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RESEARCH

Maximilian Horn

Technology Acceptance, Path Dependence, and the Demand for Robo-Advisory Services

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Digitalisierung verändert Unternehmen und Behörden, unser Privatleben und unsere Gesellschaft. Organisationen, die wettbewerbsfähig bleiben wollen, müssen die dadurch notwendigen Veränderungen aktiv mitgestalten. Die Rolle der IT muss sich in diesem Zusammenhang vom Kostenfaktor zum Werttreiber wandeln. Weiterentwicklungen der IT-Kernkompetenzen sind nötig. In dieser Reihe werden wissenschaftlich fundierte und praktisch relevante Erkenntnisse zur Digitalisierung veröffentlicht. Praktiker finden darin vielfältige Anregungen für die Gestaltung und Verbesserung von Strukturen, Prozessen und IT-Systemen. Wissenschaftler erhalten Impulse für die Beschreibung, Erklärung, Prognose und Gestaltung der Digitalisierung.

Digitalization is changing businesses and governments, our private lives and our societies. Organizations that want to remain competitive must actively shape the changes that are necessary as a result. In this context, the role of IT must change from a cost factor to a value driver. Further developments of the IT core competencies are necessary. This series publishes scientifically sound and practically relevant findings on digitization. Practitioners will find many suggestions for the design and improvement of structures, processes and IT systems. Scientists receive impulses for the description, explanation, prediction and design of digitisation.

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This dissertation was written at the University of Bremen and defended in the examination colloquium before the reviewers Prof. Dr. Martin Missong and Prof. Dr. Kristina Klein on July 11, 2023.
Diese Dissertation wurde an der Universität Bremen erstellt und im Prüfungskolloquium vor den Gutachtern Prof. Dr. Martin Missong und Prof. Dr. Kristina Klein am 11. Juli 2023 verteidigt.

ISSN 2662-4788 ISSN 2662-4796 (electronic)
Forschung zur Digitalisierung der Wirtschaft | Advanced Studies in Business Digitization
ISBN 978-3-658-44678-9 ISBN 978-3-658-44679-6 (eBook)
https://doi.org/10.1007/978-3-658-44679-6

This Springer Gabler imprint is published by the registered company Springer Fachmedien Wiesbaden GmbH, part of Springer Nature.
The registered company address is: Abraham-Lincoln-Str. 46, 65189 Wiesbaden, Germany

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Acknowledgements

I extend my deepest gratitude to my doctoral supervisor, Prof. Dr. Martin Missong, who made my doctoral studies an instructive journey with his imaginative suggestions, strong commitment, and high quality standards. His great openness to new ideas enabled me to shape this journey in a self-determined way. I would like to emphasize his strong sense of humor, which has always made working with him a great pleasure.

Special thanks are also due to Prof. Dr. Stefan Mittnik, who contributed his theoretical expertise and practical experience as co-founder of Scalable Capital on the topic of robo-advisors at the CEQURA 2021 conference and as an external reviewer in the colloquium. I am equally grateful to Prof. Dr. Martin Möhrle, whose input improved the quality of the dissertation in the final stage.

I would like to thank all the partners of Berg Lund & Company, especially Markus Berg and Dr. Torsten Lund, who initiated the contact to Prof. Dr. Martin Missong and made it financially possible through a flexible part-time model. In addition, they gave me the opportunity to present the most important findings of my dissertation at a major conference in the field of retail banking.

My thanks extend to Philipp Wierzchowski for his diligent support with data collection and to Lea Hashagen for her invaluable graphical contributions and recommendations. Mary Trost contributed to the linguistic development of the thesis, who, as a Brit, managed to recognize British spelling in a text based on American English.

The emotional support that I received was particularly important during my doctoral journey: My parents, Eva-Maria Horn and Rolf-Ulrich Horn, have been my pillars throughout the doctoral phase, especially when I needed a sympathetic ear. They also actively supported me in making the best possible use of my time through (partly joint) workations. I would like to thank my partner, Noor-A-Kasida Maria Islam, who has been a constant source of support and understanding, which enabled me to concentrate fully on my dissertation. Her dedication, reflected in numerous readings and invaluable feedback during the culmination of my doctorate, was crucial to my dissertation's completion.

As the true contribution of my parents and my partner cannot be put into words, I would like to dedicate this thesis to them.

