THEORIES, MODELS, AND FRAMEWORKS FOR THE USE AND ACCEPTANCE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

TEORIAS, MODELOS E ESTRUTURAS DE USO E ACEITAÇÃO DE TECNOLOGIAS DE INFORMAÇÃO E COMUNICAÇÃO

TEORÍAS, MODELOS Y MARCOS PARA EL USO Y ACEPTACIÓN DE LAS TECNOLOGÍAS DE LA INFORMACIÓN Y LA COMUNICACIÓN

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Abstract

This study reviews a chronological evolution of the main theories, models, and frameworks of information and communication technologies use and acceptance over the last 80 years. It was possible to identify fundamental variables related to the theme and the relationships between the developed works, promoting a better understanding of these studies' history and contributing to future research on the use of new technologies, especially after the disruptive scenario of 2020. We performed a literature review, identifying 19 studies over 80 years. The study includes seminal theories of communication, innovation, and human behavior, and those produced from the combination of previous models and cases in which models' evolution allowed great explanatory power. The most applied ones are UTAUT and TAM. The study brings a complete look at the theories, favoring managerial applications in services and other fields.

Keywords: Historical evolution, Technology use, Technology acceptance.

Resumo

Este estudo revisa uma evolução cronológica das principais teorias, modelos e estruturas de uso e aceitação das tecnologias de informação e comunicação nos últimos 80 anos. Foi possível identificar variáveis fundamentais relacionadas ao tema e as relações entre os trabalhos desenvolvidos, promovendo um melhor entendimento da trajetória desses estudos e contribuindo para pesquisas futuras sobre o uso de novas tecnologias, principalmente após o cenário disruptivo de 2020. Realizou-se uma revisão da literatura, identificando 19 estudos em 80 anos. O estudo inclui teorias seminais de comunicação, inovação e comportamento humano, e aquelas produzidas a partir da combinação de modelos anteriores e casos em que a evolução dos modelos permitiu grande poder explicativo. As mais aplicadas são UTAUT e TAM. O estudo traz um olhar completo sobre as teorias, privilegiando aplicações gerenciais em serviços e outras áreas.

Palavras-chave: Evolução histórica, Uso de tecnologia, Aceitação de tecnologia

Resumen

Este estudio revisa una evolución cronológica de las principales teorías, modelos y marcos de uso y aceptación de las tecnologías de la información y la comunicación durante los últimos 80 años. Se logró identificar variables fundamentales relacionadas con la temática y las relaciones entre los trabajos desarrollados, promoviendo una mejor comprensión de la historia de estos estudios y contribuyendo a futuras investigaciones sobre el uso de nuevas tecnologías, especialmente después del escenario disruptivo de 2020. Una revisión de la literatura identificando 19 estudios en 80 años. El estudio incluye teorías seminales de la comunicación, la innovación y el comportamiento humano, y las producidas a partir de la combinación de modelos y casos anteriores en los que la evolución de los modelos permitió un gran poder explicativo. Las más aplicadas son UTAUT y TAM. El estudio aporta una

mirada completa a las teorías, favoreciendo las aplicaciones gerenciales en servicios y otros campos.

Palabras clave: Evolución histórica, Uso de tecnología, Aceptación de tecnología.

1 INTRODUCTION

Information and communication technologies (ICTs) usage by individuals are a long-time concern for researchers and practitioners. Bellini (2018) describes three moments of maturation: inclusion, equality, and effectiveness, under the concept of one's digital effectiveness, associated with an individual's use of ICTs in desirable ways, and the digital effectiveness manifestation in three dimensions: access, cognition, and behavior.

Information System (IS) use has long been a central construct in many studies (Burton-Jones et al., 2020). Researchers and organizations are interested in understanding human attitudes, intentions, and behaviors towards new technologies. Organizations had already been in the process of increasing the adoption and use of virtual relationships and transactions, including the frequent launch of new systems and applications.

Despite the difficulty of using and adapting to these new operation modes, and although some people are still resistant to new technologies (Heinze et al., 2017), the global sanitary crisis in 2020 made everyone review their relationships with technological resources. Transformation of needs through the adoption of technologies, whether by organizations, commerce or individuals, was driven by the social isolation to which a large part of the world population. Suddenly, our activities previously done in person had to be converted into remote activities with abrupt massive adoption of the home office, homeschooling, and e-commerce (Fuchs, 2020). Given this scenario and the increasing studies on the use of technology, it is crucial to obtain a complete understanding of how theories, models and frameworks of information and communication technologies (ICTs) have evolved.

There are meta-analyzes and theory reviews published (Marangunic & Granic, 2015; Alkhwaldi & Kamala, 2017; Taherdoost, 2018), but most of them face acceptance models without a chronological structure of the theories' evolution without comparing the models and frameworks' addressed variables. Thus, the present study describes a chronological evolution

of the main theories, models, and frameworks related to ICTs over 80 years, allowing a complete understanding of them. Beyond providing an overview of each model's constructs and variables, the present research highlights the relationships and comparisons.

2. EVOLUTION OF STUDIES AND THEORIES RELATED TO THE USE OF ICTS

The speed with which companies innovate and launch services with new technologies is higher and reinforced by the current global context (Fuchs, 2020). Nonetheless people do not always adopt a new technology, either due to difficulty to use or lack of knowledge. There are several modeling proposals in the literature regarding new technology readiness, use and acceptance and studies evaluating the predisposition and resistance to adopt technology-based products and services (Brito & Ramos 2019). Cognitive and affective constructs were used concerning consumers' intention to adopt or be prepared to accept and use technological innovation. Hence, the theory of communication, theories of innovation, and social-cognitive psychology theories that evaluate the individual’s behavior are considered part of the studies of models and theories of technology use and acceptance. They are premises for constructing these models and theories because access, cognition, and behavior are part of ICTs use (Bellini, 2018). The present study mapped and presented chronologically into decades, 19 theories, models, and frameworks related to ICTs.

