance are unrelated to Business.

The Covid-19 pandemic additionally provides evidence of the impact of Purchase and Preferences on Health. For example, the demand for hygiene products has changed (Kumari and Bhateja, 2022). The nature-related preferences of urban dwellers also changed as a result of Covid, and that in turn, had an impact on Purchase and Preferences (Stankowska and Stankowska-Mazur, 2022). Similar changes also appeared in Purchase Preferences for COVID-19 testing and vaccines; Okoye et al., (2022). Based on these findings, the fifth hypothesis is:

H05. Health to 5G for acceptance is unrelated to Purchase and Preferences.

4. Results and discussion

5G technology could have a major impact on both the consumer market in the coming years and consumer behavior. This new technology will bring the speed and quality of wireless networks to a higher level, but it also will be very divisive for consumers. Some consumers are accepting of the new technology and are open to purchasing 5G, while other potential users are skeptical due to 5G's possible adverse effects on health, the environment, or other areas.

Our questionnaire, which addressed these matters, was completed by 402 Hungarian respondents. No incomplete or invalid responses were received. As a result, all respondents' views were used in the analysis. The sample primarily includes responses from birth group 1996–2010 and 1982–1995 but also includes responses from birth group 1965–1981 and 1946–1964 to a lesser extent. The demographic characteristics of the sample are shown in Table 1. The table shows the exact distribution of respondents in each demographic group, expressed in percentage and frequency terms. A *t*-test was also performed. In this article, the results are briefly described.

The target group consisted of younger generations (birth group 1996–2010 and 1982–1995) of Hungarian consumers because prior research has shown them to be the most open to 5G-based services (Reicher, 2018). Fig. 2 provides a visual representation of the respondent's place of residence.

Consumers from all parts of the country were contacted in varying proportions, and Hungarians living in Slovakia also responded to the questions. However, the vast majority of respondents came from Western Transdanubian, Central Transdanubian, and Central Hungary. These three regions are the most economically developed areas in Hungary. In terms of development, Central Hungary leads the ranking, followed by the West Transdanubian region and the Central Transdanubian region. The socio-economic indicators of the three regions mentioned are mostly above the national average (KSH, 2018). Given these regions' economic development, we can assume that most respondents are familiar with modern technologies and already own a wide range of electronic

Table 1
Demographics.

Measure	Categories	Frequency	Percentage %
Gender	Female	267	66,3
	Male	135	33,5
	Other	0	0
Year of birth (generation)	1996–2010 (Z generation)	310	76,9
	1982–1995 (Y generation)	74	18,4
	1965–1981 (X generation)	17	4,2
	1946–1964 (Baby Boomer)	1	0,2
Education	Vocational training	1	0,2
	Vocational school	2	0,5
	High school	170	42,2
	Vocational high school	59	14,6
	Vocational training based on graduation	75	18,6
	Higher vocational education	36	8,9
	College, higher education (BSc, BA)	44	10,9
	University, Master's Degree (MSc, MA)	13	3,2
	Doctoral Degree (PhD, DLA)	2	0,5
People living in a household	1–3	190	47,3
	4–6	207	51,5
	7–10	5	1,2
Regular independent earnings	Yes	240	59,6
	No	162	40,2

Source: own processing

devices.

The processing of the responses of the target group involves several analyses. The validity and reliability of the model are best assessed by item reliability and discriminant validity. At the beginning of the analysis, the mean standard deviation and the factor loading values (FLV) provide an overview of the validity of the responses to the questions and statements in the questionnaire. Since those values mostly exceed 0.7, the responses seem to be valid. The analysis is presented in Table 2, with a split between internal and external factors. Factor loading values are correct for most attitude settings. The group of "Perceived Values" and "Consumer Purchase Behavior" attitudes are highlighted, where the FLV exceeds 0.7 for all statements.

In PLS models, the relationship between manifest and latent variables can be of two types: reflective or formative. Reflective models assume that an increase/decrease in the latent variable causes a change in the indicators. In formative models, the hypothesized relationship is in the opposite direction, i.e., the change in indicators is reflected in the change in latent variables (Jarvis et al., 2003; Nagy Judit and Bernschütz, 2017) We assumed a reflective relationship in keeping with the attitude-type latent variables (Fig. 3).

