Perspective for the Use of Adoption Theories in Artificial Intelligence

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Abstract — **The evolution of diffusion and adoption theories models took place during the last half of 20th century. Despite the longevity they are still used today, and the use was increasing in the last years, reflecting its importance as valid tools to understand the complexity of technology adoption phenomenon. During the last twenty years, one of the areas in the field of information technologies that re-emerged with a most advanced development, was artificial intelligence. This study aims to identify what is the state-of-the-art on adoption theories of information technologies at individual level, and what challenges comes from artificial intelligence that could stress the conventional adoption theories. Finally, a new work is described as a proposal to overcome these challenges.**

Keywords - Explainable Artificial Intelligence; Human-Computer Interaction; Adoption Theories; Acceptance Frameworks.

I. PROBLEM AND RELEVANCE OF THEME

Research on adoption and the use of new technologies has gone for decades and several evaluation models were created [1]. These models are important because they can aid to capture the drivers of adoption of different kinds of technologies, by different adopters and in different contexts of adoption. The problem lies in knowing, to what extent these models are able to capture the details of the adoption drivers of new and emerging technologies, such as Artificial Intelligence (AI), and whether they are able to capture other details such as, the Organizing System (OS) where the diffusion occurs.

The subject seems to be relevant to us as we are experiencing a moment of great expansion of AI, however, without the right tools for analysis, we risk losing the ability to share and compare diffusion practices between experiments, as well as, losing the opportunity to extract data about which will be the best drivers of diffusion of this technology. Moreover, assuming that eXplainable Artificial Intelligence (XAI), could be an improvement in the field of Human Computer Interaction (HCI) and in the context of delivering Artificial Intelligent (AI) technologies, we want to evaluate and focus future models proposals in the field of XAI.

II. THE ASSOCIATED RESEARCH OBJECTIVES AND TOPICS

The research is part of the research project for the Doctoral Program in Information Science and Technology of the Instituto Universitário de Lisboa, scheduled for completion in January 2024.

The research began with a review of the existing literature on the most widely used acceptance models at the individual level. This review resulted in a survey and classification of the constructs present in these models. Some research work has already been carried out on cases of failure relating the respective causes pointed out, on attempts to use conventional models in capturing AI diffusion drivers.

The objectives that guided the literature review and the methodological choice of the project are:

A. General Research Objective

To develop an adoption model that contribute to the diffusion of AI and to what extent, the use of eXplainable Artificial Intelligence (XAI) is an element that facilitates the adoption for end users.

B. Specifics Research Objectives

- What are the constructs of the most used acceptance adoption theories?
- What kind of adoption drivers these constructs represent?
- What are the main weaknesses of the common adoption theories when dealing with AI and modern diffusion organizing systems?
- What are the modern requirements of the diffusion ecosystems that we all must understand well to facilitate adoption of emerging technologies?

III. PRESENTATION OF WHAT IS ALREADY KNOWN

A. A Resume of The Literature Review

From the literature review we resume that these models started to be developed and applied in the context of sociological studies, assuming that the adoption of behaviors (such as technological adoption) is always a sociological behavior and reflects a social change [2]. These models are always analytical models and are presented as a set of constructs, representing the hypothetical drivers for adoption (as independent variables) and a set of relationships toward the final measured adoption (the depended variable). The use

of the models allows the researchers, to understand what of these constructs better explains the level of adoption of some behavior.

One of the most foundational theories is the Theory of Reasoned Action (TRA) that comes from social psychology [3] and was extensively applied to predict several human behaviors, including information system's adoption either individually or organizationally. Strongly focused on individual's beliefs it addresses two constructs: "attitude toward behavior"; and "subjective norm".

The Theory of Planned Behavior (TPB) [4] is an extension of the TRA It adds the "perceived behavioral control" construct to the two already presented in the TRA as "the perceived ease or difficulty of performing the behavior"

The Diffusion of Innovations (DOI) [2] is defined as the process "by which an innovation is communicated through certain channels over time among the members of the social system". According to [2] the rate of adoption of innovations is explained by a set of variables which are divided in five groups as explained: perceived attributes of innovation; type of innovation-decision; communication channels; nature of the social system and finally, the extend of change agent's promotion efforts. The perceived attributes of innovation are: "relative advantage"; "compatibility"; "complexity"; "trialability"; and "observability". The three types of innovation-decisions are: "optional innovation-decisions"; "collective innovation-decisions"; and finally "authority innovation-decisions". Other determinants influencing adoption rate are: "communication channel"; "nature of the social system"; and "change agent's promotion efforts".