2.1 1940S THROUGH 1970S: MODELS THAT GROUNDED ICT USE AND ACCEPTANCE STUDIES

The Uses and Gratifications (U&G) studies date back to the 1940s, analyzing why people listen to the radio, quiz shows on the radio (Herzog, 1940). U&G theory is an axiomatic theoretical approach because its principles apply to almost every mediated communication type, including traditional media, such as newspapers, and interactive media, such as the Internet (Ko et al., 2005).

Motivations, behavioral usage, and gratifications are three primary U&G constructs that communication researchers extensively examined. This theory, which deals with motivating and gratifying factors, investigates why people use media and the bonuses derived

from media use and access. With technological advances, studies link U&G theory to the use of new technologies, as in the case that assessed whether the younger audience was leaving radio for new technologies, such as MP3 players, Internet radio, and satellite radio (Albarran, 2007). Luo et al. (2006) integrate the Technology Acceptance Model (TAM) and U&G theory to create an integrated model that can predict both usage and satisfaction of Internet-based information services. Raza et al. (2020) developed a conceptual framework involving U&G with the Theory of Planned Behavior (TPB)

The Innovation Diffusion Theory - IDT (Rogers, 1962), starts from the concept that diffusion is the process by which an innovation is communicated by certain channels, during a certain period, between members of a society or of a social group. Innovations do not diffuse linearly across the different segments of a society or of a social group. This theory has been applied in studies to investigate the adoption of technology in different environments. One of the applications was to investigate factors that affect behavioral intentions of employees in using the e-learning system, combining the Innovation Diffusion Theory (IDT) with the TAM (Lee et al., 2011).

The Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975), applied in technology studies, evaluates predictors of behavior and of behavioral intention. The model divides the antecedent beliefs of behavioral intention between attitudes and norms, indicating that one's behavioral intention depends on the individual's attitude and subjective norm. According to the authors, an attitude represents one's general feeling of favorability or not concerning an object stimulus. One conceives beliefs about an object and, automatically and simultaneously, acquires an attitude towards that object. A subjective norm, on the other hand, portrays the influence of the environment on intentions. Individuals' beliefs and influences, weighted by their attributed importance, affect behavioral intention (Fishbein & Ajzen, 1975).

By relating behavior theory to technology, the TRA indicates that accepting or rejecting a technology results from an intention to perform behavior influenced by beliefs and by subjective norm (Fishbein & Ajzen, 1975). In general, there is a tendency to perform a behavior when this behavior is positively or a belief that others consider it essential (Ajzen, 1985). Sheppard et al. (1988) developed a meta-analysis of the TRA. Even though the authors

questioned the application of this model in activities for which it was not planned, they concluded that Fishbein and Ajzen's model has a robust predictive utility. It is also true for situations and activities that do not fit in conditions initially specified and that modifications and refinements were feasible For example, Internet banking's behavioral use was a study applied to technology that evaluated the TRA and other models (Yousafzai et al., 2010).

In 1977, the Theory of Interpersonal Behavior (TIB) (Triandis, 1977) proposition was that intentions are an immediate antecedent of behavior and habits mediate behavior, and these two influences are moderated by facilitating conditions. The model also includes attitudes and social and emotional factors. This model was applied to technology studies, when investigating Cyberloafing, that is, actions of employees who use the Internet access at work for personal use, while pretending to do legitimate work (Betts et al., 2014).

2.2 1980s

As an extension of the TRA, Theory of Planned Behavior (TPB) (Ajzen, 1985) brought up to the TRA model the dimension of perceived behavioral control and, in 1986, the author presented another study about the TPB, relating perceived behavioral control directly to behavior (Ajzen & Madden, 1986). This dimension is linked to an individual's perception of a particular behavior's practice, whether by the ease or difficulty encountered. In a given situation, intentions do not always lead to real behavior (Ajzen, 1985). The model is comprised of the three main factors that influence behavioral intention: attitude, subjective norm, and the referred perceived behavioral control, representing beliefs of control that indicate the perceived presence of factors that can facilitate or inhibit behavioral use (Ajzen, 2002).

Each control factor's perceived power to inhibit or facilitate a purchase contributes to the perception of control over this behavior directly proportional to one's subjective probability that the control factor is present. Studies on TPB relations and new technologies have already included evaluating electronic services (Chen & Li, 2010).

In 1986, the Social Cognitive Theory (SCT) emerges, highlighting that human behavior is related to the interaction between personal factors, behavior, and the environment

(Bandura, 1989). The SCT emerged from the Social Learning Theory reformulations, directly correlating with a person's perceived self-efficacy and behavioral change (Bandura, 1977a). Cognitive processes regulate behavior, and human beings can predict the results of their actions before the behavior. The SCT was developed from the perspective of Social Learning Theory, according to which human beings are characterized in terms of five capacity resources in psychological functioning: "symbolic capacity" - giving meaning to symbols, whether images or words; "vicarious capacity" - learning from observing others; "premeditation capacity" – motivating yourself and guiding your actions in advance; "self-regulation capacity" - personal control over your thoughts, feelings, actions, and motivations, allowing you to mediate external influences; and "self-reflective capacity" - analyzing your experiences, changing thoughts, and thinking about your own thought processes (Bandura, 1977b).

