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Efficiency of information and communication technology adoption by entrepreneurs

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Abstract

Purpose – This study seeks to improve the understanding of the motivation driving the entrepreneurs of micro, small and medium enterprises (MSMEs) to integrate ICTs and why this process is easier for some. The unified theory of acceptance and use of technology (UTAUT) is a suitable framework for this analysis. Our research aims to establish an explanatory typology based on the optimization of individual perceptions of entrepreneurs and usage intentions which enables identification of those groups that possess a greater intention to use ICTs in their businesses. This sheds light on how these factors influence their information and communication technology (ICT) adoption intentions within their businesses.

Design/methodology/approach – This study adopts an alternative approach and methodology to contribute new insights into academic discourse regarding the Unified Theory of Acceptance and Use of Technology (UTAUT). Building upon the theoretical foundation of the UTAUT, the present study pioneers the application of Data Envelopment Analysis (DEA) to a dataset encompassing 436 Spanish entrepreneurs. The objective is to examine the combination of diverse UTAUT perceptions that optimise the intention to implement ICTs in their companies while minimising anxiety associated with the adoption of new technologies (the outputs). Based on the results obtained, an explanatory typology is established that combines perceptions and usage intentions.

Findings – When applied to our group of entrepreneurs, DEA reveals that certain individuals can optimise their intentions with their current perception levels. This discovery has enabled us to create an explanatory typology through an examination of the efficiency of various perception-intention and/or anxiety combinations. Our proposed typology aims to shed light on the debate as to why not all perceptions translate into intentions and why certain entrepreneurs have a greater intention to use ICTs. An investigation of these efficient entrepreneurs reveals a wide range of combinations, which encompasses both those in harmony with effective usage behaviour and those deviating from such behaviour.

Research limitations/implications – DEA provides a snapshot of efficiency at a specific point in time and does not account for dynamic changes or adjustments over time, and DEA efficiency scores are relative measures that depend on the efficiency of other decision-making units in the dataset. The identification of appropriate benchmark units for comparison can be challenging, especially in heterogeneous datasets and cross-cultural analysis. In this respect, the UTAUT literature is lacking in cross-technology and cross-cultural comparisons.

Practical implications – Our methodology and results have implications for business management, business accelerators and economic policy. A detailed study of these clusters could reveal potential barriers and obstacles hindering the effective implementation of ICTs in MSMEs, thereby enabling researchers to focus on individuals who do not align with the model. Entrepreneurs classified in the most unfavourable typologies can take steps to enhance their perceptions, while administration and business accelerators can focus their efforts on these entrepreneurs.

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Originality/value – The application of the UTAUT model on individual entrepreneurs receives limited coverage in the existing literature. To the best of our knowledge, this is the first study to utilise a DEA methodology within the framework of the UTAUT model (in contrast to the prevalent use of structural equation modelling in previous studies related to UTAUT). This analysis contributes fresh empirical evidence to the academic discourse on technology adoption models among individual entrepreneurs. Our methodology is a tool that reveals potential barriers and obstacles in individual perceptions that hinder the effective implementation of ICT in certain types of entrepreneurs.

Keywords , UTAUT, Entrepreneurship, Data envelopment analysis, ICTs, Anxiety
Paper type Research paper

1. Introduction

In recent decades, developments in Information and Communication Technologies (ICTs) have significantly influenced various social and economic domains, thereby contributing towards globalisation. ICTs encompass a set of tools (hardware and software), processes, and methodologies, including communication tools, mobile devices, the internet, network infrastructure, video conferencing, e-learning, and satellite systems (Kumar *et al.*, 2023; Martini *et al.*, 2023). These technologies facilitate the digitisation and real-time manipulation of information (Swanson and Ramiller, 2004; Thompson and Strickland, 2004; Stavropoulos, 2022; Ali *et al.*, 2023). They are crucial for the development and improvement of communications, by facilitating global information transmission and improving efficiency in productive and economic processes (García-Machado *et al.*, 2023). At the firm level, ICTs enhance the management of information and knowledge within companies, by accelerating processes and improving the reliability of both business-to-business (B2B) and business-to-consumer (B2C) interactions (Kamarudin *et al.*, 2024; Amato *et al.*, 2024). When firms fail to adopt ICTs and to adapt to market digitalisation, they not only miss out on its benefits but also face declining performance, thereby falling behind competitors who do embrace these changes. In fact, the adoption of ICTs constitutes a pivotal factor in remaining competitive and acts as an essential tool that enables firms to efficiently combine and optimise their resources to generate value (Lee *et al.*, 2024; Altwaijri *et al.*, 2024).

All these aspects are even more important in the case of Micro, Small, and Medium-sized Enterprises (MSMEs). These MSMEs face many challenges, such as high expenses, inadequate skills (Estrada-Cruz *et al.*, 2024), lack of government support, and even negative perceptions towards ICT (Kamarudin *et al.*, 2024), which hinder the implementation of such technologies.

Several researchers have conducted studies to analyse the factors contributing towards the implementation of technology (Cooper and Zmud, 1990; Fichman, 2004; Al-Amin *et al.*, 2024). In this respect, technology acceptance models emerge as the clear choice for conducting such analyses (Momani, 2020; Lee *et al.*, 2024). These theories and models have sought to understand why certain consumers, individuals, companies, and business groups are more inclined than others to use and adopt such innovations (Swanson and Ramiller, 2004; Damanpour and Wischnevsky, 2006; Ireta Sanchez, 2023; Lenz *et al.*, 2023). In particular, these models have proven instrumental in capturing decision-making processes within organisations (Venkatesh *et al.*, 2012). Various factors, including usefulness, ease of use, complexity, and social influence, can influence users' decisions and intentions regarding the adoption and utilisation of any technology (Momani, 2020). Currently, research in this area continues to be of great interest to researchers from various disciplines (Machado De Freitas and Silva Da Rosa, 2022; Lee *et al.*, 2024; Lenz *et al.*, 2023).

With these premises, this study aims both to ascertain the factors that motivate entrepreneurs of MSMEs to integrate ICTs into their businesses, and to determine how this integration process can be facilitated. The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh *et al.*, 2003, 2012; Venkatesh and Zhang, 2010) constitutes a theoretical framework crafted to elucidate and forecast user behaviour concerning the adoption and utilisation of technologies. The UTAUT synthesises key constructs from earlier models that date back to the 1980s, thereby establishing a robust framework for the analysis of

users' acceptance and adoption intentions regarding new technologies (Momani, 2020). Empirical research has focused on examining the causal relationship and the impact of perceptions on behavioural intention using various types of regressions and structural equations. In this regard, empirical studies explain at least 70% of the variance in the intention to use technology (Taiwo and Downe, 2013; Rejali *et al.*, 2023). Despite significant progress, the debate regarding the intention to use technology remains ongoing and it is therefore necessary to continue investigating why certain perceptions fail to translate into intentions.

