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Research Paper

Determinants of Green Smartphone Application Adoption for Sustainable Food Consumption Among University Students

Arian Matin *
Tornike Khoshtaria **
Nugzar Todua ***
Ola Bareja-Wawryszuk ****
Tomasz Pajewski*****
Nia Todua ******

ABSTRACT

This study aims to investigate the determinants of green smartphone application adoption among users. The study employs content richness model and modified Unified Theory of Acceptance and Use of Technology (UTAUT) as well as extrinsic constructs such as customisation and environmental concerns. A quantitative approach using a survey is utilised by collecting 700 responses. The data is analysed using Structural Equation Modelling (SEM) and three machine learning techniques including Artificial Neural Networks (ANN), Classification Regression Tree (CRT) and Chi-Squared Automatic Interaction Detection (CHAID). The results indicate that UTAUT, customisation and environmental concerns positively impact the adoption of green applications. Further analysis revealed fitness of analytical methods and the importance of variables for the overall sample and the subsamples derived. The study provides theoretical and practical contributions to academics, marketers and software developers in understanding consumer behaviour in the field. The result assist developers and marketers to decipher consumer behaviour towards green applications for sustainable consumption. The research contributes to theory and practice by employing an integrative model to investigate the role of technology in sustainable consumption. Moreover, the findings revealed the fitness of three machine learning methods to analyse the data collected for green consumption and the importance of variables in the model. The data is collected by employing convenience sampling. Hence, the results cannot be generalised accurately. Furthermore, data collection is conducted using a cross-sectional approach. Future researchers can add to the findings using a probability sampling and/or longitudinal data collection to generalise the results and reveal the changes in consumer behaviour.

Keywords: Technology adoption; Green smartphone applications; Sustainability; Food consumption behaviour; UTAUT; SEM; Machine Learning

* International Black Sea University, Georgia. E-Mail: arianmatin@outlook.com
** Teaching University Geomedi, Georgia. E-Mail: tornike.khoshtaria@geomedi.edu.ge
*** Ivane Javakashvili Tbilisi State University, Georgia. E-Mail: nugzar.todua@tsu.ge
**** Siedlce University of Natural Sciences and Humanities, Poland. E-Mail: ola.bareja-wawryszuk@uph.edu.pl
***** Helena Chodkowska University of Technology and Economics, Poland. E-Mail: tomasz.pajewski@uth.edu.pl
****** Ivane Javakashvili Tbilisi State University, Georgia. E-Mail: niatodua24@gmail.com

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1. INTRODUCTION

Digital platforms have severely disrupted the markets in various manners from communication and collaboration to consumer behaviour (Goliński & Kozłowski, 2021). Moreover, the environmental impact of industrial production leading to the leap towards sustainability has become an increasingly significant factor influencing the decision-making process. Sustainability has recently affected the government, industrial, and consumer decision-making processes. All stakeholders endeavour to facilitate cleaner, resource-efficient production (Bengtsson and Ågerfalk, 2011; Hilpert *et al.,* 2014).

Technological advancements such as Information Technology (IT) systems have provided a new foundation for achieving resource-efficient production. IT systems have made various contributions to sustainability, from introducing new technologies to reducing energy consumption and efficiency during production and logistics processes (Perera *et al.,* 2018; vom Brocke *et al*., 2013)

However, most studies have focused on sustainability through IT systems at corporate or government levels. The lack of comprehensive research evaluating consumer perceptions towards sustainable IT systems has created a gap in linking corporate and legislator efforts with public awareness and consumption behaviour. The first step is to raise the level of awareness among users through digital platforms and assist them in identifying the essence of green consumption. Due to widespread usage, Smartphone applications can play a significant role in shaping green consumption (Bekaroo *et al.,* 2018; Brauer *et al.,* 2016; Lazzarini et al., 2018; Lemos Barboza & Arruda Filho, 2019; Singh, 2021).

It is determined that consumers` selection can be directed towards sustainable and organic products as the awareness of their choices' environmental impacts increases. Hitherto, researchers have explored the influence of eco-labelling on packages and providing sustainability rankings at the point of purchase (Osman & Thornton, 2019; Osman *et al.*, 2021). Even though packaging and point-of-purchase data can assist consumers in their perception of quality and selecting sustainable products, the extent of their impacts is limited (Grunert *et al.*, 2014; Song *et al.,* 2019; Temple, 2020). With Smartphones becoming widespread, researchers have emphasised the significance of digital platforms and Smartphone applications on both business-to-business and consumer selections (Chiu et al., 2022; Matin et al., 2023). The effect of these applications can be both in assisting regular purchasing processes with price and quality comparisons or facilitating sustainable and healthy consumption among customers (Kannan & Li, 2017; O'Rourke & Ringer, 2016; Remondes, 2021; Weber, 2021). In the context of higher education institutions, prior studies indicated that students do not engage in sustainable food consumption practices consistently due to low levels of awareness and understanding, however, the results may vary from sample to sample (Greene & Weller, 2012). Hence, this research attempts to measure the impact of green smartphone applications on sustainable food consumption among university students.

For this study, green Smartphone applications are defined as software designed for Mobile devices offering background information about various products. The information provided by the applications covers energy consumption during the production and transportation of the item and the product's overall environmental impact (Brauer *et al.,* 2016; Weiss et al., 2012). Previously, researchers have explored the traits and requirements for computing software packages that preserve energy on electronic devices and lower environmental impacts (Haraty & Bitar, 2019). Furthermore, sustainable lifestyle has been determined to include various dimensions. The need to investigate each of those dimensions from awareness and interest to purchasing behaviour is emphasised by previous researchers (Lubowiecki-Vikuk et al., 2021). As noted, even though the effect of packaging and software energy consumption have been tested among users. Prior literature indicated that younger cohorts of the population are more inclined to engage with brands and businesses through online channels (Mróz, B. 2021). As a result, understanding the determinants of green consumption through digital channels can be of significant interest for the researchers and practitioners. The current study focuses on an unexplored area, investigating the adoption of track and tracing applications among users.

However, this study extends the literature in two ways; firstly, by measuring the adoption of green Smartphone applications to guide the consumer towards green consumption regarding items such as groceries. The research introduces an integrative approach using the Content Richness model and the unified theory of acceptance and use of technology along with customisation and environmental concerns as extrinsic components. Secondly, the study compares three machine learning methods to test the fitness of data analysis for each method and discovers the importance of constructs determining the Unified Theory of Acceptance and Use of Technology (UTAUT) and overall adoption of green smartphone applications. The research also provides practical implications for marketers and software developers in designing and disseminating applications in the market. Therefore, the following objectives are formulated:

- To investigate the impact of the Content Richness model on perceived performance expectancy of green smartphone applications
- To find the effect of customisation on perceived effort expectancy of green smartphone applications
- To test the influence of UTAUT dimensions on the adoption of green smartphone applications
- To examine the effects of customisation and environmental concerns on the adoption of green smartphone applications

The next section explores previous literature investigating UTAUT in various contexts and formulating the hypotheses. Following the literature review, the methodology is explained and data analysis is conducted. Finally, the findings are discussed, theoretical and practical implications as well as limitations of the research, along with recommendations for future studies, are explained.

