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Technology acceptance of the PFAS Guide among European companies

Gina Zheng[1] *and Abby Muricho Onencan*[2]
[1]*Nijmegen School of Management, Radboud University, Nijmegen, The Netherlands*
[2]*Law and Business Department, Erasmus School of Law, and Erasmus Initiative on Dynamics of Inclusive Prosperity, Erasmus University Rotterdam, Rotterdam, The Netherlands*

Abstract

In 2023, European governments submitted a proposal to comprehensively ban per- and polyfluoroalkyl substances (PFAS), prompting a shift toward PFAS-free alternatives. However, recent research has emphasized the need for an integrated approach to chemical assessment and environmental management rather than abrupt PFAS substitution, as alternatives may pose similar or greater risks. The PFAS Guide was developed to aid corporations in this critical transition. Its goal is to simplify PFAS identification, safe substitution, and gradual elimination. This study applies the Technology Acceptance Model (TAM) to assess how perceived usefulness (PU) and ease of use of the PFAS Guide impact corporate intentions to adopt it. Our analysis, based on responses from 104 European companies, demonstrates a positive link between PU, ease of use, and a company's intent to adopt the PFAS Guide. This underscores the importance of corporations perceiving the PFAS Guide as a valuable and user-friendly resource, given its substantial impact on PFAS phase-out. Descriptive statistics revealed an interesting finding: 51.9% of the participants fell into the "other" group, as outlined in the PFAS Guide. This raises questions regarding the grouping of companies into various sectors. Based on our results, we propose improvements to the PFAS Guide by broadening sector representation to encompass a more diverse range of industries with sector-specific guidance, ensuring content relevance, and accentuating user experience using interactive resources. Future research should focus on the actual adoption and use of the guide to gain deeper insights into adoption rates and long-term PFAS Guide utilization. Furthermore, additional investigations should incorporate subgroup analyses, data triangulation, and a longitudinal approach to enhance our understanding of the factors that support and hinder integrated chemical assessment and environmental management. These research efforts are pivotal in guiding chemical policy and management practices, contributing to a PFAS-free future. *Integr Environ Assess Manag* 2024;20:2175–2188. © 2024 The Author(s). *Integrated Environmental Assessment and Management* published by Wiley Periodicals LLC on behalf of Society of Environmental Toxicology & Chemistry (SETAC).

KEYWORDS: Per- and polyfluoroalkyl substances; PFAS Guide; PFAS pollution; Technology Acceptance Model; Technology adoption

INTRODUCTION

Per- and polyfluoroalkyl substances (PFAS) are a class of chemicals that pose a significant threat to both human health and the environment because of their toxicity, persistence, and mobile and bioaccumulative attributes (Buck et al., 2021). PFAS have permeated our daily lives and are found in diverse products, including outdoor apparel, food packaging, stain-resistant textiles, nonstick cookware, and various electronics (Buttle et al., 2023; Onencan, 2022). PFAS enhance the durability and functionality of these items, satisfying industrial and consumer preferences for longevity, practicality, and convenience. The persistent nature of PFAS renders them resistant to degradation, leading to global contamination (Ilieva et al., 2023). Studies have established links between PFAS exposure and various health risks in both humans and animals, including cancer, reproductive issues, and compromised immune system (European Environment Agency, 2022).

Mounting evidence of these harmful effects prompted proactive measures from European governments. On January 13, 2023, the Netherlands, Germany, Denmark, Sweden, and Norway submitted a joint proposal to the European Chemicals Agency (ECHA) to restrict PFAS production and use (ECHA, 2023). This proposed ban on chemicals used for their water-repellent, stain-resistant, and nonstick properties in everyday products presents a

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Address correspondence to onencan@law.eur.nl
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significant challenge for industries. This could set a precedent for reevaluating the safety of previously unregulated chemicals and impact global regulatory landscapes. The European Union (EU)-proposed restriction, if approved, may deem more chemicals unsafe despite being previously deemed safe.

Given the proposed ban on the entire group of PFAS chemicals, some companies have initiated transitions toward safer PFAS-free alternatives (ChemSec, 2023a, 2023b). However, this transition presents two key challenges. First, even if PFAS are not intentionally added, they are often used in manufacturing processes, leading to cross-contamination. Many companies remain unaware of whether their products contain PFAS due to complex international supply chains or cross-contamination (Isaacs-Thomas, 2022; Onencan, 2024). Second, some companies have attempted to use alternative forms that tend to be more hazardous and mobile (ChemSec, 2022). Holden et al. (2023) warns against swift transitions to PFAS-free alternatives that could be equally or more harmful.

Considering this complex context, transitioning toward safer alternatives requires significant capacity building, but many companies lack adequate knowledge about these substances (ChemSec, 2023c, 2023d). Recognizing this knowledge gap, ChemSec (2023d) developed a PFAS Guide to support the phase-out of PFAS. This Guide provides companies with essential information and best practices for identifying and replacing PFAS in their products and processes.

The effectiveness of such guides has traditionally been assessed through outcome evaluation and measurement of the actual PFAS reduction after implementation. Although valuable, this approach often neglects crucial insights into the guide's perceived utility and ease of use from the user's perspective, also known as process evaluation. This type of evaluation, as explained by Webb et al. (2019, p. 20), assesses “an intervention's mechanisms of impact (or active ingredients).” Process evaluation offers valuable insights into the context and the most significant factors influencing PFAS Guide adoption (Stevens et al., 2008; Webb et al., 2019). Studies focusing specifically on the process evaluation of online guides are scarce.

This study addresses a significant gap in knowledge regarding the perception and adoption of online resources such as the PFAS Guide. Despite conflicting findings on user acceptance of such resources (Marangunić & Granić, 2015; Williams et al., 2015), few studies have explored online guides (Pandey et al., 2020), and none have investigated the acceptance of the online PFAS Guide or similar national-level PFAS resources.

This research not only bridges the scientific understanding of PFAS Guide acceptance with real-world consequences (Landis, 2020) but also provides valuable insights for future PFAS research on environmental policies (Buck et al., 2021; Gaines et al., 2023) and ecological risk assessments (Holden et al., 2023). By connecting user perceptions with the guide's effectiveness, our findings ultimately promote evidence-based decision-making for developers and users alike.

Following this introduction, we delve into the theoretical foundation of the Technology Acceptance Model (TAM), followed by a detailed discussion of our methodology and data analysis. We then present our findings, discuss them, and conclude with a summary of the research implications and recommendations for future research.

THEORY AND HYPOTHESES

Technology Acceptance Model (TAM)

With technology continuously developing and entering daily routines in both private and corporate settings, researchers have delved into the field of user acceptance of technologies over several decades (Marangunić & Granić, 2015). Several theoretical frameworks related to the acceptance of technologies and innovations have been developed over time. One such framework is the Theory of Reasoned Action (TRA). It aims to understand a person's behavior based on their intention to perform a particular action (Rondan-Cataluña et al., 2015). According to the TRA, the behavioral intention (BI) is influenced by attitude and subjective norms (Ajzen, 1980; Fishbein & Ajzen, 1977). The TRA explains one's intention to carry out a certain action in general but does not explain the intention to accept technologies.