Construct validity and reliability (Table 3) constitute another basis for evaluating the model. It identifies these analyses as essential tools for expressing and measuring test constructs (Gefen and Straub, 2005; Hair et al., 2016). Further convergence validity is the degree to which the measures of similar construction are combined or converged (Hair et al., 2016; Hair et al., 2016). If the explained AVE (Average Variance Extracted) equals or exceeds 0.5, the efficiency of convergence is confirmed (Fornell and Bookstein, 1982). Of the constructs, only Purchase and Preferences and Values scored above 0.5. In their case, the AVE score proves convergent validity. An AVE of at least 0.5 is highly recommended.

Another reliability indicator is Cronbach's alpha, which provides a test to check whether the scales are consistent, or whether the statements in each scale are measuring what they are supposed to measure. Its value can range from 0 to 1. When calculating Cronbach's alpha, the reliability estimates for determining internal consistency should be greater than 0.70 (Field and Miles, 2009). Only one construct, Health, slipped below the threshold of 0.7. That does not necessarily diminish the significance of the results of our questionnaire, but instead calls the construct's validity into question.

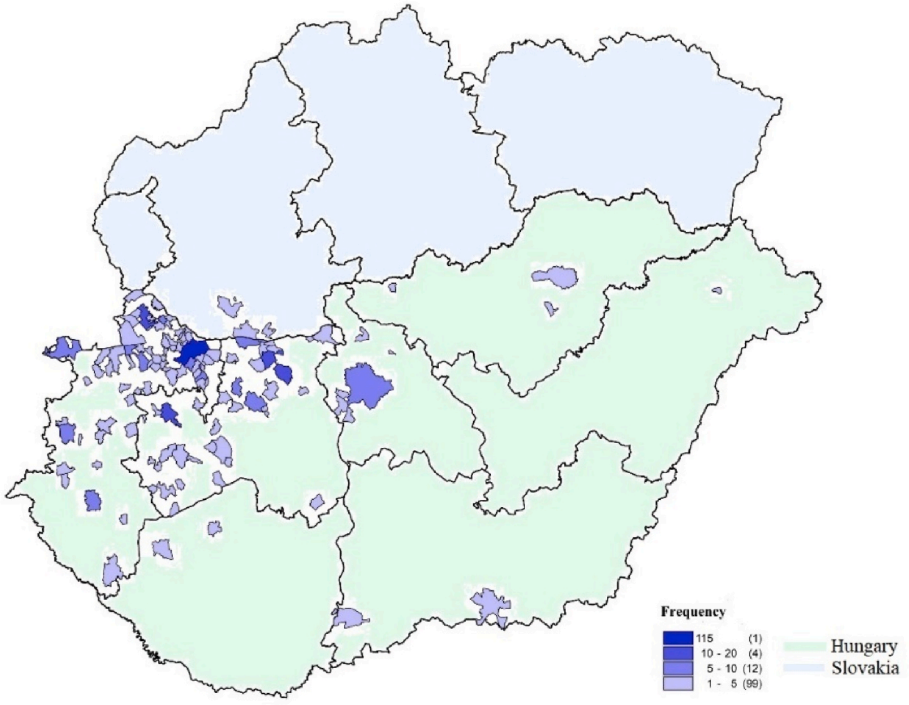


Fig. 2. Residence of respondents (Location).
Source: own processing.

Table 2
Outer loadings.