The present study adopts an alternative approach and methodology in order to contribute new insights to this ongoing academic research. Instead of examining the relationships of impact, this research analyses which individuals are more efficient in transforming their perceptions into usage intentions. To this end, by drawing upon an extended UTAUT model as the theoretical framework, our study applies Data Envelopment Analysis (DEA) to a dataset covering 436 Spanish entrepreneurs. The objective is to examine the combination of diverse UTAUT model perceptions that optimises the intention to implement ICTs in their companies while minimising anxiety associated with the adoption of such new technologies. This will enable the establishment of an explanatory typology to identify the most efficient group with the highest likelihood of performing the effective behaviour.

Specifically, there are three aspects of our study worth highlighting:

Firstly, our study aims to address a research gap by analysing the implementation of ICTs at the individual entrepreneur level, since the specialised literature has primarily focused on the firm level, principally in large firms (Ali and Osmanaj, 2020; Odoom and Kosiba, 2020; Atwal *et al.*, 2021; Ghosh *et al.*, 2022; Amato *et al.*, 2024). Specifically, our analysis aligns with the focus of technology acceptance models at the individual entrepreneur level. In a recent literature review conducted by Lee *et al.* (2024), the authors observe that the existing literature provides limited coverage on the application of the UTAUT model to entrepreneurs. In MSMEs, the personality and traits of the individual business owners play a major role in influencing the adoption of ICTs (Taylor, 2019; Nazir and Khan, 2024). In MSMEs, entrepreneurs commonly serve as the founding proprietors and are pivotal in management and in making strategic decisions for their enterprises (Fernández-Serrano and Romero, 2013; Sánchez-Báez *et al.*, 2020).

Secondly, our investigation utilises Data Envelopment Analysis to explore the UTAUT model, in contrast to the prevalent use of Structural Equation Modelling, Common Factor Analysis, Factor Analysis, and Regression Analysis in previous studies (Tamilmani *et al.*, 2021; Liu *et al.*, 2021). To the best of our knowledge, this analysis is the first to incorporate DEA into the UTAUT framework.

Therefore, this study is interested in the combination of perceptions held by individual entrepreneurs that leads to a specific behaviour and goes beyond merely studying the relationships between the variables of the model, as have been addressed in other investigations. Furthermore, although DEA has been employed in models of technological diffusion at the macroeconomic level (for example, Keles and Alptekin, 2023; Shabani *et al.*, 2013), as well as at the firm level (Bernal *et al.*, 2018), no study has yet used the 4 perceptions of the UTAUT model as inputs to measure efficiency regarding intentions.

Lastly, this study explores anxiety, a relatively underexplored variable concerning the UTAUT model (Gunasinghe and Nanayakkara, 2021; Adikoeswanto *et al.*, 2022). Traditionally, the UTAUT views anxiety as an external variable that indirectly influences intention (Venkatesh *et al.*, 2003; Wang *et al.*, 2024; Dwivedi *et al.*, 2011). However, in this study, anxiety is considered as an undesirable outcome and is given equal weight to that of the intention to use. Our focus is on the identification of combinations of perceptions that maximise intention while minimising anxiety.

Building upon this background, the ensuing sections of this paper are structured in the following way: Section 2 presents a review of the literature on the UTAUT model and scrutinises its theoretical framework components. In Section 3, the database is outlined, and the variables earmarked for DEA are discussed in detail. Section 4 covers the discussion of the results, followed by an exploration of the primary conclusions, limitations, and proposals for future research.

2. Literature review and theoretical framework

2.1 Enhancing micro-enterprises through ICT

Information and Communication Technology enhances efficiency, productivity, and market visibility, thereby providing firms with strategic advantages by optimising operations, improving communication, and fostering competitiveness and sustainability (Oláh *et al.*, 2021; Gnambs, 2021; Singh *et al.*, 2019). They enable a better use of resources, enhanced knowledge creation, and improved access to new market opportunities and innovations (Saura *et al.*, 2024; Kamarudin *et al.*, 2024), especially for micro-entrepreneurs (Smallbone *et al.*, 2002; Kumar *et al.*, 2023; Karabetyan, 2023; Altwaijri *et al.*, 2024).

Due to the COVID-19 pandemic, the use of ICTs increased rapidly, and significantly bolstered economic resilience and mitigated adverse impacts for firms (Atsuko and Karazhantva, 2020; Estrada-Cruz *et al.*, 2024). Entrepreneurs employed ICTs to increase their competitiveness, reduce costs, and maintain operations during crises (Martini *et al.*, 2023). Such entrepreneurs were more flexible, creative, and resilient, which highlights the essential role of ICT in crisis management and strategic decision-making (Kreuzer *et al.*, 2022; Bertschek *et al.*, 2023).

Despite the clear benefits of ICTs, MSMEs often experience delays in digital transformation due to several challenges. Their small size limits access to essential financial, technological, and human resources (Li *et al.*, 2017; Meyer *et al.*, 2022). Key barriers include inadequate infrastructure, lack of skills (Estrada-Cruz *et al.*, 2024), high costs, insufficient support, and overly complex policies (Reuschke *et al.*, 2021; Slinger *et al.*, 2024). Furthermore, limited credit access, insufficient government incentives, and the need for better technology education further hinder their progress (Estébanez *et al.*, 2022; Andaregie and Astatkie, 2021).

Other research highlights the importance of perceptions and attitudes towards the adoption of ICTs (Bvuma and Marnewick, 2020). Factors, such as the limited understanding of ICT benefits, concerns regarding risks and trust issues, and challenges related to their ease of use (Purwantini and Anisa, 2021; Loo *et al.*, 2024), cause technology to remain underutilised in these firms, thereby preventing entrepreneurs from fully benefitting from its adoption and use (Yu *et al.*, 2017).

In this respect, technology acceptance models constitute effective frameworks for the analysis of how cognitive factors and perceptions influence the intention to adopt new technologies.

2.2 UTAUT and the technology acceptance models

Over the past forty years, researchers have conducted studies to analyse the individual and organisational behavioural factors that influence the acceptance or refusal of the introduction of technology.

The first theory on the adoption of innovation was the *diffusion of innovation theory* (DOI) (Rogers, 1962). According to DOI, the adoption process of innovation can be categorised into five stages: knowledge, persuasion, decision, implementation, and confirmation. Furthermore, the theory highlights the importance of certain factors, such as the attributes of the innovation, communication channels, social systems, timing, and the characteristics of the adopters themselves, in influencing the rate of adoption (Lenz *et al.*, 2023).

In the 1980s, this research received a significant boost from the secular contribution of Davis *et al.* (1989). Based on the *Theory of Reasoned Action* (TRA) (Ajzen and Fishbein, 1980) and the *Theory of Planned Behaviour* (TPB) (Ajzen, 1985), Davis *et al.* (1989) developed the *Technology Acceptance* Model (TAM). To explain the attitude towards adopting and using new technology, the TAM introduced new perceptions: perceived usefulness (PU) and perceived ease of use (PEoU) (Hewavitharana *et al.*, 2021). Venkatesh and Davis (2000) extended the TAM (TAM2) by identifying two additional variables that influence PU: social

influence processes and cognitive instrumental processes (Lee *et al.*, 2024; Sprenger and Schwaninger, 2021).