Abstract

This thesis aims at modeling and investigating the demand for robo-advisory services empirically. Thus, it seeks to contribute to the accessibility of financial markets for private investors. This objective is pursued by applying two approaches: the integration of individual path dependence into established models of technology acceptance (TAM and UTAUT) and the analysis of the impact of product features (services, cost structures etc.) on the demand for robo-advisory services. Relevant insights for the information systems (IS) community, suppliers of robo-advisory services, and governmental institutions are derived based on the theoretical and empirical results.

I expanded the unified theory of acceptance and use of technology (UTAUT) with the idea of path dependence deriving a path dependence augmented UTAUT model (PDA-UTAUT model). The path dependence in this model is operationalized as the acceptance of a basic product or technology, e.g., the investment on the stock market, which enables the usage of a new or advanced technology, e.g., robo-advisor technology, and influences the attitudes towards the new or advanced technology, e.g., the performance expectancy attributed to robo-advisor technology. The PDA-UTAUT model was adapted to robo-advice by including additional relevant constructs. I tested this robo-advisor-specific model using online survey data from Germany (n = 1102) and the USA (n = 1093) employing partial least square (PLS) regressions. The results demonstrate that path dependence is an important factor for the acceptance of and attitudes towards the advanced technology of robo-advisory. Furthermore, the PDA-UTAUT model can account for factors with diverging effects on the basic and new technology conclusively. Other technologies warranting an explicit modeling of path dependence are pointed out and recommendations on the application of the PDA-UTAUT model are provided.

The decisive role of product attributes for technology acceptance is mirrored by their inclusion in the first technology acceptance model (TAM) by Davis 1985. Nevertheless, the focus of academic research has shifted away from them. A structured process to identify product attributes which impact technology acceptance is presented and applied to robo-advisors: A longlist of attributes was derived from the academic, industry, and consumer literature. The empirical data for these attributes were collected for 40 German and 34 American robo-advisors allowing a statistical comparison of both markets. The relative importance of selected attributes for customers' decision making was evaluated with a choice-based conjoint analysis (CBC) relying on online survey data from Germany (n = 330) and the USA (n = 288). The most relevant attributes were subsequently included in an adapted PDA-UTAUT model accounting for supply effects and tested using online survey data from the USA (n = 750) employing PLS regressions finding support for the effect of selected attributes on the intention to adopt robo-advisor technology and the influence of path dependence on the attitudes towards robo-advisors.

Contents

Abbreviation

AGE	Age
AI	Artificial intelligence
API	Application programming interface
AuM	Assets under management
AVE	Average variance extracted
CA	Conjoint analysis
CBC	Choice-based conjoint analysis
DOI	Diffusion of innovations
EDU	Education
EE	Effort expectancy
EI	External influence
ESSM	Ethical stance (towards the stock market)
ET	Emotional trust
ETF	Exchange-traded fund
FAM	Familiarity (with the use of robots)
FinTech	Financial technology
FL	Financial literacy
FL_A	Advanced financial literacy
FL_B	Basic financial literacy
FR	Financial risk attitude
GEN	Gender
HB	Hierarchical-Bayes-analysis
HTMT	Heterotrait-monotrait ratio
I	Income
IDT	Innovation diffusion theory
II	Interpersonal influence

IINV	(Behavioral) intention to invest (on the stock market)
IIRA	(Behavioral) intention to invest with a robo-advisor
INRA	Investors not invested using robo-advisors
INV	Investment on the stock market
IS	Information systems
IURA	(Behavioral) intention to use robo-advisor technology
IWRA	Investment with a robo-advisor
MM	Motivational model
MNL	Multinomial logistic regression
MPCU	Model of PC utilization
NFC	Near-field communication
NI	Non-investors
OLS	Ordinary least squares
PE	Performance expectancy
PEOU	Perceived ease of use
PI	Personal innovativeness
PLS	Partial least squares
PPR	Perceived privacy risk
PU	Perceived usefulness
RA	Robo-advisor(s)
REIT	Real estate investment trust
RLH	Root likelihood
RPA	Robotic process automation
RUM	Random utility model
SCT	Social cognitive theory
SD	Standard deviation
TAM	Technology acceptance model
TC	Trust in competence
TI	Trust in integrity
TPB	Theory of planned behavior
TRA	Theory of reasoned action
UTAUT	Unified theory of acceptance and use of technology
VIF	Variance inflation factor
Vs.	Versus
WEA	Wealth
WTP	Willingness to pay

Introduction

1

Financial markets bring together actors seeking financing (e.g., private companies or the government) with actors seeking to invest their money profitably (e.g., private investors). Thus, the efficiency and accessibility of financial markets are in the interest of the overall economy as well as of the individuals within an economy.

