ASSESING ROMANIAN FARMERS' MOTIVATION FOR DIGITALIZATION: A UNIFIED THEORY OF ACCEPTANCE AND USAGE OF TECHNOLOGY (UTAUT) BASED RESEARCH MODEL

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Abstract: *The digital agriculture adoption strive by farmers could be assimilated with the adoption efforts of the computer technologies (ICT) by their respective users in other professional fields. Therefore, this paper proposes the adaptation of the Unified Theory of Acceptance and Usage of Technology (UTAUT) model to explore the motivations for the use of digital tools by field crop farmers in Romania. The history of TAM and UTAUT is explored as well as the usage of UTAUT2 and UTAUT3 in digital agriculture adoption studies globally. Furthermore, comparison is also made with other farmer studies based on a different research architecture conceived also to explore their motivations to use digital agriculture tools. The proposed model is building on the decades long research and validation of the UTAUT model, and it will be employed in subsequent quantitative studies to evaluate the Romanian farmers' motivations to embrace the digital agriculture technologies and practices. The paper is the outcome of the individual research done by the author and it was enhanced following academic debates and conference presentations. It is deemed to have a dual applicability, as a field tool for academic research but also provides guidance for companies developing digital tools for farmers in Romania and beyond.*

Keywords: Digital Agriculture/Agriculture 4.0; Technology Acceptance Models.

JEL classification: Q16, Q31, Q32, Q33, Q55.

1. Introduction

Digital agriculture is about using digital technologies for a more productive, more efficient, and less ecologically impactful farming. Earlier works (Markovits, 2022, 2023) using bibliometric maps support the description that digital agriculture, also known as Agriculture 4.0, is digitally enhanced (Bucci, Bentivoglio and Finco,, 2018) precision agriculture (ISPA, 2019) using industry 4.0 technologies such as: sensors, cloud computing and artificial intelligence (Braun, Colangelo and Steckel, 2018, Kamilaris, Karakoulis and Prenafeta-Boldu, 2017) with the intent to generate solutions for a smart/smarter farming: more productive, more efficient, more environmental friendly and less climate dependent.
The commonly held opinion in the reviewed literature on the topic (Abbasi, Martinez and Ahmad,2022, Albiero et al., 2020, Dayiloglu and Turker, 2021, Elijah et al., 2018, Goedde et al., 2020, Klerkx, Jakku and Labarthe,2019, Latino et al., 2021, Liakos et al., 2018, Roland Berger 2015, 2017, Saiz-Rubio and Rovira-Mas, 2020, Zambon et al., 2019, Zhai et al.,

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2020) is that, digital agriculture is a direct application of the recent innovations in sensor technology (e.g. multispectral cameras), digital image processing (e.g. satellite images), data analysis (big data, cloud computing, deep learning), data visualization as well as satellite positioning systems (e.g. GPS and RTK) using the connectivity offered by the Internet of Things (IOT) in the monitoring of crops, farm works management (sowing, treatments, irrigation, harvesting, inbound and outbound logistics) and administration of the farm assets such as: inputs (seeds, crop nutrition products, crop protection products, fuel), land, water, machine tool fleets.

Considering that all of the above can be done by using specialized software and very often with dedicated hardware we might consequently state that day to day activities in digital agriculture require the extensive use of Information and Computer Technologies (ICT). Therefore, knowing the levers that stimulate or inhibit usage of ICTs seems the right starting point in understanding the levers for usage and adoption of digital agriculture.

The literature that focused on the key barriers to the adoption of Agriculture 4.0 (Bucci, Bentivoglio and Finco, 2018, Pierpaoli et al., 2013, Tey and Brindal, 2012) revealed the following list of factors: cost, lack of technical skills, limited access to technology due to infrastructure or connectivity issues, resistance to change, concerns about data privacy and security.

