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Evaluating Attitudes Toward Microchip Implants: A Comparative Study of five Eastern European Countries

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Background and purpose: Technology acceptance has been researched for decades. While some technologies are widely accepted, others are perceived as a threat, such as microchip implants. In this study, a two-step structural equation modeling approach was used to evaluate a new research model on microchip implant acceptance.
Methodology: A structural equation modeling model was developed to identify what influences the perceived acceptance of microchip implants. To determine differences in attitudes toward microchip implants, the study was conducted in five Eastern European countries.
Results: The results show that the influence of the factors does not differ significantly across the countries studied. Age, trust, and perceived usefulness affected the overall intention to use microchip implants, while ease of use was significant in only one country. Differences were found in perceptions of the right to privacy and conspiracy theories. The usefulness of microchip implants in pandemic was significant in all countries.
Conclusion: Small differences in attitudes towards microchip implants suggest that a general model of microchip implant acceptance could be constructed based on the data collected. In addition to these findings, our study noted the lack of legislation for microchip implants in the region and a lack of knowledge about this technology.

Keywords: *Microchip implant, Near field communication, Behavioural intentions, Structural equation model, Technology acceptance model*

1 Introduction

Since the first decade of the 21st century, the use of microchips in living organisms has been increasingly reported in the literature. Initially, aspects of the implementation of microchip implants (MIs) dominated as a tool for the identification of animals, particularly dogs and cats (Garcia et al., 2020; Turoń et al., 2015). Subsequent reports on

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the use of MIs can generally be divided into two groups: medical and non-medical use.

In the medical field, MIs have been used to access medical records and vaccination (Rotter et al., 2008), to detect patients with changes in mental status (Fram et al., 2020), to monitor patients' heart, blood glucose levels, and general health (Sundaresan et al., 2015), for drug delivery systems (Barbone et al., 2019; Magnusson & Mörner, 2021; Suhail et al., 2021), for visual organs, and smart dentures (Madrid et al., 2012). They have been used for birth control (Shafeie et al., 2022), surgical treatments (Suhail et al., 2021) or to support treatment such as activation of damaged brain parts (Łaszczyca, 2017). In addition to healthcare applications, MIs have also been used to identify the deceased after natural disasters (Meyer et al., 2006).

Alongside medical applications, there are numerous studies in the literature on the use of MIs in non-medical settings. MIs have been used for personal identification (K. Michael et al., 2017; Rotter et al., 2008), purchases and contactless payments (K. Michael & Michael, 2010), access to secured doors, workplaces or smart homes (Carr, 2020; Rotter et al., 2008) and even cryptocurrency transactions (K. Michael, 2016), tracking people indoors, monitoring employee activity (Banafa, 2022; Rodriguez, 2019), and launching applications (Heffernan et al., 2016; Rohei et al., 2021; Siibak & Otsus, 2020) or enhancing innate abilities (Heffernan et al., 2017).

Despite the abundance and diversity of microchip implant (MI) applications, they are treated as a controversial advanced technology, and the benefits of their use in daily life must be balanced with privacy (Carr, 2020), ethical considerations (Moosavi et al., 2014), health risks due to animal test results (Albrecht, 2010; Sapierzyński, 2017), security (Huo, 2014), and legal issues (Graveling et al., 2018).

Another issue that is raised just as frequently in the literature is the possibility of people being controlled by the government or criminal organizations (Gagliardone et al., 2021; Gu et al., 2021). The introduction of microchips in everyday devices has also raised concern among users. These concerns include widely accepted privacy (or loss thereof) and ease of fraud (Graveling et al., 2018).

During the COVID-19 pandemic, the MI technology and the diversity of its uses received additional attention for and against its use. In any case, it is evident that the need for identification of individuals is increasing not only in healthcare but also in society. Despite a considerable number of reports on the use of MIs and discussions for and against their use, research on the acceptance of MIs by individuals is limited and mainly restricted to a specific group or smaller samples of potential users. Moreover, differences or similarities in the acceptance of MIs by the country of origin have not been explored in any of the cases presented.

The first study on the acceptance of MIs found in the literature was conducted by Smith (2008) and included only students. A few years later, Achille et al. (2012) and Perakslis & Michael (2012) conducted a study on the acceptance of MIs, but it was limited to a specific age group, whereas the studies presented by K. Michael et al. (2017) and Perakslis et al. (2014) were limited to small business owners. In addition, the research by Mohamed (2020) was limited to a sample of people with various disabilities. The research by Pettersson (2017) and Boella et al. (2019) used interviews to understand the reasons for using MIs, thus both studies included smaller samples. To gain insight into personal perspectives on the adoption of MIs, Shafeie et al. (2022) included open-ended questions in their survey. The resulting model for behavioral intention to use MIs is very thorough, but the sample size was limited and statistical significance of differences in demographic characteristics was not possible.

The study presented by Pelegrín-Borondo et al. (2017) included a large and diverse sample in terms of basic characteristics. Their acceptance model explained over 73% of the intentions to use MIs. However, the study was limited to the Spanish population. In contrast, the study by Olarte-Pascual et al. (2021) included a large international sample, but it was not large enough to identify cross-cultural differences.

The study presented by Gangadharbatla (2020) included a larger and more representative sample, but the results were evaluated using only basic statistics, which limits the conclusions that can be drawn from the findings. Although Chebolu (2021) included a smaller sample of students in the study, an attempt was made to identify differences in the use of MIs based on demographic characteristics. The results indicated that gender, religion, education, and race/ethnicity were not significant factors in the use of MIs. The report on changing perceptions of biometric technologies by Franks & Smith (2021) revealed a slight increase in willingness to use MIs compared to the previous year. Furthermore, the study concluded with a general understanding among the 99 interviewers in Australia that MIs are an inevitable part of the future. As the overview indicates, existing technology acceptance models do not fully capture distinctive factors that shape the acceptance of MIs. Up to this point, it was not clear how factors such as age, trust, perceived usefulness, ease of use, privacy concerns and conspiracy theories affect the acceptance of MIs.

The research team at the Faculty of Organizational Sciences, University of Maribor has been studying attitudes toward MIs since 2014 (Werber et al., 2018). In the meantime, MI technology has evolved and attitudes toward technology have also changed due to the recent pandemic. Carr (2020) even believes that MI can be a solution to reduce contacts and risks after pandemic outbreaks. Due to the changes in attitudes toward MIs, described above, the research model presented in Werber et al. (2018) and Žnidaršič, Baggia, et al. (2021) was updated and the study was expanded to include a sample from a larger geographic region. Furthermore, given the paucity of knowledge regarding the variation in attitudes towards MI across different countries, an international cross-sectional study was conducted in five countries within the Eastern European region. To date, no research has been conducted on a large, heterogeneous sample that would allow for the identification of differences or similarities in the adoption of MIs according to country of origin. The objective of this research is to address the aforementioned research gap by including a large and diverse sample of participants from different countries and assessing potential differences in their perceptions of MIs following the outbreak of the COVID-19 pandemic. Aligned with this, the dearth of research on the perceived usefulness of MI in the context of pandemics was addressed. Differences in the acceptability of MIs after the pandemic outbreak of COVID-19 were assessed using the two-stage Structural Equation Modeling (SEM) approach. The object examined in this study is an MI the size of a grain of rice (2 × 12 mm) that cannot be tracked from a distance and serves as an identification device using the Near Field Communication (NFC) standard and radio frequency identification device (RFID).

The remainder of the paper is organized as follows: First, the literature on the adoption of MIs is discussed. Second, the theoretical framework for the construction of the research model is presented, followed by the presentation of the research model, the data collection procedure, and the description of the statistical methods used in this research. The third section on the results includes the descriptive statistics of the questionnaire items, the evaluation of the measurement model, the multigroup analyses, the tests, and the results of the structural model. It also discusses the results, including theoretical and practical implications, limitations, and directions for future research. At the end, the conclusions of the study are presented.

2 Review of research studies in the field of microchip implants

The wave of the COVID-19 pandemic, particularly the prospect of vaccination, triggered a period of heightened concern about microchipping (Ullah et al., 2021). In addition, unspecified organizations were accused of trying to take over the world (Gu et al., 2021; Kozik, 2021). There were conspiracy theories that pointed to the faked triggering of a pandemic in order to implant microchips in people (Moscadelli et al., 2020) and thus to the absolute and unlimited possibility of state surveillance of society (Gagliardone et al., 2021).