The Technology Acceptance Model (TAM) [5] model is based on "perceived usefulness", and "perceived ease of use". TAM was one the most used models in research about adoption. However some limitations are found as are resumed in [1]: the use of subjective measures that condition the verifiability of the conclusions; the complexity inherent to human persons, context and environment of use are not taken into account; and just as behavior has to be considered a means to an end, so the intention to use cannot be sufficiently representative of actual use. Based on limitation of the model, a new proposal was created [6] in order to make the model more capable to capture the drivers of adoption. The new model commonly named TAM2 introduce a set of new variables: "subjective norm"; "voluntariness"; "image"; "experience"; "job relevance"; "output quality"; and "result demonstrability". A combination of the TAM2 [6] and a posteriori study [7] allow to the development of new release of TAM, the TAM3 [8]. Two news groups of constructs were added: anchors as general beliefs regarding computers and computer use, and adjustments as beliefs based on practical experiences. The added constructs are defined as: "computer self-efficacy"; "perception of external control"; "computer anxiety"; "computer playfulness"; "perceived enjoyment"; and finally "objective usability".

The Motivation Model (MM) [9] resumed that people adopt technologies based on a motivational perspective, either extrinsic or intrinsic. Introduces two generic constructs: "extrinsic motivation" and "intrinsic motivation".

The PC Utilization Model (PCUM) [10] was developed as a model capable to explain the PC use. The following constructs where used to test the model: "job-fit with PC use"; "complexity of PC use"; "long term consequences of PC use" ; "affect toward PC use"; "social factors influencing PC use"; and "facilitating conditions for PC use".

The Social Cognitive Theory (SCT) [11] purpose a new model for measuring and test computer self-efficacy. The social cognitive theory presents the following set of constructs: "encouragement by others"; "others' use"; "support"; "outcome expectations"; "computer self-efficacy"; "affect"; and "anxiety".

Based on previous developments on TRA, TAM, MM, TPB, TAM2, DOI, SCT and PCUM the Unified Theory of Acceptance and Use of Technology (UTAUT) [12]. The model is defined with following set of constructs: "performance expectancy"; "effort expectancy"; "social influence"; and "facilitating conditions". The model presents also four moderate variables that influence adoption more specifically in the participation of some constructs: "gender"; "age"; "experience"; and "voluntariness of use". Trying to improve more the capacity of explanation's variance in behavioral intention an extension of UTAUT was proposed, namely UTAUT2 [13]. The new model presents the following new constructs: "hedonic motivation"; "price-value"; and "habit". The model presents three moderate variables. They are: "gender"; "age"; and "experience".

Using the classification proposed in [14] we can group all these constructs on five categories:

- Task related characteristics: relating to the job characteristic supported by the innovation.
- Technology-related characteristics: relating to characteristics of the innovation for itself.
- Individual characteristics: relating to personal traits or intrinsic characteristics of the individuals using the innovation.
- Interpersonal factors: social or relational characteristics
- Situational factors: professional characteristics of the environment

A first read on these categories, let us think we have all the conditions to evaluate the diffusion of AI using them, and there is nothing to make us think that it is necessary to develop something more specific for AI.

B. Shortcomings of Adoption Theories

The extension of adoption theories seems to be always an open area of research. As we can observed in most of the models presented, we may conclude many times, the intention of the authors to reuse some work of previous applied models. The intuition is that each one is trying to add something better. Another and common way to extent models is to combine one or two previous models in one new approach [15] or, to adopt one model and try to make some minor adjustments, adding or removing some constructs but without altering the fundamental structure of the original one [18]. The fact is, these models may

become very hard to be used if, they include too many drivers of adoption in an attempt to capture the most variance in constructs. Some authors explore the incapacity of some models to be capable to explain decisions and behavior across a so wide range of different technologies [18], others reclaim that these models should include constructs from other disciplines of management in order to explain the adoption process of new technologies [19], or to include wide integrative view of the different approaches and stages of the adoption process [14] such as, acceptance stage, post-acceptance and outcomes. AI is one more complex technology inside the scope of IT and is for itself a wide area of research with real different approaches and goals. A recent study on acceptance theories applied to artificial intelligence-based intelligent products was performed in [20]. The authors highlighted the opportunity to study acceptance theories in the field of artificial intelligence. According with these authors, few studies explain the drivers of the intention to adopt taking in consideration particularities of AI-based intelligent products, which may be considered a problem in the research field of the theories of adoption when applied to AI. To add more chaos to the already existing chaos we may state the hypothesis that AI is considered a General-Purpose Technology (GPT), such as was the steam engine, the electricity, the transistor, etc., as opposed to a single purpose technology such as, a toaster or a washing machine, for which, the purpose of the innovation is well known, and the adoption population is relatively homogeneous. The GPT appears itself generic until is applied in the space of an Application Sectors (AS). Several articles analyze the characteristics of the complexity of the economy-wide dynamics fostered by GPTs and its diffusion [21] [22][23] [24]. Refocusing on the adoption theories, they seem to have real limitations when trying to capture the complexity of GPT diffusion [25][26]. Moreover, most of the business models where new economics are realized, are in fact complex and networked organizing systems [27], where the diffusion doesn't happen any more in a transaction oriented business model, and instead, through concepts of shared and circular economy, calling upon the creation of alliances and platforms where the businesses area allowed to create, add and capture economic value [28]. This recall, the importance to understand the details of the organizing system where the diffusion is going to happen. In short, it is highly unlikely that conventional adoption theories have good arguments for capturing the spread of AI as a complex technology through these new economic dynamics.