2. Literature review

2.1 Models for Technology Acceptance (TAM/TAM2/UTAUT/UTAUT2/UTAUT3)

The extensive use of computer-based technologies in commerce, telecommunications, medicine, banking followed more recently by home entertainment, education and even smart homes justifies the decades long interest and accompanying research work in studying the drivers of technology acceptance and usage (Marikyan and Papagiannidis, 2023, Moon and Kim, 2001, Wang et al., 2021)

The earliest model, named the Technology Acceptance Model (TAM), was formulated by F.D. Davis while at the University of Michigan in 1989 (Davis, 1989) and sustained that perceived usefulness (PU) and perceived ease of use (PEOU) (see also Venkatesh and Davis, 1996) of a technology are the key determinants of user acceptance other words if a technology is perceived to be useful and easy to use then it is more probable to be adopted. Almost a decade later, Venkatesh and F.D. Davis extended the original TAM to the TAM2 (Venkatesh and Davis, 2000) by adding to the two original core constructs of TAM, perceived usefulness (PU) and perceived ease of use (PEOU), two additional factors: social influence processes (subjective norm, voluntariness, and image) and cognitive instrumental processes (job relevance, output quality, result demonstrability).

In 2003, Venkatesh (University of Maryland), Morris (University of Virginia), G.B. Davis (University of Minnesota), and F.D. Davis (University of Arkansas) unified the factors influencing the acceptance and usage of technology in a model known as: The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). The new model combined eight prominent models at the time: Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975), the Theory of Planned Behavior (TPB) (Ajzen, 1985), the Social Cognitive Theory (Bandura, 1986), the Technology Acceptance Model (TAM) (Davis, 1989), the Motivational Model (MM) (Davis, Bagozzi and Warshaw, 1989), the Model of PC Utilization (MPCU) (Thompson, Higgins and Howell, 1991), a model combining the Technology Acceptance Model and the Theory of Planned Behavior (Taylor and Todd, 1995) and the Innovation Diffusion Theory (DOI) (Rogers, 2003).

The UTAUT model proposed four key determinants of technology acceptance:

- *Performance Expectancy*: the belief that using a particular technology will augment job performance or make tasks easier to accomplish.

- *Effort Expectancy*: the belief that using a technology will be easy and requiring less effort.
- *Social Influence*: the influence of social factors such as colleagues, supervisors, and other social relationships as well as norms on the individual's decision to accept and use a technology.
- *Facilitating Conditions*: the perception that the necessary resources, support, and infrastructure are available to facilitate the use of the new technology.

UTAUT also considers that *gender, age, experience, and voluntariness of use*, could moderate the relationships between the four key determinants and technology acceptance.
In the validation process the eight individual models explained between 17 percent and 53 percent of the variance while the Unified Theory of Acceptance and Use of Technology (UTAUT) explained 77 percent of the variance in behavioral intention to use the technology and 52 percent of the variance in technology use (Venkatesh et al, 2016) thus outperforming the eight individual models. One of the main limitations of the model was that it was constructed to assess the behavior of employees in an organizational setting while non-organizational usage of technology was not studied. Arguably, consumers would behave differently vs employees.
In order to extend the validity of the model also for non-organizational settings (i.e., consumers) UTAUT2 was created as an extended version (Brown and Venkatesh, 2005) of the UTAUT model and included additional constructs such as “hedonic motivation”, “price value” and “habit” while removing “voluntariness” as moderating factor (Venkatesh, Thong and Xu, 2012). The new model considers that the use of technology by individuals in a non-organizational setting is also influenced by these three new constructs (hedonic motivation, price value, habit) and moderated by age, gender and experience. The “price value” construct is a valuable new addition as it accounts for the fact that unlike in the organizational setting in the case of consumers there is a cost for adopting the new behavior. This is also an important construct for our situation where farmers will most likely have to pay for at least part of the digital services, making UTAUT2 a better model to study farmers’ technology acceptance and usage in a business model that requires them to pay at least for part of the services rendered. A UTAUT2 questionnaire that includes the additional constructs could look like below:

1. *Performance Expectancy (PE)*
    - Using the technology enables me to accomplish tasks more quickly.
    - The technology enhances my effectiveness in performing tasks.
    - The technology improves my job performance.
2. *Effort Expectancy (EE)*
    - Learning to use the technology is easy for me.
    - I find the technology easy to use.
    - The technology is user-friendly.
3. *Social Influence (SI)*
    - People who influence my behavior think that I should use the technology.
    - People whose opinions I value think that I should use the technology.
    - People who are important to me think that I should use the technology.
4. *Facilitating Conditions (FC)*
    - The necessary technical support is available to me for using the technology.
    - I have the resources necessary to use the technology effectively.
    - The technology is compatible with other systems I use.
5. *Hedonic Motivation (HM)*
    - Using the technology is enjoyable for me.

- The technology provides me with a pleasurable experience.
- I find the technology fun to use.

6. *Price Value (PV)*
   - The benefits of using the technology justify its cost.
   - The technology offers good value for the money.
   - The cost of using the technology is reasonable.
7. *Behavioral Intention to Use (BIU)*
   - I intend to use the technology in the near future.
   - I plan to use the technology regularly.
   - I expect that I will use the technology frequently.
8. *Use Behavior (UB)*
   - I currently use the technology.
   - I have used the technology in the past.
   - I use the technology on a regular basis.

The history to date of technology acceptance models also includes the amendment of the UTAUT2 (Dwivedi et al., 2019) where “attitude” partially mediates the effects of performance expectancy, effort expectancy, facilitating conditions and social influence on behavioral intent as well as a direct effect on usage behavior.

UTAUT3 (Farooq et al., 2017) is characterized by the introduction of the “personal innovativeness” construct. However, The Web of Science search for “UTAUT3” materials yielded only 5 articles, 2 related to payments (Chen et al., 2019, Saha and Kiran, 2022) and 3 related to education (Tiwari et al., 2022, Gupta, Mathur and Narang , 2022, Gunasinghe et al., 2020) suggesting a relatively small number of use cases.

One of the most important UTAUT2 extensions present in the literature is the one done to assess the willingness to pay for agricultural IoT by Shi and his team (Shi et al., 2022). They examined the factors influencing the willingness to adopt and pay for the Internet of Things (IoT) in the agricultural sector, by interviewing 345 farmers (premium fruit growers) from the northern districts of Bangladesh. The used model emulated the UTAUT 2 from which Habit (HB) was eliminated and new constructs were added: Trust (TT), Government Support (GS) and Willingness To Pay (WTP). The Structural Equation Modeling confirmed that effort expectancy (EE), performance expectancy (PE), facilitating condition (FC), price value (PV), personal innovativeness (PI), hedonic motivation (HM), government support (GS),and trust (TT) influence the willingness of Bangladeshi farmers to adopt the IoT(WTA), that in turn determines the willingness to pay (WTP). The study also revealed that the willingness to adopt (WTA) moderates the association between performance expectancy (PE), price value (PV), and willingness to pay for the IoT (WTP):

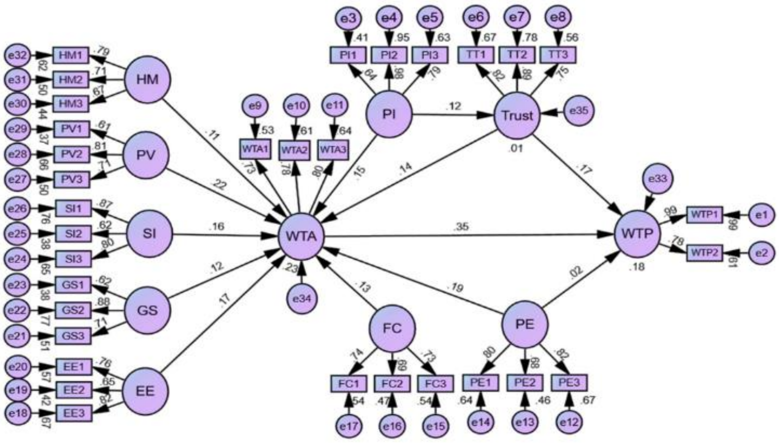

Figure 1. PLS-SEM model
Source: Shi et al., 2022

It is a rather novel and rare study about the behavior of rural customers with respect to innovation adoption (IoT in agriculture) indicating precise reasons for the voluntary adoption of the IoT in agriculture (WTA) and willingness to pay for it (WTP).

2.2 The Uptake and Usage Theory

Rose and his colleagues (Rose et al., 2016), implemented a mixed learning plot among British farmers comprising a baseline survey with 244 face to face quantitative interviews with farmers, a number of 78 semi-structured interviews with farmers and advisers as well as a one day workshop with 39 researchers, policy makers and decision support application manufacturers. The aim of this research was to understand what factors would favor the adoption of agricultural decision support systems both by farmers and their advisers. Decision support systems are a subset of all the digital agricultural tools that could be used in a farm and enable decision making in the farm thus representing a core enabler of decision making conducive to more productive, more efficient, more environmentally friendly and less weather dependent farming. 15 factors that influence the adoption and usage of agricultural digital decision support systems were identified in this study. The resulting model was named The Uptake Model, and it affirms that usability, cost-effectiveness, performance, relevance to user, and compatibility with compliance demands are the motivations that would persuade a farmer to adopt a certain decision support system. Age, type of farming, digital literacy level and size (scale) of farm are positive or negative moderators (named modifiers in the study) while the intensity of the promotional activity and the ability to facilitate the possibility to solve any compliance needs for the farmers will augment the probability of adoption as shown below:

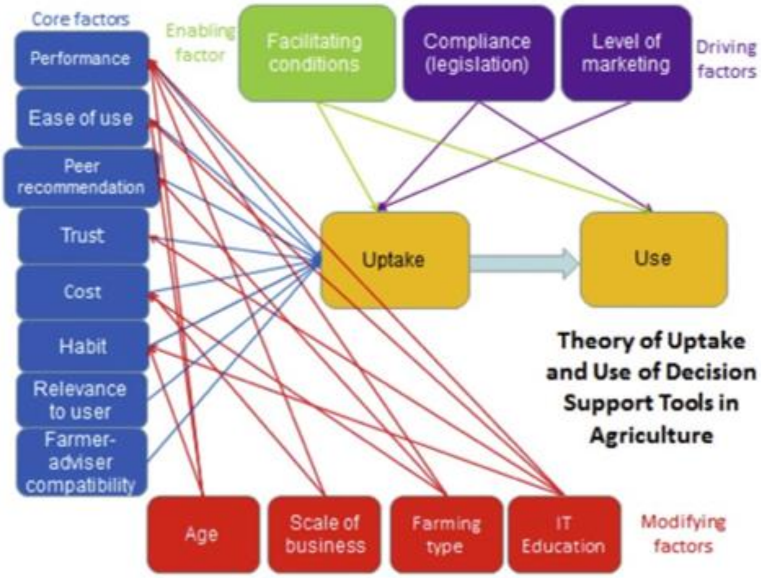

Figure 2. The Decision Support Tools in Agriculture Uptake and Usage Model
Source: Rose et al, 2016

The resulted model had a very strong resemblance in both the constructs identified as well as their inter-relationships to the UTAUT2 model. The behavioral intent to use a specific decision support tool is influenced by performance expectancy, ease of use, peer recommendation, trust, cost, habit, relevance to user, farmer-adviser compatibility, while age, scale of farming, farming type, IT education, amplify or inhibit the strength of the above mentioned factors. Behavioral intent has a direct effect on uptake (as defined by them, adoption in the spirit of this paper). The internet signal, compatibility with existing systems, fit within the workflow of the end user are identified as enabling factors. A novelty and source of strength for this model is the finding that compliance (helping a farmer or adviser to satisfy legislative or market requirements) and level of marketing have a determining influence on uptake.
It is noteworthy to remark that in the discussion part of the article the authors draw a direct similarity line with the UTAUT2 model (Venkatesh, Thong and Xu, 2012).