Associating the theory of communication, the theories of innovation and the theories of social-cognitive psychology with the world of technology, the Technology Acceptance Model (TAM) emerges, considered as an extension of the TRA, but focused on technology. In this model, technology acceptance is influenced by perceived usefulness, perceived ease-of-use, and subjective norm (Davis, 1989). The TAM analyzes whether users will adopt a new technology based on diverse factors. For instance, perceived usefulness (PU), that considers the degree to which an individual believes that the use of a specific system can improve his performance at work; and perceived ease-of-use (PEOU), that considers the degree to which an individual believes that the use of a specific system would be effortless and easy to use. TAM proved to be useful. However, it should integrate variables related to human and social change processes and related to an innovation model (Legris et al., 2003).

The TAM and its variations are frequently studied by researchers, presenting applications in different research fields. More recent studies have applied the TAM to analyze issues related to personal innovation´s impact on using social networking sites (Wijesundara & Xixiang, 2017). Also, the effects of compatibility and resistance to change on the intention to use mobile technologies in pre-service (Prieto et al., 2017). TAM was analyzed,,using the

internet in Yemen´s organizations, concluding that TAM predicts the system's use and user satisfaction with internet use (Isaac et al., 2018).

2.3 1990s

The TOE (Technological-Organizational-Environment Framework) is technology acceptance model, focused on the business environment, and examines three influencing dimensions on technology acceptance: technological, organizational, and environmental (Tornatzky & Fleischer, 1990). The technological dimension analyzes internal and external technologies, including equipment and processes; the organizational one includes organizational characteristics, including structure, autonomy, and resources availability; and the environmental one deals with the competitive scenario, regulatory issues, and the industry itself. Some examples of studies that used the TOE dealt with the exchange of electronic data (Kuan & Chau, 2001), with e-commerce (Rodríguez-Ardura & Meseguer-Artola, 2010), and with e-readiness (Aboelmaged, 2014).

The Model of PC Utilization -MPCU (Thompson et al., 1991) was adapted from the TIB (Triandis, 1977), and presents six variables: long-term consequences of PC use, related to results that have a counterpart in the future; job fit with PC use, representing the extent to which an individual believes that using such technology increases his own performance; complexity of PC use, which demonstrates the extent to which an innovation is perceived regarding the difficulty of PC use; affect toward PC use, which presents the feeling associated by the individual with a particular act, which can be satisfaction, pleasure, depression, disgust, displeasure or hatred; social factors influencing PC use, which deal with those factors that influence PC use, indicating that individuals adopt common elements of culture, not only from the social reference group, but also from the relationships they maintain in different social situations; and facilitating conditions for PC use, which express objective factors in the environment that facilitate a fact, according to observers. Al-Khaldi and Wallace (1999) evaluated the influence of attitudes on personal computer use, concluding that social factors,

affect, job fit, and facilitating conditions were variables that showed significant results for personal computer use.

The third model of the 1990s was the Motivational Model (MM) (Davis et al., 1992), which was applied to study the adoption and use of information technology. The Motivational Model (MM) suggests that individuals' behavior is based on extrinsic and intrinsic motivations. The extrinsic motivation refers to the achievement of desirable results, and the intrinsic one concerns the execution of the activity itself that influences behavior, reinforcing expected results (Davis et al., 1992). While perceived usefulness, perceived ease of use, and subjective norm, derived from the TAM, are characterized as extrinsic motivations, pleasure is intrinsic motivation, as it deals with the perception of pleasure and satisfaction in performing a behavior (Davis et al., 1992; Venkatesh & Davis, 2000). The motivational model was also evaluated using microcomputers in North America (Igbaria et al., 1996). Results indicated that perceived usefulness is the primary motivator and that skills play a critical role, affecting microcomputers use.

2.4 2000s

After investigating the role of technology in the customer-company relationship and the growing number of products and services based on technology, a study analyzed how prepared people were to work with technology, motivated by observing the difficulties people face while dealing with technological systems. The result was Technology Readiness Index Model (TRI) (Parasuraman, 2000), based on qualitative research on customers' reaction to technology. A scale should be applied in studies that focus on understanding technology's role in marketing and customer service (Parasuraman, 2000).

The TRI has four dimensions, with innovation capacity and optimism as drivers of technological preparation, while discomfort and insecurity are understood as inhibitors (Parasuraman, 2000). Optimism represents a positive view of technology and the belief that it provides people with greater control, flexibility, and efficiency in their lives. Innovation capacity (or innovativeness) deals with individuals' ability to be pioneers in technology and thought leaders. Discomfort is related to the perception of lack of control over technology and

being oppressed by it. Insecurity refers to distrust in the correct functioning of technology and concerns possible negative consequences for people. The combination of the TRI´s dimensions results in yielding five types of consumers (Parasuraman & Colby, 2002): explorers; pioneers; skeptics, paranoid, and laggards. Wiese and Humbani (2019) studied technology readiness for mobile payment apps, identifying 20% of pioneers, 15,6% of explorers, 39,7% of skeptics-hesitant, and 24,8% of paranoids. This result is essential as this provides marketers with the opportunity to tailor-make strategies to satisfy customer needs.

In the same year of 2000, using the TAM as a starting point, the TAM2 model was presented (Venkatesh & Davis, 2000), including theoretical constructions that measure social influence processes, such as subjective norm, voluntariness, and image, in addition to instrumental cognitive processes, such as job relevance, output quality, and result demonstrability. The TAM2 model presents voluntariness and experience as moderating variables, taking the former to distinguish definitions of mandatory usage and voluntary usage. Even when users realize that the system's adoption is mandatory, use intentions vary because some users are unwilling to comply with these requirements. Experience is also treated as a moderating variable, considering the hypotheses that the direct positive effect of subjective norm on use intention and perceived usefulness of systems is decrease with the increase of experience (Venkatesh & Davis, 2000).