C. The Challenges of Explainable Artificial Intelligence

Notable developments have been done referring machine learning and deep learning as a set of methods to enable computer recognition. Although of the impressive notability of some machine learning applications, some of models built based on these techniques acts as black-boxes, reducing adoption, trust, and creating a set of problems in the diffusion of AI based innovations [29]. A recent interest for an old field of research and development aimed at bringing the relationship between humans and intelligent agents closer together is the so-called XAI - EXplainable Artificial Intelligence. XAI can improve the human-machine interaction by delivering AI products with a set of characteristics that can be considered as value added features. The following list highlights the current set of these features: "understandability (or equivalently, intelligibility)" as "the characteristic of a model to make a human understand its function – how the model works – without any need for explaining its internal structure or the algorithmic means by which the model processes data internally"; "comprehensibility" as "referring to the ability of a learning algorithm to represent its learned knowledge in a human understandable fashion"; "interpretability", as "the ability to explain or to provide the meaning in understandable terms to a human"; "explainability" as "the notion of explanation as an interface between humans and a decision maker that is, at the same time, both an accurate proxy of the decision maker and comprehensible to humans"; and finally "transparency" as "a characteristic of model if by itself it is understandable". These characteristics have almost no similarities with the constructs presented in the conventional adoption theories.

D. AI and Ethics

AI is more than ever a discipline that has been in focus of political and government officials. The biggest concern is to guarantee a utilization of what is defined as a responsible artificial intelligence. In [30] are resumed a set of concerns that should be under umbrella of the governance of artificial intelligence. Concepts such as privacy, accountability, safety and security, fairness and non-discrimination, human control of technology, professional responsibility, and finally the promotion of human values.

IV. Methodology proposed to solve the problem

The design and methodological approach of this research does not differ so much from what can be considered a standard approach. It comprises an inception phase (1), a phase of research and literature review (2), the developing of an analysis model (3), the selection of research and data analysis techniques (4), data collection (5), data processing (6), the production of conclusions and recommendations (7), and finally the phase for writing the research work (8).

A. Purpose development

This is an inception phase. It includes to think about the background of the PhD program, the scope of work and strategy to address the problem.

B. Research

Essentially composed by the literature review, aims to collect pertinent information related to the area in general and, problematic research in particular.

C. Development of the analyses model

Being a model of analysis a representation of the reality that we intend to investigate, in this case related to the adoption of AI, it always represents a theoretical scheme composed of the essential dimensions to be studied in the form of concepts or variables, key factors and relationships between them.

Being the objective of this PhD, the development of a final adoption framework for AI applications at an individual level, the investigation is going to be inductive and descriptive, as it is necessary to develop concepts and ideas from patterns centered: on data collected by other researchers (1) or; from hypothesis development and with field tests to measure the

evidences that some concepts are good proposals of constructs for capturing the drivers of AI adoption. In this sense the method comes close to the grounded theory.

D. Investigation and data analysis techniques

The type of research to be developed is essentially quantitative since, the field test with formulated hypotheses allow to verify the veracity of the hypotheses to explain the dependent variable, that is, there is a causal relationship with the dependent variable.

E. Data collection

The first important question in data collection is to define the data collection target, that is, who we are going to survey. As this is a project that aims to design an AI adoption framework at the individual level, we primarily want to ask users of AI innovations. Secondarily, we can always ask other stakeholders since, the use of this type of systems always takes place within a organizing system.

F. Data processing

The analysis of models after survey in adoption frameworks frequently uses SEM (Structural Equation Modeling), in order to allow examining multiple influences and multiple responses simultaneously. Given its flexibility and breadth of applications, SEM offers a means to develop and evaluate ideas about complex multivariate relationships.

V. Expected results

Results should be presented with evidence about the weaknesses of common adoption theories when applied to the field of AI. Results should also be concerning about, proposals of alternatives models to analyze adoption of AI/XAI capable to capture as well as the characteristics of the organizing system through which diffusion occurs (including access to resources such as data, skills, platforms, business models dynamics), and is more or less limited by AI principles imposed by governments.

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