At the beginning of the 21st century, Venkatesh *et al*. (2003) proposed the Unified Theory of Acceptance and Use of Technology (UTAUT). The present study employs this UTAUT framework.

In this respect, the UTAUT is one of the most exhaustive theoretical models developed for the comprehension of the essence of technology utilisation. The model stems from thirty-two primary factors derived from eight models, encompassing the Theory of Reasoned Action (Sheppard *et al.*, 1988), the Motivational Model (Vallerand, 1997), the Technology Acceptance Model (Venkatesh and Davis, 2000), the Theory of Planned Behaviour (Ajzen, 1991), the PC Utilisation Model (Thompson *et al.*, 1991), the integrated TAM and TPB model (Taylor and Todd, 1995), the Innovation Diffusion Theory (Rogers, 1995), and the Social Cognitive Theory (Bandura and National Inst of Mental Health, 1986). The model integrates insights from information systems, psychology, and sociology (Venkatesh *et al.*, 2003).

The UTAUT model identifies four key factors that influence behavioural intention and the behaviour of using new technologies: performance expectancy, effort expectancy, facilitating conditions, and social influence. Alongside these direct factors, various indirect factors (mediators and/or moderators) also influence the adoption of technology: these encompass aspects such as gender, age, prior technology experience, and the voluntary choice to utilise such technology (Wang *et al.*, 2009, 2010; Huang *et al.*, 2013; Anwar *et al.*, 2017; Tzafilkou and Protogeros, 2018; Nisreen *et al.*, 2018; Ameen *et al.*, 2018; Shaouf and Altaqqi, 2018). Further variables have been considered in expanded models. In this respect, computer anxiety has been investigated as an external factor use and it is suggested that higher levels of anxiety may attenuate the relationship between performance expectancy and intention (Marangunić and Granić, 2015; Arning and Ziefle, 2007; Wang *et al.*, 2024).

Although Venkatesh *et al.* (2012) expanded the UTAUT model (UTAUT 2) by using three new constructs (habit, hedonic motivation, and price value) in an effort to clarify the acceptance and utilisation of technologies by consumers (Handoko, 2020; Handoko *et al.*, 2019; Martinez and McAndrews, 2022), the UTAUT was in fact initially conceived to investigate employee choices regarding technology adoption within professional environments.

The UTAUT model has demonstrated superior explanatory power over other technology acceptance frameworks and has established itself as a well-developed and comprehensive model for the understanding of technology acceptance (Puriwat and Tripopsakul, 2021). At least 70% variance has been successfully observed to explain the behavioural intention of using technology (Taiwo and Downe, 2013). In recent research, Rejali *et al.* (2023) compares three user acceptance models (TAM, TPB, and the UTAUT) to assess user acceptance of fully automated vehicles in Iran. All three models successfully explained the behavioural intention to use these vehicles. The TPB and the UTAUT models each explained with 70% of the variance in behavioural intention, and that of the TAM model with less than 60% variance.

Comprehensive literature reviews summarising the evolution and application of these models are available in Williams *et al.* (2015), Dwivedi *et al.* (2020), Tamilmani *et al.* (2021), Liu *et al.* (2021), Machado De Freitas and Silva Da Rosa (2022), Ghobakhloo *et al.* (2022), Blut *et al.* (2022), and Lee *et al.* (2024). In recent years, the UTAUT has been extensively employed to scrutinise a variety of technologies that encompass the internet and websites, tax payment systems, mobile technology, government management, and various others (Ke and Wei, 2004; Gupta *et al.*, 2008; Manrai *et al.*, 2021; Islam and Khan, 2021). Regarding the implementation of ICTs, certain studies are dedicated to particular contexts. For example, Al-Saedi *et al.* (2019) focus on the review of mobile payment adoption, Alghatrifi and Khalid (2019) discuss the study of IPV6 adoption, and Tamilmani *et al.* (2018) examine predictors of mobile application adoption.

These studies have predominantly been scrutinised at the organisational level (Apfel and Herbes, 2021; Sargent *et al.*, 2012; Chang *et al.*, 2015, 2019; Puriwat and Tripopsakul, 2021),

with fewer studies concentrating on individual entrepreneurs or MSMEs (for instance, Lee *et al.*, 2024; Odoom and Kosiba, 2020; Azman and Zabri, 2022; Salimon *et al.*, 2023).

In the latter scenario, the UTAUT has been employed to analyse the adoption of mobile applications (Abed, 2021), the Internet of Things (Abushakra *et al.*, 2022), the use of digital channels in distribution (Bellaaj, 2021), the use of financial services online (Rahman *et al.*, 2020), and the acceptance of health-related ICTs amongst the elderly in the community (Vassli and Farshchian, 2017). Further empirical studies applied to the collective of MSME entrepreneurs are therefore necessary in order to understand their behaviour under the UTAUT framework.

2.3 An efficient combination of personal perceptions for ICT adoption

The innovation process within organisations, including the adoption of ICTs, is influenced by internal and external variables. Furthermore, the size of the company is related to the dynamics it imparts to innovation activities (Adam and Alarifi, 2021; Carvalho *et al.*, 2021). The entrepreneur of an MSME performs essential functions for the successful operation of their company: securing and managing capital; planning, organising, and overseeing business activities; and making tactical decisions that guide the firm's strategy and growth (Guzmán and Santos, 2001; Fernández-Serrano *et al.*, 2019). By taking on these roles, the entrepreneur is responsible for managing the majority of tasks required to ensure the company's stability, efficiency, and long-term success. Although the adoption of ICTs is usually studied at firm level (Yu and Tao, 2009; Lee *et al.*, 2024), in MSMEs, individual entrepreneurs, as leaders, make strategic decisions regarding the implementation of ICTs. In this way, the perceptions and intentions of individual entrepreneurs are fundamental to understanding the final behaviours adopted, which have repercussions on their entrepreneur behaviour (Krueger, 2003; Varma, 2018).

Intentions to act constitute good predictors of behaviour since they are mental representations that reflect the influence of the environment on an individual's perceptions of both context and self (Ajzen, 1991; Van Gelderen *et al.*, 2018). These representations may differ between individuals due to the presence of various cognitive biases (Baron, 1988).

As highlighted in the preceding section, the original UTAUT was designed to explain technology acceptance and utilisation in organisational contexts (Moghavvemi *et al.*, 2013). The UTAUT identifies four crucial factors that influence behavioural intention: performance expectancy, effort expectancy, facilitating conditions, and social influence.

(1) Performance expectancy (PE) is acknowledged as the most influential predictor of intention. It is defined as the extent to which individuals believe that utilising the system will enhance their job performance (Davis, 1989; Venkatesh and Morris, 2000; Blut *et al.*, 2022).