Digitization and process automation enable business models that were not possible or profitable before. In banking and finance, these new businesses are known as financial technology (FinTech) companies. FinTech companies utilize emerging technologies as algorithms, artificial intelligence (AI), big data, blockchain, open application programming interfaces (API), or robotic process automation (RPA). FinTech companies cover areas as diverse as peer-to-peer-lending, open banking, social trading, and robo-advisors. Using these new technologies, FinTech companies can increase the efficiency and accessibility of financial markets.

This thesis concentrates on the financial technology of robo-advisory services, which have flourished in the last decade. Notably, robo-advisors allow private investors to access financial markets at relatively low costs and often with a lower minimum investment as compared to traditional advisors. Thus, robo-advisors might provide an opportunity for those who are not invested on the stock market yet. Non-investors currently constitute 82.9% of the German population in 2021 (Balonier et al. 2022 from *Deutsches Aktieninstitut*) and 42% of the US-American population in 2022 (Saad and Jones 2022 from *Gallup*).

Robo-advisors are automated and algorithm-based services to invest on the stock and bond markets without requiring human interaction or judgment. These services are offered by banks, financial advisory firms, or start-ups relying on standardized questionnaires on investors' risk attitudes, investment goals and

M. Horn, *Technology Acceptance, Path Dependence, and the Demand for Robo-Advisory Services*, Forschung zur Digitalisierung der Wirtschaft | Advanced Studies in Business Digitization, https://doi.org/10.1007/978-3-658-44679-6_1

planning intervals. They provide a recommendation on how to split assets between different classes and offer the asset management to execute the recommendation. Some robo-advisors offer additional services like tax loss harvesting. Robo-advisors typically derive revenues from their services by charging fees in proportion to the assets under management (AuMs) invested in them.[1,2]

Whether robo-advisory will replace, augment or simply co-exist with established advisory approaches is yet to be seen. Hybrid models of human advisors augmented with robo-advisor technology are already on the market (e.g., TD Ameritrade and Fidelity). They offer the advantages of robo-advisory (e.g., 24/7 availability and cost efficiency) combined with the traditional focus on human relationships and trust of established financial advisory and wealth management firms (Chowney and Fragnière 2014).

This thesis aims at providing a model and empirical investigation of the private demand for robo-advice. This investigation shall allow a better understanding of the demand behavior of private investors. These findings can substantiate the strategies of suppliers of robo-advisory services to achieve profitable growth as well as public institutions to increase the share of stock investors in the population.

Governmental institutions of major economies promote financial market participation, especially for the purpose of retirement planning. This objective is often motivated by the vulnerabilities that pay-as-you-go, as opposed to funded pension schemes, exhibit due to an aging population. In January 2023, the German Federal Minister of Finance, Christian Lindner, proposed a program called "Aktienrente". The aim of the program is to introduce stock market investment as an additional pillar of the German public retirement insurance ("gesetzliche Rentenversicherung") to counteract the effects of demographic change and allow a participation in the returns achieved on global financial markets. In a similar vein, the government of the USA has been granting tax breaks to

[1] An example of a wider definition of robo-advisory can be found in D'acunto and Rossi 2019, who study a portfolio optimizer offered by an Indian brokerage firm. The tool uses Markowitz 1959 based mean-variance optimization to construct and visualize portfolio weights using Indian stocks. Trading operations had to be approved by consumers.

[2] D´Acunto and Rossi 2021 discuss the expansion of the term robo-advisory to all personal finance choices households face. Examples for this broader view of robo-advice are the online real estate marketplace Zillow, the discount real estate brokerage Redfin and the social financial management app Status Money. Although this broader definition might become mainstream in the future, this dissertation confines itself to tackling adoption of portfolio allocation technologies. To the author's knowledge none of the said companies market their services as robo-advisory up until now.

the employer-sponsored, defined-contribution, personal pension 401(k) accounts since 1978.