2. LITERATURE REVIEW

The revision of the previous literature indicated that content richness model and UTAUT along with customisation play a significant role in adopting new technologies. Ensuing previous studies, performance expectancy, as a component of UTAUT, is designed as the second-order construct impacted by the content richness model. Due to the nature of green applications leading to sustainable consumption, this study adds external constructs such as customisation and environmental concerns into the model. Hence, this section reviews the previous literature understanding the elements impacting the adoption of new technologies, including smartphone applications. Subsequently, the hypotheses are formulated to examine the impacts of green smartphone application adoption.

2.1 Content richness model

Primary constructs of content richness have been explored previously in the technology sector. The model defines content richness as available resources on the platform to improve user experience. Firstly, the information needs to cover a wide enough range of topics for the user. The platform ought to provide up-to-date information to the users. The information offered on the platform should also be relevant to the users` needs. (Chang & Tung, 2008; De Wulf *et al.,* 2006; Doll & Torkzadeh, 1988; Eiriksdottir & Catrambone, 2011; Jung *et al.,* 2009; Park *et al.,* 2009;) According to the above-noted traits, the model delineates three dimensions: timeliness, relevance and sufficiency. Previous studies have tested the impact of the noted constructs on the technology acceptance model. Their findings indicate that all three constructs are antecedents of users` perceived usefulness in various fields in the technology sector (Almarzouqi *et al.,* 2022; Chen & Lan, 2014; Lee, 2006; Park *et al.,* 2012; Young & Lehto, 2013;). Under UTAUT model perceived usefulness is covered in performance expectancy (Kemp et al., 2019). Even though, Pindeh *et al.* (2016) excluded timeliness and relevance constructs when examining the influence of content richness on perceived usefulness. Their study primarily focused on language learning through the mobile application. Nonetheless, the mentioned impact has yet to be tested for green mobile applications. The researchers accept all three dimensions since green applications` functionalities, such as traceability and health concerns, require recent and pertinent data. Therefore, this study posits:

- H1: Timeliness positively impacts green Smartphone applications` performance expectancy.
- H2: Relevance positively impacts green Smartphone applications` performance expectancy.
- H3: Sufficiency positively impacts green Smartphone applications` performance expectancy.

2.2 Customisation

Customisation is suggested as another construct influencing adoption and user experience in adoption online retailing (Morales-Solana et al., 2022). Customisation refers to the extent to which the platform can conform and personalise its content to the user`s needs and specifications. Suitable flexibility within the platform can enable the user to receive their required information precisely and quickly. Consequently, it leads to ease of use derived from greater perceived control and emotional satisfaction (Bilgihan *et al.,* 2015; Lee & Cranage, 2011; Rose *et al.,* 2012; Tam & Ho, 2005). As a result, various Smartphone applications allow users to store and manipulate their information for faster and easier utilisation (Hsiao *et al.,* 2016).

Prior studies have explored the influence of customisation on the Technology Acceptance Model. The findings determine that customisation can be considered an antecedent to the technology acceptance model. Specifically, the customisation construct has proven to facilitate perceived ease of use. Customised platforms can reduce the user`s effort in obtaining and utilising needed information. The direct impact of customisation on experience and usage has also been tested and confirmed. (Alnawas & Aburub, 2016; Kim & Baek, 2018; Magrath & McCormick, 2013; McLean *et al.,* 2018). Under UTAUT model, perceived ease of use is defined as effort expectancy (Kemp *et al*., 2019). Hence, this study utilises the customisation dimension and extends the literature by testing the impact of the construct on effort expectancy and adoption of the green Smartphone application sector. Therefore, the following hypothesis is formulated:

- H4: Customisation positively impacts green Smartphone applications` effort expectancy.
- H5: Customisation positively impacts the adoption of green Smartphone applications.

2.3 Unified Theory of Acceptance and Use of Technology (UTAUT)

Initially Technology Acceptance Model (TAM) was designed to explain individuals' acceptance of new information technology and information systems (Davis, 1989; Lee, Hsieh & Hsu, 2011). TAM facilitates understanding why individuals adopt a particular technology to perform a specific task (Davis, 1989; Venkatesh & Davis, 2000; Nasidi et al., 2022; Wallace & Sheetz, 2014). Moreover, The Technology Readiness Index (TRI) was designed to comprehend the readiness of potential users to adopt new technologies (Parasuraman & Colby, 2015). The index contains dimensions such as innovation, optimism, insecurity, and discomfort. The UTAUT was developed as a more comprehensive model to encompass the constructs in TAM and extend to other variables. Two main constructs in TAM are covered under performance and effort expectancy under the UTAUT model. The model then adds two more variables, social influence and facilitating conditions (Cabero et al., 2016; Venkatesh & Davis, 2000; Venkatesh et al.,2003). The UTAUT was also considered a more relevant model than TRI for green smartphone applications since it directly measures the perception of the user concerning the practicality and ease of use of the green applications.

Researchers have defined social influence or value as the extent of acceptance of the target technology by an individual`s family and peers. While, facilitating conditions explain the infrastructure support for integrating the target technology (Almousa et al., 2020; Venkatesh et al.,2003). In this study, the authors did not include facilitating conditions since the main environmental factor is owning a Smartphone and all respondents possess Smartphones and are able to download green applications. Even though UTAUT was initially designed to measure technology acceptance among employees in firms, researchers have extended its implications to consumer behaviour in various fields from online banking and educational institutions to mobile social commerce (Abbad, 2021; Chen, 2011; Huang *et al*., 2013; Kim & Lee, 2022).

Subsequently, UTAUT evaluates whether an individual develops favourable or unfavourable attitudes towards adopting certain technologies, which determines the level of intention to adopt these technologies (Chin & Todd, 1995; Kim, 2016; Wang *et al.,* 2012;). Nevertheless, external elements such as social, cultural, and political factors can affect the correlations within the model (Davis, 1989; Dwivedi *et al.*, 2019). This study extends the literature by testing modified UTAUT model to measure green Smartphone application adoption. The research also adds another extrinsic variable, environmental concerns, due to nature of green applications. Hence, the study posits:

- H6: Perceived performance expectancy positively impacts adoption of green Smartphone applications
- H7: Perceived effort expectancy positively impacts adoption of green Smartphone applications
- H8: Perceived social value positively impacts adoption of green Smartphone applications

2.4 Environmental concerns

Environmental concern has been linked to green consumption behaviour among consumers. It can be traced back to the level of anxiety an individual feels regarding the environmental impact of various industries. Specifically for consumers, these perceived impacts can influence the product they purchase. Environmental concern can be a product of objective eco-literacy (Aldrich *et al.,* 2007; Franzen & Meyer, 2010; Sousa et al., 2021; Vainio & Paloniemi, 2014).