Subjective norm, in turn, defined as an individual’s perception that most people who are important to them think whether they should or should not perform the behavior in question (Fishbein & Ajzen, 1975), is the same variable of the TRA, demonstrating the relationship between the TRA and the TAM2. Job relevance is the individual’s perception of system applicability in their work activities. Output quality refers to how well the system will perform the tasks, and result demonstrability deals with the tangibility of results obtained from technological innovation. A behavioral use of Web 2.0 sites was evaluated, using TAM2 model and results indicated that current Web 2.0 sites are generally accepted by users (Wu et al., 2011). The variables subjective norm, job relevance, output quality, result demonstrability, perceived ease of use, use intention, and behavioral use influence users’ perception of the degree of interaction and sharing optimized by Web 2.0.

In 2003, the Unified Theory of Acceptance and Use of Technology (UTAUT) emerged after reviewing the literature on various existing models for assessing technology acceptance (Venkatesh et al., 2003). The UTAUT is based on the unification of eight models: TRA, TPB, TAM, TAM2, MM, MPCU, IDT, and SCT. The model has four exogenous variables, namely: performance expectation, effort expectation, social influence, and facilitating conditions, also contemplating four moderating variables, such as gender, age, experience, and use voluntariness.

The performance expectation was defined as the extent to which the individual believes that the system can contribute to improving performance; effort expectation is related to an individual's effort and ability to deal with technology; social influence consists of people's influence on individual's use of the system; and facilitating conditions refer to the existence of technical infrastructure and support for the use of the system (Venkatesh et al., 2003). In the model, while the first three described exogenous variables explain behavioral intention (endogenous variable), the variable "facilitating conditions" (exogenous variable) explains behavioral use (endogenous variable). The moderating variables intensify the relationship between exogenous and endogenous variables in the model (Venkatesh et al., 2003). The role of the Unified Theory of Acceptance and Use of Technology (UTAUT) in the context of internet banking adoption showed that the four predictors, performance expectation, effort expectation, social influence, and facilitating conditions, were significant and had a significant variation in the prediction of user's intention to adopt internet banking (Rahi et al., 2018).

In 2007, the Consumer Acceptance of Technology model (CAT) was developed, based on the first TAM model, and by searching a technology acceptance model that also encompassed cognitive and affective aspects (Kulviwat et al., 2007). This model encompassed the TAM´s foundation and the emotion paradigms known as Pleasure, Arousal, and Dominance - PAD (Kulviwat et al. 2007). Based on the CAT model and analyzing the operating system of the Personal Digital Assistant (PDA) from Microsoft's Pocket PC, a study concluded that it is essential to combine measures of social influence in product

development processes, once attitudes towards high-tech products can be influenced by consumers' social networks (Nasco et al., 2008).

By 2008, the TAM3 model was presented (Venkatesh & Bala, 2008), adding new variables for analysis, among them: computer anxiety, which refers to individual's degree of apprehension or fear when faced with the possibility of using computers; computer playfulness, related to the degree of cognitive spontaneity in interactions with computers; computer self-efficacy, that refers to individual's belief that a person can perform a specific task, using computer; perception of external control, which are facilitating conditions that represent the extent to which an individual believes in the existence of an organizational and technical infrastructure to support the use of the system; perceived enjoyment, that refers to perceiving system use as pleasant; and objective usability, which represents comparison of systems, based on the actual level of effort required to complete specific tasks.

The TAM3 model features recent studies related to the evaluation of educational data mining (Wook et al., 2016), of intentions of Dutch citizens during the operation of a miniature smartphone application (Minkman et al., 2017), and of users' acceptance of Business Intelligence and Customer Relationship Management systems in capital market operating institutions (Sönmez, 2018).

2.5 2010s

As of 2010, other studies were presented with different approaches that intertwine the existing models' variables and dimensions. For instance, the Technological Personal Environment (TPE) model (Jiang et al. 2010), is related to individuals' technology acceptance behavior in three dimensions: technology, people, and environment. With an individual focus, the referred model assesses a rational level of decision, maximization of utility, and an irrational level of decision, due to social pressure and imitation behaviors (Jiang et al., 2010). For example, the acceptance of payment made via cell phone was evaluated, using the TPE model (Hunafa et al., 2017). Among the results found, personal factors positively affect consumer's perceived usefulness of mobile payment, while environmental factors positively affect perceived ease of use.

A new model called UTAUT2 was presented in 2012, based on the UTAUT. The variables hedonic motivation, price value, and habit were included, and the moderating variable use voluntariness was excluded (Venkatesh et al., 2012). According to the UTAUT2 model, hedonic motivation is defined as the fun or pleasure derived from technology use. The Price value brings consumers' cognitive exchange between technology's perceived benefits and the monetary cost to use them. Habit is considered a measure according to which people believe they automatically perform a behavior (Venkatesh et al., 2012). The UTAUT2 has been applied in different studies to predict mobile use (Tak & Panwar, 2017; Bendary & Al-Sahouly, 2018) to analyze factors affecting the acceptance of blended learning in medical education (Azizi, et al., 2020).

In the same year of 2012, the Technology Adoption Propensity Index (TAP-I) model was presented, with a scale of 14 items to measure consumer's technology adoption propensity (Ratchford & Barnhart, 2012). The TAP-I has four dimensions of consumer's technology adoption propensity: two inhibiting factors (dependence and vulnerability), and two contributing factors (optimism and proficiency). This model addresses issues similar to those proposed in the TRI, even though the authors did not state that. In 2014, the Technology Readiness Index (TRI) review resulted in the TRI2.0 model (Parasuramam & Colby, 2014). According to the authors, although similar in the general structure and model dimensions, the TRI2.0 questionnaire has only 16 items.