(2) Effort expectancy (EE) is characterised as the level of ease associated with the use of technology. In our context, it signifies the degree to which an entrepreneur perceives that incorporating ICTs into their business is straightforward and/or demands minimal effort (Venkatesh *et al.*, 2003; Blut *et al.*, 2022).

(3) Social influence (SI) involves perceptions of the opinions held by significant others, including friends and family, as well as other entrepreneurs, suppliers, etc., regarding the adoption of a specific behaviour (Venkatesh *et al.*, 2003; Blut *et al.*, 2022).

(4) Facilitating conditions (FC) are defined as the entrepreneur's perception of the extent to which they possess an organisational and technical infrastructure supportive of ICT use in their business (Venkatesh and Zhang, 2010; Blut *et al.*, 2022).

Moreover, Behavioural Intention (BI) refers to an individual's cognitive inclination to engage in a specific behaviour (Ajzen and Fishbein, 1980). Davis *et al.* (1989) are featured among the early proponents that suggested that intention to use technology influences actual usage. In

essence, intention emerges as the primary predictor of action: heightened intention correlates with an increased likelihood of behaviour engagement (Ajzen, 1991; Taylor and Todd, 1995). In the context of our study, BI indicates the extent to which entrepreneurs are willing to make an effort to implement and use ICTs in their businesses (Blut *et al.*, 2022).

Lastly, anxiety (AN) encompasses the emotional dimension of technology use. Technological anxiety is defined as the apprehension or fear, or negative affective reaction of an individual when faced with the possibility of using new technologies (Simonson *et al.*, 1987; Bozionelos, 1996). Venkatesh *et al.* (2003) have demonstrated that anxiety is conceptually and empirically different from effort expectancy and lacks a direct effect on intention; hence, it is often modelled as a mediating variable (Venkatesh, 2000; Chiu and Wang, 2008; Abu-Shanab and Pearson, 2007; Jong and Wang, 2009). However, there are studies that do report a direct effect (Gunasinghe and Nanayakkara, 2021).

According to the meta-analysis from Dwivedi *et al.* (2011) and that of Blut *et al.* (2022), performance expectancy shows the highest number of significant relationships with behavioural intention, followed by social influence, effort expectancy, and facilitating conditions. For the attainment of these results, researchers have focused on analysing the causal relationships between perceptions and intention. Thus, Williams *et al.* (2015) and Xue *et al.* (2024) state that structural equation modelling (SEM), regression analysis, thematic analysis, the *t*-test, and analysis of variance are the most commonly used statistical methods. On average, 70% of the sample variance in behavioural intentions has been explained. This implies that not all perceptions translate into the final intention. Hence, the integration of a variety of methods or new methodologies would provide a more comprehensive and nuanced understanding of the data (Xue *et al.*, 2024).

Each individual has a different level of each perception based on their personal characteristics (Venkatesh *et al.*, 2003). For example, a person with high performance expectancy but low effort expectancy has a different intention to use compared to someone with the opposite perceptions, even if they share the same context. It is therefore important to consider the combination of perceptions of each user.

Building upon these ideas, the present study adopts an alternative approach: instead of analysing how perceptions affect usage intention for making predictions, we examine how much perception is required to generate a particular intention. This enables us to identify the efficiency of the analytical units (entrepreneurs) in relation to their set of perceptions. In this way, it is possible to identify which individuals or groups are more "efficient" in translating their perceptions into intention.

Drawing from these propositions, this study examines the presence of individuals (entrepreneurs) who possess a more effective combination of perceptions than that of others. However, the efficiency of a perception combination does not inherently imply its suitability for driving the effective behaviour. This opens the avenue for the scrutiny of which combinations of perceptions-intention/anxiety are the most apt for inducing effective usage behaviour. In this context, these individual perceptions can be viewed as resources (inputs) that can be optimally combined to attain specific levels of usage intention (desired output). Moreover, it is imperative that this amalgamation of perceptions also minimises the levels of anxiety arising from the use of ICTs (undesirable output).

Based on this idea, this article proposes the following "hypothetical production function":

$$Q\left(Max.\,intention\,use + Min.\,anxiety\right) = f\left(Performance\,Expectancy, Effort\,Expectancy, Social\,Influence, Facilitating\,Conditions\right).$$

Given these considerations, our study aims to answer the following research questions:

RQ1. Are there entrepreneurs who possess an efficient combination of perceptions that maximises their levels of intention to use ICT and minimises their levels of anxiety?

RQ2. Are certain combinations of perceptions more conducive than others towards influencing the final usage behaviour of ICTs in businesses?

3. Empirical analysis

3.1 Dataset and variables

The database utilised in this study originates from the research project titled "CTs in the creation and consolidation of innovative enterprises (PID2019-110166GB-I00)". The study focuses on Spanish adults, for whom the data collection for online questionnaires occurred between February–May 2022. The surveyed population is drawn from two primary groups: firstly, entrepreneurship support organisations, such as Andalucía Emprende, Catalunya Empren, CEEI Galicia, Empréndelo Madrid, the Chambers of Commerce, and the Explorer Program (BSCH bank); and secondly, graduates of the University of Seville. Responses were categorised based on the stage of the entrepreneurial process at the time of the survey. A total of 1,244 surveys were collected, of which 436 were completed by entrepreneurs with over one year of business activity (310 from entrepreneurship centres). The average age within this subgroup is 39 years old (with a standard deviation of 8.9), with approximately 56,7% being men and the remaining respondents identifying as women (189 cases).

The questionnaire utilised in this study incorporates the UTAUT scale (Venkatesh *et al.*, 2003), which facilitates the measurement of perceptions and behavioural intention. This scale comprises a total of 16 questions that gauge the four perceptions outlined in the model. Furthermore, four questions are included to assess the perception of technological anxiety, and three for usage intention. These scales are coded on a Likert scale ranging from 1 to 7 (representing "completely disagree" to "completely agree"). All scales have undergone validation in numerous prior studies (see Venkatesh and Davis, 2000), and in our case, results pertaining to construct reliability and validity further affirm their reliability: Cronbach's Alpha and Extracted Mean Variance = EE (0.933 and 0.83), EU (0.931 and 0.82), FC (0.68 and 0.62), SI (0.8 and 0.77), AN (0.88 and 0.72), and BI (0.86 and 0.78).

For the purpose of our analysis and considering that the incorporation of latent variables may give rise to interpretation challenges in data envelopment analysis (DEA), latent variables are computed based on their mean values. The correlations between these variables are detailed in Table 1.

3.2 Methodology

As previously discussed, the majority of studies applying the UTAUT have utilised structural equation modelling (through employing software such as AMOS, SmartPLS, and LISREL) and linear regression analysis (through SPSS). In these instances, the objective is to scrutinise the direct and indirect relationships between variables (both latent and observed) within a theoretical model that is amenable to validation.