Traditional models of technology acceptance serve as a starting point to analyze the demand for robo-advisory services.[3] The most prominent models of technology acceptance are the unified theory of adoption and use of technology (UTAUT) developed by Venkatesh et al. 2003 and its predecessor the technology adoption model (TAM) developed by Davis 1985. UTAUT and TAM have been widely adopted to investigate the adoption intention and behavior of different information technologies. The UTAUT model assumes that the behavioral intention (to use a technology) alongside facilitating conditions influence usage behavior (of a technology). The behavioral intention is influenced by performance expectancy, effort expectancy, and social influence. The relationship between independent and dependent constructs can be moderated by different mostly demographic factors. Various factors have been considered in addition to the main constructs of the UTAUT and TAM to model the adoption of diverse technologies without changing the core models. The details of the models will be explained in Chapter 2.

Although the UTAUT model serves as a baseline, it is not sufficient to model the usage of robo-advisors, as their acceptance is influenced by the stock market participation of their potential clients. Stock market participation directly affects the acceptance of robo-advisor technology, as it constitutes a necessary condition. I refer to stock market investments as a basic product/technology for the new technology of robo-advisory.

The process by which investment behavior influences the demand for robo-advisors can be conceptualized as a case of individual path dependence (Nelson and Winter 1982; Arthur 1989; Arthur 1996). A general framework will be provided on how to model individual path dependence in UTAUT models. This general framework will be adjusted to robo-advice.

Building on this theoretical basis, an empirical analysis using PLS regressions on survey data from Germany and the USA shall provide answers to **research question 1:**

> *How does the individual investment behavior influence the demand for robo-advisory services?*

[3] Thus, this thesis can be seen as part of the information systems (IS) literature.

Evidence for the importance of product features[4] on product adoption can be found throughout the history of technology. Features have played a decisive role in the breakthrough or prevention of various technologies. The following examples illustrate the importance of features for technology adoption:

- **Electric cars:** At the dawn of the car industry in the late 19th century, electrically powered cars were competitors to gasoline-powered cars.[5] However, electric cars lost out to gasoline-powered cars, due to a lack of range, long charging times, and expensive production.
- **iPhones:** Apple's iPhone was not the first attempt to make smartphones mass marketable, however, the first one successfully establishing a new mass market (Gartner 2022). According to home users' preferences elicited by surveys, the iPhone was easy to use and equipped with the following features: 3G compatibility, third-party software integration, GPS, e-mail, and voice recognition.
- **Flash memories**[6]: Initially, flash memories were unsuccessful in the traditional hard disk markets (e.g., PCs) because of their low capacity and reliability. However, due to their small size, low power consumption and high speed, they were used in USB sticks, digital cameras, and MP3 players. Based on these increased sales, flash memories continued their success in laptops and other mobile devices.

Thus, it can be assumed that product features also play a role for the demand for robo-advisory services. Hence, I investigate how to integrate objective product features of robo-advisors, i.e., features that can be quantified and do not constitute attitudes and perceptions, into the PDA-UTAUT model. Suitable features of robo-advisors are identified using a systematic market overview of current features of robo-advisors in Germany and the USA. A choice-based conjoint analysis (CBC) using survey data from Germany and the USA allows a selection of features by their relative impact on customer decision making. These features are included and tested within an adapted PDA-UTAUT model using data from a second survey from the USA providing evidence on **research question 2:**

[4] The terms "feature" and "attribute" are used synonymously in this thesis. The terms are defined and discussed in depth in Chapter 5.

[5] The first speed record over 100 km/h was achieved by an electric car (Bourgarit and Plateau 2005).

[6] This example was adapted from Christensen 1997.

How do features influence the demand for robo-advisory services?

The ideas behind both research approaches of this thesis are established for a long time: While the concept of path dependence is known at least since the 1980s (Nelson and Winter 1982; Arthur 1989; Arthur 1996), product features were an integral part of the first model of technology acceptance, TAM, proposed by Davis 1985. The implication of individual path dependence for technology acceptance has not been conclusively discussed in the IS literature.[7] I argue that individual path dependence is not limited to the technology of robo-advice, but it can be expected to play a role for the acceptance of other technologies or products as well. An example for a basic product might be a mobile phone with near-field communication (NFC) for the new technology of mobile payment. Arthur 1996 took the software Java as an example which serves as a basic technology to other computer programs, i.e., advanced technologies.

Although some researchers in the field of IS recommend product features to influence the constructs of models of technology acceptance (Belanche et al. 2019; Wu and Gao 2021), empirical investigations of product features remain scarce. Thus, this thesis follows the recommendation of members of the IS community to analyze the role of product features empirically, e.g., Benbasat and Barki 2007 in the *Journal of the Association for Information Systems.*

This thesis provides a theoretical basis and empirical methods to investigate the following questions structured by their imputed target audience:

IS researchers might find answers to the following questions relevant:

- How can the impact of basic technologies on the adoption of a new technology be represented in a UTAUT model and for which technologies is this useful?
- What is a systematic process for evaluating and testing the impact of product features on customer demand?