In contrast, the TRI had 36, which reduces the questionnaire's application time without losing its validity. Qualitative and quantitative research was carried out to elaborate on this new model, resulting in reducing items and technological update terms (Parasuraman & Colby, 2014). Ramírez-Correa et al. (2020) validated TRI2.0 model, applying a latent cluster analysis with data from a sample in Chile and obtained five groups of users quite similar to those achieved by Parasuraman and Colby (2014).

Nevertheless, studies involving technology acceptance and use have been applied around the world and continue showing variations. For example, in Japan, a study about consumers' motivation in online airfare purchases included two variables, long tail, and trust, to understand whether these variables influence customers' motivation to choose online

shopping channels (Singh & Matsui, 2017). Another study included the variable risk in the UTAUT2 to analyze factors that influence Jordanian customers' intentions and adoption of Internet banking (Alalwan et al., 2018). The UTAUT2 can be evaluated as the most complex and advanced model, considering the number of variables involved and the possibilities that it allows.

3 Comparative synthesis of the historical evolution

From the presented historical analysis on studies regarding models that assess technology readiness and acceptance, Figure 1 presents the models and the theories related to technology readiness and acceptance, described previously, and the respective theories of innovation and psychology that were premises to support the development of those related to technology.

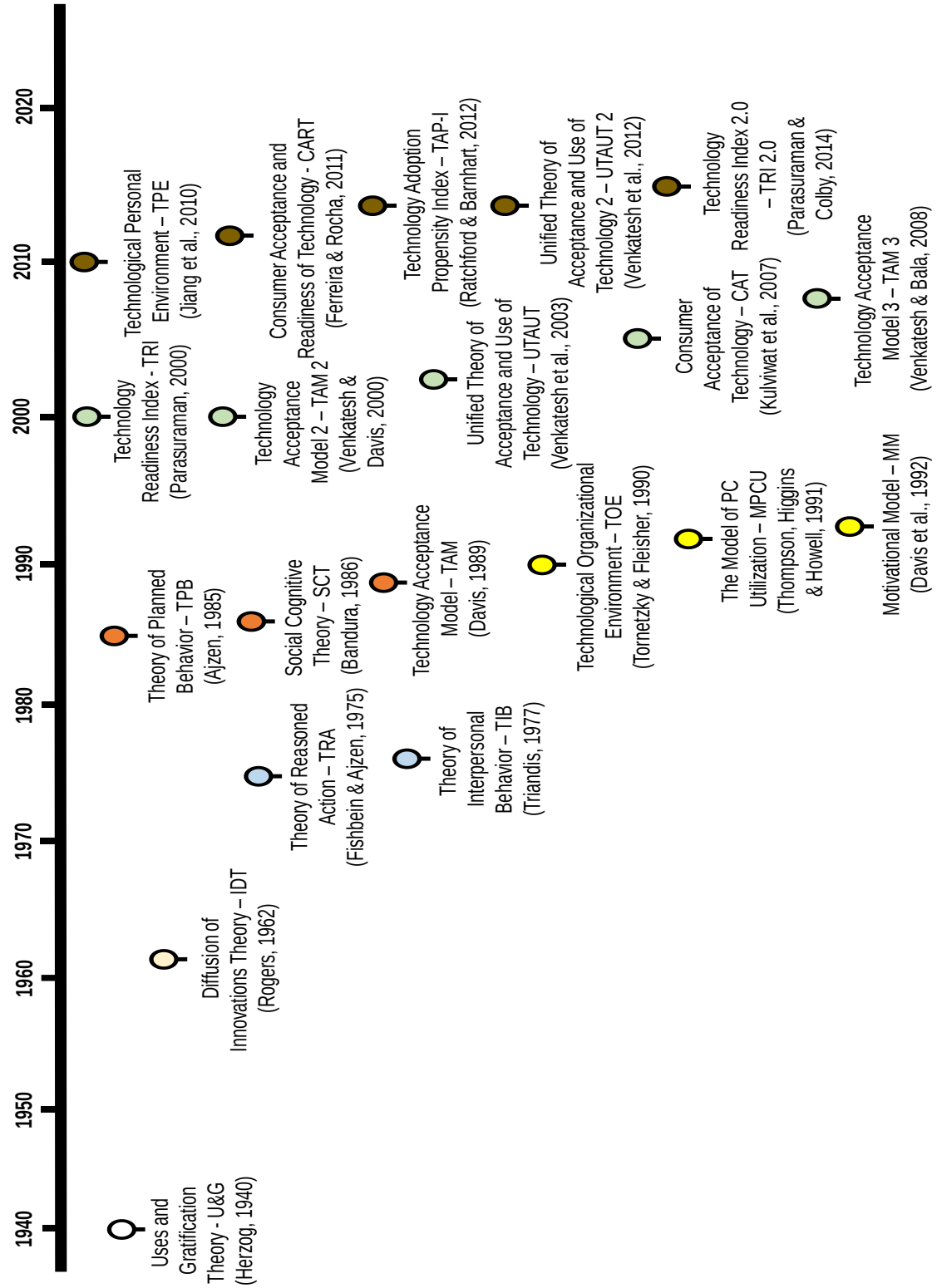

Figure 1. Chronological evolution timeline of models and theories on technology readiness and acceptance

Figure 1 shows that the most applied models in studies on individual's relationship with new technologies, and that presented more than one version over the years, was: TAM (Davis, 1989) and UTAUT (Venkatesh et al., 2003), which aim at assessing consumers' technology acceptance and use of technology-based products and services.

The studies present relationships between the described theories. For instance, the IDT was the foundation for the TOE and UTAUT models. The TRA was used in modeling the TIB, the TPB, and the TAM. The UTAUT was based on the IDT, the TPB, the SCT, the MM and the TAM.