2.3 The Romanian context

One specificity of the Romanian field crops professional agriculture is the fact that farms tend to be overwhelmingly family businesses with an atomized structure of plots. In the author's practitioner experience very often farms of above 400 hectares are spread over several tens of plots sometimes situated within a radius of 25 to 30 kilometers. These businesses are building their operational and economic scale through the exploitation of family's owned land but also exploiting rented arable land. Land exploitation is seldom done in organized cooperatives (Dumitru, Micu and Sterie, 2023) although subsidies accessibility and realization of the potential to create a common purchasing power could stimulate the reinvigoration of cooperatives.
Another important specificity of the Romanian agricultural landscape, that might have an impact on the digitalization adoption rate in farms, is that very often the inspired entrepreneur, the founding figure of the business, would still be involved in the day-to-day

operation of the farm. Most often a he who is nowadays aged 55+ or even 60+ (Rovný, 2016) who brings in his own way of dealing with innovation (Motoc, 2022). The rising generation of professional farmers is more digital savvy, coming either from the younger inheritors or the hired professionals, and thus there is a strong likelihood that they would be more inclined to use digital tools in managing the farm (Motoc, 2022).
While admitting the progress and gains likely to result from the adoption of digital agriculture, it remains a rather complex and multifaceted cross generational learning process (Balan et al. 2019, Bratianu, Stanescu and Mocanu, 2021, Gerli et al., 2022, Medvedev and Molodyakov, 2019).
The stride towards digital farming practices and technologies in its core is also very much a knowledge management process within farms. Besides the technological changes (acquisition, installing, calibration, exploitation of technology), the new digital practices imply knowledge acquisition, organizing, storing, retrieving, as well as sharing an organization's knowledge assets to facilitate decision-making, problem-solving, learning, and innovation (Bratianu, 2002, 2018, 2022). Furthermore, it is important to highlight and consider the fact that moving from a traditional way of managing the farm to a way aided by the 4.0 tools it also represents a move from tacit (habitual way of doing things) to an explicit and rational way of managing and deciding in the family farm (Bratianu and Motoc, 2022), thus showcasing the knowledge transformation processes from spiritual and emotional knowledge to rational knowledge as explained by the knowledge fields theory (Bratianu and Bejinaru, 2023).
A Web of Science search for “digital agriculture” materials and Romania, yielded a corpus of 59 articles with were mapped for the minimum co-occurrence of keywords: 2 occurrences. Out of a total of 309 keywords, 36 keywords respected that and generated 5 clusters as shown in Figure 3:

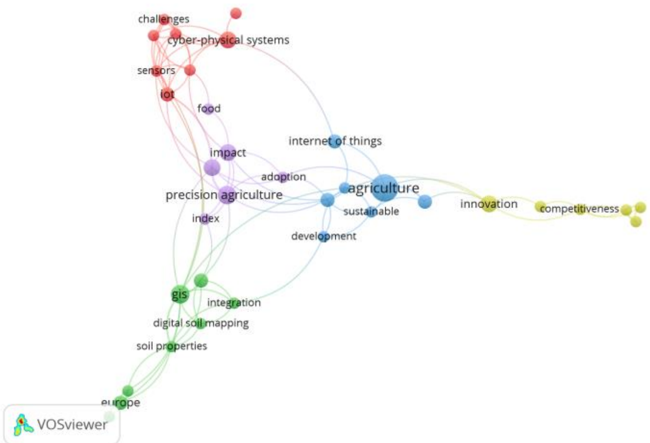

Figure 3. The keywords map of materials containing “digital agriculture” originating from Romania at 2+ co-occurrences
Source: WoS,December 17, 2023

In this corpus of articles Zeca’s report stands out (Zeca, 2021). It presents the results of a national survey done at the beginning of 2021 about the Romanian farm managers’ fears and expectations from the implementation of smart technologies. However, it is a rather descriptive research that does not construct a model.

3. Methodology

Online libraries and article repositories (Web of Science, Scopus, Taylor and Francis, Google Scholar), consulting firm reports (Goedde et al., 2020, Roland Berger 2015,2019) as well as references used in the doctoral school classes (Bratianu, 2022, Pînzaru, Anghel and Mihalcea, 2017, Pinzaru, Zbuchea and Vitelar, 2019, Pinzaru et al., 2022) as well as thematic and author searches on Research Gate (social network for scientists and researchers) were used to enrich the literature review for the above-mentioned keywords and concepts with focus on barriers to adopting digital agriculture and tools to measure factors influencing adoption rates.

4. Results and discussion

To better understand the scope of the relevant literature a query of the Web of Science (WoS) database was done using the key words “digital agriculture”, and “adoption”. A corpus of 630 materials were extracted having a total number of 2558 authors that used 3272 author keywords.