Davis (1985) used the TRA as the foundation for developing the TAM. Davis' (1985) original conceptual model is widely used to understand and predict user acceptance (Marangunić & Granić, 2015; Zhang et al., 2019). In the earliest version of TAM, Davis (1985) proposed that user acceptance depended on the attitude to use (ATT). The TAM asserts that attitude is determined by a person's perceived usefulness (PU) and perceived ease of use (PEU) of a technology or system (Davis, 1985; Marangunić & Granić, 2015; Zhang et al., 2019). Perceived usefulness refers to “the degree to which a person believes that using a particular system would enhance their job performance” (Davis, 1989, p. 320). Conversely, PEU is defined as the extent to which a person holds the view that using a system is effort-free (Davis, 1989).

Over time, several modifications have been made to TAM, including incorporation of the BI construct and removal of ATT. Behavioral intention was included in the model because Davis, Bagozzi, et al. (1989) found a significant direct relationship between PEU, PU, and BI. Owing to the multiple refinements of TAM, some studies have retained ATT (Wang et al., 2022; Zhang et al., 2023), whereas Gefen and Straub (1997) exclude both ATT and BI. Because of the belief that intention can be formed without developing an attitude, ATT was ultimately eliminated from the TAM framework, and this position has continued to obtain supportive findings from empirical studies (Rondan-Cataluña et al., 2015). Considering these discoveries, the conceptual framework of this study was amended to include BI rather than ATT.

The literature contains contrasting views on the relationship between PU and PEU in BI. Dulcic et al. (2012) stated that PEU is the most important variable for BI because a system that is difficult to use is not beneficial to performance. By contrast, other researchers perceive PU as a stronger determinant of BI than PEU; people are inclined to accept a more complex technology if they perceive its usefulness (Park et al., 2014; Rondan-Cataluña et al., 2015). These instances align with studies that assume that PEU indirectly influences PU. If users expect the system to be easy to use, they are more likely to perceive it as useful (Davis, Bagozzi, et al., 1989; Landry et al., 2006). Rosly and Khalid (2018) found a significant relationship between PEU and PU, suggesting that employees would view the system as useful if it were easy to use. Consequently, this study's conceptual model incorporates the link between PU and PEU.

Both PU and PEU are influenced directly by external variables and antecedents. These variables are not necessarily fixed as they vary according to the research subject or field of scope (Davis, 1989; Dulcic et al., 2012; Marangunić & Granić, 2015). Although these typically refer to factors such as system characteristics, user training, and involvement in design, they tend to vary according to the technology and research focus (Chuttur, 2009; Ramkumar et al., 2019; Zhang et al., 2019). As there is no fixed set of external variables, some studies have focused solely on Davis' (1989) item scales to determine PEU and PU (Chuttur, 2009; Dulcic et al., 2012; Landry et al., 2006; Rosly & Khalid, 2018). As the current study is specifically interested in the relationships between PEU, PU, and BI, other external variables will not be further examined.

Key variables and hypotheses

The research question is: "What is the role of perceived ease of use (PEU) and perceived usefulness (PU) on the behavioral intention (BI) toward using the PFAS Guide?" We used TAM constructs and developed hypotheses to determine the BI to use the PFAS Guide.

Perceived ease of use. Perceived ease of use refers to the belief held by companies that utilizing the PFAS Guide is a minimal or effortless task. With respect to PEU, academics have emphasized the simplicity of navigation and clarity of the information provided (Davis, 1989; Ghani et al., 2019). Consequently, the online navigation of the PFAS Guide and the clarity of the information presented are of utmost importance in the assessment of PEU. The first hypothesis is as follows:

H1a *PEU has a significant influence on BI to use the PFAS Guide.*

H1b *PEU has a positive influence on BI to use the PFAS Guide.*

Perceived usefulness. Perceived usefulness refers to the degree to which an individual believes that their usage of the PFAS Guide improves their company's performance in phasing out PFAS. Perceived usefulness evaluates the perceived quality of the information provided by the PFAS Guide to companies (Bach et al., 2016). In this article, the term "performance" refers to an individual's assessment of the extent to which the information presented in the PFAS Guide facilitates their organization's efforts to phase out PFAS (Richard et al., 2009). Accordingly, we hypothesize as follows:

H2a *PU has a significant influence on BI to use the PFAS Guide.*

H2b *PU has a positive influence on BI to use the PFAS Guide.*

Relationship between PEU and PU. Several studies have established the positive influence of PEU on PU (Davis, Bagozzi, et al., 1989; Landry et al., 2006; Park et al., 2014; Rondan-Cataluña et al., 2015). These findings imply that a user expects a system to be more useful if they believe it is easy to (learn how to) use it. Hence, we formulate the following hypotheses:

H3a *PEU has a significant relationship with PU of the PFAS Guide.*

H3b *PEU has a positive influence on PU of the PFAS Guide.*

Behavioral intention. Behavioral intention refers to the firmness of one's resolve to perform a specific conduct or action. In TAM, this concerns one's intention to use a specific technology, which consequently infers actual usage (Davis, Bagozzi, et al., 1989). In the current study, BI is the outcome variable used to measure one's intention to use the PFAS Guide in the future based on their levels of PEU and PU.

MATERIALS AND METHODS

The PFAS Guide

The PFAS Guide is a free, online resource that helps companies identify products containing toxic PFAS chemicals and phase them out. Launched in 2023, it is accessible to any company or individual wanting to phase out PFAS. This finding supports worldwide efforts to reduce the use of PFAS. The guide has five chapters: Investigate, Phase-Out, Concern, Regulation, and Sector.

Chapter 1 provides advice on how to communicate PFAS in the supply chain and what to do if companies do not get the answers they need or want to verify the information. It also contains a supply chain communication checklist and guidelines for chemical analysis. Chapter 2 emphasizes that successful PFAS substitution involves a comprehensive analysis of the specific functions of each application, highlighting cases where PFAS may not be necessary, such as cosmetics and bicycle oils. This underscores the importance of evaluating potential alternatives based on factors such as hazards, functionality, availability, cost, and environmental impact. Pilot testing before full-scale substitution is advised to address the unforeseen challenges. Chapter 3 offers insights into the effects of PFAS on human health, wildlife, and the environment, while Chapter 4 outlines PFAS regulations in the EU, the USA, and worldwide through the Stockholm Convention. The final chapter provides sector-specific reports categorized into electronics, food packaging, textile paints, coatings, cosmetics, construction, and other industries.

Instrument design

Qualtrics software was used to create an online survey based on the model items (see Table 1). The survey used a 5-point Likert scale with two variations, ranging from "strongly agree" to "strongly disagree" and "extremely unlikely" to "extremely likely." Participants could access the anonymous questionnaire on any device and complete it within 15–20 minutes.

Two introductory questions were used to determine the industry in which the company operates and its status regarding PFAS. The questionnaire consisted of three matrix tables with multiple statements regarding PU, PEU, and BI. The statements were based on relevant items of the constructs used in previous studies to assess TAM (Davis, 1985, 1989; Davis, Bagozzi, et al., 1989; Ghani et al., 2019; Lederer et al., 2000; Park et al., 2009). Therefore, five statements focused on the PEU items, as shown in Table 1. We adapted the PEU statements from two different papers, four of which were adapted from Davis (1989) and "ease of navigation" was derived from Lederer et al. (2000), as the guide used a similar structure to that of an online website. On the other hand, there were six statements related to participants' PU based on Davis (1989), which were slightly adjusted to fit a corporate setting.

The last matrix table contained a final statement inquiring about the participants' intention to use the PFAS Guide in the future. This was adapted from the study by Park et al. (2009), wherein they inquired about participants' intention to use the technology in the future. In addition, there were two open questions regarding the participants' perceptions of the main benefits of the PFAS Guide and the proposed areas of improvement. To obtain adequate responses from the participants, including those unfamiliar with the PFAS Guide and/or PFAS in its entirety, a link

TABLE 1 Items in the model and their factor loadings (all loadings are significant at $p < 0.05$)

#	Item	Question	Adapted from	Component 1	Component 2
PEU: Perceived ease of use[a]					
1	Ease of navigation	I find it easy to navigate the PFAS Guide	Davis (1989) and Lederer et al. (2000)	0.267	0.619
2	Ease of finding information	It is easy to find the information I need		0.298	0.835
3	Clear and understandable	The PFAS Guide process is clear and understandable		0.362	0.559
4	Minimum mental effort	Using the guide requires minimum mental effort		0.292	0.584
5	Perceived ease of use overall	Overall, I find the PFAS Guide easy to use		0.177	0.953
PU: Perceived usefulness[b]					
1	PFAS phase-out efficiency	The guide provides efficient ways to phase out PFAS	Davis (1989)	0.623	0.369
2	Quality of investigations	The guide improves the quality of my company's PFAS investigations		0.765	0.191
3	PFAS phase-out productivity	The guide increases my company's efforts to phase out PFAS		0.583	0.236
4	PFAS phase-out effectiveness	The guide improves the effectiveness of my company's efforts to phase out PFAS		0.819	0.216
5	Perceived usefulness and perceived ease of use	The guide makes it easier to phase out PFAS		0.745	0.307
6	Perceived usefulness overall	Overall, I believe that the PFAS Guide is useful to my company		0.693	0.454
BI: Behavioral intention[c]					
1	Behavioral intention	I intend to use the guide in the future	Park et al. (2009)		

Abbreviation: PFAS, per- and polyfluoroalkyl substances.
[a]Likert scale: 1 = strongly disagree, 2 = somewhat disagree, 3 = neither disagree nor agree, 4 = somewhat agree, and 5 = strongly agree.
[b]Likert scale: 1 = strongly disagree, 2 = somewhat disagree, 3 = neither disagree nor agree, 4 = somewhat agree, and 5 = strongly agree.
[c]Likert scale: 1 = extremely unlikely, 2 = somewhat unlikely, 3 = neither likely nor unlikely, 4 = somewhat likely, and 5 = extremely likely.

to the online guide was provided. The participants evaluated the guide's ease of use and usefulness while completing the questionnaire.

Data collection: Recruitment strategy, participant characteristics, and privacy

To capture a diverse range of perspectives regarding the PFAS Guide, our participant recruitment strategy unfolded in two key phases. Initially, we targeted individuals within organizations familiar with PFAS chemicals, such as employees of PFAS manufacturing companies, members of PFAS-free movements, and those working in industries prone to PFAS exposure, such as food packaging and textiles. We assumed a basic understanding of PFAS chemicals within such companies because of their professional environment; however, we acknowledge that individual knowledge might vary.

Our primary outreach involved email with a linked questionnaire supplemented by online contact forms and direct, InMail, and open profile LinkedIn messages. While we prioritized PFAS-aware individuals, prior knowledge of the guide itself was not mandatory because the online tool had just been launched and very few companies had knowledge or experience with it. Our focus was on gauging the intention to use based on first impressions and perceived usability.

During the questionnaire testing phase, we recognized that our initial sampling strategy within PFAS-aware companies overestimated the assumed level of PFAS familiarity among the participants. Outreach and response data revealed a wider range of knowledge than anticipated, with a significant proportion lacking prior knowledge of PFAS. This discrepancy between our assumptions and the actual participant demographics led to a few adjustments in both the questionnaire design and participant recruitment strategy.

The second phase involved in-person approaches to reach a wider audience. Recognizing the value of broader perspectives, we expanded recruitment to include individuals from organizations that potentially lack direct PFAS experience. To ensure informed participation, we made two key adjustments to the questionnaire during the questionnaire testing phase. First, we provided a readily available link to the PFAS Guide, offering essential context and understanding regardless of their initial knowledge level. Second, we included a clear statement emphasizing that neither personal company involvement with PFAS nor prior PFAS Guide experience were prerequisites for participation. We also made minor improvements in clarity based on initial company feedback. Importantly, no participants were excluded from providing feedback based on their familiarity level. These adjustments were made during the questionnaire testing period and the results were based on the final survey.

By implementing these two recruitment phases and questionnaire adjustments, we gathered valuable insights from individuals with diverse backgrounds and knowledge levels. This ultimately led to a more comprehensive and representative evaluation of the PFAS Guide.

The online questionnaire used a data collection strategy that protected participant privacy by using robust pseudonymization and an "opt-out" consent mechanism. This allowed us to collect data while ensuring that individual or corporate reidentification is highly unlikely. We prioritized participants' rights by providing a privacy notice, not requesting any personal data, offering an accessible opt-out option at any stage of completing the questionnaire (we did not include incomplete responses in our analysis), and anonymizing the data after analysis.

Sampling and data cleaning

A questionnaire was distributed to 388 companies and groups of companies, although the total population was uncertain because of the challenge of identifying companies with knowledge of PFAS. Nonprobability sampling methods were used, partly based on a list of companies engaged in EU PFAS discussions and selective inclusion of individuals and companies active in online discussions related to PFAS and the PFAS Guide. A minimum sample size of 380 was determined using the Krejcie and Morgan (1970) table, given the unknown population size. Ultimately, 104 responses were received by the end of May 2023, with a response rate of 26.8%. Data cleaning involved categorizing responses and removing extraneous information while maintaining anonymity and confidentiality. Of the 104 responses, 52 were complete, resulting in a completion rate of 50%. The dataset was also checked for outliers with minimum and maximum values; however, no deletion was necessary in this step. Finally, to organize the dataset for subsequent analyses, the variable names and labels were adjusted for clarity.

Measurement validation

The research quality was tested by assessing its validity and reliability. Validity helped check whether the study was measuring what was intended, while reliability provided certainty that the data outcomes fit the research objective (Field, 2018).

Content validity. To ensure the content validity of the items for measuring PEU, PU, and BI, factor analysis was conducted on 11 items (Field, 2018). Our study collected data using a questionnaire with numerous items measuring various aspects of the construct under investigation. Therefore, we chose factor analysis to help condense these many items into a smaller number of underlying factors, capturing the essential dimensions of the construct, and simplifying further analysis. By identifying the factors that explain the interrelationships between the questionnaire items, we can assess the construct's internal validity. This helps us to verify whether the items truly measure the intended core concept and contribute to a coherent understanding of the construct.

Factor analysis (principal axis factoring) was used as the extraction method because PEU and PU are latent variables that cannot be measured directly. Factor analysis aims to identify clusters of variables that are highly correlated with each other, as it helps explain the maximum amount of common variance by reducing our set of variables (items) to a smaller set of factors (PEU and PU) (Field, 2018). Hence, the validity of the items for each construct can be tested using factor analysis. First, we tested the appropriateness of factor analysis for the current dataset (Field, 2018). This was evaluated based on the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy. The KMO value should be higher than 0.50 (Field, 2018). In this case, the appropriateness of the factor analysis was ascertained because the KMO-test value was higher than the required value ($0.833 > 0.50$). Bartlett's Test of Sphericity was used to check whether there was a correlation between the items. The results of Bartlett's Test of Sphericity were significant ($\chi^2 = 343.242$; $p < 0.001$). Given the correlation between the variables, we judged it appropriate to use factor analysis on the data (Field, 2018).

Next, the initial factor solution was calculated to extract the factors and test the correlations. The table for Total Variance and the accompanying scree plot were checked for eigenvalues. The eigenvalue should be greater than 1 (Guttman–Kaiser rule) to assess the variance captured and explained by a factor (Field, 2018). This was the case for the two factors in the table, showing that they explained 60.41% of the variance. The Scree plot displayed two similar factors at the point of inflection. In other words, these two factors are relevant for extraction.

In the subsequent step, we measured the degree to which the variables were loaded onto the two factors. The table of communalities was assessed for any items with a factor loading below 0.20, because this would indicate a very low proportion of an item's explained variance (Field, 2018). No items were removed based on the minimum criteria. Subsequently, orthogonal rotation was performed to improve the interpretation of the relevant factors. An orthogonal method was used to keep factors independent of each other, aligning with the intention to test for both PEU and PU as separate constructs (Field, 2018). Accordingly, a varimax rotation was applied, and the output revealed that no communalities fell below the minimum threshold (<0.20). Therefore, none of the items were removed from the dataset.

Subsequently, the rotated factor matrix was checked for the factor loadings of the scale items for the two constructs. Stevens (2012) recommended a threshold of a value greater than 0.40, while adhering to a minimum difference of 0.20 between the highest and the second-highest factor loading on an item if there are cross-loadings (Field, 2018). Table 1 (also see Figure 1) indicates that the five items of PEU loaded onto the second factor. It was noted that item PU_overall exceeded the value of 0.40 for both factors, and yet had a difference greater than 0.20, with a higher loading on the first factor. Therefore, the six remaining PU items can be interpreted as loading onto the first factor.

The number of items per construct correlates with the operationalization of the conceptual model (see Figure 1). Thus, we did not find any invalid items that could have been removed. The lowest factor loadings belonged to PEU_clarity and PU_efforts, whereas the highest factor loadings belonged to PEU_overall and PEU_find_info.

Construct reliability. Construct reliability ensures that our measures consistently assess the intended concept and that our findings are meaningful and replicable. Unreliable measures can introduce random errors. This can mask the real connections between variables, leading to misleading conclusions. Even strong relationships could be mere chance, not genuine. High reliability strengthens our confidence that the observed relationships reflect true causal mechanisms and not just random noise. Ultimately, strong construct reliability boosts research credibility. This shows that we built a solid and dependable measurement tool, leading to more meaningful, trustworthy, and impactful research outcomes.

After validity was established, reliability was determined using Cronbach's α. We conducted an analysis to check the internal consistency of a construct using multiple items or indicators (Field, 2018). Hence, two reliability tests were performed; one for PEU and the other for PU. The tests revealed that both PEU and PU had good reliability (>0.80), as summarized in Table 2 and illustrated in Figure 1.

Detailed reliability statistics were used to improve the reliability of each item when individual scores were below the threshold ($\alpha < 0.60$). A rule of thumb is that an item may be removed if Cronbach's α increases with a value of $\alpha > 0.05$, but not if the increase is below $\alpha < 0.001$ (Field, 2018). The tests showed that all were reliable, except for three items: PEU_clarity ($\alpha = 0.589$), PEU_mental_effort ($\alpha = 0.584$), and PU_efforts ($\alpha = 0.590$). However, the deletion of any of the items would not result in an increased Cronbach's α for the desired value ($\alpha > 0.05$). Moreover, because the scores were only slightly below the threshold ($\alpha < 0.60$), the decision was ultimately made to retain all three items (see Table 1). In addition, no deletion of items helps retain the content validity that was determined earlier (Field, 2018). After assessing the content and construct validity and reliability, the dataset was prepared for descriptive and inferential statistics.

Inferential statistics. When conducting research, regression analysis is a useful tool for examining the correlation between two variables, particularly when the researcher wishes to gain insight into their relationship. This statistical tool is essential for forecasting the reasons behind the adoption and utilization of new technologies. The TAM indicates that ease of use and usefulness of a product or service are crucial factors that influence people's technology acceptance decisions. Regression analysis allows us to assess the significance of these factors and the reasons behind them.

First, it helps us build models that predict how likely someone is to use the PFAS Guide based on their

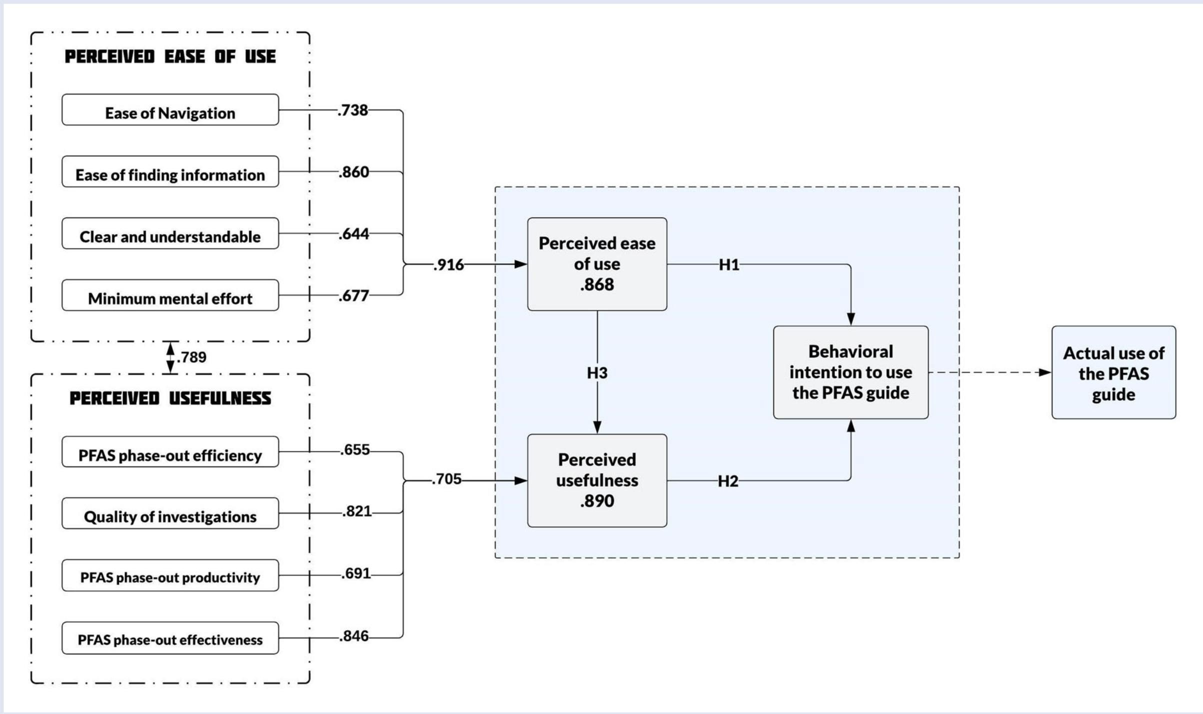

FIGURE 1 Results of validity, reliability, and construct reliability measurements. PFAS, per- and polyfluoroalkyl substances

perceptions. The input in this model is their perception of ease of use and usefulness and the output is their chance of trying it. This information is valuable for developers, marketers, and anyone wanting to get people to use their innovations.

Second, regression analysis helps us determine which factors are most important in making the decision. Are people swayed more by how easy it is or how helpful they think it will be? This kind of insight helps us to create targeted strategies to convince people to try new innovations. If ease of use has the greatest influence, the developer company could focus on clear tutorials and a smooth setup process. This knowledge helps developers to create interventions and strategies that make technology more appealing and useful for everyone.

Standardized path estimates are utilized to portray the consequences of the TAM structural equation model's path investigation. These path estimates reflect the relative strength of one variable's impact on another. Standardized estimates convert variables' unique scales into a standard metric, allowing researchers to identify directed dependencies among variables. In contrast to unstandardized coefficients, which are influenced by the scales of the original variables, standardized estimates eliminate the influence of different measurement scales. This enables researchers to directly compare the relative importance and direction of the effects exerted by various independent variables on the dependent variable. This insight is vital for identifying the most significant factors influencing the phenomenon under investigation.

TABLE 2 Reliability statistics for PEU and PU

Construct	Cronbach's α	*N* of Items
Perceived ease of use (PEU)	0.868	5
Perceived usefulness (PU)	0.890	6

RESULTS

Descriptive statistics

Descriptive statistics were used for the data obtained from the two introductory questions. This reveals basic insight into the respondents' company and/or organization in terms of (1) the industry in which it operates (Table 3) and (2) their current corporate status regarding PFAS (Table 4). This section also provides an overview of the basic information regarding the group means and standard deviations of the dataset.

Descriptive statistics (see Table 4) show that the majority (52%) of the participants were employed by a company or organization that operates in industries other than the options provided beforehand ($N = 52$). From the responses, it can be concluded that these industries include energy, biotechnology, information technology (IT), transportation, consulting, food production, distribution, and retail. Further descriptions consisted of information regarding the status of the company or organization in relation to PFAS (see Table 4). Nearly half (46%) of the respondents indicated that their company or organization did not have plans to become PFAS-free or were uncertain. A quarter of the sample was

TABLE 3 Respondents' companies and/or organizations by industry, $n = 52$

		Frequency	Percent	Cumulative percent
1	Electronics	1	1.9	1.9
2	Food packaging	5	9.6	11.5
3	Textile	6	11.5	23.1
4	Paints, coatings, and varnishes	1	1.9	25.0
5	Cosmetics	7	13.5	38.5
6	Construction	5	9.6	48.1
7	Other	27	51.9	100.0
	Total	52	100.0	

PFAS-free from the beginning, whereas another quarter was in transition. The remaining group is the smallest (3.8%), consisting of companies that are PFAS-free after transitioning (Table 4).

Next, we took a closer look at the items that corresponded to PEU, PU, and BI. Descriptive statistics for PEU displayed an overall mean score of 3.40 (SD = 0.83). This indicates a positive perception of the ease of use of the PFAS Guide. Among the items, PEU_navigate had the highest mean value ($M = 3.62$), implying that the respondents believed that the PFAS Guide was easy to navigate. The descriptive statistics for PU showed that there was an overall mean score of 3.60 (SD = 0.73). Similar to the PEU construct, this indicates a positive perception of the tool's usefulness. Among the six items, PU_overall had the highest mean value ($M = 3.75$). This implies that the participants found the PFAS Guide useful in general rather than a specific indicator of the PU construct. Lastly, the descriptive statistics for BI displayed a mean score of 3.19 (SD = 1.30). This points toward a positive BI to use the PFAS Guide, which would be in line with the hypotheses stated earlier.

Correlation analysis to test the relationships between the variables

We conducted a correlation analysis to test the relationships between the relevant variables. The goal was to establish the existing correlations between PEU, PU, and BI, for which the criterion was set at $p < 0.05$ to indicate statistical significance. According to Hauke and Kossowski (2011), Spearman's rho correlation coefficient is suitable for ordinal measurement-scale data. We computed three correlation tables to test the following hypotheses:

H1a *PEU has a significant relationship with BI to use the PFAS Guide.*

H2a *PU has a significant relationship with BI to use the PFAS Guide.*

H3a *PEU has a significant relationship with PU of the PFAS Guide.*

For each hypothesis, a significant correlation coefficient was found for output. The results revealed the following correlations: PEU and BI ($r\,(50) = 0.38$, $p = 0.003$), PU and BI ($r\,(50) = 0.53$, $p < .001$), and PEU and PU ($r\,(50) = 0.63$, $p < 0.001$). All three correlations were statistically significant and showed relatively positive relationships (see also Figure 2, which visualizes the positive correlation between PEU and PU). Regression analysis was performed as the final step to understand the influence of the variables on the respective correlations.

Regression analysis: Predicting and understanding causal relationships

This study opted for three separate linear regression analyses to test the remaining hypotheses. Regression analysis is appropriate for predicting and understanding the relationships between variables, which is necessary for answering the remaining hypotheses (Field, 2018).

H1b *PEU has a positive influence on BI to use the PFAS Guide.*

H2b *PU has a positive influence on BI to use the PFAS Guide.*

H3b *PEU has a positive influence on PU of the PFAS Guide.*

The first analysis focused on PEU as the independent variable and BI as the dependent variable to test H1. The regression output was statistically significant ($F\,(1, 50) = 8.63$, $p = 0.005$), indicating that PEU plays a significant role in influencing BI to use the PFAS Guide. The R^2 value was also

TABLE 4 Respondents' companies and/or organizations by current PFAS status, $n = 52$

		Frequency	Percent	Cumulative percent
1	PFAS-free from the beginning	13	25.0	25.0
2	PFAS-free after transitioning	2	3.8	28.8
3	In transition to become PFAS-free	13	25.0	53.8
4	Uncertain or no plans to become PFAS-free	24	46.2	100.0
	Total	52	100.0	

Abbreviation: PFAS, per- and polyfluoroalkyl substances.

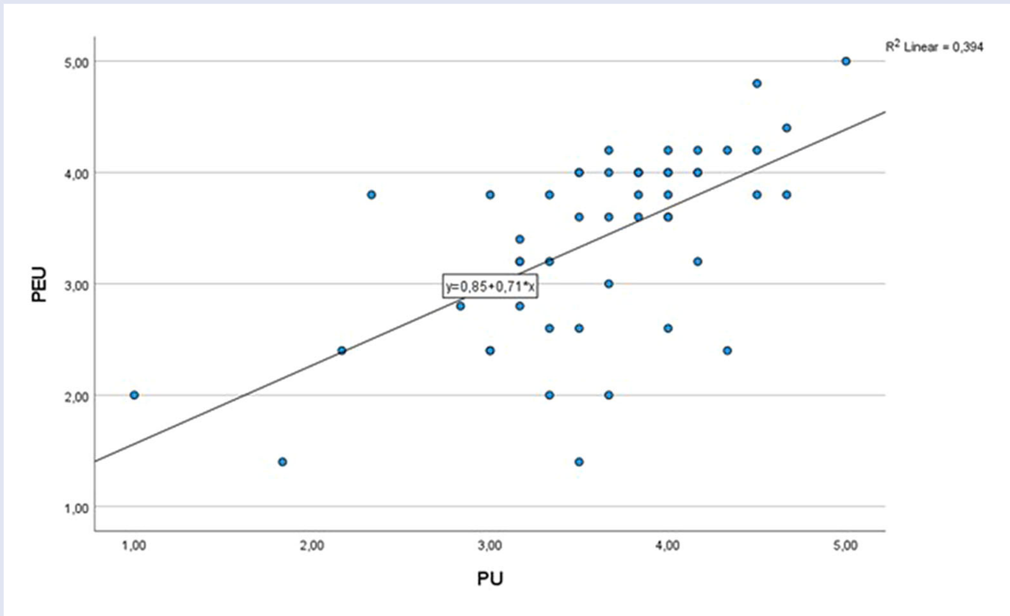

FIGURE 2 Scatterplot of the correlation between PEU and PU. PEU, perceived ease of use; PU, perceived usefulness

checked for the explained variance of the model. The results showed that $R^2 = 0.147$, explaining 14.7% of the variance in BI. Next, the PU construct was used as the independent variable and BI as the outcome variable. The results were statistically significant (F (1, 50) = 20.80, $p < 0.001$) and revealed an R^2 value of 0.279, explaining 27.9% of the variance in BI. This is notably higher than the PEU's explained variance in BI. Finally, regression analysis was performed to assess the influence of PEU on PU. The model outcome was significant (F (1, 50) = 32.50, p = <0.001), and 39.4% of the variance in PU was explained by PEU ($R^2 = 0.394$). In summary, both PEU and PU had a significant positive influence on BI when using the PFAS Guide. In addition, although PU has a stronger impact than PEU, PEU plays a significant role in determining PEU.

DISCUSSION

Summary of findings

Six hypotheses were developed based on TAM to answer the main research question: "What is the role of (1) perceived usefulness and (2) perceived ease of use in the behavioral intention toward using the PFAS Guide?" These hypotheses were supported by the outcomes of the data analysis. Figure 3 presents an overview and visualization of the structural equation model outcomes. This resulted in several key findings. First, both PEU and PU correlate with a person's BI in relation to using the PFAS Guide. Second, these two factors had a positive impact on BI to use the guide. Third, among these factors, PU emerged as the most influential determinant of BI. Finally, PEU and PU also correlate, wherein PEU plays a significant role in positively influencing PU.

Figure 3 shows the standardized path estimates representing the expected relationships and influences. In Figure 3, there are no dashed arrows because we did not observe any nonsignificant effects. As previously discussed, the hypothesized relationships (H1a, H2a, and H3a) were significant, and all three hypotheses to test the relationships between the variables were supported. In addition, all the proposed positive relationships (H1b, H2b, and H3b) were found to be statistically significant. Hence, the original TAM (Davis, 1989), as proposed, effectively explains the intention of companies to use the PFAS Guide to phase out these toxic chemicals. In the context of this study, PU and PEU significantly and meaningfully impacted the intention to use the PFAS Guide. However, because we limited our study to BI, the dashed arrows between BI and the actual usage of the guide were not replaced by a solid line. However, using consistent significant results, we could predict that increased PU and PEU will positively influence BI, and this may eventually lead to more companies using the guide to phase out PFAS chemicals.

Discussion of findings

This study aims to fill a significant research void regarding the intention to utilize an online resource known as the PFAS Guide. This study makes three notable contributions that distinguish it from the others. First, we explained the drivers behind companies' BI to use the guide, providing valuable insights into what motivates individuals within a particular organization to embrace such online resources. Second, this study presented a tailored scale based on the original TAM scales for testing PEU and PU by Davis (1989), which was adjusted to suit the assessment of PFAS phase-out in an organizational context. This scale was subsequently

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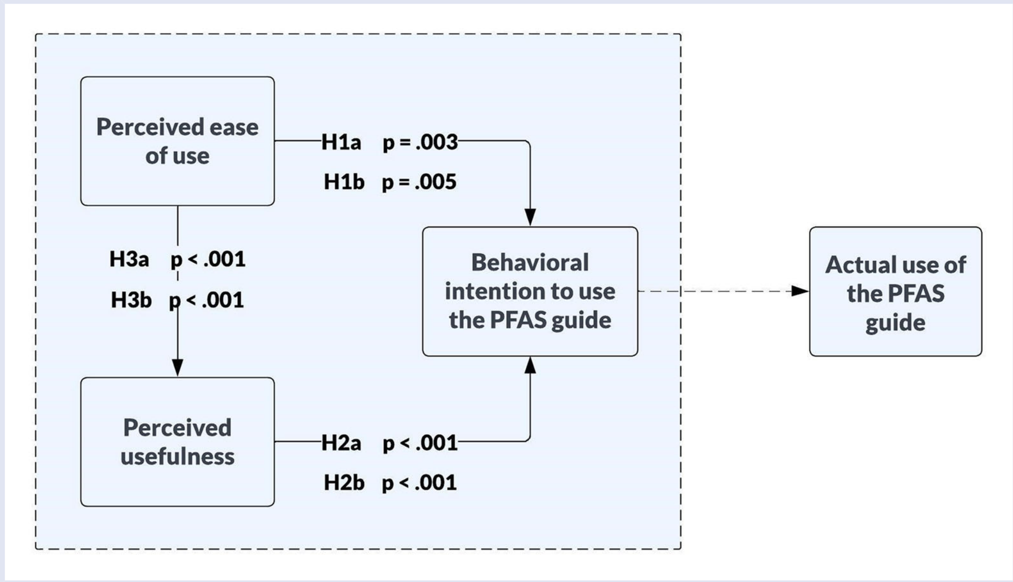

FIGURE 3 Conceptualization of standardized path estimates representing expected relationships and influences. PFAS, per- and polyfluoroalkyl substances

validated through content validity tests, and none of the communalities fell below the minimum threshold. However, during the assessment of construct reliability, the following factors: "Clear and understandable," "minimum mental effort," and "PFAS phase-out productivity" scored slightly below the threshold ($\alpha < 0.60$). Nevertheless, the decision was made to retain all three items, as deleting them would compromise the content validity. Further investigation is required to determine the effectiveness of the proposed scale and the three items. Third, the research was conducted on a sample of companies at different stages of the PFAS phase-out, which validated the effectiveness of the model in predicting user behavior. This study shifted the focus from organizations to individuals, reflecting the evolving landscape of PFAS capacity development interventions. Ultimately, this study provides valuable insights into the acceptance and utilization of online guides by corporate users, uncovering the complexities of their decision-making and shaping the future of digital resource adoption.

The descriptive statistics revealed an interesting finding: 51.9% of the participants belonged to the "other" group, as outlined in the PFAS Guide. This raises the question of the veracity of grouping companies into various industry sectors. Further elaboration by respondents on the nature of "other" companies revealed representation from a diverse range of sectors, including energy, biotechnology, IT, transportation, consulting, food production, distribution, and retail. It may be necessary to engage in further deliberations and reach a consensus to ensure that all companies that need to phase out PFAS feel included with sector-specific information that is relevant to their needs.

Our findings from the correlation analysis are consistent with prior studies that have used the TAM. The relationships between PEU, PU, and BI, as conceptualized within the TAM, have been found to be significant (Davis, Bagozzi, et al., 1989). Over time, subsequent research has accumulated substantial empirical evidence to support the significance of the relationship between these constructs (Ghani et al., 2019; Marangunić & Granić, 2015; Rondan-Cataluña et al., 2015). Correlation and regression analyses yielded statistically significant relationships between variables. Our findings support H1a, H2a, and H3a, which align with previous findings based on the TAM framework. In essence, the proposed relationships between PEU, PU, and BI, in relation to the PFAS Guide, have been found to be significant. It is highly probable that the guide will be favorably received and implemented by organizations seeking to eliminate the use of PFAS.

Regression analysis of the remaining hypotheses (H1b, H2b, and H3b) was conducted to investigate the causal relationships between the variables and was supported by the results. Previous studies have proposed positive associations between TAM constructs and business technologies and systems (Bach et al., 2016; Dulcic et al., 2012; Marangunić & Granić, 2015; Rosly & Khalid, 2018). Consequently, the study posited that the correlations between the constructs would be positive, leading to the performance of regression analysis to determine whether there were significant outcomes. This was achieved and a positive effect was found between PEU and BI, PU, and BI, and PEU and PU. The results of this study are in line with previous research in the field of technology acceptance.

Recommendations: Contributions to practice

The participants offered valuable feedback and suggestions for improving the online PFAS Guide. One participant recommended visual aids, suggesting "a conceptual diagram on the home page" to provide a quick overview for users. Expanding accessibility, participants called for translating the guide into "more languages." For practical implementation, some participants proposed specifications tailored to their industry. One participant suggested using "product serial numbers" to identify PFAS-containing products in a specific supply chain. Others, like a participant from the building and construction industry, requested "more insight on the materials" containing PFAS, while another asked for "more coating relevant entries" in the sectoral sections. Focusing on awareness and utilization, some participants recommended starting by "familiarizing branches more about PFAS," suggesting the need for internal education. Others emphasized promotion, stating "advertise/promote the guide: let the guide be more out in the open" and advocating for "increase[d] incentives" to encourage its use.

Participant feedback pinpointed key areas for improvement of the online PFAS Guide. Users directly stated that the guide "does not feel motivating to use," suggesting engagement and appeal issues. Concerns about "navigating the website not feeling intuitive" point toward potential information architecture or structure problems. Specific mentions of a "non-working search bar, overlapping text, and malfunctioning section buttons" highlight the need for immediate technical fixes. Engaging in elements such as quizzes and success stories can boost appeal, while intuitive structure, clear labeling, and a functional search bar will enhance navigation. Finally, one participant felt "overwhelmed by the amount of information," suggesting that the guide could benefit from improved organization, chunking of information, using multimedia, and providing summaries to combat information overload. User testing, a content governance plan, and targeted promotion will guide continuous improvement and ensure that the guide effectively supports companies to effectively phase out PFAS.

Furthermore, to address the underrepresentation of vital sectors, it is crucial for developers to actively engage with companies spanning a broad spectrum of industries, including those initially grouped under the generic category of "others." This approach not only rectifies exclusion but also promotes inclusivity within the online guide. To mitigate sector representation bias, developers should customize the guide based on specific parameters, such as the sector, PFAS phase-out stage, and geography. This tailored approach enhances the guide's usefulness, particularly for users with distinct needs and varying regulatory contexts. By incorporating these additional details, the guide will accommodate a more diverse audience and provide more targeted support.

Recommendations: Contributions to science and intervention design

The research results indicate that improvements can be made to the PFAS Guide in terms of user friendliness, content relevance, and sector representation. These recommendations are intended to improve the overall effectiveness and utility of the PFAS Guide.

The research confirms Dulcic et al.'s (2012) findings that PEU plays a critical role in influencing BI because if the PFAS Guide is difficult to use, it will not be beneficial to companies as they transition to PFAS-free alternatives. Enhancement of PEU should be the focus of future revisions to the PFAS Guide by implementing practical suggestions from respondents. PFAS Guide developers should provide clear instructions, resources such as videos, and a comprehensive overview of the PFAS Guide to enhance user experience. To guarantee successful knowledge transfer, the respondents recommended implementing external-facing activities, such as organizing awareness-raising events, conducting orientation workshops, and incorporating a question-and-answer section in the guide. These activities ensure that knowledge is effectively conveyed and understood, and user doubts are addressed.