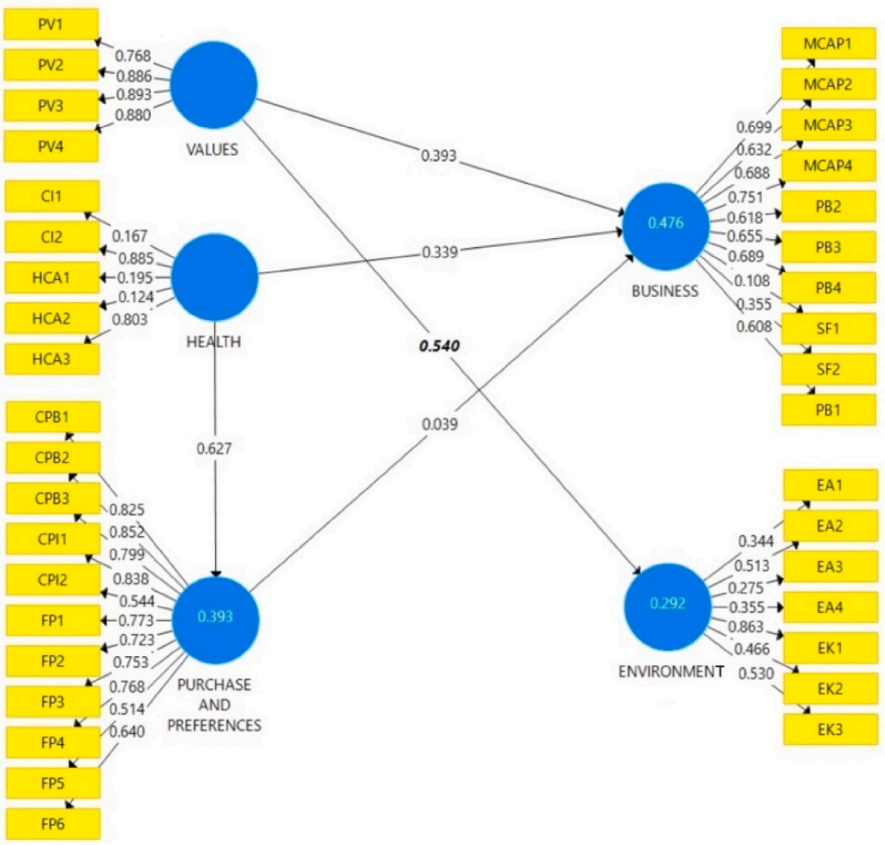
		Factors	Mean	Standard Deviation	Factor loading values
EXTERNAL FACTORS					
Business	**Perceived Benefits**	PB1: As far as I know, 5G can provide high-speed services.	4,5249	0,77081	0,608
		PB2: As far as I know, 5G can provide high-quality services	4,3731	0,81450	0,618
		PB3: As far as I know, 5G can provide entertainment	4,0522	0,97590	0,655
		PB4: As far as I know, 5G services are useful.	3,9975	0,97984	0,689
	Perceived Sacrifices	SF1: As far as I know, 5G services can be expensive.	3,3881	1,06106	0,108
		SF2: As far as I know, 5G services will waste time.	3,2711	1,06338	0,355
	Product Market Creation Ability	MCAP1: As far as I know, new 5G technology products will introduce many completely new features to the market	3,5498	1,07743	0,699
		MCAP2: As far as I know, new 5G technology products will create new customers	3,4925	1,06225	0,632
		MCAP3: As far as I know, new 5G technology products will cater to a market that doesn't exist yet and, therefore can change the market greatly.	3,7662	0,98368	0,688
		MCAP4: As far as I know, new 5G technology products will be useful to future potential users in some way, even if potential markets are not well articulated.	3,7711	1,00986	0,751
Environment	**Environmental Awareness**	EA1: I consider the potential environmental impact of my actions when making my decisions.	3,8483	0,98586	0,344
		EA2: I would like to describe myself as environmentally responsible.	3,7861	0,93638	0,513
		EA3: I am worried about wasting and destroying the earth's resources.	4,1766	0,95596	0,275
		EA4: Even if I feel inconvenient, I would like to take more environmentally friendly actions.	4,0647	0,92663	0,355
	Environmental Knowledge	EK1: I know that I adopt environmentally safe technology.	2,9204	1,03487	0,863
		EK2: I am very knowledgeable about 5G radiation and its related environmental issues.	2,5025	1,10372	0,466
		EK3: I know that I buy products that are environmentally safe as I am more cautious about my health.	3,2214	0,95444	0,530
INTERNAL FACTORS					
Values	**Perceived Values**	PV1: As far as I know, Compared to the sacrifice I need to pay, the use of 5G offers value for money.	3,3010	0,99447	0,768
		PV2: Taking all the pros and cons into consideration, the use of 5G is beneficial to me.	3,4826	1,11034	0,886
		PV3: Despite my unfamiliarity with 5G, the use of 5G is worthwhile for me.	3,2114	1,07919	0,893
		PV4: Overall, the use of 5G gives good value.	3,4701	1,15845	0,880
Health	**Health Consciousness Attitude**	HCA1: I carefully choose 5G technology to ensure good health.	3,1617	1,13270	0,195
		HCA2: I often think about health issues related to different pollution.	3,3881	1,12050	0,124
		HCA3: I think I will be a 5G consumer with health conscious.	3,2761	1,03354	0,803
	Adoption Intention	CI1: I would think about my health first then intend to continue or discontinue 5G.	3,6667	1,06325	0,167
		CI2: I think I will continue to use 5G after I use 5G.	3,4328	1,05069	0,885
Purchase And Preferences	**Consumer Purchase Behavior**	CPB1: I often purchase new 5G technology products when they are available on the market.	2,9378	1,10930	0,825
		CPB2: I try to purchase new 5G technology products even though they are more expensive.	2,6095	1,11405	0,852
		CPB3: In any case, I usually choose new 5G technology products.	2,4428	1,13786	0,799
	Consumer Purchase Intention	CPI1: I plan to use new 5G technology products if it is available.	2,8930	1,19057	0,838
		CPI2: I predict I will use new 5G technology products in the future.	2,1070	1,39325	0,544
	Consumer Preferences	FP1: I would switch mobile phones to use 5G.	2,2637	1,21918	0,773
		FP2: I would switch providers to use 5G.	2,2662	1,24996	0,723
		FP3: I would be willing to pay more for faster internet.	3,0945	1,27552	0,753
		FP4: I would switch to 5G for a better video experience.	2,9154	1,34101	0,768
		FP5: I would choose shopping in the virtual space over the traditional one if I could "try on" clothing products in the virtual space, for example.	3,2637	1,34744	0,514
		FP6: I would be willing to replace my traditional household items with smart devices.	3,2139	1,26688	0,640