Previous studies found that willingness to pay, overlooking discrepancies in prices and other sacrifices such as travel and time costs are higher among consumers concerned about the future of the environment (Fraj-Andr´es & Martínez-Salinas, 2007; Kim & Choi, 2005; Meyer & Liebe, 2010; Sapci & Considine, 2014). Nevertheless, the level of sacrifice consumers is willing to make for sustainable consumption is bound by some factors. Firstly, the consumer considers the cost discrepancy between green and non-green alternatives. Moreover, the noted sacrifice depends on how consumers` trust towards companies` sustainability campaigns (Choi & Fielding, 2013; Farjam *et al.,* 2019; Matthes & Wonneberger, 2014). Furthermore, studies have indicated that environmental concern is not the sole reason consumers adjust their behaviour. Therefore, researchers have incorporated this dimension as an extrinsic variable with other models to test its impact as a collective (Bamberg, 2003; Saari *et al.,* 2021; Wang, 2017).

Nonetheless, the level of awareness regarding the impact of human behaviour towards the environment is increasing rapidly. Thus, environmental concern is becoming a worldwide phenomenon (Borges et al., 2021; Givens & Jorgenson, 2013; Hadler & Haller, 2013). The primary function of green Smartphone applications is to enable sustainable consumption among consumers. As a result, this study 186tilizes environmental concern as another extrinsic factor and TAM to test its effect on user adoption. Thus, the following is posited:

- H9: Environmental concern positively impacts the adoption of green Smartphone applications

3. METHODOLOGY

A cross-sectional design was used to test the green Smartphone application adoption dimension. A web-based questionnaire was distributed among university undergraduate and post graduate students in Poland and Georgia since online grocery purchases are more common among younger segment of the market (Brüggemann & Pauwels, 2022). The data was collected between August 8, 2022, and November 3, 2022. The official email addresses of students were used to circulate the survey. A total number of 5 universities participated in the data collection. The survey was translated into Georgian and Polish for the respective subsamples and pilot tested among 20 students in each country to ensure the respondents can comprehend the questions with ease. Out of 1004 emails sent to collect the data, 700 responses were collected making the response rate of roughly 70%. The sample consists of 338 respondents from Georgia and 362 from Poland.

As noted, a total of 700 responses were obtained, using convenience sampling, analysed by confirmatory factor analysis and Structural Equation Modelling (SEM) (Greene & Weller, 2012,). SEM was employed since it enables concurrent evaluation of all the dimensions in the model (Bryne, 2013). Furthermore, to ensure the accuracy of responses, the authors included trap questions, negatively coded, to prevent respondents from answering the questions without carefully reading the items (McLean *et al.,* 2018). The study employed 5-point Likert scale questions (1=strongly disagree to 5= strongly agree). The constructs and measurements are presented in annex 1 at the end of the article.

Additionally, this study combines SEM with three machine learning techniques to compare the fitness of the analyses and the results in the context of green consumer behaviour (Ebrahimi et al., 2022; Shaikh, 2022). The result of ANN generated relative importance of constructs for the model. ANN was also utilised to test the significance among two subsamples (respondents residing in Poland and Georgia) as well as grouping subsamples into high and low tendency of green application adoption. ANN findings were then tested and compared to CHAID and CRT methods (Yau & Tang, 2018). Previously, researchers have compared the fit of neural and non-neural networks machine learning methods (e.g., decision trees) to test coded qualitative data and 5-star scale ratings (Alantari et al., 2022; Ghose et al., 2019; Zhang and Godes, 2018). This study seeks to test the diagnostic ability of the analysis methods on 5 points Likert scale items.

Demographic details of the sample indicate it consists of 271 males 43.7% and 429 females 56.3 %. Gender distribution among subsamples were roughly similar with 45% male and 55% female for Georgian and 43% male and 57% female in Polish subsamples. The majority of participants are between 18 to 25 year-olds (89 %), 26 to 35 year-olds (5.8%) and 36 to 45 (2.8 %). 46 to 55 and 56 or older share a mere 2 %. The authors also collated the details regarding Smartphone operating system the respondents use. IOS users constituted 53.4 % of the sample, while Android users 45.3 %, followed by Windows and other system users, count the rest of the 1.3 %.

According to the theoretical framework, we constructed the following research model for our study to facilitate the research process.

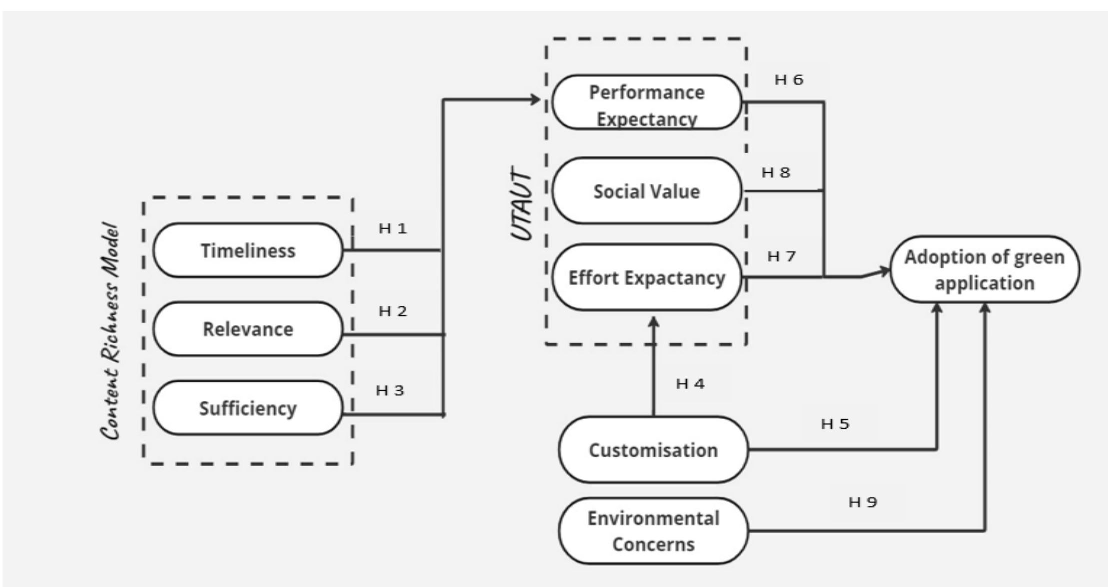

Figure 1. Research model

4. RESULTS

To measure the reliability and validity of the research model, the study utilises confirmatory factor analysis. The reliability of items and constructs was tested using Cronbach`s alpha and Composite reliability tests. Constructs exhibiting values higher than 0.7 using Cronbach`s alpha test were accepted regarding internal reliability. The study also set the threshold for Composite Reliability at 0.7. The results indicated that all the constructs in the model are reliable. Moreover, the Convergent Validity of the model was tested by computing the average variance extracted (AVE) with 0.5 thresholds. Factor loadings were also calculated, setting the threshold at 0.7 (Khoshtaria *et al.,* 2021; Matin *et al.,* 2021; Podsakoff *et al.,* 2003). Discriminant validity was also evaluated by generating a cross-loading table (see annexe 2). The results confirm the validity of the research model.