Moreover, studies that compared the application of different models over time to verify their effects were identified. For instance, Madden et al. (1992), when comparing the TPB and TRA models, concluded that the TRA is applicable when the behavior in question is under volitional control, that is, when the individual has real control over actions. Nonetheless, when behavior violates the volitional control hypothesis, the TPB seems superior to the TRA in predicting the target behavior. The authors pointed out an improvement in the TPB model's explanatory power, with the inclusion of perceived behavioral control once behavior's explained variance increased. The variable significantly improved the prediction of intentions and get behaviors.

Another comparison was made in a study that found out that the unified CAT model explained more than 50% of the technology adoption variance. In comparison, the TAM model explains between 17% and 33% of this behavioral intention (Kulviwat et al., 2007).

The models' interrelationship demonstrates similarities in their structures to variable composition, but with different theoretical foundations for technology use and acceptance. Different uses of the models can be observed when applied in organizational systems, focused on users' acceptance of corporate systems, or applied in social technologies, focused on the individual's end-user. The technology readiness approach aims at understanding how much users are available and prepared for new technologies. The TAM versions have been the most applied ones. However, the two UTAUT models involve greater complexity once they have a theoretical origin based on eight joint models, as previously described.

From a more detailed perspective, Table 1 consolidates the theories and models related to technology use and acceptance, in chronological order, with the indication of the authors who developed them, their addressed variables, and examples of studies that adopted them in the specific context of technology acceptance and use.

Table 1

Consolidation of the evolution of studies on models and scales related to technology

Theories and Models	**Authors**	**Addressed variables**	**Application example**
U&G	Herzog (1940)	- Motivations - Behavioral Usage - Satisfaction - Gratifications	- Albarran (2007) - Ko et al. (2005)
IDT	Rogers (1962)	- Relative advantage - Compatibility with systems and values - Complexity – transition ease - Possibility to test - Visibility of change	- Lee et al. (2011)
TRA	Fishbein ar Ajzen (1975)	- Attitudes and subjective norms lead to intention - Intention leads to behavior	- Yousafzai et al. (2010)
TIB	Triandis (1977	- Intentions influence behavior - Habits mediate behavior - Moderating variables: facilitating conditions	- Betts et al. (2014)
TPB	Ajzen (1985)	- Attitudes in relation to behavior; subjective norms, and perceived behavioral control lead to intention - Intention leads to behavior	- Chen and Li (2010) - Shih and Fan (2013)
SCT	Bandura (1989	- Human behavior resulting from personal factors, behavior, environment, and regulated by cognitive	- Compeau et al. (1999)

Theories and Models	Authors	Addressed variables	Application example
		processes	
TAM	Davis (1989)	- External variables influence perceived usefulness and perceived ease-of-use, and both influence attitude use - Attitude use influences behavioral intention regarding use, which, in turn, influences system effective use	- Prieto et al. (2017) - Wijesundara and Xixiang (2017)
TOE	Tornatzky ar Fleisher (1990)	- Technological, organizational, and environmental dimensions influence technology acceptance	- Aboelmaged (2014)
MPCU	Thompson et al. (1991)	- Long-term consequences, job fit, complexity with use, affect toward use, social factors, and facilitating conditions influence Personal Computer (PC) use	- Al-Khaldi and Wallace (1999)
MM	Davis et a (1992)	- Intrinsic and extrinsic motivations influence behavior	- Igbaria et al. (1996)
TRI	Parasuraman (2000)	- Optimism and innovation capacity drives technological preparation. - Discomfort and insecurity inhibit technology use intention	- Wiese and Humbani (2019)
TAM2	Venkatesh ar Davis (2000)	- Experience, subjective norms, image, job relevance, output quality, and result demonstrability influence perceived usefulness - Experience, voluntariness, perceived usefulness, and perceived ease of use influence use intention - Use intention influences behavior	- Wu et al. (2011)
UTAUT	Venkatesh et a (2003)	- Performance expectation, effort expectation, and social influence influence behavioral intention - Facilitating conditions influence behavioral usage - Moderating variables: sex, age, experience, use voluntariness	- Rahi et al. (2018)

Theories and Models	Authors	Addressed variables	Application example
CAT	Kulviwat et a (2007)	- Inclusion of cognitive and affective aspects to the TAM	- Nasco et al. (2008)
TAM3	Venkatesh ar Bala (2008)	- Inclusion of new variables to the TAM2 model – computer anxiety, computer playfulness, computer self-efficacy, perception of external control, perceived enjoyment, objective usability	- Minkman et al. (2017) - Wook et al. (2016) - Sönmez (2018)
TPE	Jiang et a (2010)	- Technology, people, and environment influence technology acceptance behavior	- Hunafa et al. (2017)
UTAUT2	Venkatesh et al. (2012)	- Performance expectation, effort expectation, social influence, facilitating conditions, hedonic motivation, price value, habit, and experience influence behavioral intention - Habit and experience influence behavioral usage - Moderating variables: age, sex, and experience	- Azizi et al. (2020) - Tak and Panwar (2017)
TAP-I	Ratchford ar Barnhart (2012	- Inhibiting factors of technology adoption propensity: dependence and vulnerability - Contributing factors of technology use: optimism and proficiency	- Magotra et al. (2015)
TRI 2.0	Parasuraman and Colby (2014)	- The same dimensions of the TRI, but with an instrument with lesser number of items, without losing measurement validity	- Ramírez-Correa et al. (2020)

Figure 2 shows a "genealogy" of the models divided into three branches, two of acceptance and one of readiness or propensity of use. The TAM branch has its backbone the idea and variables from U&G, TRA, TIB, and TPB: Behavior, Behavioral Intention, Attitude, and Subjective Norm, and includes as fixed variables: Perceived Usefulness and Perceived Ease of Use. The CAT model originated from TAM. The UTAUT branch has in its origin eight models: TRA, TPB, TAM, TAM2, MM, MPCU, IDT, and SCT, and fixed the variables: Performance Expectancy, Effort Expectancy, Facilitating Conditions, Gender, and Age.