Source: own processing

Discriminant validity is an aspect of construct validity that examines how different a latent variable is from other factors (Hair et al., 2016; Malhotra, 2019; Shah et al., 2021b). Testing the correlation matrix between constructs is a popular method for determining discriminant validity. Table 4 reports the discriminant validity test results for this study.

The concept of discriminant validity emphasizes the importance of applying both discriminant and convergent validation techniques when assessing test results (Campbell and Fiske, 1959). A successful evaluation of discriminant validity shows that a concept is not highly correlated with other tests designed to measure theoretically different concepts. Nevertheless, there is no standard value for discriminant validity. However, a result less than 0.70 suggests that discriminant validity likely exists between the two scales. In contrast, a result greater than 0.70 suggests that the two constructs overlap significantly and thus likely are measuring the same thing. Table 4 illustrates the results of discriminant validity.

The PLS method was employed to determine the relevance and predictive impact of the structural model's pathway. Subsequently, it also was used as a bootstrap procedure (Fig. 4) to determine the significance level of the path coefficients. Table 5 displays the t-statistic results, which reflect the stability of the hypotheses. They show that H02 (Values-Environment) and H05 (Health-Purchase and Preferences) can be rejected at a significance level of $\alpha = 0.05$. The other three null



Source: own processing

Fig. 3. PLS algorithm estimates (Loading and Coefficients).
Source: own processing.

Table 3
Construct validity and reliability.

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Business	0,799	0,844	0,843	0,372
Environment	0,739	0,88	0,684	0,261
Health	0,635	0,678	0,575	0,302
Purchase And Preferences	0,913	0,932	0,928	0,545
Values	0,880	0,888	0,918	0,736

Source: own processing

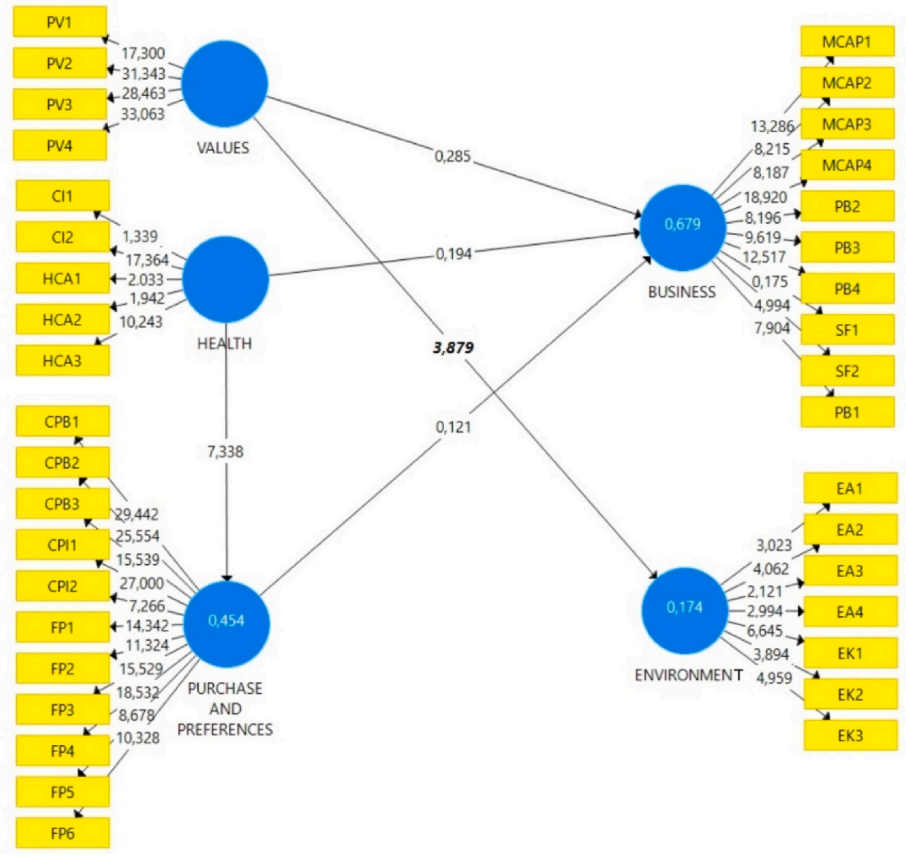
Table 4
Inter-item correlations and discriminant validity.