Table 1. Pearson correlations between variables

	ER	ER	ER	ER	ER	ER
ER	1	0.724**	0.715**	0.547**	0.577**	−0.198**
EE		1	0.594**	0.660**	0.520**	−0.309**
IS			1	0.544**	0.610**	−0.043
CF				1	0.502**	−0.212**
IC					1	−0.047
AN						1

Note(s): **The correlation is significant at the 0.01 (bilateral) level
Source(s): Authors' own work

This study represents the initial attempt to apply a UTAUT framework using Data Envelopment Analysis (DEA). This type of analysis has been employed in the evaluation and scrutiny of appropriate methods of technology transfer (Kahrizeh and Ghaderi, 2014; Anokhin *et al.*, 2011). It has been utilised to evaluate the processing of entities, such as cities, schools, higher educational institutes, and hospitals, and to evaluate the performance of various processes that involve the use of multiple inputs and outputs, such as teaching processes, banking processes, technology forecasting and evaluation, and, of course, production processes (Johnes, 2006; Cvetkoska, 2011; Aristizábal-Torres *et al.*, 2017; Fernández-Serrano *et al.*, 2018; Čiković and Lozić, 2022; Papatheodorou *et al.*, 2021; Berbegal *et al.*, 2022; Wildani *et al.*, 2023; Keles and Alptekin, 2023). In this respect, although DEA has been utilised in numerous studies on technological diffusion, none have incorporated the perceptions of the UTAUT model as inputs concerning the intention to use ICTs.

Data Envelopment Analysis finds its roots in the research of Farrell (1957), Debreu (1951), and Koopmans (1951). These researchers employed multiple inputs to establish a straightforward measure of a firm's efficiency. This technique, since it is non-parametric, facilitates the assessment of the efficiency of a group of decision-making units (DMUs). It enables the assessment of the comparative performance between all units in the sample, by highlighting levels of inefficiency by positioning each unit in relation to a predefined production boundary. Within this framework, the assessment of relative efficiency involves measuring an economic unit's outcomes against those achieved by efficient or peer units (Førsund and Hjalmarson, 1974; González-Rodríguez *et al.*, 2010; Campos and Velasco, 2013; Expósito García *et al.*, 2017; Expósito and Velasco, 2021). This methodology proves particularly advantageous when scrutinising the intricate, often undisclosed, relationships between multiple inputs and outputs.

On the other hand, this study integrates one of the most recent advancements in DEA methodology, thereby broadening the optimisation problem to encompass undesirable and negatively valued products. Specifically, the model developed by Sueyoshi and Goto (2012) aims to minimise these undesirable products in an optimisation process that simultaneously seeks to maximise desirable products.

Given these considerations, our model examines the relative efficiency of input combinations (entrepreneurs' perceptions) that yield a range of outputs, that encompass both desirable (behavioural intention) and undesirable (anxiety) outputs. This analysis contributes fresh empirical evidence to the academic discourse on technology adoption models among individual entrepreneurs.

In analytical terms, the mathematical formulation is articulated as follows: The j technical units ($j = 1, \ldots, n$) employ m inputs X_j to generate two vectors of products: one desirable G_j and one undesirable B_j. It is assumed that $X_j > 0$, $G_j > 0$, and $B_j > 0$ for each j ($j = 1, \ldots, n$). An unknown vector of structural intensity variables, denoted as $\lambda = (\lambda_1, \ldots, \lambda_n)^{\mathrm{T}}$, is introduced. These variables, being unknown, serve to establish a connection between inputs and products through a convex combination.

From these variables, the problem that maximises the inefficiency of technical unit k ($k = 1, \ldots, n$) concerning all units is derived through the following expression, where $m = 4$, $s = h = 1$ (Sueyoshi and Goto, 2012):

$$\mathrm{Max}\ \xi + \varepsilon \left[\sum_{\mathrm{i}=1}^{\mathrm{m}} \mathrm{R}_{\mathrm{i}}^{\mathrm{x}}\, \mathrm{d}_{\mathrm{i}}^{\mathrm{x}} + \sum_{\mathrm{r}=1}^{\mathrm{s}} \mathrm{R}_{\mathrm{r}}^{\mathrm{g}}\, \mathrm{d}_{\mathrm{r}}^{\mathrm{g}} + \sum_{\mathrm{f}=1}^{\mathrm{h}} \mathrm{R}_{\mathrm{f}}^{\mathrm{b}}\, \mathrm{d}_{\mathrm{f}}^{\mathrm{b}} \right]$$

$$\mathrm{s.t.} \sum_{\mathrm{j}=1}^{\mathrm{n}} \mathrm{x}_{\mathrm{ij}}\, \lambda_{\mathrm{j}} + \mathrm{d}_{\mathrm{i}}^{\mathrm{x}} = \mathrm{x}_{\mathrm{ik}} (\mathrm{i} = 1, \ldots, \mathrm{m}),$$

$$\sum_{j=1}^{n} g_{rj}\,\lambda_j - d_r^g - \xi g_{rk} = g_{rk}\,(r = 1,\ldots,s),$$

$$\sum_{j=1}^{n} b_{fj}\,\lambda_j + d_f^b + \xi b_{fk} = b_{fk}\,(f = 1,\ldots,h), \tag{1}$$

$$\sum_{j=1}^{n} \lambda_j = 1, \lambda_j \geq 0\,(j = 1,\ldots,n),$$

$$\xi \text{ unrestricted}$$

$$d_i^x \geq 0\,(i = 1,\ldots,m), d_r^g \geq 0\,(r = 1,\ldots,s), \text{and } d_f^b \geq 0\,(f = 1,h).$$

R is the range resolute throughout the upper and lower bounds of inputs, desirable outputs and undesirable outputs, and is expressed by following expressions:

$$R_i^x = (m+s+h)^{-1}\left(max\left\{x_{ij}|j=1,\ldots,n\right\}\text{-}\,min\left\{x_{ij}|j=1,\ldots,n\right\}\right)^{-1}$$

$$R_r^g = (m+s+h)^{-1}\left(max\left\{g_{rj}|j=1,\ldots,n\right\}\text{-}\,min\left\{g_{rj}|j=1,\ldots,n\right\}\right)^{-1}$$

$$R_f^b = (m+s+h)^{-1}\left(max\left\{b_{fj}|j=1,\ldots,n\right\}\text{-}\,min\left\{b_{fj}|j=1,\ldots,n\right\}\right)^{-1}$$

The variables d_i^x, d_r^g, d_f^b are referred to as slack variables. ξ indicates the radial movement towards the efficient boundary of the technical unit k under study, and ε is a sufficiently small number. The objective function of the model (1) indicates the inefficiency of the technical unit k, $(k = 1,..,n)$.

The first constraint written as $\sum_{j=1}^{n} x_{ij}\lambda_j = x_{ik} - d_i^x$, indicates that the technical unit must reduce, in its input, x_{ik}, the amount of d_i^x, in order to reach the efficient boundary.

Likewise, the second constraint written as $\sum_{j=1}^{n} g_{rj}\,\lambda_j = g_{rk} + \xi\, g_{rk} + d_r^g$ indicates that the technical unit has to increase in its output, g_{rk}, the quantity of $\xi\, g_{rk}$ in the radial movement and d_r^g value in slack, in order to reach the efficient boundary. This is similar for the third restriction. The fourth constraint gives us the convex combination of structural variables.

The value of the unified efficiency (θ) under natural disposability is measured as:

$$\theta^* = 1 - \left[\xi^* + \varepsilon\left(\sum_{i=1}^{m} R_i^x d_i^{x*} + \sum_{r=1}^{s} R_r^g\, d_r^{g*} + \sum_{f=1}^{h} R_f^b d_f^{b*}\right)\right]$$

where the superscripts * indicate the optimal values obtained in model (1) for each of the technical units k, for $k = 1,\ldots,n$.

Once the efficiency measure of the analysed decision-making units (entrepreneurs) has been obtained, we will proceed with a classification based on cluster analysis. Given the substantial number of observations within our database, and in order to provide a more comprehensive view of the data, our analysis will combine hierarchical clustering and k-means clustering (Tudor, 2019). Initially, hierarchical clustering can offer a good overview of the data structure and assist in determining the appropriate number of groups for k-means analysis. Subsequently, the k-means clustering analysis divides the observations into a predefined number of groups in a manner that minimises variance within the groups and maximises variance between the groups.

4. Results

The outcomes are obtained subsequent to conducting our DEA model estimation using DEAP Version 2.14 software. The average efficiency is 0.83. There are notable disparities between entrepreneurs (the standard deviation is ± 0.224, with a minimum efficiency level of 0.15) (see Figure 1).

The results indicate that 28 entrepreneurs exhibit combinations of perceptions with unitary technical efficiency (see Table 2). Consequently, the remaining entrepreneurs are categorised as inefficient in their efforts to maximise their intentions to use ICTs while minimising their anxiety.

An exploration of these efficient entrepreneurs reveals a diverse array of perception combinations that incorporate both those elements that align with and those that diverge from effective usage behaviour.

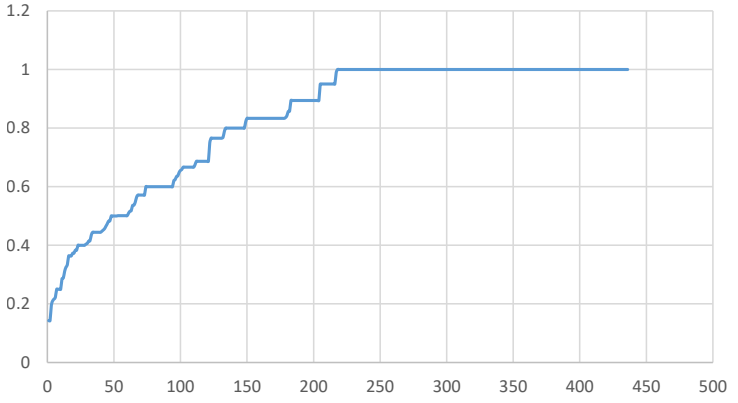
In accordance with Section 3, in order to categorise the potential combinations within the entire sample, a two-phase cluster analysis is undertaken. In the initial phase, a dendrogram from a hierarchical cluster analysis (employing group linkage and Euclidean distance) unveils six groups at a suitable level of disaggregation. A K-means clustering analysis is then performed, thereby generating six groups categorised by the level of intention, along with their respective means, as outlined in Table 3 and Figure 2.

In general terms, these clusters may be characterised as follows:

(1) Efficient with Enhancing Perceptions: Cluster 1, the most extensive cluster, demonstrates the highest efficiency and stands out as the optimal candidate for predicting usage behaviour. This cluster exhibits elevated levels across all perceptions, coupled with the highest levels of intention and the lowest levels of anxiety. The observation that they also boast the highest average efficiency implies a high degree of effectiveness in amalgamating their perceptions.

(2) Enhancing Perceptions under Anxiety: Cluster 2, comprising only 41 observations, displays noteworthy characteristics. Despite possessing a heightened level of intention, its primary trait is a notable level of anxiety. Lower scores in expectations of effort and facilitating conditions may be linked to this increased anxiety level, which sets it apart from Cluster 1.

(3) Overloaded Perceptions under Anxiety: Cluster 3 demonstrates the lowest efficiency levels. Considering the perceptions of these entrepreneurs, one would expect higher



Source(s): Authors' own work

Figure 1. Ordered efficiency

Table 2. DMU with efficiency = 1

DMU	Performance	Effort	Social	Facilitating	Intention	Anxiety
104	4.50	2.00	1.75	2.00	2.00	1.75
130	6.25	5.75	6.25	3.00	7.00	1.00
171	7.00	5.25	4.00	4.50	7.00	1.00
173	5.50	5.50	1.00	3.75	3.00	1.00
174	1.75	2.75	1.75	1.25	4.00	6.50
196	1.00	4.00	2.50	3.75	2.33	3.00
215	7.00	7.00	4.00	2.25	6.67	1.75
225	1.75	3.75	1.00	2.50	1.67	1.50
233	1.50	1.50	1.00	2.25	1.33	1.75
235	6.00	5.00	7.00	5.75	7.00	1.00
238	4.00	1.75	1.75	2.25	7.00	3.25
239	2.00	1.00	3.00	3.25	3.00	6.25
271	3.00	2.75	2.50	3.25	6.00	1.00
273	2.00	2.00	2.00	2.75	2.00	1.00
280	1.00	1.50	2.50	1.75	1.00	5.50
293	7.00	2.00	7.00	2.25	6.33	2.50
302	5.00	5.25	2.50	2.50	4.00	1.00
311	7.00	4.00	7.00	0.75	5.00	4.00
315	2.00	1.50	2.00	2.25	2.00	1.25
322	7.00	4.50	6.00	5.25	7.00	1.00
328	4.50	1.50	4.00	2.25	5.67	3.00
360	4.00	2.75	1.50	1.50	3.00	5.50
386	1.00	1.00	1.00	2.25	6.33	7.00
405	5.50	4.75	7.00	2.25	5.00	1.00
408	3.25	3.25	4.50	1.50	2.00	1.00
413	2.75	1.00	2.50	1.50	1.33	7.00
421	5.50	7.00	6.00	6.75	7.00	1.00
431	1.25	1.50	2.25	2.75	4.67	4.75

Source(s): Authors' own work

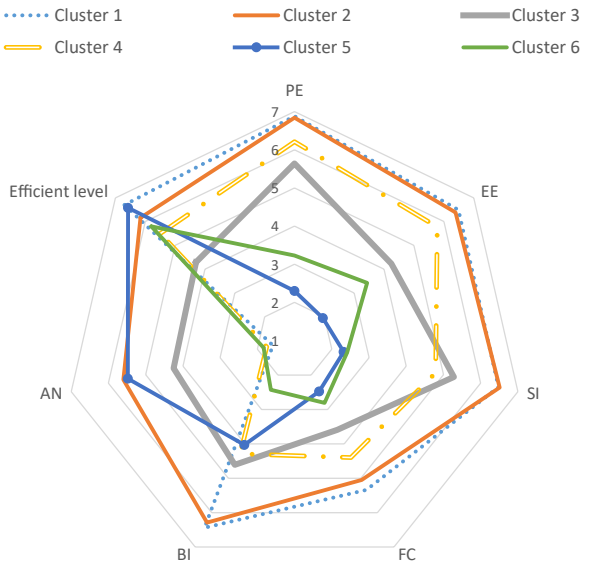
Table 3. Cluster centres – by intention to use

Clusters (cases)	1 (n_1 = 188)	2 (n_2 = 41)	3 (n_3 = 51)	4 (n_4 = 118)	5 (n_5 = 11)	6 (n_6 = 27)
PE	6.88	6.84	5.64	6.21	2.30	3.23
EE	6.49	6.39	4.24	5.78	1.95	3.43
SI	6.48	6.51	5.28	4.79	2.32	2.41
FC	5.34	5.05	3.59	4.40	2.48	2.81
BI	6.44	6.29	4.61	4.29	4.03	2.43
AN	1.58	5.60	4.25	1.75	5.48	1.83
Efficient level	0.95	0.86	0.55	0.75	0.93	0.80

Source(s): Authors' own work

intention levels. However, despite having lower facilitating conditions compared to Cluster 1, this remains insufficient to account for their elevated anxiety levels.

(4) Overloaded Perceptions: Cluster 4, the second-largest cluster, represents a variation of Cluster 3. Its efficiency level below the global average suggests that, given these perception levels, their intention levels should be higher. Similar to Cluster 3, enhancing their combinations of perceptions could potentially elevate their overall effective usage behaviour.



Source(s): Authors' own work

Figure 2. Clusters

(5) Limiting Perceptions under Anxiety: Cluster 5 is marked by the lowest levels across all perceptions. However, when combined efficiently, it produces average intention levels. Interestingly, even their heightened anxiety remains lower than that of Cluster 2.

(6) Limiting Perceptions: Lastly, Cluster 6 represents a variation of the preceding cluster, distinguished by low and inefficient perception levels, which positions them below the average. Consequently, this cluster exhibits the lowest levels of usage intention, which indicate that individuals within this group are the least likely to effectively implement ICT.

The "Matrix of Cluster Characteristics", as presented in Table 4, offers a comprehensive overview of the results obtained from the aforementioned two-phase cluster analysis. This matrix encapsulates the essential features of the identified clusters, as detailed in Table 3, and offers a visual representation of the distinctive characteristics attributed to each cluster based on their levels of intention.

Table 4. Matrix of cluster characteristics

Cluster no.	Efficiency	Perception	Intention	Anxiety
Cluster 1	High	High	High	Low
Cluster 2	High	High	High	High
Cluster 3	Low	Moderate	Moderate	Moderate
Cluster 4	Low	High	Moderate	Low
Cluster 5	High	Low	Low	High
Cluster 6	Low	Low	Low	Low

Source(s): Authors' own work

On answering our research questions outlined in the previous section, the confirmation of various combinations of efficient perceptions becomes evident. However, not all these combinations exhibit high levels of intention and low anxiety. In other words, not every efficient combination proves most conducive to driving effective ICT usage behaviour. Clusters 1 and 2, characterised by the highest levels of usage intention, suggest that their members possess a heightened likelihood of executing the final behaviour, albeit with potential effects from anxiety.

Moreover, the utilisation of DEA facilitates an analysis of necessary changes to enhance the efficiency of the scrutinised units through projections. Table 5 encompasses inefficient entrepreneurs from three of the examined clusters, with the projections of perceptions indicating the values required to maximise results.

For Entrepreneur 260, categorised in the "enhancing perceptions under anxiety" cluster, there exists an opportunity to decrease all their levels, with a particular focus on EE and SI (by 75%) and FC (by 50%). This adjustment is projected to elevate their intention levels (by 17%) and simultaneously alleviate anxiety (by 33%).

Conversely, Individual 88, situated in the "overloaded perceptions under anxiety" cluster, could attain maximum intention levels and reduce anxiety by halving EE and SI. Lastly, Entrepreneur 124 from the "overloaded perceptions" cluster has the potential to refine their perceptions by diminishing EE and FC, which would result in an increase in intention (by 20%) and a reduction in anxiety (by 25%).

5. Discussion and implications

The UTAUT stands as a robust and extensively employed model in technology implementation (Odoom and Kosiba, 2020; Atwal *et al.*, 2021). However, it is not exempt from limitations. As Venkatesh *et al.* (2003) highlighted, usage intention might not fully encompass the impact of external factors, unforeseen events, uncertainties, and/or behaviours beyond individual control, which can result in a lack of correlation between perceptions, intention, and behaviour. In this respect, the models can clarify approximately 70% of the determinants that influence the intention and behaviour pertaining to technology utilisation (Machado De Freitas and Silva Da Rosa, 2022; Rejali *et al.*, 2023). The empirical development of this model has methodologically progressed through structural equation systems and linear regressions by linking latent variables (perceptions) with intentions, and intentions with effective behaviour. In a recent literature review, Lee *et al.* (2024) underscore that PE provides the most widely encompassing explanation at 79.17%, followed by FC (52.08%) and EE (39.58%), while SI only explains an average of 16.67% across 48 analysed studies.

From a theoretical point of view, our study addresses several limitations identified in previous research on the application of the UTAUT model. It contributes to the ongoing discourse among researchers who argue that the predictive capabilities of the UTAUT model can be further refined (Blut *et al.*, 2022), and it also provides new insights and broadens the scope of application of the UTAUT framework, while carrying both theoretical and practical implications. In particular, our analysis proposes an alternative analytical approach to the UTAUT analysis framework. This study focuses on enhancing the understanding of the

Table 5. Values and projections (examples)

	Values						Projections					
DMU	PE	EE	SI	FC	BI	AN	PE	EE	SI	FC	BI	AN
260 (Cluster 2)	6.75	6.75	6.75	5.25	6.00	4.75	4.00	1.75	1.75	2.25	7.00	3.25
88 (Clúster 3)	6.25	6.00	5.00	4.75	5.00	4.00	5.13	3.07	2.60	3.10	7.00	2.40
124 (Cluster 4)	6.00	5.75	5.00	5.00	5.67	2.75	5.53	3.53	2.90	3.40	7.00	2.10

Source(s): Authors' own work

UTAUT by employing a methodology that analyses how the model perceptions can be combined. While the existence of perceptions driving intentions is crucial, every individual possesses their own unique combination of these perceptions. The objective is to identify combinations of perceptions that maximise the behavioural intentions regarding ICT implementation. This process entails a systematic examination of various perceptual factors and their potential impact on the formation of behavioural intentions. To the best of our knowledge, our study represents the first attempt to integrate DEA methodology into the UTAUT framework.