The third branch deals with readiness and propensity of use and is represented by the TRI and TAP-I. The diffusion Innovation Theory (DOI) is the base of these models considered frameworks for analyzing individual traits. As the DOI presents five segments of adopters: innovators, early adopters, early majority, late majority, and laggards, TRI uses variables of optimism, innovativeness, discomfort, and insecurity to determine individual traits as explorers, skeptics, pioneers, hesitators and avoiders of technologies, and TAP-I works with factors of optimism, proficiency, dependence, and vulnerability.

Figure 3 compares the variables used in each of the most applied models related to the "family tree" of TAM and UTAUT. Most models' backbone suggests that users' intention to use technology is the predictor of behavior related to actual system usage. People's attitudes towards using technology determine the intention to use technology. In the TAM model, the attitude is determined by two specific beliefs: perceived usefulness and perceived ease of use. It is possible to observe that the models use different languages, but the intention is similar in attitude and technology use results. The variables were distributed and classified as Dependable (D), Predictor (P), and Moderator (M), showing the similarity of the core proposal of analyzing attitude predicting intention and intention predicting behavior towards the use of technologies.

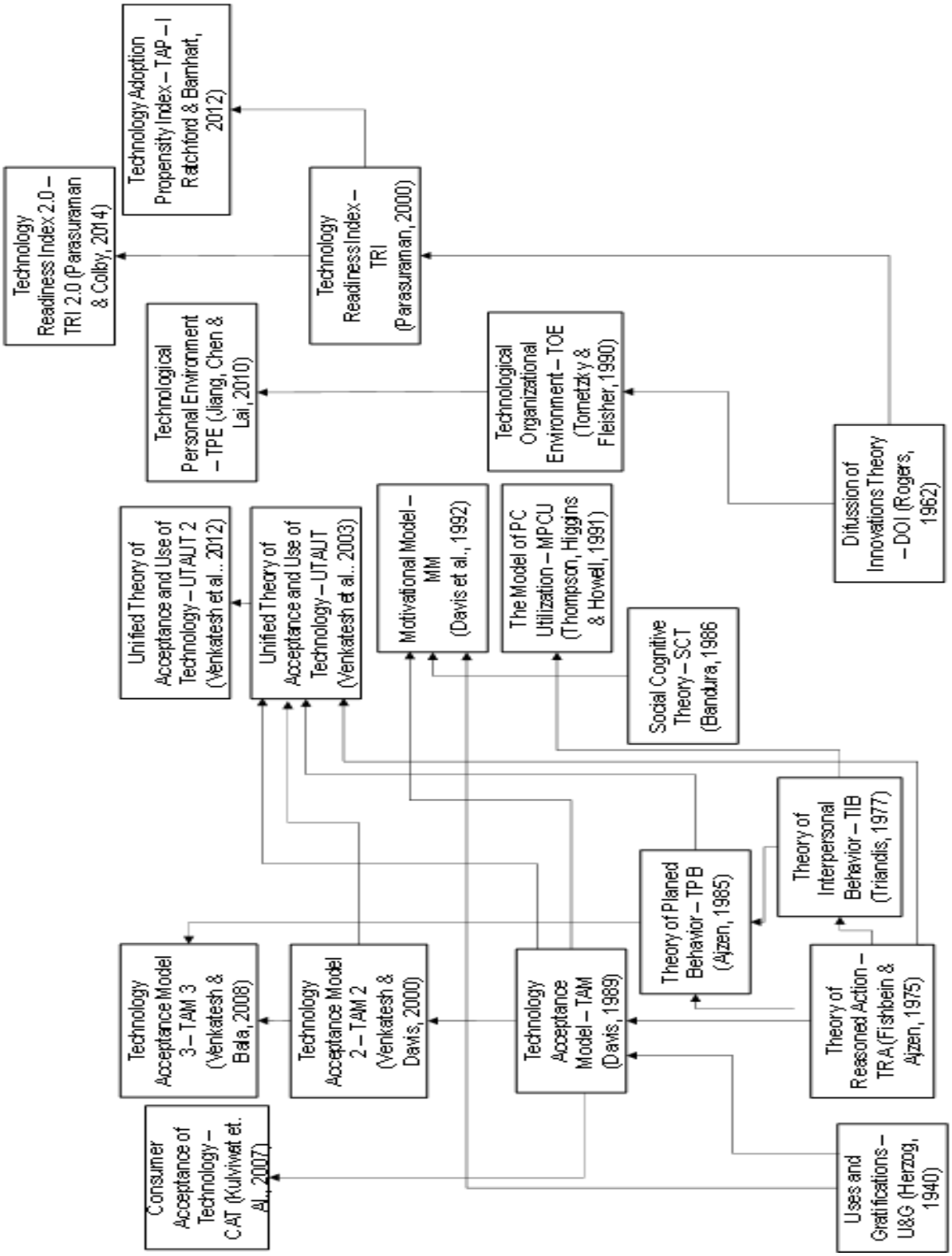

Figure 2. Genealogy of ICT´s Theories, Models and Frameworks

SCT	TRA	TPB	TIB	TAM	TAM2	TAM3	UTAUT	UTAUT 2
Behavior (D)	Behavior (D)	Actual Usage (D)	Behavior (D)	Actual Usage (D)	Usage Behavior (D)	Usage Behavior (D)	Usa Behavior (D)	Usa Behavior (D)
	Behavioral Intention (P) (D)	Behavioral Intention (P) (D)	Intention (P) (D)	Intention to use (P) (D)		Intention to use (P) (D)	Behavioral intention (P) (D)	Behavioral intention (P) (D)
	Attitude (P)	Attitude (P)	Attitude (P) (D)	Attitude towards use (P) (D)				
	Subjective Norm (P)	Subjective Norm (P)	Norms (P)		Subjective Norm (P)	Subjective Norm (P)		
		Perceive Behavioral Control (P)						
Environmental Factors			Social factors (P) (D)	External Variables (P)			Social Influence (P)	Social Influence (P)
				Perceived usefulness (P) (D)	Perceived usefulness (P) (D)	Perceived usefulness (P) (D)		
				Perceived ease of use (P) (D)	Perceived ease of use (P) (D)	Perceived ease of use (P) (D)		
					Image (P)	Image (P)		
					Job Revelvant (P)	Job Revelvant (P)		
					Output quality (P)	Output quality (P)		
					Result Demonstrability (P)	Result Demonstrability (P)		
					Experience (M)	Experience (M)	Experience (M)	Experience (M) (P)
					Voluntariness (M)	Voluntariness (M)	Voluntariness of use (M)	
						Computer self-efficacy (P)		
						Perception of external control (P)		
						Computer anxiety (P)		
						Computer playfulness (P)		

SCT	TRA	TPB	TIB	TAM	TAM2	TAM3	UTAUT	UTAUT 2
						Perceived enjoyment (P)		
						Objective usability (P)		
							Performance Expectancy (P)	Performance Expectancy (P)
							Effort Expectancy (P)	Effort Expectancy (P)
			Facilitating Conditions (P)				Facilitating Conditions (P)	Facilitating Conditions (P)
Personal Factors							Gender (M)	Gender (M)
							Age (M)	Age (M)
								Hedonic Motivation (P)
								Price Value (P)
			Habits (P) (D)					Habit (P)
			Beliefs about outcomes (P)					
			Evalution of outcomes (P)					
			Roles (P)					
			Self-concepts (P)					
			Emotions (P)					
			Affect (P) (D)					
			Frequency of past behavior (P)					
Legend: Type of Variables: (P) - Predictor; (D) - Dependable; (M) - Moderator								

Figure 3. Variables of ICT models

TAM and UTAUT are the two main models applied by researchers to analyze information and communication technologies' acceptance and use. Although they work with