These were mapped using VOSviewer (*van Eck and Waltman, 2010*) version 1.6.19 (released on January 23rd, 2023) for 10+ co-occurrences (see figure 3) and resulted 76 key words distributed in 4 clusters as follows: adoption models (32items), agriculture 4.0 (28 items) , digital agriculture (11 items) and systems (5 items).

To further stimulate the thematic clustering of these materials, the co-occurrence criteria was raised to 15+ co-occurrences and resulted also a four clusters structure. Noteworthy, the new maps generated at this level of co-occurrence (see figure 4) reveal the centrality of the UTAUT2, Information and Computer Technology, Adoption and Acceptance.

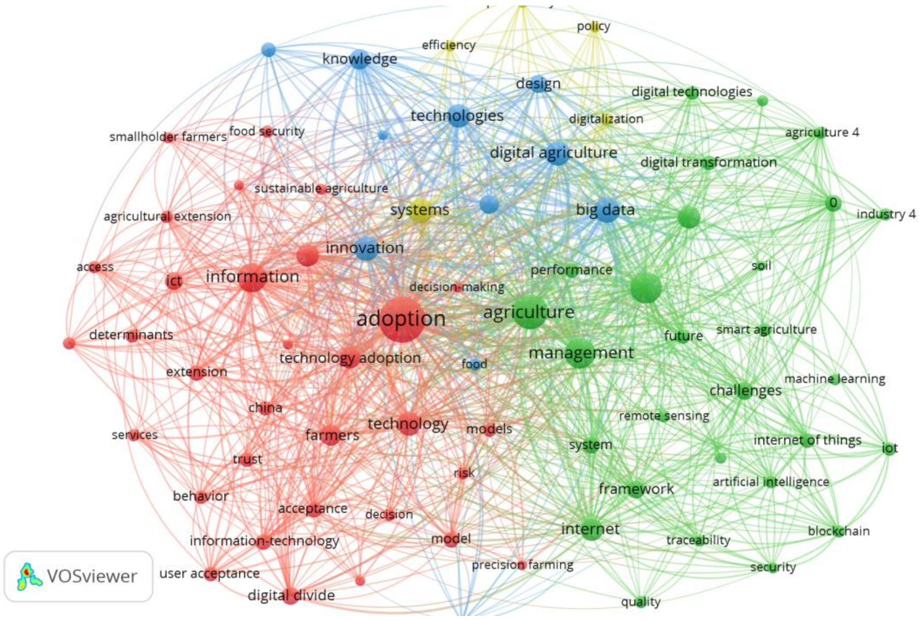

Figure 4. The keywords map of materials containing “digital agriculture” and “adoption” at 10+ co-occurrences
Source: WoS, July 2nd, 2023

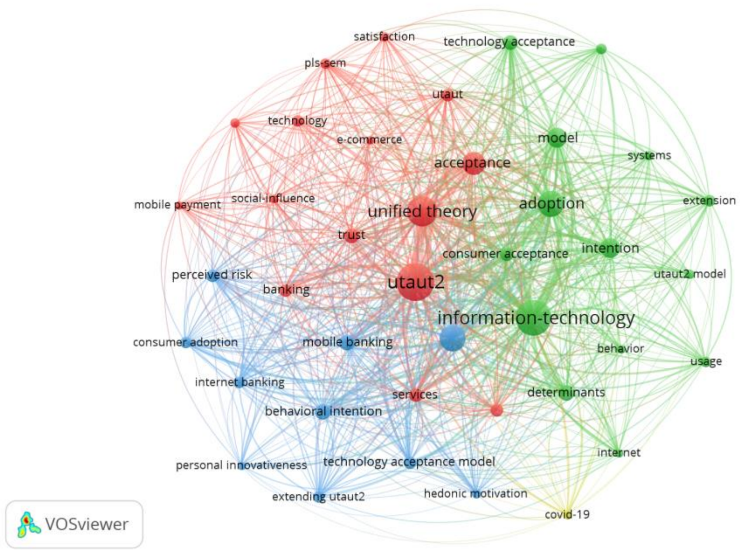

Figure 5. The keywords map of materials containing “digital agriculture” and “adoption” at 15+ co-occurrences.
Source: WoS, July2nd, 2023

Following the recommendation of the UTAUT author (Venkatesh et al., 2016) the UTAUT2 core model could be extended to fit the purpose of this study. The newly proposed model is constructed using the comparative table below:

Table 1: The unified model proposal (Author’s proposal)

Venkatesh, Thong and Xu, 2016	Shi et al., 2022	Rose et al., 2016	Proposed Model
Perform. Expectancy	Perform. expectancy	Performance	Yes
Effort Expectancy	Effort expectancy	Ease of Use	Yes
Social influence	Social Influence	Peer recommendation	Yes
	Trust	Trust	Yes
Price Value	Price Value	Cost	Yes
Habit		Habit	Yes
		Relevance to user	No
		Farmer-adviser compatibility	No
		Age	Yes
		Scale of business	Yes
		Farming type	No
		IT education	Yes
Facilitating Conditions	Facilitating Condition	Facilitating Conditions	Yes
		Compliance	Yes
		Level of marketing	No
Behavioral Intent	Willingness to Adopt	Uptake	Yes

Hedonic Motivation	Hedonic Motivation		No
	Pers. Innovativeness		Yes
	Government support		No
New Conception of Acceptance and Use	Willingness to Pay	Usage	Yes

Source: Author's elaboration

Because the adoption of digital agricultural tools is mainly for professional usage it is deemed acceptable to eliminate from the model the Hedonic Motivation (HM) factor. The farming type is also considered a non-variable as explorations are to be done in homogeneous groups of farmers, practicing similar farming types. All the other eliminated factors are also deemed to play a minor role in the Romanian context (marketing level, the farmer adviser compatibility, government support as phrased in Shi et al., 2022) and thus could be eliminated making the model easier to apply.
Consequently, the proposed model would be emulating an extended UTAUT2 model following the below conceptual framework:

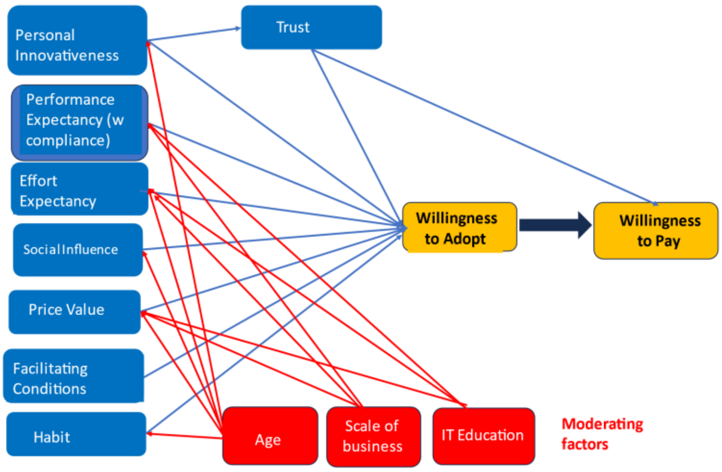

Figure 6. Proposed conceptual model
Source: Author's proposal

5. Conclusion

As proven across time, through its genesis and evolution the UTAUT model (Venkatesh et al, 2016) is a solid model (*Tamilmani et al., 2021*) that could be used in a research project that aims to understand the motivations of Romanian field crop farmers (arable farming) to adopt digital agriculture technologies and practices and even explore their willingness to pay for these services.
The intent is to use this model in a subsequent quantitative measurement of Romanian farmers motivations to embrace Agriculture 4.0. The study, a premier for Romania will use PLS-SEM to validate the applicability of this model also for the Romanian farmers. A preliminary qualitative consultation with practicing digital farmers is also planned. The present paper is a premier in the literature about Romanian farmers and it is deemed to be a valuable tool for both researchers that could use the proposed model as field research too

as well as developers of digital tools for farmers who could use it to hone their tools to maximize perceived utility and ease of use. The model also suggests other avenues to promote these tools emphasizing utility of tools that ease the task of regulatory compliance. Finally, the social influence dimension of the model suggests ways and means to use change agents in the persuasive endeavor for digital agriculture adoption.

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Bio-note

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