Based on our research, it can be inferred that a positive PEU of the PFAS Guide is associated with a positive perception of its usefulness. Therefore, companies that perceive the guide as easy to use are more likely to find it useful (Davis, Bagozzi, et al., 1989; Landry et al., 2006). It is crucial to note that further efforts are required to enhance the guide's PU, as companies tend to endorse a more complex PFAS Guide if they deem it valuable (Park et al., 2014; Rondan-Cataluña et al., 2015). Based on the respondents' suggestions, improvements can be made to PU by providing a more extensive list of alternatives for each PFAS application, offering a more comprehensive overview of specific products containing PFAS, supplementing the information with additional sector-specific details for a broader range of sectors and PFAS applications, and collaborating with companies to simplify the PFAS phase-out process. Developers should strive to balance user-friendliness and content, and consider incorporating a user-friendly interface, feedback integration, and interactive features such as an online community.

Limitations and future research

This study had seven limitations that offer opportunities for future research. First, the small sample size ($n = 52$) may have affected the generalizability of the results because the limited number of viable survey responses may not accurately reflect the attitudes and behaviors of the population. While this size allowed for initial exploration of the PU of the PFAS Guide, it necessitates cautious interpretation of the findings. Recognizing the potential for response bias, we urge further investigations with larger and more diverse participant pools. Future studies should prioritize recruiting individuals across a wider range of familiarity levels with PFAS and the guide itself, ensuring a more representative sample and strengthening the generalizability of the conclusions. Additionally, incorporating mechanisms to control potential response bias (e.g., social desirability bias) could enhance the reliability of future research results. We also recommend the use of other types of methodologies, such as focus groups or structured interviews, to better understand what works or does not work with online guides.

These approaches offer greater potential for revision or adjustment to enhance interventions, as feedback is generally more detailed and refined than simple survey responses.

Second, we acknowledge the limitation of a relatively low survey response rate (26.8%). While this sample allowed for an initial exploration of the PU of the PFAS Guide, it raises concerns about potential nonresponse bias and necessitates cautious interpretation of the findings. Based on these findings, it was not clear whether there were any nonresponse effects, and we had no reason to surmise that the results would have been different if the response rate had been stronger. Future studies should stratify the sample to ensure that a reasonable number of sectors are represented and include mechanisms that assess nonresponse effects.

Third, given the underrepresentation of specific industry sectors in the responses (e.g., chemical manufacturing companies, firefighting foam companies [defense and firefighters], heating, cooling and refrigeration companies, rubber and tires companies, polyurethane insulation companies, medical devices companies, automobile companies, etc.), we cannot confidently generalize the findings to these domains. Moreover, 52% of the participants fell outside the predefined industry options, suggesting diverse and potentially underrepresented perspectives, highlighting the need for further research with broader and stratified sector coverage. Additionally, the results might not fully reflect the needs and perceptions of those actively engaged in PFAS policy (PFAS phase-out advisers, regulators, commerce, and advocacy organizations). Further research targeting these groups would provide valuable insights and strengthen the generalizability of the findings.

Fourth, the study focused on BI to use the PFAS Guide, but this does not necessarily reflect actual usage. Future research should measure actual guide usage to bridge the intention–action gap and investigate usage patterns across different PFAS industry sectors and transition stages.

Fifth, the study's subgroup analysis based on industry and transition stages may oversimplify the complexity of responding companies. To address this, future research should delve deeper into subgroups, collect concrete data, and conduct more nuanced analyses.

Sixth, recruiting participants for PFAS-related studies proved challenging, and some respondents lacked awareness of PFAS. Future studies should allocate more time for participant consultation and data triangulation.

Finally, the use of cross-sectional data limits the understanding of long-term technology acceptance for PFAS. Future research should use longitudinal analyses to track changes over time and identify the factors influencing technology acceptance throughout the PFAS phase-out process.

CONCLUSION

The phasing out of PFAS is a global challenge. Recent research has emphasized the need for an integrated approach to chemical assessment and environmental management, as substituted alternatives may pose similar or greater risks. The PFAS Guide was developed to aid corporations in this transition, with the goal of simplifying PFAS identification, safe substitution, and gradual elimination. This study applies the TAM to assess the intent of European companies to adopt the PFAS Guide based on PU and ease of use. Our analysis, which is based on responses from 104 companies, shows a positive correlation between PU, ease of use, and intent to adopt the PFAS Guide. This underscores the importance of corporations perceiving the PFAS Guide as a valuable and user-friendly resource, given its significant impact on PFAS phase-out.

Future revisions should prioritize ease of use and implement practical suggestions, such as clear instructions, videos, and a comprehensive overview. Respondents recommended implementing external-facing activities, such as awareness-raising events, workshops, and incorporating a question-and-answer section in the guide. They also proposed enhancing usefulness by providing more information on PFAS alternatives, offering a comprehensive overview of specific PFAS products, supplementing with additional sector-specific details, and collaborating with companies to simplify the PFAS phase-out process. In addition, the guide should incorporate a user-friendly interface, feedback integration, and interactive features, such as an online community, while balancing user-friendliness and content. Finally, we recommend broadening sector representation to encompass a more diverse range of industries with sector-specific guidance to ensure content relevance.

Future research should focus on the actual adoption and use of the PFAS Guide to gain deeper insights into adoption rates and long-term use. Investigations should include subgroup analyses, data triangulation, and a longitudinal approach to better understand the factors that support and hinder integrated chemical assessment and management, guide integrated chemical policy and practices, and contribute to a PFAS-free future.

AUTHOR CONTRIBUTION

Gina Zheng: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; software; writing—original draft; writing—review and editing. **Abby Muricho Onencan**: Conceptualization; project administration; supervision; validation; visualization; writing—original draft; writing—review and editing.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

OPEN DATA BADGE/OPEN MATERIALS BADGE

This article has earned an Open Data Badge and Open Material Badge for making publicly available the digitally shareable data necessary to reproduce the reported results. The data and material are available at https://10.17605/OSF.IO/8ZQEJ. Learn more about the Open Practices badges from the Center for Open Science: https://osf.io/tvyxz/wiki.

DATA AVAILABILITY STATEMENT

Data and associated metadata are publicly available and can be accessed through the following DOI 10.17605/OSF.IO/8ZQEJ or alternatively through this link: https://osf.io/8zqej/.

ORCID

Gina Zheng http://orcid.org/0009-0001-2299-2819
Abby Muricho Onencan http://orcid.org/0000-0002-5465-4806

SUPPORTING INFORMATION

TABLE S1: PFAS Guide survey.
TABLE S2: PFAS Guide survey: Recommendations from respondents.
TABLE S3: Frequency of the number of valid and missing data.
TABLE S4: Factor analysis.
TABLE S5: Total variance explained.
TABLE S6: Component matrix.
TABLE S7: Rotated component matrix.
TABLE S8: Descriptives and reliability analysis.
TABLE S9: Correlation analysis.
TABLE S10: Regression analysis.
FIGURE S1: Scree plot for the factor analysis.
FIGURE S2: Scatterplots for the correlation analyses.

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