different variables, one is not superior to the other. With different approaches, both are used in the personal and organizational analysis of ICTs. Nevertheless, as shown in Figure 3, TAM focuses on Perceived usefulness, Perceived ease of use to be explained by independent variables as Image, Job Relevant, Output quality, and Result Demonstrability. UTAUT is favored when analyzing the influence of Performance Expectancy, Effort Expectancy, Facilitating Conditions in Behavioral intention, using social-demographics variables like gender as moderators' variables. It is also interesting to use UTAUT2 when researchers are interested in analyzing price value because it can influence adoption decisions.

The third branch of Figure 2 is considered an index Family composed of TRI, TRI2.0, and TAP-I, as they work with readiness and propensity to adopt new technologies. These readiness and propensity indexes should be used when the interest is in identifying individual traits. TRI works with four dimensions: optimism and innovativeness are drivers of technology readiness, whereas discomfort and insecurity are inhibitors. For the TAP index, optimism and proficiency are contributors, and dependence and vulnerability are inhibitors. This branch is more applicable to measure a consumer's likelihood to embrace new technologies with a marketing bias where it is possible to identify individual traits in the use of technologies.

4 Conclusions

This article proposed establishing a chronological design of ICTs theories, models, and frameworks that analyze the use, acceptance, adoption, and readiness of new technologies, based on an 80-years literature review. To do that, it raised and systematized 19 theories, models, and frameworks on ICT use and acceptance, involving technological aspects and issues related to the fields of communication, psychology, and human behavior. The technologies frameworks are in a continuer evolution, working with different variables to obtain more precise answers and a better understanding of new technologies uses.

It is featured the possibility of expanding the application of different combinations between the models, as well as the investigation with moderating and mediating behavior variables that prove to be related to acceptance of new technologies. Hence, this historical-

chronological-evolutionary mapping highlights the importance of theories and models, to analyze the use of new technologies, and emphasize the technological market dynamism, requiring systemic theoretical adjustments to understand the end-user effectively. Furthermore, it provides greater clarity to the field, allowing a complete look at future studies development theories.

Moreover, for the disruptive scenario of 2020 and the growing use of new technologies, there may be even more questions than answers. Therefore, many theories, models, frameworks, and practices in recent years will need to be reviewed to bring greater clarity to the social and commercial relations mediated by technologies in the next decades. This study allows us to have a complete overview of the last 80-years of technology use, acceptance, and readiness. Maybe we face a cutting-edge era with new technology interactions among people, new occupational careers, and new educational perspectives. All of the possibilities need to be explored, learning from technology history, and bringing new theories.

As study limitations, we point out that a systematic literature review was not carried out to identify each model's studies' specifics results that analyze technology acceptance and use. Thus, a recommendation for future studies is to include a comparative meta-analysis of the models' effects in different contexts. An evaluation of studies to see if there is a tendency to apply each theory to a specific technology can be developed. We recommend developing additional qualitative studies to identify possible new variables that may influence new technologies' use and acceptance. Regarding quantitative studies, we suggest using more robust statistical models to understand human behavior in the face of technological changes, including longitudinal design studies, to follow up individual’s behavioral change over time, including specific events that may be relevant to the understanding of each period.

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