Table 1. Construct reliability and validity

Construct		Loading	Alpha	CR	AVE
Timeliness	Tmlns 1	.815	.812	.820	.534
	Tmlns 2	.727			
	Tmlns 3	.827			
	Tmlns 4	.747			
Relevance	Relev 1	.720	.834	.834	.559
	Relev 2	.764			
	Relev 3	.812			
	Relev 4	.776			
Sufficiency	Suff 1	.807	.865	.866	.619
	Suff 2	.864			
	Suff 3	.855			
	Suff 4	.794			
Customisation	Custmz 1	.783	.833	.834	.559
	Custmz 2	.836			
	Custmz 3	.834			
	Custmz 4	.767			
Performance expectancy	Perex 1	.816	.755	.766	.454
	Perex 2	.704			
	Perex 3	.792			
	Perex 4	.729			
Effort expectancy	Effex 1	.837	.894	.898	.688
	Effex 2	.796			
	Effex 3	.853			
	Effex 4	.736			
Social value	Socva 1	.838	.845	.849	.586
	Socva 2	.857			
	Socva 3	.837			
	Socva 4	.743			
Environmental concerns	EnvrCnc 1	.809	.829	.835	.628
	EnvrCnc 2	.842			
	EnvrCnc 3	.781			
Adoption of Green applications	SmrtApp 1	.888	.970	.971	.892
	SmrtApp 2	.904			
	SmrtApp 3	.913			
	SmrtApp 4	.906			

The fitness of the model was then explored by computing absolute and comparative fit values. Comparative Fit Index (CFI) stood at .896, and Incremental Fit Index (IFI) at .896. Furthermore, Goodness of Fit (GFI) was calculated at .861 and Root Mean Squared Error of Approximation at .65, chi-square value was also computed at 3.952. Thus, the authors can support the overall model fit (Byrne, 2013; Torlak *et al.,* 2019). Nearly 35% of respondents indicated that they have used green applications previously while 64% have not.

4.1 Hypothesis testing and analysis

In the table below, we summarise the test results of hypothetical relationships.

Table 2. Results of the hypotheses

Hypothetical Relationships		Est	S.E.	C.R	P	Status
H1	Timeliness ---> Performance expectancy	.099	.016	6.390	***	Supported
H2	Relevance ---> Performance expectancy	.226	.025	9.196	***	Supported
H3	Sufficiency---> Performance expectancy	.099	.022	4.432	***	Supported
H4	Performance expectancy ---> Smart App Adoption	.320	.027	11.940	***	Supported
H5	Effort expectancy ---> Smart App Adoption	.054	.025	2.153	.031	Supported
H6	Customisation ---> Effort expectancy	.001	.020	.030	.976	Not Supported
H7	Customisation ---> Smart App Adoption	.119	.023	5.157	***	Supported
H8	Social value ---> Smart App Adoption	.073	.023	3.149	.002	Supported
H9	Environmental concerns ---> Smart App Adoption	.151	.022	6.810	***	Supported

As we can observe, only H6 is not supported as the P value is well above the significance level of .05.

4.2 Artificial Neural Networks (ANN)

ANN analysis was first carried out to compare the machine learning methods. The impact of the components constituting the content richness model was tested separately on performance expectancy (Figure 3) since the constructs do not directly impact green smartphone application adoption. The result indicated that relevance (RLV) is the main driver of performance expectancy (PEREX), followed by timeliness (TML) and sufficiency (SUFF) (table 3). The second stage of the analysis included Effort expectancy (EFFEX), Performance expectancy (PEREX), Social value (SOCVA), Customisation (CUST), and environmental concerns (ENVIC).

The analysis utilised a multilayer perceptron approach by employing a hyperbolic tangent activation function and standardised neuron values. The study partitioned the sample by assigning 80% for training and 20% for testing to prevent overfitting (Li´ebana-Cabanillas *et al.,* 2018; Sharma and Sharma, 2019). The relative errors resulting from the training (0.454) and testing partitions (0.448) were evaluated. The low discrepancy between the error terms allowed the researchers to conclude a satisfactory precision for the model. Moreover, squared multiple correlations for the residuals were calculated ($R^2 = 0.0002$), which determined that the error term does not impact the analysis of the model (Almarzouqi *et al*., 2022; Aryadoust and Baghaei, 2016).

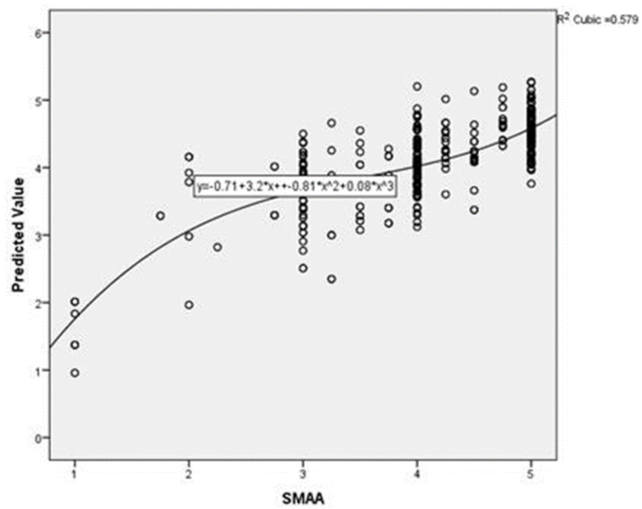

Figure 2. Goodness of fit

Finally, the goodness of fit was tested for the ANN model and compared against SEM to evaluate the accuracy of the analysis. ANN rendered a fit of $R^2 = 0.579$ using the cubic fit method (Figure 2), while SEM resulted in a fit of $R^2 = 0.29$. The higher goodness of fit value generated by the ANN approach revealed that the analysis is more suitable to expound upon the dependent construct variance (Leong *et al.,* 2019). The following figures illustrate the ANN results.

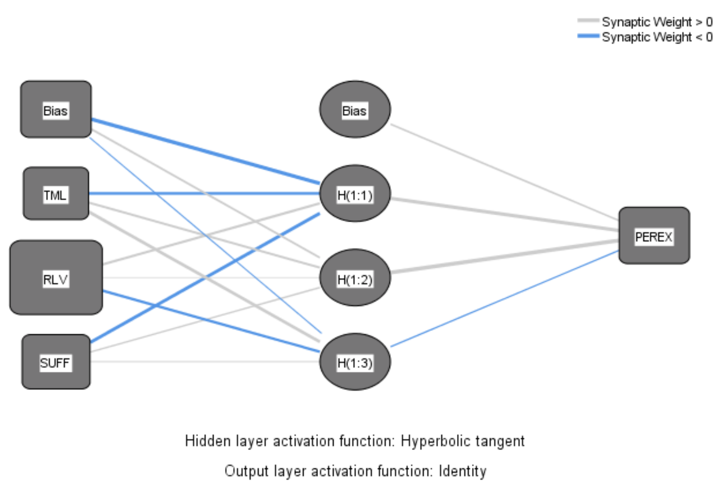

Figure 3. ANN analysis (first fragment)

Table 3. Independent Variable Importance (Performance expectancy)