Furthermore, our study addresses other gaps in the applied literature. First, it explores ICT adoption at the MSME level, whereas prior research has primarily focused on large firms (Atwal *et al.*, 2021; Ghosh *et al.*, 2022; Amato *et al.*, 2024).

Second, individual entrepreneurs constitute a group that has been largely ignored in the empirical context of the UTAUT (Odoom and Kosiba, 2020; Blut *et al.*, 2022; Lee *et al.*, 2024). A significant proportion of data in UTAUT research has been collected from student and/or consumer samples (Lee *et al.*, 2024), which may not always be representative of real business scenarios (Dwivedi *et al.*, 2011). Our study, conducted with entrepreneurs, addresses this limitation by providing insights that are more reflective of technological adoption in firms (Kumar *et al.*, 2023; Karabetyan, 2023; Altwaijri *et al.*, 2024; Estrada-Cruz *et al.*, 2024).

Third, our study sheds light on the critical role of perceptions and attitudes in ICT adoption, and addresses barriers to the use of technologies (Purwantini and Anisa, 2021; Loo *et al.*, 2024). Thus, it contributes to a deeper understanding of how entrepreneurs can overcome these cognitive obstacles and fully harness the potential of ICTs (Yu *et al.*, 2017). In this respect, anxiety has traditionally been included as an indirect factor in UTAUT models (Gunasinghe and Nanayakkara, 2021). In our analysis, anxiety is placed on an equal footing with intention, in recognition of the fact that usage perceptions can also involve negative feelings. In other words, anxiety is an undesirable outcome (a negative output) that must be considered within this study framework. In this regard, various studies have explored how the use of new technologies can exert an impact on physical and mental health, specifically concerning stress and/or anxiety (Fernández-Batanero *et al.*, 2021).

Lastly, certain researchers have claimed that there are challenges in accurately predicting usage behaviour across diverse populations, which can limit the predictive accuracy of the model (Williams *et al.*, 2015; Lee *et al.*, 2024). Given the current dominance of the USA as the principal location for collecting primary data, and the relatively limited work conducted in other regions, there is a clear opportunity for researchers to expand the geographical scope of UTAUT studies. By conducting this study in Spain, we address this empirical gap in the literature.

Our DEA results demonstrate that certain individuals can maximise their intentions with their current perception levels. By combining clustering techniques, an explanatory typology has been obtained that analyses the efficiency of combinations of perceptions, intentions, and anxiety. This descriptive classification can provide a more nuanced and comprehensive understanding of the phenomena regarding the implementation of ICTs in MSMEs (Kumar *et al.*, 2023; Altwaijri *et al.*, 2024; Estrada-Cruz *et al.*, 2024; Amato *et al.*, 2024).

This methodology and results may also provide implications for business management, business accelerators, and economic policy. A detailed study of our clusters could reveal potential barriers and obstacles that would hinder the effective implementation of ICTs in MSMEs, thereby enabling researchers to focus on individuals who do not align with the model (Yu *et al.*, 2017; Purwantini and Anisa, 2021; Loo *et al.*, 2024). Entrepreneurs classified in the most unfavourable typologies can take steps to enhance their perceptions, while administration and business accelerators can focus their efforts on these entrepreneurs through, for example, improvements in their technological capabilities, credit access, and/or support infrastructure (Estébanez *et al.*, 2022; Andaregie and Astatkie, 2021; Reuschke *et al.*, 2021; Slinger *et al.*, 2024).

In this respect, Clusters 1 and 6 include those individuals with the highest and lowest probabilities, respectively, of carrying out the final behaviour. The other clusters illustrate the fact that there is room for improvement within these intention models. These groups consist of individuals with combinations whereby, although they are theoretically favourable for behaviour execution, they remain inefficient because they either fail to reach the expected intention level or encounter high anxiety levels that may limit their willingness to execute the final behaviour. Cluster 3 emerges as the most inefficient in combining model perceptions.

Our classification therefore serves as a tool to explain the possible differences between small firms regarding the reasons for the adoption of technology. In this respect, adoption of ICTs has proven essential for enhancing resilience and supporting strategic decisions during crises (Atsuko and Karazhantva, 2020; Martini *et al.*, 2023). However, anxiety toward technology can impede entrepreneurs' ability to make crucial strategic decisions, particularly in challenging times, preventing them from fully utilising ICTs to improve competitiveness and reduce costs (Kreuzer *et al.*, 2022; Bertschek *et al.*, 2023). Our DEA and cluster classification can be a tool that indicates the specific changes required to improve the efficiency of the examined units through projections, thereby allowing for the application of corrective measures of a more precise nature, particularly on anxiety.

6. Conclusions and future research directions

This study aims to enhance the understanding of the motivations behind why certain entrepreneurs in micro, small, and medium-sized enterprises integrate ICTs more successfully than do others. To contribute novel insights into the UTAUT discourse, this study employs Data Envelopment Analysis, a method not previously applied within this framework. By analysing a dataset of 436 Spanish entrepreneurs, the study examines how various UTAUT perceptions can optimise ICT adoption intentions while minimising anxiety related to new technology. This DEA reveals that certain entrepreneurs can effectively enhance their ICT adoption intentions based on their current perceptions by combining clustering techniques, and an explanatory typology has been obtained. Not only does this typology help to identify those groups with a higher propensity for ICT adoption and reveal the factors influencing these intentions, but it also clarifies why not all perceptions translate into adoption intentions. The typology identifies two extremes: "Efficient with Enhancing Perceptions", characterised by high levels of perception, intention, and low anxiety; and "Limiting Perceptions", marked by low and ineffective perception levels.

Certainly, our study is not without its limitations. In particular, moderating variables whose effects have been confirmed in the UTAUT should be incorporated, such as gender, and the latent constructs should be rendered compatible with DEA methodology. Similarly, we have solely focused on intentions, and it is crucial to analyse the transition into action in order to validate our generalisability of a theory and the context dependence of its predictors. DEA provides a snapshot of efficiency at a specific point in time and fails to account for dynamic changes or adjustments over time. DEA efficiency scores are relative measures that depend on the efficiency of other decision-making units in the dataset. The identification of appropriate benchmark units for comparison can be challenging, especially in heterogeneous datasets and cross-cultural analysis.

Future lines of research aim to address these limitations, especially via the examination of the intention-action link by means of a longitudinal study of the surveyed individuals to provide a comprehensive view of the acceptance and usage model. This would also enable an analysis of whether our classification provides a better explanation of the intentions and effective behaviours and whether it enables complementing results to be obtained under the UTAUT. Furthermore, the comparison of different countries and/or cultural contexts, as well as a gender differentiation analysis, would also enhance the robustness of our results. Likewise, the use of new DEA methodologies, such as probabilistic DEA and Bayesian DEA, may be of interest to add robustness to our study.

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