	Business	Environment	Health	Purchase And Preferences	Values
Business	0,610				
Environment	0,458	0,511			
Health	0,609	0,523	0,550		
Values	0,524	0,545	0,627	0,738	
Purchase And Preferences	0,632	0,540	0,625	0,692	0,858

Source: own processing

hypotheses associated with the proposed model are rejected. Thus, the proposed model included a total of five hypotheses, of which three cannot be rejected and two can be rejected. That is an interesting result where two significant correlations can be observed. However, it is surprising because there is a significant correlation between all the factors in the literature. This raises a question as to whether the factors were well-defined or whether the results reflect significant underlying relationships between distinct (and well-defined) variables. Perhaps, it may be necessary to test a larger number of responses.

This study examined and tested five hypotheses that proposed a relationship between each factor. The analyses showed that the relationship between consumer values and business is weak. Therefore H01: Values of 5G for acceptance is unrelated to Business cannot be rejected. Hypothesis H02 focused on consumer values and the environment. Based on the results, hypothesis H02: Values of 5G for acceptance is not positively related to Environment can be rejected. Hypothesis H03 focused on consumer attitudes towards health and business based on literature research. In the hypothesis testing, the null hypothesis was rejected, thus hypothesis H03: Health (benefits from the acceptance of) 5G is unrelated to Business cannot be rejected. Business indicators are not related to consumer values. Based on the analysis, the purchasing and preferences' relationship with business also is weak. Consequently, hypothesis H04: Purchase and Preferences for 5G for acceptance is unrelated to Business cannot be rejected. One of the most common consumer preferences was the health factor. Today, a significant proportion of consumers aspire to a health-conscious lifestyle. Unsubstantiated reports claim that 5G radiation has had harmful effects on health. The analysis here, though, demonstrated that the relationship between the two attitude groups is weak. Consequently, H05: Health to 5G for acceptance is unrelated to Purchase and Preferences can be rejected. The results from testing hypotheses H01 and H04 are particularly surprising. Both the literature and the secondary data suggested that there would be some relationship between consumers' values and preferences and business. The opposite finding, though, raises the question of whether the attitudinal adjustments based on the validated scales provide an



Source: own processing

Fig. 4. PLS bootstrapping of the model.
Source: own processing.

Table 5
Path coefficient of the model.

	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values
Health - > Business	0,544	0,663	2807	0,194	0,846
Health - > Purchase And Preferences	0,674	0,688	0,092	7338	0,000
Purchase And Preferences - > Business	−0,157	−0,208	1299	0,121	0,904
Values - > Business	0,487	0,414	1709	0,285	0,776
Values - > Environment	0,417	0,446	0,107	3879	0,000

Source: own processing

accurate basis for the studies. Some of the statements may have been clear to the consumer, perhaps too complex. For example: "MCAP3: As far as I know, new 5G technology products will cater to a market that doesn't yet exist, and therefore can change the market greatly". Or, "MCAP4: As far as I know, new 5G technology products will be useful to future potential users in some way, even if potential markets are not well articulated". Likewise, "EK1: I am very knowledgeable about 5G radiation and its related environmental issues"; "EA3: I am worried about wasting and destroying the earth's resources"; and "EK3: I know that I buy products that are environmentally safe I am more cautious about my health". All five of these attitude statements group several objects together. In these cases, it can be problematic for respondents to decide on which part of the agreement scale they should rate the overall statement. Hence, future research should include clearer attitude statements to obtain less ambiguous results.