	Importance	Normalised Importance
TML	.366	73.7%
RLV	.496	100.0%
SUFF	.138	27.8%

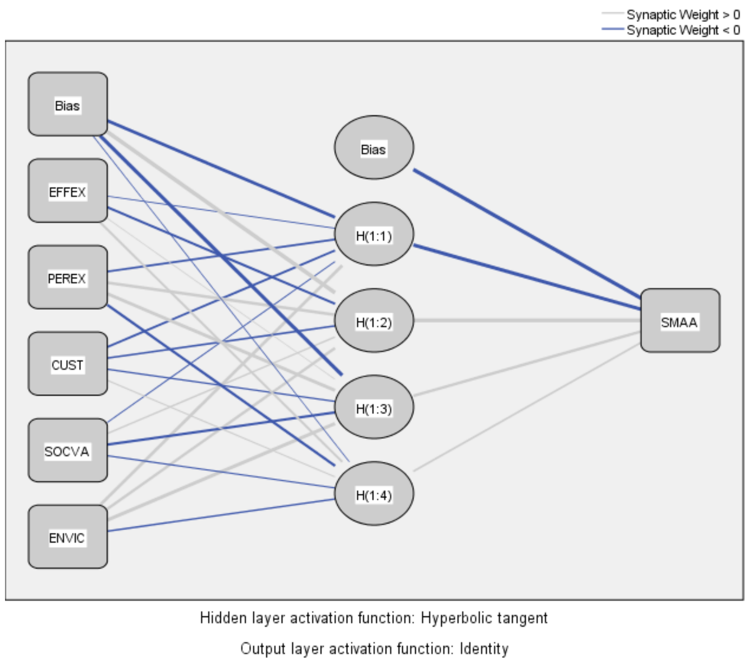

Figure 4. ANN analysis (second fragment)

4.3 Exogenous constructs importance analysis

The analysis revealed that performance expectancy is the main determinant of green Smartphone Application Adoption (SMAA), followed by environmental concerns, customisation, social value, and effect expectancy.

Table 4. Independent Variable Importance

	Importance	Normalised Importance
EFFEX	.137	45.3%
PEREX	.302	100.0%
SOCVA	.152	50.2%
CUST	.203	67.2%
ENVIC	.207	68.7%

The study then divided the sample into two groups and conducted separate ANN analyses on each subsample (Weller et al., 2014). The analyses exposed interesting results. The first subsample consists of respondents residing in Poland and the second subsample are residents in Georgia. The analysis revealed relative errors were lower for both subsamples by utilizing the Sigmoid activation function using two hidden layers (Annexes 3 and 4). effort expectancy is the primary driver of SMAA in both subsamples. However, among respondents in the first subsample (Poland), customisation is the second impacting variable followed by environmental concerns, health consciousness and effort expectancy (table 5).

Table 5. Independent Variable Importance subsample 1

	Importance	Normalised Importance
EFFEX	.025	4.3%
PEREX	.594	100.0%
SOCVA	.036	6.1%
CUST	.195	32.7%
ENVIC	.149	25.1%

The analysis from the second subsample revealed that environmental concern becomes the second important variable, followed by customisation, social value, and performance expectancy (table 6).

Table 6. Independent Variable Importance subsample 2

	Importance	Normalised Importance
PEREX	.017	3.6%
EFFEX	.467	100.0%
SOCVA	.077	16.6%
CUST	.106	22.6%
ENVIC	.334	71.5%

The analysis determined respondents from both countries are incentivised primarily by utilitarian motivator (performance expectancy). However, customisation and environmental consciousness change their level of importance between the two subsamples. Among respondents from Poland, application personalisation can play a more significant role in adoption rate. While, among Georgian respondents' environmental concerns is a more essential element for the adoption of the applications.

4.4 Decision tree determining model

To further compare the fitness of machine learning methods to the study, the authors utilised decision tree classification. The model tests the predictive ability of machine learning models using scale items (Song & Kim, 2018). In line with previous methods, the adoption of green Smartphone applications for sustainable consumption was considered as the outcome. Performance expectancy, effort expectancy, social value, customisation, and environmental concerns were placed as independent variables.

Initially, the Chi-squared Automatic Interaction Detection (CHAID) method was applied to the data. The analysis generated seven terminal nodes. The results revealed that similar to ANN analysis, performance expectancy is the primary indicator of adoption. While, the second branch determines that social value is the second driver for adoption (3.75 to 4, 33%). The result is displayed below:

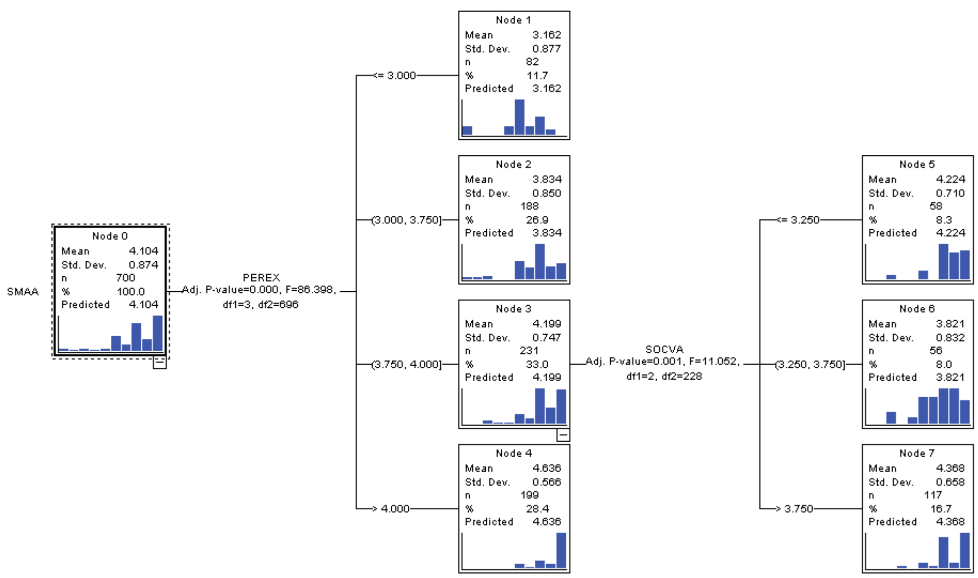

Figure 5. CHAID Decision tree

However, the analysis indicated that overall risk of incorrect predictions using CHAID decision tree is very large for testing sample (risk estimate= 0.54). Therefore, diagnostic ability of decision tree cannot precisely predict the majority of cases in the dataset.

The same procedure was conducted using THE Classification and Regression Tree (CRT). CRT provides relative importance of variables making it a touchpoint for comparison to CHAID and

ANN analyses (Romano et al., 2014). The advantage of CRT is that the method allows combining nominal and exploratory as well as scale datasets (Breiman et al., 1984). The result rendered six terminal nodes. Once again, performance expectancy was computed to be the primary indicator and social value was the secondary driver (≥3.875, 61%) (Annex 5). Similar to CHAID method, the regression tree also produced high-risk estimates (0.583), rendering the analysis incompatible with the dataset.

Interestingly, the predictive power of both Chi-Squared Automatic Interaction Detection and Classification and Regression Tree drastically increased for the subsample of respondents with high intention to adopt the applications (CHAID risk estimate= .159 and CRT risk estimate= .161). While, among respondents with low adoption tendencies, the risk estimate for both methods was back to near-random selection levels (CHAID risk estimate= .430 and CRT risk estimate=.459) indicating an incompatible fit of the method to the dataset (Appendix 1 supplementary material).

Among respondents with high adoption tendencies, the CHAID method determined performance expectancy followed by social value and environmental concerns are the main predictors of adoption. While CRT methods included only performance expectancy and social value as the drivers for the adoption of green smartphone applications (Appendix 2 supplementary material).

5. DISCUSSION

This study adds to the findings of previous researchers indicating the effect of content, in the technology sector, on perceived usefulness (Almarzouqi *et al.,* 2022; Chen and Lan, 2014;) by confirming the impact on performance expectancy under UTAUT. Furthermore, this research determined the impact of customisation on the adoption rate among consumers in the technology segment (Hsiao *et al.,* 2016; Kim & Baek, 2018). Previous literature has theorized the link between customisation on ease of use as a dimension of the Technology Acceptance Model (Bilgihan et al., 2015; Lee & Cranage, 2011). However, the impact of customisation on Effort Expectancy as a dimension of the UTAUT has not been explored. This research tests the impact of customisation on Effort Expectancy in the context of green smartphone applications. However, the findings revealed that the impact of customisation on green smartphone application`s effort expectancy is not significant. The results partly contradict the previous findings theorizing the effect of customisation on perceived ease of use. Nonetheless the previous studies have tested the link in the context of TAM and this research investigated the relationship in the context of UTAUT.

Since green smartphone applications are designed for sustainable consumption, this study included environmental concerns as another external construct (Saari *et al.,* 2021; Sapci and Considine, 2014; Wang, 2017). Previous studies have indicated that the level of awareness and environmental concerns affect purchasing behaviour (Borges et al., 2021; Givens & Jorgenson, 2013). Nevertheless, the link between environmental concerns and the use of track and tracing smartphone applications has not been investigated by previous studies. This research examined the impact of the environmental concerns as an extrinsic construct, along with the UTAUT and customisation on the adoption of green applications. The result determined that the level of environmental concerns among users can elevate green application adoption.

The UTAUT model was developed to investigate the adoption of target technology among intended users. The model was later tested in various sectors such as the education sector and mobile applications use (Abbad, 2021; Kim & Lee, 2022; Venkatesh et al.,2003). However, this study seeks to add to the previous body of literature by investigating the impact of UTAUT dimensions on adoption of track and tracing green smartphone applications. The results indicated that performance expectancy, effort expectancy, and social influence affect the level of adoption of the applications among users. The research revealed that consumers expect a user-friendly application with ample content that can be customised to their requirements. Consumers adopting green applications also tend to be oriented towards a healthy lifestyle and being environmentally conscious.

This study contributes to previous findings in several directions. Past researchers have utilised the technology acceptance model in other fields of technology (Mousa *et al.,* 2020; Rafique *et al.,* 2020) and to assess the intention to use conventional smartphone applications (Lazzarini et al., 2018; Lemos Barboza & Arruda Filho, 2019). This research extends the literature by testing the impact of UTAUT on green applications facilitating sustainable consumption.

This study also included external constructs (customisation and environmental concerns) (Farjam et al., 2019; Saari et al., 2021) complementing UTAUT to arrive at a more comprehensive model. The noted constructs and the content richness model resulted in an integrative model predicting green smartphone application adoption.

Furthermore, the study employs ANN to complement SEM analysis of previous literature (Almarzouqi et al., 2022; Aryadoust & Baghaei, 2016; Sharma & Sharma, 2019). ANN analysis revealed a higher fit for the model in non-linear predictions. The authors extended the literature, conducting ANN analysis for subsamples in the model by dividing the respondents into Polish and Georgian residents. Subsequently, by grouping subsamples into high and low tendencies of green application adoption. The result emphasises the necessity of flexibility in the model in terms of focus on specific constructs.

The analysis of the dataset was designed to compare the findings and predictive ability of ANN against two non-neural network machine learning techniques, specifically decision trees (Alantari et al., 2022; Romano et al., 2014). The study adds to the literature by examining the fit of noted machine learning techniques to estimate the adoption tendency for green Smartphone applications. The analysis showed that Chi-Squared Automatic Interaction Detection as well as Classification and Regression Tree methods can be utilized for predicting behaviour for the segment of consumers with high adoption tendencies. Moreover, the study contributes to the literature by comparing the estimates of decision tree methods to ANN results. The examination revealed that the accuracy of ANN analysis in determining the importance of independent variables is higher than the CRT method (Appendix 3 supplementary material). The study determines that apart from the segment with high adoption tendencies, where decision tree generates low-risk estimates, the overall data can be analysed more accurately using ANN analysis. Unlike ANN, non-neural network analyses also prioritised the role of social influence indicating variability of findings by different machine learning methods.

The research can assist marketers and managers through diverse means. Firstly, by including external constructs, the study revealed the traits of consumers willing to adopt the green application. The result can support practitioners in segmenting the market and precise targeting. The findings can also assist developers in prioritising elements such as content quality and customisation to elevate the adoption of green applications. Previous literature has recommended that technology developers regularly update the platform information and functionality to boost the adoption rate (Almarzouqi et al., 2022; Chen & Lan, 2014). Thus, this study suggests that application developers cover and track a more comprehensive range of products regarding environmental impact and reduce the response time for consumers seeking information from the application.

Another practical implication of the study is confirming the effect of customisation on user adoption tendencies (Kim & Baek, 2018; McLean *et al.,* 2018). The research suggests that developers personalise green applications to users` specific needs. Personalised design can decrease the effort and time required by the user to request and retrieve environmental information about the products, such as emissions and carbon footprint.

The results can also assist marketers seeking green consumption in persuasion techniques, among consumers from different countries, to adopt green applications. The findings determined that practitioners should focus on performance expectancy for both segments of the consumers. However, to persuade consumers, from first subsample, to adopt green applications, marketers should highlight the application's personalised design while promoting the social value and norms of green consumption. While environmental impact of sustainable consumption should be prioritised for the consumers from the second subsample. The reason behind significance of environmental impact among the second subsample can be found in legal and economic development. Georgia, as a developing country, does not possess the legal guard rails necessary to protect the environment and promote sustainable consumption. Therefore, consumers may compensate the lack of oversight by placing a higher emphasis on environmental concerns.

6. CONCLUSION

This study is empirical research evaluating green smartphone application adoption. The research combined the content richness model as a determinant of UTAUT. The integrative model used in the study revealed that UTAUT intensifies consumers' tendencies to use green smartphone applications. Moreover, the study determined that the content richness model elevates the adoption tendency through performance expectancy.

6.1 Limitations of the study

Even though the study extends the literature, some limitations can be further examined in the future. The survey method revealed significant findings; however, the study’s cross-sectional nature limits the findings to a specific timeframe. Moreover, the study categorised consumers into two main groups according to two main subsamples from Georgia and Poland. The authors recommend that future researchers explore further consumer classifications to examine other potential configurations (Um *et al.,* 2022). Frthermore, the non-probability sampling method was utilised for data collection, limiting the ability to generalise the results. Lastly, the research utilized 5-points Likert scale items to measure the constructs and determine the relationships hypothesised in the model. This limits exploring the wider spread of responses along the scale (Tarka, 2017).

6.2 Recommendations for future studies

Due to cross-sectional nature of this study, future researchers can expand the findings and conduct cohort or longitudinal analysis to test the model (Almarzouqi et al., 2022). Moreover, the current research employed a non-representative sampling method. As a result, the authors suggest that future researchers use a representative sample to evaluate the application of the model and configurations obtained from the analysis. Moreover, the study used predetermined models such as the Content Richness model and UTAUT, therefore future researchers can expand the findings by employing exploratory and qualitative methods to discover richer data and the potential determinants of green smartphone application adoption. The future research can also expand beyond use of the green application and measure the degree and kind of engagement with the applications by employing quantitative and qualitative methods respectively.

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Annexe 1. Research construct and measurement

Construct	Items	Adopted from
Timeliness	It normally faster than I expect to find items on the app It normally does not takes too long searching for items on the app Green Smartphone applications provide updated information It does not take long searching for items on the app	Almarzouqi *et al.,* (2022) De Wulf *et al.,* (2006) McLean *et al.,* (2018)
Relevance	Green Smartphone applications provide adequate content. I consider green Smartphone applications as a valuable source of information. Green Smartphone applications provide acceptable content that meets my needs. Shopping from the app makes my life easier.	Almarzouqi *et al.,* (2022) De Wulf *et al.,* (2006) Weber (2021)
Sufficiency	Green Smartphone applications offer adequate information. Green Smartphones applications offer sufficient information when I use it. Green Smartphone applications offer the information I need for personal use. Green Smartphone applications offer the information I need for personal use.	Almarzouqi *et al.,* (2022) De Wulf *et al.,* (2006)

Effort expectancy	Learning to use the app is easy for me I find it easy to get the app to do what I want it to do My interaction with the app is clear and understandable I find the app to be flexible to interact with It is easy for me to become skillful at using the app (Dropped) I find the app easy to use (Dropped)	Davis (1989) McLean *et al.,* (2018) Venkatesh et al. (2012)
Performance expectancy	I believe that the use of the mobile device application would make my shopping process more effective I believe that the use of green mobile device application would make my shopping process more convenient I think that I would save time by using green mobile device application while shopping I believe that, in general, using green mobile device application in my shopping process would have been useful	Shukla and Sharma (2018) Venkatesh et al. (2012)
Social influence	People who are important to the me think that I should use the application People who influence my behaviour think that I should use the application My friends recommend the applications as an efficient way to shop My family support the use of the applications	Abbad, (2021) Venkatesh et al. (2012)
Customisation	It feels like the app is talking personally to me as a customer The app can be personalized to my needs It is important to me that the app feels like my personal area when I use it The requirement to log into the app makes me feel recognized as a customer	McLean *et al.,* (2018) Rose et al. (2012)
Environmental concerns	I am concerned about the environment The condition of the environment affects the quality of my life I am willing to make sacrifices to protect the environment	Matthes & Wonneberger, (2014) Weber (2021)
Adoption of Smartphone applications	Using green Smartphone applications is recommended Using green Smartphone applications helps me I will use green Smartphone applications if available in the future I intend to keep using of mobile app for buying groceries in the future	Davis *et al.,* (1989) Rai and Selnes (2019) Venkatesh *et al.,* (2003)