Providers of robo-advisory services and governmental institutions might be interested in answers to the following questions:

- What is the impact of stock market investment on the adoption of robo-advisory services?

[7] Some recent studies on the acceptance of robo-advice have dealt with path dependence only indirectly by excluding participants who do not invest without referring to path dependence explicitly (Fan and Chatterjee 2020; Todd and Seay 2020).

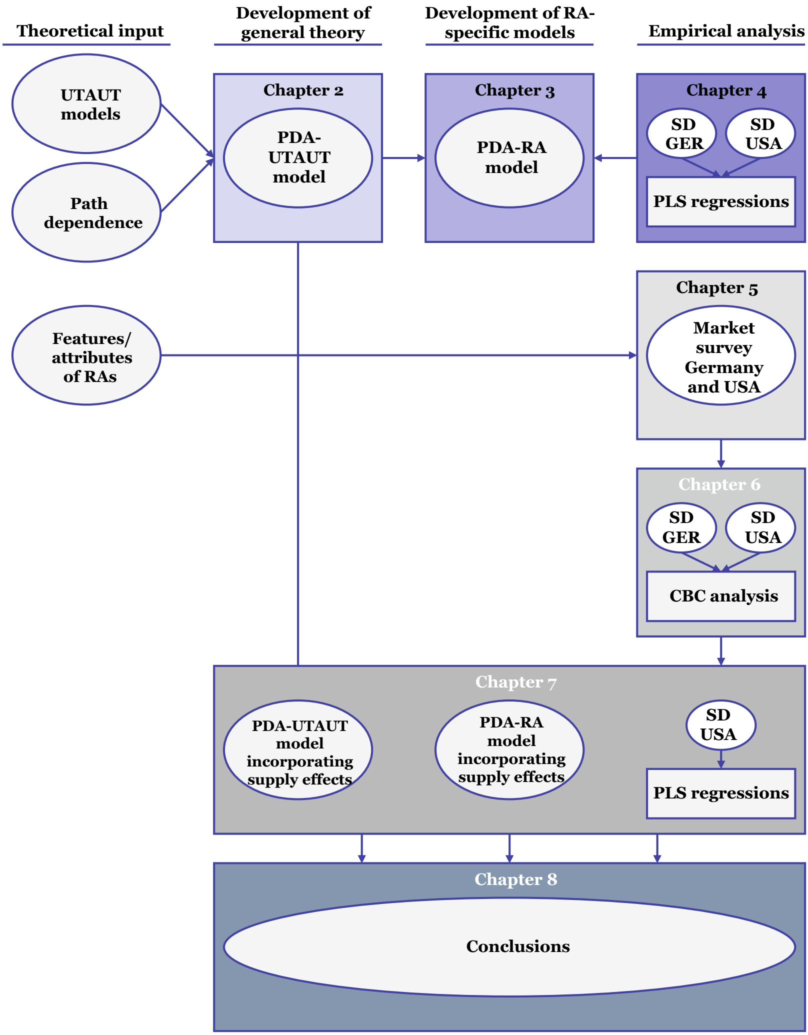
- Can robo-advisors increase the share of stock market investors in Germany and the USA?
- Do German and American robo-advisors match customer preferences with the product features that they currently offer?
- Which product features are relevant for the acceptance of robo-advisors?

As the empirical methods are applied on convenience samples, although trying to approximate representative samples as closely as possible, and are based on new theoretical approaches, the empirical findings of this thesis can be considered as exploratory.

The following chapters structure this thesis:

- Chapter 2 combines the established UTAUT model and the theory of path dependence to derive a path dependence augmented UTAUT model (PDA-UTAUT model) including recommendations on its applicability to other technologies.
- Chapter 3 adapts the PDA-UTAUT model to the specificities of the robo-advisor technology.
- Chapter 4 tests the robo-advisor specific PDA-UTAUT model with partial least squares (PLS) regressions using online survey data from Germany and the USA.
- Chapter 5 conducts a market survey of product features of German and American robo-advisors based on a list of features derived from the academic and industry literature.
- Chapter 6 includes notable product features derived from Chapter 5 in a choice-based conjoint study (CBC) based on online survey data from Germany and the USA deriving the relative importance of these features for private customers.
- Chapter 7 derives a PDA-UTAUT model accounting for supply effects which is adapted to robo-advisor technology. This model is tested with PLS regressions employing online survey data from the USA.
- Chapter 8 summarizes the findings of the thesis deriving theoretical and empirical implications, especially for providers of robo-advisory services as well as governmental institutions. Furthermore, it points out limitations and opportunities for future research.