It should be noted, however, that fears related to the implantation of microchips in humans did not arise with the outbreak of a pandemic. Since the beginning of the 21st century, the literature has pointed to efforts by various governments to control citizens (which microchipping was intended to enable). Some of the long-standing accusations likely came directly from science fiction literature and questioned trust in public authorities (Gagliardone et al., 2021). For example, the literature pointed to the possibility of replacing human intelligence with easily controlled implanted microchips (Foster & Jaeger, 2007). Microchip implantation could become a common practice that allows the government to monitor citizens (Gu et al., 2021) – first in children (Gasson & Koops, 2013) and later gradually in the monitoring of prisoners and workers (K. Michael et al., 2017; Milanovicz, 2012). Eventually, people even invoked religion and referred to the chip as a mark of the beast (Heffernan et al., 2017; Mohamed, 2020).

Despite these beliefs, MI technology has evolved over the years, especially with regard to security issues (Masyuk, 2019). People use MIs on a voluntary basis (Oberhaus, 2018), some even due to the requirements of their employers (K. Michael et al., 2017). Technological development and the use of insertion aids have increased significantly (Sabogal-Alfaro et al., 2021). At the same time, the social stigma associated with these devices has decreased and the general willingness to use MIs is slowly increasing (Franks & Smith, 2021; Gangadharbatla, 2020; Perakslis et al., 2014). The increased knowledge about non-technological objects inserted into the human body, such as piercings and contraceptives, has contributed to the rise and widespread acceptance of the use of technological injectables (Heffernan et al., 2017).

The use of MI enables various benefits, from storage, rapid scanning and processing of large amounts of data, to saving time or consolidating processes (Adhiarna et al., 2013). According to Paaske et al. (2017), organizations can benefit from MIs by saving time and money through real-time traceability, identification, communication, and other data.

Although such technologies have already been adopted by the market and by individuals, research on the willingness of individuals to adopt MI is either lacking or inconclusive (Mohamed, 2020), depending on the application area (Sabogal-Alfaro et al., 2021), or on a specific age group (Perakslis & Michael, 2012).

Nevertheless, some insights into the acceptability of MIs were obtained. Despite the small sample, Chebolu (2021) found that trust in technology and motivation correlate with the use of MIs. In relation to motivation factor, Franks & Smith (2020) found that recent identity crime victims were more than twice as willing to use MIs than non-victims. Based on the interviews conducted, both Boella et al. (2019) and Pettersson (2017) identified health concerns as well as privacy and safety issues as factors inhibiting the use of MIs. In addition, Pettersson (2017) identified lack of knowledge about the technology as a reason for skepticism about MI. Similarly, Franks & Smith (2021) reported that additional information about MIs was deemed necessary before participants would consider MIs.

Gangadharbatla (2020) investigated the factors that influence the adoption of embedded technologies and proposed a model based on the Technology Acceptance Model (TAM) with several additional factors. The results show, among other things, that male and younger respondents are more likely to have positive attitudes toward embedded technologies. Although the results are interesting, Gangadharbatla (2020) used only basic statistics in his study. Pelegrín-Borondo et al. (2017) examined the factors influencing intention to use MIs in Spain using a causal model based on a modified version of TAM. Their results suggest that affective and normative factors, such as positive emotions and social norms, should be considered when promoting MIs. According to a study by Olarte-Pascual et al. (2021) on the acceptance of wearable and implantable technologies, ethical judgment has a high explanatory power for the intention to use in the digital natives group. In particular, for implantable solutions, egoism has the highest explanatory power for intention to use.

Sabogal-Alfaro et al. (2021) identified the determinants of intention to use non-medical insertable digital devices in Chile and Colombia using the Unified Theory of Acceptance and Use of Technology (UTAUT2) model as the framework for their study. Their results suggest that known predictors of intention have less impact than predictors such as habit and hedonic motivation. Concerns and expectations about MIs were examined by Shafeie et al. (2022). As in previous research, Shafeie et al. (2022) used a survey to assess the acceptability of MIs with an extension of TAM. However, they also included open-ended questions to collect participants' personal views. Different determinants of acceptance were identified and categorized into concerns and expectations. Werber et al. (2018) analyzed the perceptions of microchip implants in one country, and later expanded their study to three countries (Žnidaršič, Baggia, et al., 2021). However, because most of the studies presented were conducted before the outbreak of the COVID-19 pandemic, the results of these studies may be slightly outdated.

The studies presented examined the willingness to adopt MIs, whereas Siibak & Otsus (2020) interviewed fourteen employees who already use MIs. The analysis revealed that the social environment plays a major role in the adoption of MIs. Specifically, employees who used MI were seen as more loyal and committed to the company than their colleagues who declined to use MI.

3 Research model and methods

3.1 Theoretical framework

In this study, the extended model based on TAM was used as the basis for developing questionnaires to investigate the attitudes and factors influencing the use of MIs in different countries of the Eastern European region during the COVID-19 pandemic.

The extended model includes all the basic components of TAM (Venkatesh & Davis, 2000): Perceived Ease of Use (PEU), Perceived Usefulness (PU), Behavioral Intention to Use (BIU), and adds the personal factor of Perceived Trust (PT). In addition, age and variables that include the specifics of the MI technology were added as predictors: Privacy Right (PR), Privacy Threat (PTh), Technology Safety (TS), Health Concerns (HC), and Painful Procedure (PP).

PEU was originally proposed by (Davis, 1989) and defined as the extent to which a person believes that the use of technology is possible without effort. From the original 14 measurement items for PEU proposed by Davis (1989), (Venkatesh & Davis, 2000) reduced the number of measurement items to four, whereas Venkatesh et al. (2012) reformulated this construct into Effort Expectancy, which is measured with four items. Since MI technology is not yet widely used, the pilot study conducted by Werber et al. (2018) showed that survey respondents have difficulties in determining ease of use. On the other hand, using MI is quite easy after the initial process of implantation. Therefore, the measurement items for PEU in the present study were formulated slightly differently than in previous research by Davis (1989), Venkatesh et al., (2012) and Venkatesh & Davis (2000). We defined PEU as the degree of constant availability of the multiple functions of MI, which cannot be lost. Similar to Davis (1989), PU was used to describe people adopting a new technology because they expect to benefit from it or because they find it useful. The BIU construct included items about whether respondents would use MIs for various purposes.

PT refers to individuals' confidence that government, banks, and health care systems will be able to provide certain standards of technology safety (TS), security against threads (PTh), and human rights protection (PR) in the areas of identification, tracking, and archiving of personal information, financial transactions, and patient data.

HC refers to four possible threats from the use of MI: the possibility of movements in the body (Graveling et al., 2018), health threats from possible allergies (Gillenson, 2019), effects on emotional behavior, or other types of health threats (Rotter et al., 2008; van der Togt et al., 2011). In addition, the implementation of MI is painful for some people (M. G. Michael & Michael, 2010), which raises even more health concerns. Age must also be considered when discussing technology acceptance, as younger people are more likely to adopt new technologies (Burton-Jones & Hubona, 2006; Morris & Venkatesh, 2000).

After the outbreak of COVID-19, three additional variables, hypothesized to influence the decision to accept MI, were identified: 1) usefulness of Microchips in Pandemic (MP), 2) Conspiracy Theory (CT) and 3) Fake News (FN).

Indeed, the pandemic situation has revived conspiracy theories and fake news. Some of the conspiracy theories are related to MIs and may influence the credibility of fake news (Halpern et al., 2019) or even vaccination refusal (Ullah et al., 2021). In general, conspiracy mentality reduces trust in official sources and thus increases perceived threats to privacy (Imhoff et al., 2018). CT and FN were therefore added as predictors for the variable PT.

Perceived fear of COVID-19 (Al-Maroof et al., 2020) and perceived COVID-19 risk (Aji et al., 2020) were found to influence the PEU and PU of technology. Therefore, the variable MP is included in the study.

3.2 Research model

Based on the literature review and the theoretical framework presented, a research model with fourteen research hypotheses is proposed, as shown in Figure 1. Nine variables were adopted from the 2017 international cross-sectional study (Žnidaršič, Baggia, et al., 2021). Six variables were added to the three basic components of TAM (PEU, PU and BIU): PT, HC, PP, TS, PTh, PR, and age. Three variables were also added due to lifestyle changes in recent years: CT, FN, and MP.