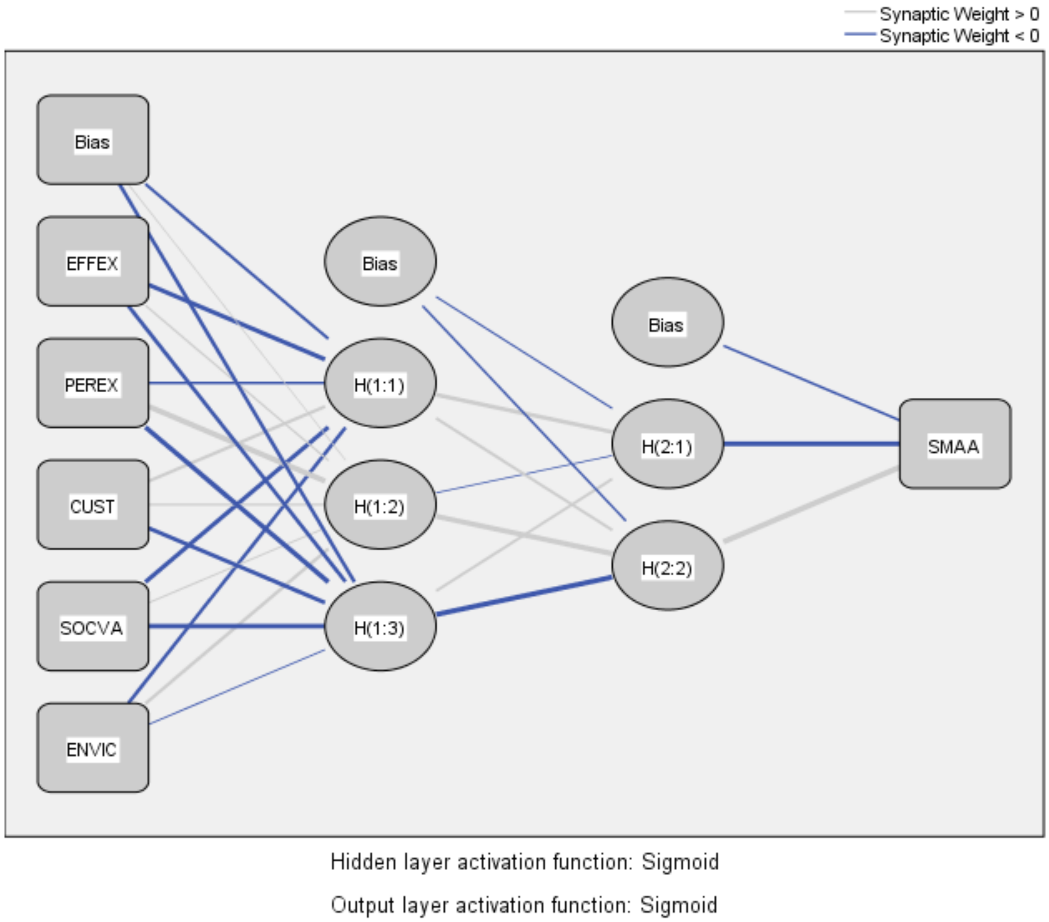
Annex 2. Factor tabulation matrix

	Component								
	1	2	3	4	5	6	7	8	9
Tmlns1	-.065	-.023	.051	.026	.093	-.028	**.815**	-.001	.062
Tmlns2	.104	.062	-.052	-.003	.237	.018	**.727**	.091	.049
Tmlns3	.133	.133	-.009	-.007	.072	-.010	**.827**	.062	.076
Tmlns4	.104	.142	.101	.025	.148	.118	**.747**	.005	.081
Relev1	.088	.146	.130	-.123	**.720**	-.010	.079	.023	.105
Relev2	.099	.184	.097	.007	**.764**	.030	.166	.009	.225
Relev3	.059	.119	.125	.007	**.812**	.024	.138	.050	.028
Relev4	.115	.117	.032	-.003	**.776**	.038	.194	-.025	.098
Suff1	.096	.038	**.807**	-.052	.189	-.062	.072	.027	.117
Suff2	.028	.102	**.864**	-.072	.109	-.049	.037	.028	.083
Suff3	.027	.042	**.855**	.047	-.048	.043	.015	-.028	-.078
Suff4	.096	.027	**.794**	-.146	.131	.036	-.028	-.002	-.091
Effex1	.061	.041	-.064	-.060	-.043	.072	.086	**.816**	-.105
Effex2	-.029	.032	.062	.076	.114	-.042	.031	**.704**	.070
Effex3	.100	-.017	-.059	.013	-.015	-.052	.011	**.792**	.051
Effex4	-.043	.019	.070	.005	-.010	.013	.014	**.729**	.148
Perex1	.229	**.837**	.085	.009	.165	.087	.067	.022	.135
Perex2	.276	**.796**	.021	.041	.108	.111	.109	.088	.156
Perex3	.228	**.853**	.030	.053	.153	.061	.063	-.010	.092
Perex4	.196	**.736**	.102	-.036	.188	.022	.111	.004	.097
Custmz1	.111	.115	-.012	.071	.048	**.783**	.009	-.023	-.084
Custmz2	.032	.029	.015	.041	-.035	**.836**	.009	.018	.147
Custmz3	.110	.020	-.074	.066	-.030	**.834**	.040	-.069	.050
Custmz4	.036	.061	.046	.004	.090	**.767**	.026	.054	.166
SmrtApp1	**.888**	.267	.061	.064	.119	.112	.062	.045	.084
SmrtApp2	**.904**	.245	.069	.072	.088	.106	.125	.018	.070
SmrtApp3	**.913**	.221	.094	.083	.091	.075	.071	.053	.096
SmrtApp4	**.906**	.216	.069	.050	.112	.073	.054	-.007	.112
Socva1	-.058	.026	-.065	**.838**	-.062	.058	-.031	.098	.114
Socva2	.031	.029	-.053	**.857**	-.061	.068	.032	.017	.092
Socva3	.070	.034	-.088	**.837**	.008	.032	-.055	.007	.022
Socva4	.173	-.034	.003	**.743**	.009	.026	.095	-.071	-.084
EnvrCnc1	.120	.176	.018	.000	.143	.071	.142	.037	**.809**
EnvrCnc2	.071	.129	.000	.008	.084	.117	.169	.111	**.842**
EnvrCnc3	.129	.122	-.006	.154	.207	.115	-.028	.062	**.781**

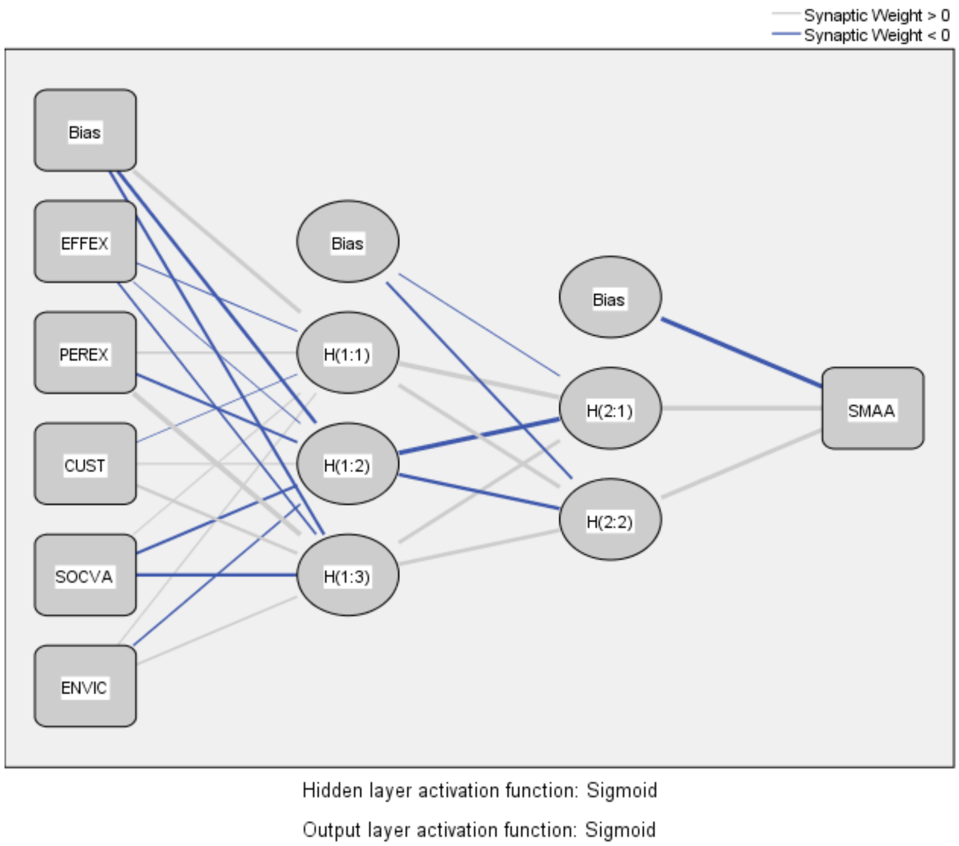
Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

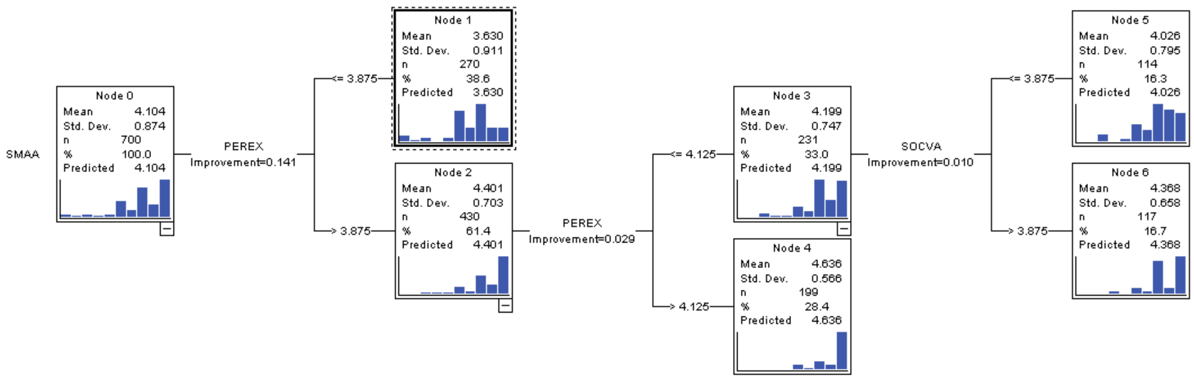
Annex 3. ANN analysis (Poland Subsample)



Annex 4. ANN analysis (Georgia Subsample)



Annex 5. Classification and Regression Tree



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