5. Conclusions

It is clear that 5G technology has a huge impact on sustainability. During the development and introduction of new networks, it is possible to increase the efficiency of the telecommunications infrastructure and to reduce energy consumption. In addition, 5G creates opportunities for the development of smart cities and intelligent transportation, which can contribute to environmental protection and sustainable urban development. And through advances in IoT (Internet of Devices) and remote healthcare, 5G technology can help ensure more equitable access to healthcare services and more efficient use of healthcare resources. 5G can thus play a key role in creating a sustainable future. The consumer attitude towards 5G is important because the acceptance and commitment of users is essential for the successful spread of the technology and the exploitation of the opportunities it offers. The study sheds light on consumers' acceptance of technology and their attitude, which will be a decisive factor in the extent to which 5G technology can contribute to the achievement of sustainability goals.

It can be concluded that consumer adoption of the current infrastructure for 5G networks and future deployment is not straightforward. The values and preferences of consumers play a major role, which may differ from continent to continent, or even from region to region, due to external environmental and cultural influences. An example is the Asian region, where the level of 5G infrastructure development is particularly high. At the same time, the openness of Asian consumers and their

environmentally conscious, sustainable approach are also outstanding. Together, these factors contribute to a successful 5G deployment and maintenance that can serve as a model for other countries around the world. Consumer acceptance is a key requirement for a long-term sustainable 5G infrastructure, without which the system may face many obstacles. The long-term orientation is not negligible for the sustainable development that 5G technology offers. If the technological development is successful, we can expect to make the quality of life sustainable on the business side as well as on the consumer side. This will also have a positive impact on the use of natural resources. One of the questions that arose in the conclusions was: how can different consumer reactions be dealt with? That is, how to deal with mistrust, uncertainty, fear. It is clear from the results of the research that Hungarian consumers are not yet sufficiently aware of 5G technology and consequently feel distrust and fear. They are uncertain about the benefits of the technology and fear the health risks that are so often publicised. They do not recognise the interaction between 5G and business, one of the reasons for this fear. The emergence of consumer groups as a result of consumer behavior might prove to be a key determinant. Additionally, health, environmental protection, and openness to technological innovation may influence behavior toward 5G networks. What can we do to reduce consumer fear and uncertainty? Education is the answer. It became clear that the most rational way to overcome fear and uncertainty would be through education. Consumers should be provided with sufficient information to make them more open to the technology and willing to accept its benefits. Consumer values and the health factor are certainly linked. Values and environment show the closest link in the research. It can be concluded that consumers' orientation towards the environment and their inclination to protect it may be strong. 5G technology often raises public questions about its harmful effects on the environment. This is a sensitive issue that needs a lot of attention. Thus, the relationship map highlights the link between consumer values and health and environment factors. This threefold system provides an excellent guide to the kind of support that would be useful in presenting education. The primary focus is on sustainability, based on consumers' environmental attitudes. It should also be emphasised that the importance of sustainability cannot be communicated in a uniform way to consumer groups. Once the key points have been formulated, education should be delivered to each consumer group using group-specific communication tools. The same communication strategy cannot be applied to all consumer groups. A group-specific communication strategy should be developed on the basis of the characteristics of each group in order to ensure effective education. During this research, it became apparent that different groups of consumers seem to emerge, with different perceptions and preferences for 5G. As a result of these different preferences, each consumer group may react differently to the new technology. Therefore, different marketing strategies may be required to reach various consumer groups. Based on this possibility, it would be useful to investigate the sample by cluster analysis to identify potential consumer groups. The results measured in the present study can be generalized to the CE countries through the example of Hungary and could be the product of a joint education initiative.

CRediT authorship contribution statement

Boglárka Eisinger Balassa: Writing – review & editing, Writing – original draft, Validation, Software, Methodology, Formal analysis, Conceptualization. **Nikolett Gyurián Nagy:** Writing – review & editing, Writing – original draft, Validation, Software, Methodology, Formal analysis, Conceptualization. **Norbert Gyurián:** Writing – review & editing, Supervision, Software, Methodology, Conceptualization.

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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