There are two types of variables included in the model. A construct or latent variable is a variable that is indirectly measured with measured variables. An item or measured variable is a variable that is measured directly with questionnaire items. In Figure 1, constructs are represented by ellipses, while items are represented as rectangles. In addition to contextual differences, statistical analyses (e.g., Confirmatory Factor Analysis (CFA) and the first step of SEM) conducted by Werber et al. (2018), Žnidaršič, Baggia, et al. (2021) and Žnidaršič, Werber, et al. (2021) have shown that the items TS, PP, and MP cannot be considered as one of the measured variables included in specific constructs, but must be included in the model as individual measured variables.

Table 1 shows the constructs and items, the scales used, and the corresponding references that determine the construct or item.

Table 1: Variables of the proposed research model with rating scale and references

<table>
<tr><th>Variable</th><th>Rating scale</th><th>References</th></tr>
<tr><td>Painful Procedure (PP)</td><td rowspan="11">5–point scale of agreement:

1 – strongly disagree
2 – disagree
3 – neither agree nor disagree
4 – agree
5 – strongly agree</td><td>M. G. Michael & Michael, 2010</td></tr>
<tr><td>Privacy Threat (PTh)</td><td>Bansal et al., 2015</td></tr>
<tr><td>Fake News (FN)</td><td>Halpern et al., 2019; Ullah et al., 2021</td></tr>
<tr><td>Microchips in Pandemic (MP)</td><td>Aji et al., 2020; Al-Maroof et al., 2020</td></tr>
<tr><td>Health Concerns (HC)</td><td>Albrecht, 2010; Foster & Jaeger, 2007; Gillenson, 2019; Graveling et al., 2018; Katz & Rice, 2009; Rotter et al., 2008; van der Togt et al., 2011</td></tr>
<tr><td>Privacy Right (PR)</td><td>Graveling et al., 2018; Lockton & Rosenberg, 2005</td></tr>
<tr><td>Conspiracy Theory (CT)</td><td>Gagliardone et al., 2021; Gu et al., 2021; Halpern et al., 2019; Imhoff et al., 2018; Ullah et al., 2021</td></tr>
<tr><td>Technology Safety (TS)</td><td>Perakslis et al., 2014</td></tr>
<tr><td>Perceived Ease of Use (PEU)</td><td>Davis, 1989; Venkatesh et al., 2012; Venkatesh & Davis, 2000; Werber et al., 2018</td></tr>
<tr><td>Perceived Trust (PT)</td><td>Graveling et al., 2018; Smith, 2008</td></tr>
<tr><td>Perceived Usefulness (PU)</td><td>1 – very bad idea
2 – bad idea
3 – neither bad nor good idea
4 – good idea
5 – very good idea</td><td>Davis, 1989; Katz & Rice, 2009</td></tr>
<tr><td>Behavioral Intention to Use (BIU)</td><td>No. of different potential MI uses</td><td>Davis, 1989; Venkatesh et al., 2012; Venkatesh & Davis, 2000</td></tr>
</table>

As shown in Table 1, most of the measured variables in the model were assessed based on the level of agreement with a particular statement. PU was also measured on a five-point Likert type scale, but here only an opinion about the idea was assessed. The BIU variable was derived from the number of different potential uses of MIs. The PP variable was measured by agreement with pain caused by MI implantation. PTh included statements about threats from various organizations and agencies, computer use, and general privacy concerns. FN was assessed by agreement with two examples of COVID-19 fake news, whereas MP was measured by a general opinion about the usefulness of MIs during the pandemic. HC included statements about possible movements in the body, impact on emotional behavior, allergies, and the nervous system. The variable PR was assessed using statements about collecting personal information without consent and the right to control personal information. Following recent research, the variable CT was assessed by the difference in beliefs about COVID-19 vaccines, government plans for surveillance and monitoring and 5G technology. Agreement with the safety of the technology was used to measure the variable TS, whereas PEU was assessed based on MI availability, multifunctionality, and inability to be lost. Possible uses of MIs were used to evaluate the variable PU, such as health monitoring, warning of health problems, storing medical information, storing organ donation information and saving lives in the form of a medical device. Opinions about the government, banks, and the healthcare system and their efforts to ensure security were used to evaluate PT.

Following the basic TAM theory (Davis, 1989), the impact of PEU and PU on BIU was hypothesized (H9b and H10). According to TAM, PU is influenced by PEU (Venkatesh & Davis, 2000), which is hypothesized in H9a. Based on previous research by Burton-Jones & Hubona (2006) and Morris & Venkatesh (2000), age has a significant influence on the adoption of new technologies. This impact is presented as H12. Werber et al. (2018) and Žnidaršič et al. (2021) identified and confirmed the existence of hypotheses H1, H2, H5, H6, and H8, as well as H11a and H11b in previous research on adoption of MIs. It is important to note that a negative impact between HC and PU is hypothesized (H5).

In accordance with the presented researches by Al-Maroof et al. (2020) and Aji et al. (2020), hypothesis H4 was made, indicating the impact of MP on PU. In addition, the negative impact of CT on PT and the correlation between FN and CT identified by Žnidaršič et al. (2021) were included in the model.

Based on the model from previous studies (Werber et al., 2018; Žnidaršič, Baggia, et al., 2021), we formulated fourteen hypotheses describing the variety of factors that

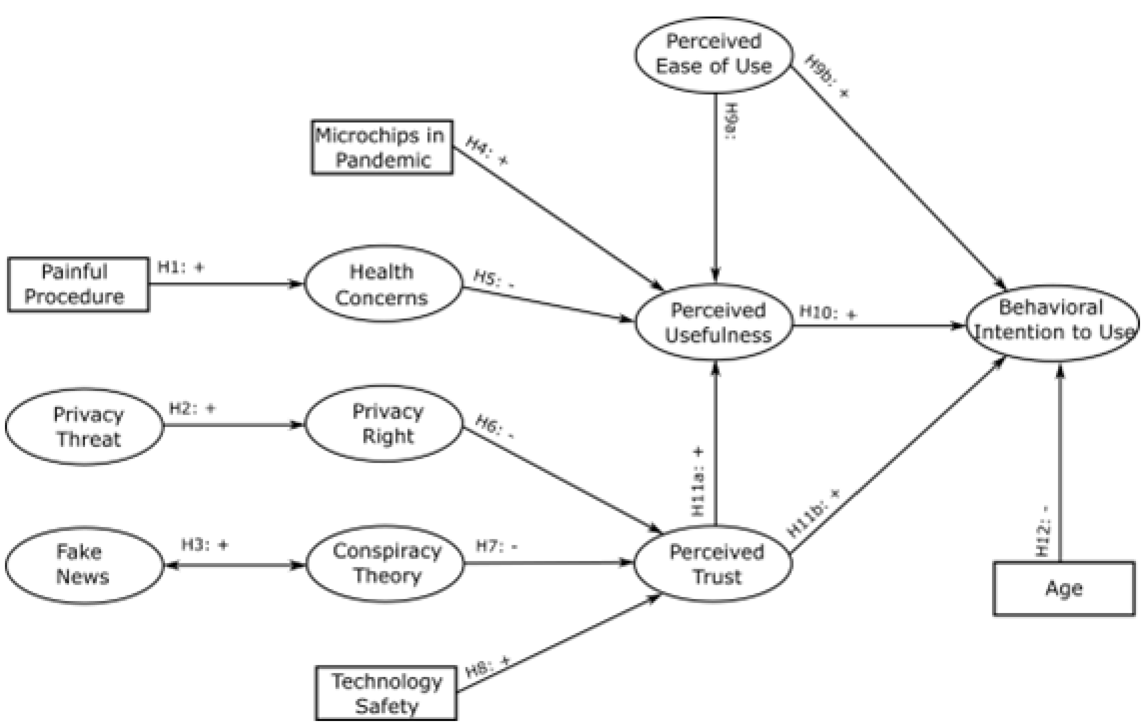

Figure 1: The proposed research model for microchip implant acceptance

influence behavioral intention to use MIs:

H1: Painful Procedure (PP) has a positive impact on Health Concerns (HC).

H2: Privacy Threat (PTh) has a positive impact on Privacy Right (PR).

H3: Fake News (FN) is positively correlated with Conspiracy Theory (CT).

H4: Microchips in Pandemic (MP) have a positive impact on Perceived Usefulness (PU).

H5: Health Concerns (HC) have a positive impact on Perceived Usefulness (PU).

H6: Privacy Right (PR) has a positive impact on Perceived Trust (PT).

H7: Conspiracy Theory (CT) has a positive impact on Perceived Trust (PT).

H8: Technology Safety (TS) has a positive impact on Perceived Trust (PT).

H9a: Perceived Ease of Use (PEU) has a positive impact on Perceived Usefulness (PU).

H9b: Perceived Ease of Use (PEU) has a positive impact on Behavioral Intention to Use (BIU).

H10: Perceived Usefulness (PU) has a positive impact on Behavioral Intention to Use (BIU).

H11a: Perceived Trust (PT) has a positive impact on Behavioral Intention to Use (BIU).

H11b: Perceived Trust (PT) has a positive impact on Perceived Usefulness (PU).

H12: Age has a negative impact on Behavioral Intention to Use (BIU).

Figure 1 graphically represents the hypotheses as relationships between variables in the research model.

The proposed model may have several limitations. The first possible limitation is the complexity of the model. To test the model and make the comparison between countries, the subsample in each country must meet the minimum sample size criteria for SEM. To validate the model, a multigroup CFA and SEM approach must be performed. At each step, all criteria must be met in order to proceed to the next step and confirm the adequacy of the model. A detailed description of the statistical methods and the process of model validation are given in the following section.

3.3 Data collection and statistical methods

Convenience sampling was used to study the acceptability of MIs. After receiving approximately half of the targeted number of responses, the age distribution was analyzed to determine if it matched Eurostat data for specific countries. If necessary, the sampling was then concentrated on specific age groups. The survey was conducted online in the spring 2021 in five countries: Poland (PL), Croatia (HR), Slovenia (SI), Ukraine (UA) and Russia (RU). Both complete and partially submitted responses to questionnaire items were used for analysis: 514 (25.76%) from Poland, 369 (18.50%) from Croatia, 405 (20.30%) from Slovenia, 401 (20.10%) from Ukraine, and 306 (15.34%) from Russia.

The research model presented in Figure 1 describes the relationships between the variables in the model. The survey data were analysed using the SEM approach (Beaujean, 2014; Kline, 2011). Each subgroup's sample size surpasses the recommended 250 cases needed to prevent model rejection according to the combined fit index criteria (Hu & Bentler, 1999).

The analysis followed the standard two-step SEM approach (Schumacker & Lomax, 2010). Firstly, a Confirmatory Factor Analysis (CFA) was conducted in order to validate the measurement model. This was followed by testing the structural relationships between the latent variables.

In the CFA, the construct validity of the measurement model was assessed using convergent validity and discriminant validity. To test the convergent validity of the measurement model, we ensured that the standardized factor loadings were not above 0.5, that the Composite Reliability (CR) for each latent variable was above 0.7, and that the Average Variance Extracted (AVE) for each latent variable was above 0.5 (Fornell & Larcker, 1981; Koufteros, 1999).

During the SEM stage, unstandardized B was computed, along with standardized path coefficients (β) for the relationships between latent variables, z-values, and the level of significance. A coefficient of determination (R^2) was calculated for each endogenous latent variable, representing the percentage of variance explained for the variable by its predictors.

The fit of both the measurement and structural models was evaluated using a range of the most commonly used fit indices. The comparative fit index (CFI) value must be at least 0.9 (Koufteros 1999), and the root mean square error of approximation (RMSEA) must be between 0.06 and 0.08 to be considered mediocre (MacCallum et al., 1996). The SRMR (standardized root mean square residual) value must be below 0.08 (Hu and Bentler 1999). While some goodness-of-fit indices (GFI), such as the CFI, are affected by model complexity, whereas the RMSEA is not (Cheung & Rensvold, 2002) Consequently, the widely-used threshold for complex models (e.g., CFI = 0.90) should be viewed with caution.

In order to complete the two-step approach outlined above, we employed MultiGroup Confirmatory Factor Analysis (MG-CFA) and MultiGroup Structural Equation Modeling (MG-SEM). These techniques were required due to the inclusion of data from five different countries in the sample. The utilization of MG-CFA and MG-SEM, enabled the assessment of measurement invariance (MInv), a pivotal step in the comparison of the same measurement model across groups defined by the selected categorical variable (Miceli & Brabaranelli, 2016).

To ensure effective cross-group comparisons of survey results, it is essential to guarantee that respondents from different countries assign comparable importance to questionnaire items (Cheung & Lau, 2011). MInv assesses the psychometric equivalence of a construct across groups (Putnick & Bornstein, 2016), whereas non-invariance indicates different structures and/or meanings attributed to the construct by respondents from different groups. The standard order for testing MInv is configural, weak, and strong invariance, with strict invariance being the final optional step (Beaujean, 2014).

We explain the results for each invariance test by examining a number of alternative fit indices (AFI), given that in large samples, the χ^2 statistics is highly sensitive to minor, insignificant deviations from a perfect model (Chen, 2007; Cheung & Rensvold, 2002). Accordingly, it is essential to examine the changes in CFI (ΔCFI), SRMR (ΔSRMR), and RMSEA (ΔRMSEA). Chen (2007) posited that a ΔCFI of -0.01 should be accompanied by a ΔRMSEA of 0.015 and an SRMR of 0.030 for metric invariance, or 0.015 for scalar or residual invariance.

All the analyses, including CFA, MInv, and SEM were conducted using the R packages lavaan (Rosseel, 2021) and semTools (Jorgensen et al., 2020). The subsequent section presents the results in accordance with the aforementioned analysis procedure.

4 Results

A representative sample of the general population was surveyed using a questionnaire. A total of 1,995 respondents who had completed at least some of the questionnaires were included in the subsequent analyses. The inclusion of partial responses permitted the consideration of the contributions of all respondents, thereby reducing bias due to controversy over the topic (e.g., some respondents may have dropped out of the survey because they disagreed with microchipping or because of their beliefs).

The composition of the sample is outlined in Section 3.3 (Data collection and statistical methods), which sets out the methodology employed in the data collection process. The mean age of the Polish sample was 33.7 years (SD = 16.24), that of the Croatian sample 27.8 years (SD = 14.09), that of the Slovenian sample 43.4 years (SD = 16.58), that of the Ukrainian sample 44.4 years (SD = 16.23), while the mean age of the Russian sample was 40.9 years (SD =12.91).

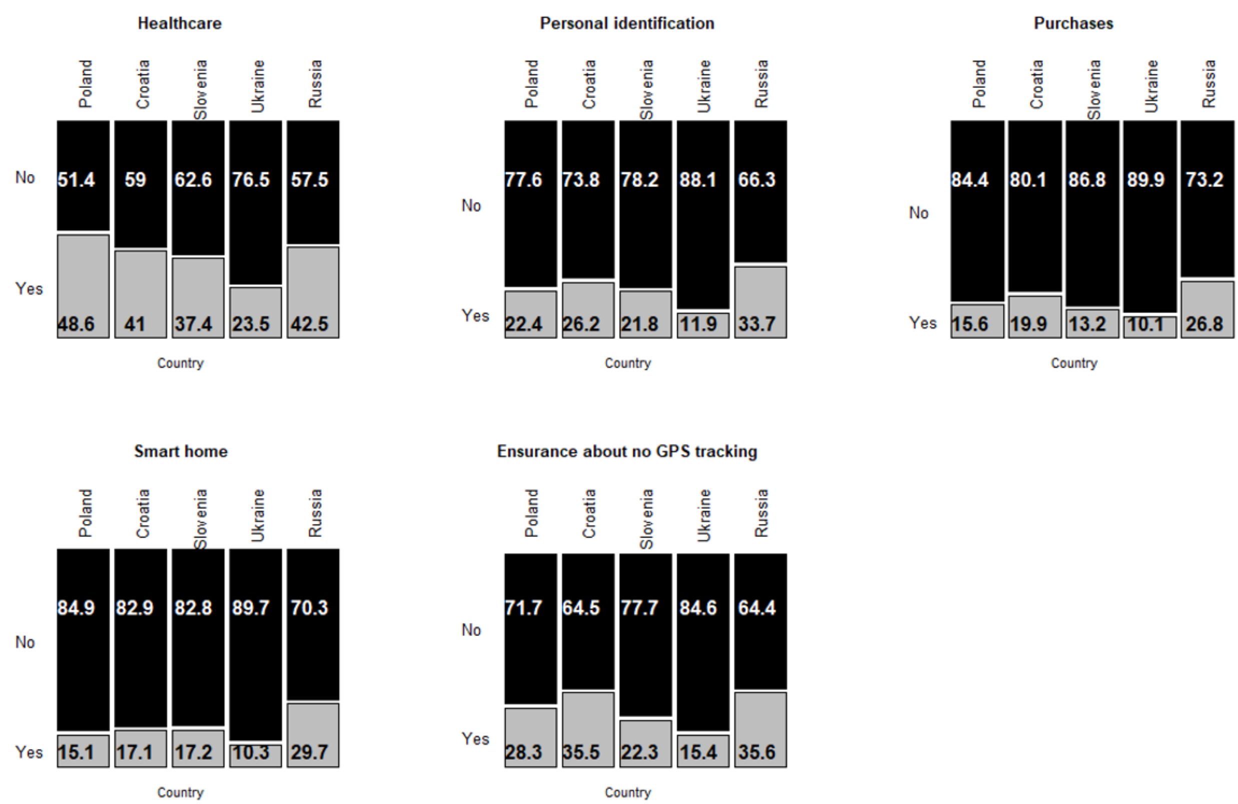

Figure 2: Percentage of respondents willing to use MI for various purposes

4.1 Descriptive statistics of the questionnaire items

As illustrated in Figure 2, a considerable proportion of respondents indicate willingness to use MIs for a range of purposes, with the highest percentage expressing a preference for their use in healthcare. This figure ranges from 23.5% in Ukraine to 48.6% in Poland. Conversely, the lowest percentage of respondents indicated that they would utilise MI for shopping and payment, as well as for smart home applications.

The number of potential MI uses was calculated as the sum of five dichotomous variables representing different uses of MI (see Figure 2). The mean values are indicated by an asterisk (*M) and are presented in boxplots in Figure 3. The mean value for the number of potential MI uses is highest in Russia (M = 1.68), followed by Croatia (M=1.39), Poland (M=1.29), Slovenia (M=1.12), and Ukraine (M=0.72).

Descriptive statistics for the questionnaire items included in the model can be found in Appendix A.

4.2 Evaluation of the measurement model

The construct validity of the set of measured items was examined to ensure that they accurately reflect the underlying theoretical variable. The construct validity was evaluated through an examination of both convergent and discriminant validity. The assessment of the overall measurement model (M1) for the entire sample was the initial step. Table 2 shows the evolution of the measurement model and the associated fit indices.

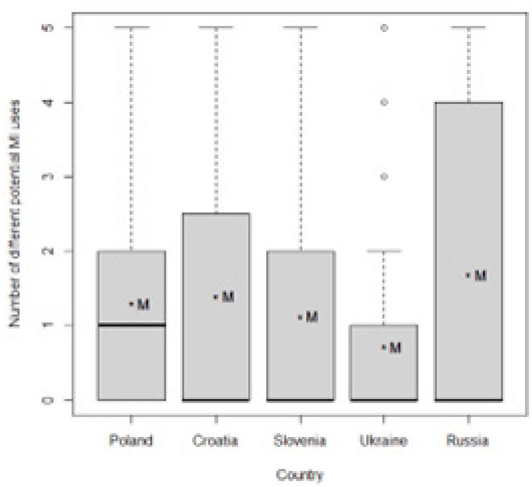

Figure 3: Boxplots for the number of different uses of MI in each country

Table 2: Measurement model development results and model fit indices

Model	χ^2	df	CFI	SRMR	RMSEA	RMSEA 90% CI
M1 – overall model	90% CI	247	0.969	0.034	0.038	0.036; 0.041
Model for each country						
MPL - Poland	567.893	247	0.946	0.049	0.050	0.045; 0.055
MHR - Croatia	461.024	247	0.949	0.045	0.048	0.042; 0.055
MSI – Slovenia	469.613	247	0.962	0.036	0.047	0.041; 0.053
MUA - Ukraine	443.751	247	0.960	0.036	0.045	0.039; 0.050
MRU - Russia	397.703	247	0.960	0.049	0.045	0.037; 0.052

Table 3: Cronbach's Alpha, Composite reliability (CR), average variance extracted (AVE), square root of AVE and correlations between constructs

				Correlations											
	Cron. Alpha	CR	AVE	PP[a]	PTh	FN	MP[a]	HC	PR	CT	TS[a]	PEU	PU	PTh	BIU[a]	Age[a]
PP[a]	/	/	/	/												
PTh	0.802	0.805	0.580	0.149	0.761											
FN	0.657	0.679	0.522	0.197	0.041	0.723										
MP[a]	/	/	/	-0.150	-0.154	0.003	/									
HC	0.898	0.900	0.693	0.604	0.313	0.292	-0.303	0.833								
PR	0.862	0.864	0.761	0.103	0.544	-0.169	-0.049	0.159	0.872							
CT	0.850	0.851	0.656	0.318	0.251	0.698	-0.184	0.530	0.020	0.810						
TS[a]	/	/	/	-0.316	-0.229	-0.107	0.401	-0.587	-0.086	-0.355	/					
PEU	0.804	0.804	0.578	-0.189	0.035	-0.236	0.337	-0.345	0.149	-0.319	0.393	0.760				
PU	0.950	0.950	0.792	-0.226	-0.131	-0.120	0.479	-0.436	0.051	-0.376	0.531	0.538	0.890			
PTh	0.891	0.892	0.734	-0.120	-0.274	0.055	0.447	-0.316	-0.107	-0.209	0.419	0.397	0.576	0.857		
BIU[a]	/	/	/	-0.161	-0.208	-0.060	0.400	-0.371	-0.008	-0.250	0.455	0.338	0.539	0.445	/	
Age[a]	/	/	/	-0.007	0.021	-0.010	-0.030	0.005	-0.111	-0.023	-0.050	0.066	-0.144	-0.074	-0.222	/

[a]The measured variables PP, MP, TS, BIU, and Age are included in the table only to compare the square root of AVE of a construct with correlations to other constructs and items. Cronbach's Alpha, CR, and AVE are not applicable for the measured variables

Table 4: Testing the measurement invariance between countries

Model (Model comparison)	χ^2 (Δχ^2)	df	CFI (ΔCFI)	SRMR (ΔSRMR)	RMSEA (ΔRMSEA)	RMSEA 90% CI
M2 – configural invariance	2335.17	1235	0.955	0.043	0.047	0.045; 0.050
M3 – weak invariance (M2)	2463.25 (128.08)	1303 (68)	0.953 (-0.002)	0.047 (0.004)	0.047 (0.000)	0.045; 0.050
M4 – strong invariance (M3)	3031.55 (568,30)	1371 (68)	0.934 (-0.019)	0.052 (0.005)	0.055 (0.008)	0.053; 0.058
M4a – partial strong invariance (M3)	2903.34 (440,09)	1367 (64)	0.939 (-0.014)	0.051 (0.004)	0.053 (0.006)	0.051; 0.056
M4b – partial strong invari-ance (M3)	2832.12 (368.87)	1363 (60)	0.940 (-0.013)	0.050 (0.003)	0.052 (0.005)	0.049; 0.055
M4c – partial strong invariance (M3)	2792,36 (329.11)	1359 (56)	0.942 (-0.011)	0.049 (0.002)	0.051 (0.004)	0.049; 0.054
M4d – partial strong invari-ance (M3)	2723.35 (260,10)	1355 (52)	0.944 (-0.009)	0.049 (0.002)	0.050 (0.003)	0.048; 0.053
M5 – strict invariance (M4d)	3137.06 (413.71)	1451 (96)	0.931 (-0.013)	0.051 (0.002)	0.054 (0.004)	0.052; 0.056

The study proceeded with an examination of the standardized factor loadings, AVE, and CR for each item in the overall measurement model (M1). The lowest value of AVE is 0.522 for the construct FN and the highest is 0.792 for the construct PU. The lowest value of CR is 0.679 for the FN construct, while the highest value (0.950) is observed for the PU construct. All three indicators exceeded the 0.5 threshold (Table 3), confirming a strong relationship between the observed variables and the underlying latent factor. The convergent validity of the latent variables is thus established, and the discriminant validity of M1 is also corroborated by the square root of the AVE for each factor in comparison with its correlations with other latent variables.

The high internal reliability is determined by Cronbach's alpha coefficients, which range from 0.802 to 0.950 for PTh and PU, respectively (Table 3). The Cronbach alpha coefficient for FN is marginally lower, yet nevertheless acceptable (α=0.657).

The overall fit of the measurement model (M1) was evaluated using the fit indices presented in Table 2. The values of the CFI (0.969), SRMR (0.034),RMSEA (0.038) along with the respective upper bounds of the 90% confidence interval (0.036,0.041) demonstrate that the model exhibits and excellent fit to the data (MacCallum et al., 1996). Based on the aforementioned results, it can be concluded that the overall measurement model fits the data well.

4.3 Testing for measurement invariance across countries (multigroup analysis)

To examine the understanding of the model variables among respondents from different countries and the fit of the model in each country, tests for measurement invariance were conducted using the hierarchical ordering of nested models (Putnick & Bornstein, 2016): configural, weak, strong, and strict invariance were assessed (Table 5).

First, it is necessary to assess whether the proposed model fits the data of each country. According to the fit indices presented in Table 2 (SRMR,RMSEA,CFI) the model fits well with all five subsamples, so our research model is confirmed in all five groups. In the next step, we move to MG-CFA and test whether the proposed model structure is the same in all countries. All fit indices, CFI and SRMR, indicate good model fit (Table 4). The supported configural invariance indicates that the factor structure of the constructs is the same in all five countries.

Furthermore, to assess weak invariance, factor loadings were constrained across groups in order to ensure comparability. The differences between the alternative fit indices of the configural and weak models provide evidence in favour of weak invariance (see Table 4).

In addition to the constrained factor loadings, the next step was to set the intercepts equal across groups (Table 4) in order to test for strong invariance. The results clearly show that the ΔCFI is above the prescribed threshold, indicating unambiguously that the intercepts are not completely invariant across the five countries. As demonstrated in the four consecutive steps (models M4a to M4d), the freely estimated intercepts of the measured items PEU1, PTh3, PTh2, and CT2 across groups were determined, as well as the partial strong variance (of model M4d).

In the next step, the error variances were set across groups. There was a significant difference in CFI between the partial strong model (M4d) and the strict model (M5), indicating a lack of fit of the M5 model. Therefore, the strong measurement invariance was not confirmed. However, as Putnick & Bornstein (2016) note, this is not a mandatory requirement and we proceeded to evaluate the structural model.

4.4 Testing the structural model

According to our research model (see Figure 1), guided by the proposed hypotheses, four measurement variables (PP, MP, TS, and age), represented as rectangles, and 14 structural paths were added to the nine variables. After evaluating the overall model, the invariance of the structural paths was assessed.

The criteria (χ^2=3871.58, df=385, CFI=0.94, and RMSEA=0.061) showed that the fit of the overall structural model was good. The research hypotheses were supported by the overall model. However, it is not clear whether these hypotheses hold true in different countries. For example, would the influence of PEU on BIU remain significant for all five countries?

Table 5: Test of the measurement invariance of the structural coefficients between countries

Structural model (SM) (Model comparison)	χ^2 ($\Delta\chi^2$)	df (Δdf)	p	CFI (ΔCFI)	SRMR ($\Delta SRMR$)	RMSEA ($\Delta RMSEA$)	RMSEA 90% CI
SM1 – partial strong invariance	5896.94	2049	/	0.865	0.155	0.069	0.067; 0.071
SM2 – structural coefficients	6020.47	2101	0.0000	0.863	0.157	0.068	0.066; 0.070
(SM2)	(54.33)	(52)		(-0.002)	(0.002)	(-0.001)	
Constrained individual paths to be equal across groups:							
SM1a: PP → HC	5,901.34	2053	0.2519	0.865	0.155	0.069	0.067; 0.070
(SM1)	(4.4)	(4)		(0.000)	(0.000)	(0.000)	
SM1b: PTh -> PR	5,892.44	2053	0.3677	0.866	0.155	0.068	0.067; 0.070
(SM1)	(-4.5)	(4)		(0.001)	(0.000)	(-0.001)	
SM1c: FN ↔ CT	5,912.43	2053	0.0038	0.865	0.155	0.069	0.067; 0.071
(SM1)	(15.49)	(4)		(0.000)	(0.000)	(0.000)	
SM1d: MP → PU	5,901.83	2053	0.1882	0.865	0.155	0.069	0.067; 0.070
(SM1)	(4.89)	(4)		(0.000)	(0.000)	(0.000)	
SM1e: HC → PU	5,907.12	2053	0.0338	0.865	0.155	0.069	0.067; 0.071
(SM1)	(10.18)	(4)		(0.000)	(0.000)	(0.000)	
SM1f: PR -> PT	5,912.56	2053	0.0031	0.865	0.156	0.069	0.067; 0.071
(SM1)	(15.62)	(4)		(0.000)	(0.001)	(0.000)	
SM1g: CT → PT	5,906.00	2053	0.0488	0.865	0.155	0.069	0.067; 0.071
(SM1)	(9.06)	(4)		(0.000)	(0.000)	(0.000)	
SM1h: TS -> PT	5,901.93	2053	0.2405	0.865	0.155	0.069	0.067; 0.070
(SM1)	(4.99)	(4)		(0.000)	(0.000)	(0.000)	
SM1i: PEU → PU	5,896.74	2053	0.5196	0.865	0.155	0.069	0.067; 0.071
(SM1)	(-0.20)	(4)		(0.000)	(0.000)	(0.000)	
SM1j: PEU → BIU	5,907.11	2053	0.0406	0.865	0.155	0.069	0.067; 0.071
(SM1)	(10.17)	(4)		(0.000)	(0.000)	(0.000)	
SM1k: PU → BIU	5,902.45	2053	0.2846	0.865	0.155	0.069	0.067; 0.070
(SM1)	(5.51)	(4)		(0.000)	(0.000)	(0.000)	
SM1l: PT → PU	5,908.58	2053	0.0205	0.865	0.155	0.069	0.067; 0.071
(SM1)	(11.64)	(4)		(0.000)	(0.000)	(0.000)	
SM1m: PT → BIU	5,909.79	2053	0.0126	0.865	0.155	0.069	0.067; 0.071
(SM1)	(12.85)	(4)		(0.000)	(0.000)	(0.000)	
SM1n: Age → BIU	5,910.00	2053	0.9911	0.865	0.155	0.069	0.067; 0.070
(SM1)	(13.06)	(4)		(0.000)	(0.000)	(0.000)	
SM3 – final model	5917.27	2077	0.2873	0.866	0.155	0.068	0.066; 0.070
(SM1)	(20.33)	(28)		(0.001)	(0.000)	(-0.001)	

Table 6: Summary of hypothesis tests for the cross-country structural model

Hypothesis & Path	Expected Sign (Constrained across groups.)	Country	*B*	*β*	z	p	Confirmed?
H1 PP → HC	+ (Yes)	PL	0.538	0.585	23.162***	0.000	Yes
		HR		0.607			
		SI		0.547			
		UA		0.640			
		RU		0.613			
H2 PTh → PR	+ (Yes)	PL	0.498	0.537	14.096***	0.000	Yes
		HR		0.502			
		SI		0.568			
		UA		0.454			
		RU		0.689			
H3[a] FN ↔ CT	+ (No)	PL	0.482	0.790	9.588***	0.000	Yes
		HR	0.432	0.514	6.960***	0.000	Yes
		SI	0.343	0.516	7.078***	0.000	Yes
		UA	0.482	0.694	10.710***	0.000	Yes
		RU	0.708	0.814	7.758***	0.000	Yes
H4 MP → PU	+ (Yes)	PL	0.188	0.223	8.590***	0.000	Yes
		HR		0.218			
		SI		0.229			
		UA		0.216			
		RU		0.236			
H5 HC → PU	- (No)	PL	-0.125	-0.111	-2.230*	0.026	Yes
		HR	-0.204	-0.206	-3.284**	0.001	Yes
		SI	-0.223	-0.226	-3.884***	0.000	Yes
		UA	-0.372	-0.369	-7.684***	0.000	Yes
		RU	-0.213	-0.228	-4.151***	0.000	Yes
H6 PR → PT	- (No)	PL	-0.328	-0.216	-4.007***	0.000	Yes
		HR	0.006	0.005	0.090	0.928	No
		SI	0.007	0.004	0.071	0.944	No
		UA	-0.074	-0.058	-1.002	0.316	No
		RU	-0.354	-0.174	-2.633*	0.008	Yes
H7 CT → PT	- (No)	PL	-0.103	-0.111	-2.177***	0.029	Yes
		HR	-0.055	-0.064	-0.979	0.328	No
		SI	-0.241	-0.243	-4.412***	0.000	Yes
		UA	-0.109	-0.108	-1.756	0.079	No
		RU	0.036	0.035	0.482	0.630	No

Table 6: Summary of hypothesis tests for the cross-country structural model (continues)

Hypothesis & Path	Expected Sign (Constrained across groups.)	Country	*B*	*β*	z	p	Confirmed?
H8 TS → PT	+ (Yes)	PL	0.348	0.401	14.889***	0.000	Yes
		HR		0.396			
		SI		0.394			
		UA		0.407			
		RU		0.426			
H9a PEU → PU	+ (No)	PL	0.412	0.252	8.954***	0.000	Yes
		HR		0.278			
		SI		0.335			
		UA		0.315			
		RU		0.377			
H9b PEU → BIU	+ (No)	PL	0.208	0.081	1.651	0.099	No
		HR	0.460	0.169	3.478**	0.001	Yes
		SI	0.029	0.015	0.301	0.763	No
		UA	0.082	0.045	0.999	0.318	No
		RU	-0.002	-0.001	-0.024	0.981	No
H10 PU→BIU	+ (Yes)	PL	0.551	0.352	14.162***	0.000	Yes
		HR		0.300		0.000	
		SI		0.350		0.000	
		UA		0.396		0.000	
		RU		0.276		0.000	
H11a PT → PU	+ (No)	PL	0.574	0.492	9.272***	0.000	Yes
		HR	0.437	0.403	6.179***	0.000	Yes
		SI	0.384	0.374	6.960***	0.000	Yes
		UA	0.261	0.256	4.486***	0.000	Yes
		RU	0.317	0.325	5.884***	0.000	Yes
H11b PT → BIU	+ (No)	PL	0.424	0.233	5.668***	0.000	Yes
		HR	0.355	0.178	5.089***	0.000	Yes
		SI	0.388	0.240	5.744***	0.000	Yes
		UA	0.138	0.097	2.077*	0.038	Yes
		RU	0.757	0.388	8.496***	0.000	Yes
H12 Age → BIU	- (Yes)	PL	-0.016	-0.169	-8.601***	0.000	Yes
		HR		-0.135			
		SI		-0.169			
		UA		-0.199			
		RU		-0.107			

[a] Correlation coefficient are reported for the hypothesis H3

The invariance of the structural model should be determined to see if the structural relationships are invariant. As shown in Table 5, the fit of the partial strong invariance model (SM1) was good. The fit of the structural model (SM2) also required that the structural coefficients are the same in all groups. The χ^2-test (p=0.000) of the two nested models indicates that the SM1 and SM2 models are significantly different at the 5% significance level, suggesting that some structural coefficients or paths vary between countries.

In successive steps, each structural coefficient was constrained to be the same across groups, and the nested models were compared. Seven paths, listed below, differ between groups at a 5% significance level:

FN ↔ CT (SM1c),
HC → PU (SM1e),
PR → PT (SM1f),
CT → PT (SM1g),
PEU→ BIU (SM1j),
PT → PU (SM1l),
PT → BIU (SM1m).

The listed path coefficients were freely estimated across five groups in the final structural model (SM3). The results are presented in the following subsection.

4.5 The final structural model

The fit of the final model was good (Table 5). Table 6 shows the results for the unstandardized (B) and standardized coefficients (β) along with the corresponding z-values.

Coefficients of determination (R^2) were reported for each endogenous construct (Table 7).

Table 7: Coefficients of determination

Construct	PO	CR	SI	UA	RU
HC	0.343	0.369	0.299	0.41	0.375
PR	0.289	0.252	0.323	0.206	0.475
PU	0.428	0.377	0.422	0.412	0.406
PT	0.224	0.161	0.214	0.182	0.211
BI	0.322	0.253	0.293	0.235	0.328

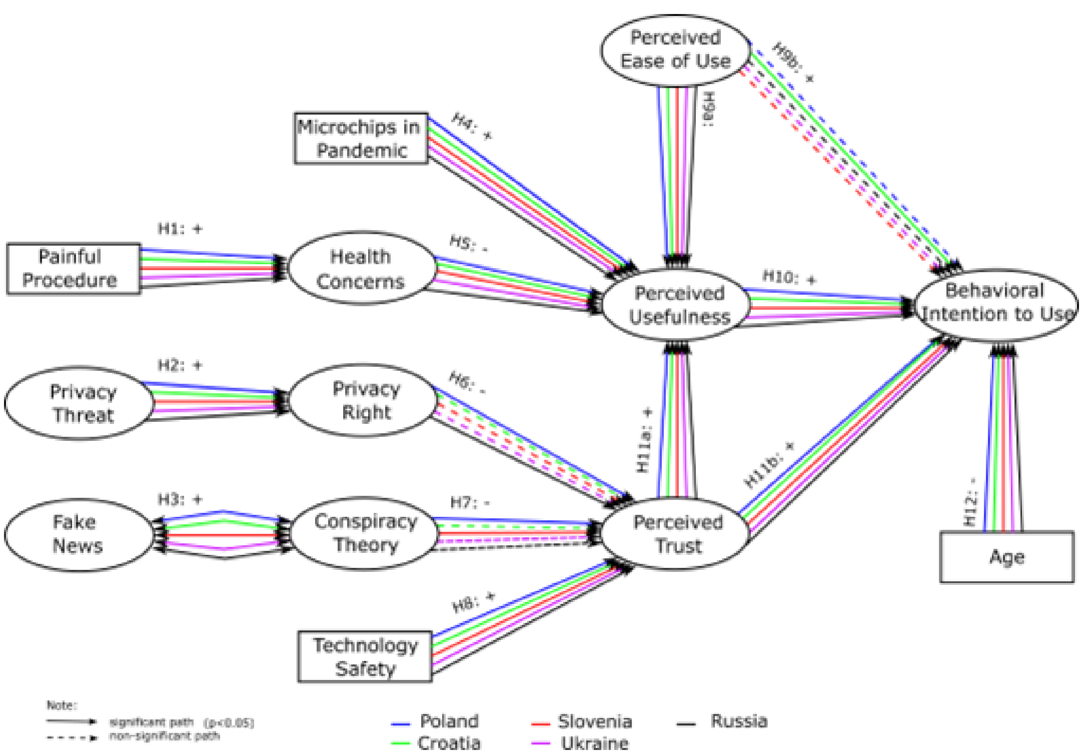

Figure 4: The results of the research model for the behavioral intention to adopt microchip implant

A graphical overview of the confirmed (solid lines) and unconfirmed hypotheses (dashed lines) is shown in Figure 4. The detailed results are discussed in the following section.

5 Discussion

Changes in the way of life are inevitable due to the different situations in the world. It is worth noting that technology plays an important role in these changes. Nevertheless, the acceptance of technology is not always positive. Despite their many benefits, MIs have not been universally adopted and are associated with health issues and privacy concerns. While there have been scattered studies on perceptions of MIs, these were conducted prior to the outbreak of the COVID-19 pandemic, which significantly changed the relationship with technology. According to Gangadharbatla (2020), future studies of embedded technologies should use a more thorough and comprehensive list of predictors of adoption and employ more sophisticated statistical methods such as SEM to examine predictors of embedded technologies adoption and use. In line with this proposal, in this paper we used the two-stage SEM approach to test the research model and identify the differences in attitudes towards MI technology in five countries of the Eastern European region. Unlike previous studies (Boella et al., 2019; Chebolu, 2021; Olarte-Pascual et al., 2021; Pelegrín-Borondo et al., 2017; Pettersson, 2017; Shafeie et al., 2022), the sample size in the present study was large enough to allow the comparison of attitudes toward MIs in different countries.

The theory of TAM (Davis, 1989) suggests that there are two positive effects of Perceived Ease of Use and Perceived Usefulness on Behavioral Intention to Use (hypotheses H9b and H10). The results show that hypothesis H10 about the impact of Perceived Usefulness is confirmed in all countries at a 5% significance level. Hypothesis H9b which assumes a positive impact of Perceived Ease of Use on Behavioral Intention to Use was confirmed only in Croatia (β=0.169) at the 5% significance level. This is in line with the results of the studies by Hidayat-ur-Rehman et al. (2022) and Gangadharbatla (2020), who also found no statistically significant influence of Perceived Ease of Use on the willingness to use smart wearable payments or MIs.

Another relationship commonly predicted in TAM applications is the positive impact of Perceived Ease of Use on Perceived Usefulness (Venkatesh & Davis, 2000), presented in this research as hypothesis H9a. This effect was confirmed in all five countries at a 5% significance level (and the magnitude did not differ statistically significantly between countries).

Of the 14 hypotheses, seven were confirmed to the same extent in all five countries at a 5% significance level, namely H1, H2, H4, H8, H9a, H10, and H12. Similar to Gangadharbatla (2020), we identified age as a significant factor influencing intention to use MIs. The hypotheses for which differences in significance or magnitude of effect were found are described in the following lines.

Shafeie et al. (2022) presented a comprehensive model of intention to use MIs, in which they defined the determinants, hopes, and concerns that influence adoption of MIs. However, their model did not include variables representing the impact of the recent COVID-19 pandemic on attitudes toward MIs. In this study, the usefulness of microchips in a pandemic and the impact of fake news and conspiracy theories were included in the model. Given the variety of sources on the relationship between fake news and conspiracy theories, we found a bidirectional relationship between these constructs. Fake News is positively related to Conspiracy Theories in all countries at a 5% significance level (H3). However, the magnitude of the effect varies and is lowest in Croatia (β=0.514) and highest in Russia (β=0.814). We found a negative impact of Health Concerns on Perceived Usefulness (H5) at a 5% significance level in all countries, but the magnitude of the impact varies and is highest in Ukraine (β=-0.369) and lowest in Poland (β=-0.111). Perceived Trust has a positive impact on Perceived Usefulness (H11a) in all countries at a 5% significance level. The magnitude of the impact in the case of H11a varies from the lowest value in Ukraine (β=0.261) to the highest value in Poland (β=0.574). Similarly, Perceived Trust has a positive effect on Behavioural Intention to Use (H11b) in all countries at a 5% significance level, although the magnitudes vary and are lowest in Ukraine (β=0.097) and highest in Russia (β=0.388).

Privacy Right has a positive impact on Perceived Trust only in Poland and Russia at a 5% significance level (H6), while the impact is not significant in the other three countries. Moreover, Conspiracy Theories have a negative impact on Perceived Trust (H7) in Poland and Slovenia at a 5% significance level, while the impact has not been confirmed in Croatia, Ukraine and Russia.

Based on economic and digital indicators, we assumed large differences in the responses of the countries studied. Ukraine and Russia, for example, are classified in different groups than other countries according to the Networked Readiness Index (NRI) (Dutta et al., 2020), indicating lower use of mobile banking and lower trust in high-tech devices. In contrast to these differences, we did not find major differences among the countries studied in attitudes toward adoption of MIs. Only three of the 14 hypotheses proved to be statistically significantly different at the 5% confidence level.

5.1 Theoretical implications

This study has several theoretical implications. First, by including five different countries in the study, we have shown that the proposed model can be used to study the characteristics and beliefs of potential MI users in different settings. Second, we have successfully implemented the proposed methodology to test and evaluate the proposed model. In this way, other researchers can use similar approaches to test and evaluate their research models. They can use the same procedure to evaluate the measurement model, conduct multigroup analyses and test the structural model. Third, our research has also shown that the proposed methodology can be used to identify differences in specific groups of participants if the sample size is large enough (e.g., by country of origin). Therefore, researchers can use this methodology to identify differences in samples when conducting SEM. Most importantly, we outlined the issues for further research on technology acceptance, specifically MIs, identifying the factors that influence acceptance and the differences or similarities in these factors across countries. Since most hypotheses were confirmed as statistically significant in all countries, we can conclude that these impacts can be studied regardless of country of origin. Instead of focusing research on differences between countries, researchers can now focus on other demographic characteristics, such as gender, education level, or employment status. In addition, further research on the acceptance of MIs can focus on identifying different perspectives on perceived ease of use, privacy rights and conspiracy theories. In addition, our results have shown that appropriate methods and approaches need to be found to reduce concerns about MI technology while increasing trust in technology.

5.2 Practical implications

In general, MIs are perceived as a controversial technology that generates debates about its advantages and disadvantages. Therefore, government agencies and society could benefit from this study by gaining insight into how to deal with the phenomenon of MI acceptance. This study confirms that perceived usefulness has an impact on the acceptance of MIs. It also implies that MI acceptance depends on age and perceived confidence. We can conclude that younger people who perceive technology as trustworthy and useful are more willing to use MIs, whereas ease of use does not play an important role in the acceptance of MIs. Therefore, to increase awareness of the use of MI and its usefulness, older people who have less confidence in technology should be targeted with various awareness activities in their lifelong education. From the responses collected, it appears that the participants in this study are not aware that MI does not provide location tracking or that it cannot move in the body. People should therefore be educated about existing forms of tracking our activities with biometric IDs, mobile or wearable devices, which are not significantly different from MIs. Government agencies should also address these concerns and better inform the public about the use of MIs, its benefits, reported uses, potential risks, problems, and advances in MI technology. Furthermore, despite some initiatives (Graveling et al., 2018) and strict bans by individual states (Coggeshall, 2021), legislation on the use of MIs is lacking. With proper legislation, society in general would have better insight into MI technology and individuals could make better decisions when considering the use of MIs. Ethical principles should be included in legislation to prevent individuals from being forced to chip by employers or legal bodies (Nicholls, 2017). Last but not least, the framework for safe use must be ensured if the adoption of MIs is to continue to grow as expected.

Consistent with the case of a Swedish company that developed MIs to carry COVID-19 passports (Teh, 2021), participants in this study consider MIs useful in the event of pandemic, although they still consider health issues with MIs. Therefore, MI developers should consider how to further improve the technology to avoid health concerns and trust issues, or even consider switching from insertable to a wearable technology to avoid the impact of these factors.

5.3 Limitations and future research

This study has several limitations. First, the data were collected in only five Eastern European countries, making our results less generalizable. Further research should therefore include a broader sample from other regions or even continents. Second, because of the extensive model and large number of questions, some demographic data, such as race or religion, were not included in the questionnaire. To gain deeper insight into the factors that influence adoption of MIs, more demographic data should be collected in future studies. Third, the model presented only identifies the factors that have a significant impact on the acceptance of MIs. This study does not address the reasons why people do or do not adopt MIs. Fourth, based on research published after the development of our model and data collection, some additional variables not included in our model should probably be considered important (e.g., social impact or monetary aspects). In addition, the inclusion of actual users of MIs in the survey would greatly contribute to the usability of the proposed model.

Our study included data from two countries that, unfortunately, have changed significantly since the study was conducted due to military conflict. It is likely that these changes will have a major impact on the future acceptance of MIs in these countries.

Because of the minor differences in the model presented, future research should create and test a common model that shows the overall importance of acceptance factors. The data collected could also be analyzed using other methods and tools to find the links between the issues that are not apparent from the model presented.

6 Conclusions

Microchip implants (MIs) are no longer just a topic of science fiction literature. Over the past thirty years, the use of MIs has evolved from single experiments (K. Michael, 2016) to broader use in organizations (Rodriguez, 2019; Siibak & Otsus, 2020). Although several studies have examined the adoption of MIs over the past decade (e.g., Boella et al., 2019; Gangadharbatla, 2020; Perakslis & Michael, 2012; Pettersson, 2017; Shafeie et al., 2022)), none of them were conducted after the COVID-19 pandemic, which significantly changed our perceptions of news and conspiracy theories (Moscadelli et al., 2020; Ullah et al., 2021). In this study, we examined the differences in attitudes and acceptance of MIs after the outbreak of the COVID-19 pandemic. The research was conducted in five countries in the Eastern European region.

It is most likely that people would use MIs for healthcare purposes, while they would mainly be unwilling to use it for shopping, payment and smart home use. Due to the large sample size, we were able to compare attitudes towards MIs in different countries, confirming the applicability of the proposed research model in different settings.

The results show many similarities in the perceptions of the participants from all countries considered. Perceived ease of use does not significantly influence the intention to use MIs (except in Croatia), but it does affect perceived usefulness. Age is a significant predictor of intention to use MIs. Younger respondents are more likely to use MIs. Safety of technology affects perceived confidence, which in turn affects perceived usefulness and intention to use. In all countries surveyed, painful procedures, health concerns, and the usefulness of microchips in pandemic have a significant impact on perceived usefulness. The reciprocal influence of fake news and conspiracy theories is significant, but they do not influence perceived trust in all countries studied.

We found some differences in the impact of privacy rights, the influence of conspiracy theories, and perceived usefulness. While only in Russia and Poland privacy rights have a significant impact on perceived trust, conspiracy theories influence perceived trust in Poland and Slovenia. Only Croatians believe that usability has a significant influence on the intention to use MIs.

In light of the findings presented, it is clear that the attitudes towards and acceptance of MIs are broadly similar in the Eastern European countries under study. Therefore, it might be interesting to extend the presented research to other regions and continents in the future.

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Appendix A: Descriptive statistics for questionnaire items