Figure 1.1 summarizes the structure of the thesis.



RA: Robo-advisors
UTAUT: Unified theory of acceptance and use of technology
PDA: Path dependence augmented
SD: Survey data
PLS: Partial least squares
CBC: Choice-based conjoint

Figure 1.1 Structure of the dissertation

Check for updates

Uniting Individual Path Dependence and UTAUT: The PDA-UTAUT Model

2

Accounting for path dependence in the modeling of the acceptance of robo-advisor technology will be organized in the following way. In Chapter 2, a path dependence augmented UTAUT (PDA-UTAUT) model will be deducted based on general and robo-advisor-specific technology acceptance as well as path dependence research. In Chapter 3, the PDA-UTAUT model will be adapted to the specific traits of robo-advisor technology. In Chapter 4, the robo-advisor-specific PDA-UTAUT model will be tested deriving practical implications from the empirical findings.

2.1 Introduction to UTAUT

The technology acceptance model (TAM) (Davis 1985; Davis 1989) and the unified theory of acceptance and use of technology (UTAUT) (Venkatesh et al. 2003) are widely used models to investigate the acceptance of information technologies. Additional constructs are added to these models to adapt them to specific contexts and technologies (Srite and Karahanna 2006; Venkatesh et al. 2012; Nistor et al. 2014; Belanche et al. 2019). It is important to consider that both TAM and UTAUT were originally developed in the context of business organizations and were later adapted to the consumer context. Adoption behavior and behavioral intention to adopt the information technology are chosen as dependent constructs contingent on the context.

The predictive role of behavioral intention for usage is decisive, but well established in the information systems (IS) literature, as described by Ajzen 1991 for the literature on the theory of planned behavior (TPB) and by Sheppard et al.

M. Horn, *Technology Acceptance, Path Dependence, and the Demand for Robo-Advisory Services*, Forschung zur Digitalisierung der Wirtschaft | Advanced Studies in Business Digitization, https://doi.org/10.1007/978-3-658-44679-6_2

1988 in their meta-study summarizing the empirical research on the theory of reasoned action (TRA). They focused on the distinction between behavior which can be performed at will, e.g., eating at a fast food restaurant (Brinberg and Durand 1983), and goals which involve a degree of uncertainty, e.g., having a child in the next two years (Davidson and Jaccard 1979). They found that intentions better predict behavior than goals. This finding supports the importance of facilitating conditions (Venkatesh et al. 2003). Taylor and Todd 1995b demonstrated the predictive significance of intention on behavior for making use of the resources of a computer resource center at a university with over 750 participants within the technology acceptance model (TAM) and two versions of the theory of planned behavior (TPB).

Based on the theory of reasoned action (TRA) (Fishbein and Ajzen 1975), Davis 1985 proposes the following constructs to explain the acceptance of specific information technologies:

- Perceived usefulness is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance".
- Perceived ease of use is defined as "the degree to which a person believes that using a particular system would be free of physical and mental efforts".

Later, the construct of subjective norm ("the person's perception that most people who are important to him think that he should or should not perform the behavior in question" Fishbein and Ajzen 1975) was added to TAM (Venkatesh and Davis 2000). TAM has been employed by researchers to investigate the consumer adoption of information technologies like e-commerce (Pavlou 2003; Gefen et al. 2003) and instant messaging (Jiang and Deng 2011). Furthermore, TAM has been used to explain technology acceptance in financial settings like mobile payments (Bailey et al. 2017) and recently robo-advisors (Belanche et al. 2019). Some research papers draw from both sources, e.g., for the mobile payment services (Thakur and Srivastava 2014).

Venkatesh et al. 2003 sought to derive a unified theory from the existing IS literature. The constructs of 8 different models were empirically validated: TRA, TAM, motivational model (MM), theory of planned behavior (TPB), a model combining TAM and TPB, the model of PC utilization (MPCU), innovation diffusion theory (IDT), and social cognitive theory (SCT). The final and henceforth standard model includes the following constructs: