Information technology maturity and acceptance models integration: the case of RDS

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Abstract

Purpose/Thesis: This article presents three methods for evaluating technological innovations, with a particular focus on information technology innovations such as information systems and services. These methods include assessing maturity, the diffusion of innovative information technologies, and their acceptance. The aim is to indicate the complementarity of these methods, which makes their integrated application appropriate.
Approach/Methods: There are two types of theories that take into account the perspectives of both the creators of information technologies (technology maturity models) and their users (technology acceptance models). The article attempts to identify the commonalities between these models to enable their joint use. The joint application of these models is demonstrated through an example using research data services (RDS) maturity models. Six RDS maturity models known from the literature were analyzed from the perspective of their completeness using the technology acceptance model (TAM).
Results and conclusions: This approach enables the assessment of maturity models from the perspective of RDS users' needs, affecting the level of their acceptance. The results indicate that existing RDS maturity models do not sufficiently consider the needs and perspectives of their users, hindering the acceptance of the technology.
Originality/Value: The article demonstrates a new point of view on information systems assessment, which serves to integrate two previously used methods of assessing the IS: maturity models and innovative information technologies acceptance models. The article proposes combining both methods to obtain a more coherent and universal research tool.

Keywords

Information system acceptance. Information system innovativeness. Information system maturity. Research data services. RDS.

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1. Introduction

Over the past two decades, information scientists and professionals in information systems (IS) have recognized the need to evaluate the quality of information system services, including those of libraries. This evaluation helps to meet user expectations, fulfill their information needs, and achieve the goals of scientific and professional organizations. Another factor that requires analysis is the widespread use of information and communication technologies (ICT), which are essential in modern information acquisition, processing, and dissemination. ICT forms the basis of electronic services (Babalhavaeji et al., 2010), but it can also create barriers that impede users' access to information. Therefore, appropriate measures are necessary to assess the quality of these services (Nitecki, 1996), which should be firmly grounded in created models of ISs and their users. Maintaining a balance between users' expectations and users' perception of the actual state, and minimizing the discrepancy between the two factors, is essential in delivering high-quality services. Thus, users are the primary source of data for evaluating the quality of information services.

Quality can be understood and defined in many different ways, for example, as a degree of excellence (Merriam-Webster, n.d.). However, five distinct yet related ways of thinking about quality are useful in the context of information activities. These include treating quality as indicative of the uniqueness of something beyond a high standard, excellence (or consistency), a tool to achieve a goal, financial value, or transformation (qualitative changes) (Harvey & Green, 1993). In the case of information activities, the most useful approaches treat quality as striving for perfection by achieving successive levels of maturity and as a tool to fulfill the stated or implied information needs of users (Derfert-Wolf, Górski & Marcinek, 2005).

Therefore, the most important factor and tool for the successful implementation of an IS is the existence of a community of users willing to use it (Shareef et al., 2011). Phenomena such as acceptance, diffusion (spread), and maturity of IS depend on the decisions of users to use these systems. While the technological development and diffusion of networked information systems of all kinds seem undeniable, the willingness of potential users to use them can sometimes be debatable.

The role of users and their needs in evaluating IS has been emphasized in the ACRL (Association of College & Research Libraries, USA) standards. According to these standards, the assessment of information systems is based on three grounds:

- inputs, seen as the raw materials of information activities – money, space, collections, equipment, and personnel;
- outputs, values used to quantify the work done, e.g. the number of advice given to users, the number of visits to the website, etc.;
- outcomes identify how information users change as a result of their exposure to information resources and services.

The assessment of the first two points can be conducted in various ways by analyzing objective quantitative indicators. However, the third point is the most crucial as the assessment of outcomes heavily relies on the user's perspective. The analysis of inputs and outputs provides an overview of the library's functioning, while the assessment of outcomes mainly aims to determine user satisfaction. It encompasses several dimensions such as services, instructions, resources, access to resources, staff, facilities, communication and collaboration, administration, and budget. This article focuses primarily on this sphere.

The purpose of the article is to present and combine various tools and models for assessing the quality of new information technologies (IT) emerging in various sciences and research environments, while describing the conditions for IT success measured by acceptance. Acceptance of IT is defined as an innovation process with user acceptance and system maturity being its significant aspects (Drljevic, Aranda & Stanchev, 2022). Acceptance is a decision-making process determined by the user's attitudes, values, and intention to use the IS (Alomary & Woollard, 2015). It directly impacts the diffusion of the IS. Maturity is understood as the successive stages of evolution that users go through in a complex information environment. It indicates the level of application of each new aspect of activity in the process (Wendler, 2012). Integrating the level of acceptance and maturity helps understand user behavior and levels (stages) of the innovation diffusion process, which is essential for sustainable and successful implementation of IS. The article focuses on the listed features of ISs: diffusion and acceptance (outcomes) and maturity (input/output), and particularly the relationship between them, described in the first three parts of the article. The fourth part presents the assessment of maturity models (MM) of research data services (RDS) as an example of organizational and technological innovation using the achievements of the information technology acceptance theory/model (TAM) from the previous parts of the article.

Answers were sought to the following research questions:

(1) What are the relationships between theories functioning in the field of implementation and acceptance of new ITs?
(2) Can the simultaneous (integrated) application of these theories facilitate the evaluation of new ITs to predict their success?
(3) Is it possible to use different assessment tools built separately within each of these theories?
(4) Is it possible to evaluate RDS maturity models using TAM structures and assumptions?

The search for answers to these questions is based on developing a conceptual model of the studied phenomena and then applying it to selected examples of RDS as parts of information systems. The resulting model is a way of expressing a particular view of an IS, with special emphasis on RDS. This procedure is the research method adopted in this work.

In the following parts of this article, we will present the relationships between various theories and models that have emerged in different research environments regarding the development of IT. We will begin by discussing the issue of IS maturity and its models. Next, we will present the theory of innovation, especially in the field of IT, and models of the diffusion of these innovations. We will then discuss information technology acceptance models with a particular emphasis on different types of TAM, mainly TAM3. Importantly, we will present a modification of the TAM model that takes into account the place of the MM. The next part will present the relationship between the previously discussed models: diffusion of innovation, acceptance of technology, and maturity of the IS. We will also introduce an element of the Gartner[1] hype cycle. The last chapter before the conclusions will present the practical use of the described relationships between theories and models to assess the completeness of six selected models of RDS maturity.

2. Theories and models used

In this section of the article, we present basic data on the maturity of information systems, IT innovation, and IT acceptance models based on a literature review.

2.1. IS Maturity

In information and library science, a lot of attention is given to the quality of information services and methods of assessing appropriate quality (Głowacka, 2009; Heath, 2011; Hufford, 2013). Several tools have been developed to measure the effectiveness of information activities, ranging from simple questionnaires to complex tools such as SERVQUAL and its derivative LibQUAL+, which is better suited to the specificity of library services (Hiller, 2001; Kiran & Diljit, 2012). LibQUAL+ is used to assess user satisfaction by measuring the differences (gaps) between three levels of maturity: minimum, actual, and optimal (expected) quality of information services, determined in three dimensions, divided into 22 parts (Jankowska, 2006; Kamath et al., 2022). Despite the widespread use of these types of tools worldwide, they are subject to criticism. From the viewpoint of commonly used theories, LibQUAL+ measures the level of disapproval rather than the attitude of the user, based on the service quality gap theory (Mauri, Minazzi, & Muccio, 2013), and therefore does not coincide with the views expressed in accepted economic, statistical, and psychological theories (Buttle, 1996).

These and many other works have led to the belief that the culture of cooperation in the field of evaluating information activities has reached full maturity

1 https://www.gartner.com/

(Hart & Amos, 2018). Despite such an extensive literature on the assessment of information activities, the issue of maturity in information processes has not found much interest among information scientists. Several works concern the maturity of libraries, including digital ones (Wilson, 2015; Hart & Amos, 2018; Thorpe & Howlett, 2020; Yang, Zhu, & Zhang, 2016; Sheikhshoaei et al., 2021). This is surprising because the study of maturity in the field of IT began in the early 1990s in the field of software engineering with the creation of the Capability Maturity Model (CMM) (Paulk et al., 1993). This model has since been used in other areas and organizations to assess the level of capability and maturity of critical processes, such as project management (Crawford, 2006), information management (Keshavarz & Norouzi, 2022), or health information systems management (Gomes & Romao, 2018).

The CMM has five maturity levels: initial, repeatable, defined, managed, and optimizing. Each level represents a measure of the effectiveness of any process or program, from immature processes performed ad hoc to fully mature processes that are continuously improved. The CMM defines the criteria and characteristics necessary to reach a certain level of maturity. Actual activities are compared in detail based on the designated criteria with a description of each maturity level, which allows determining the level of maturity that best suits the current state of the system, carrying out its audit, and setting directions for development. Data on higher, yet unachieved levels of maturity allows setting a path for system improvement (Becker, Knackstedt, & Pöppelbuß, 2009). It also becomes possible to objectively compare organizations and their ISs at different levels of detail.

However, comparisons in this area are hindered by a differentiated understanding of both the concept of maturity and the model of maturity. Maturity is defined, among others, as

- a detailed process to clearly define, manage, measure and control the evolutionary growth of the individual unit being assessed (Paulk et al., 1993);
- a state in which the organization is perfectly capable of achieving the goals it has set for itself (Anderson & Jessen, 2003);
- evaluation criterion or state of being complete, perfect, and finished (Fitterer & Rohner, 2010);
- a concept, an idea that is developed from an initial state to a final (more advanced) state, i.e., to higher levels of maturity (Sen, Ramammurthy & Sinha, 2012);
- evolutionary progress in the manifestation of specific capabilities or the pursuit of a designated goal (Mettler, 2009).

Maturity models are a tool for measuring the level of maturity, which are also defined in various ways, for example, as:

- a set of successive levels that together form an assumed or desired logical path from the initial state to the final state of maturity (Pöppelbuß & Röglinger, 2011);

- tools used in evaluating the maturity level of specific elements and in selecting appropriate actions to bring these elements to a higher level of maturity (Kohlegger, Maier & Thalmann, 2009);
- an evaluation framework that allows an organization to compare its performance with best practices or competitor practices while defining a structured improvement path (Korbel & Benedict, 2007);
- a tool for examining the current capabilities of the organization, supporting the introduction of continuous changes and improvements in a structured way (Jia et al. 2011).

This diversity of meanings, resulting from differences in defining the objectives and objects of MM, is the reason for the creation of many models in the same area of application. It implies different possible paths of development towards an individually defined state of maturity. But apart from the differences, all maturity models are similar in their structure: they define a number of assessment dimensions considered at several levels of maturity; the resulting matrix contains descriptions of activity features with varying levels of detail (Mettler, Rohner & Winter, 2010). The basic elements of these models are as follows:

- a number of levels (usually three to six);
- a description of each level (like levels from initial to optimizing in the CMM example);
- a general description of the features of each level as a whole;
- a certain number of dimensions (e.g. process areas in the CMM);
- a certain number of items or activities for each dimension;
- a description of each element or activity that can be performed at each maturity level.

The concept of using maturity models has been criticized for its weak theoretical basis among other things (Biberoglu & Haddad, 2002). The creation of models is based on good practices in a certain area and/or elements considered by practitioners as contributing significantly to success, making the selection of these factors subjective. Compliance with the model, even at its highest level, does not guarantee the success of an organization; it means that the organization has reached the designated standard of service or product, which may not be accepted by users/customers[2]. Therefore, attempts to combine maturity models with technology acceptance models described later in the article.

2 Acceptance is understood as a positive decision to use a technology, product or process based on behavioral factors. It is determined by the user's attitudes and values and is closely related to behavioral intention (Drljevic, Aranda, & Stantchev, 2022).

2.2. Innovativeness of information technology and its diffusion

According to Schumpeter (1934), innovation is a significant change in the production function consisting of a combination of production factors different from previously used and occurring in a discontinuous manner. Schumpeter distinguished innovation from invention, stating that a new scientific idea, an invention, is transformed into an innovation when it is implemented and adopted in practice[3], for example, in business. This means that the creation of knowledge, an invention, is distinct from innovation, which is the introduction of knowledge to production and dissemination (diffusion of innovation). Innovation always means change, as it involves new or improved ways of doing things. Thanks to them, new ideas can have a significant impact on organizations and the social environment (Bucciarelli, 2015). Positive changes in the previous state may result from the use of new technologies, knowledge, or materials (Oslo Manual, 2005). Therefore, the constant growth of human capabilities, the building of the potential for change, and the gradual maturation of applied solutions are the main assumptions of this theory. Interesting connections can be observed between the theory of innovation and the development of maturity in organizations and their IS (Staniszewska, 2015).

The diffusion of innovation and its theory, advocated by Everett Rogers (2003), plays a significant role as an information process. Diffusion is the process by which innovation is communicated through specific information channels over time between members of a social system. Rogers presented the innovation life cycle by distinguishing five categories of users implementing innovation. Innovators (2.5% of the market) implement innovation first, they are young, prone to risk, and have sufficient financial resources. Early accepters (13.5%) are the most opinion-forming group, they are young, educated, have a high social status, and do not switch from novelty to novelty like innovators. The early majority (34%) accepts innovation after a long time, adapts more slowly to changes, and is not opinion-forming. The late majority (34%) accepts the innovation after half of the community of potential users accepts it. Its members are skeptical about innovation and financially weaker. Laggards (16%) accept innovation last, do not like changes, are older, financially weak, respect tradition, contact only a closed group of family and friends, and are not opinion-making. At the point of exceeding the critical mass (16% of the market), technology meets the basic needs of users. From this point on, technology as such loses its importance and the functionality of the solutions used in its products, i.e., the so-called perceived usefulness of the innovative technology, becomes more important.

3 Adoption is an innovation process whose main aspects are acceptance and maturity. The degree of adoption is determined by the extent to which the technology is accepted and incorporated into approved business practices.

Rogers (2003) also identified factors that influence the level of innovation diffusion. He listed the following factors: relative advantage, complexity, compatibility, trialability, and observability. Compatibility refers to the degree to which innovation is considered compatible with the values of potential users, their previous experiences, and their needs for similar technologies. Complexity refers to the user's perceived level of difficulty in understanding the innovation and how easy it is to apply. It has a significant negative effect on the intention to use the technology. Relative advantage refers to the degree to which an innovation is considered better than the idea it replaces. It is recognized as one of the best predictors of the use of innovation. Trialability refers to the ability to test innovations on a limited scale. Observability refers to the ability of other people to see the results of innovation (Lou & Li, 2017). A review of the literature indicates that, of these five constructs, three (relative advantage, compatibility, and complexity) are the most appropriate to describe the level of acceptance of an innovative technology (Shareef et al., 2011; Gilbert et al., 2004). These features are also taken into account in technology acceptance models, which are described later.

Geoffrey Moore argued that there is a boundary (critical mass point) between early acceptance and early majority that many technologies cannot reach. Critical mass occurs at the point where the number of people accepting the innovation is so large that further dynamics of innovation growth are maintained spontaneously (Moore, 1991, 16). After exceeding it, for most users, technology becomes a secondary matter and, above all, they are looking for appropriate functionality (convenience, reliability, low costs) of solutions. Exceeding the critical mass results in the rapid development of technology and the dissemination of its products.

Innovation diffusion processes are also related to disruptive innovations (Christensen, 1997) and creative destruction theories, which describe the fate of technologies replaced by innovation. Disruptive innovations result in a product that is simpler (easier to use) and more affordable. The damaging effect is that managers compare the profitability of investing in a new business model with the profitability of an existing and operating model. This makes them find the innovation business model less attractive. In the meantime, new market participants appear who do not have such a choice and have to create a business from scratch. If they manage to create an accepted innovative product, it causes a (sometimes violent) disruption of the old technology market.

2.3. Models of information technology acceptance

The theory of innovation emphasizes the critical importance of the level of acceptance of new technology, e.g., IT, by potential users in creating the market for products utilizing this technology. The success of a new product on the market depends on its level of acceptance, exceeding the critical mass. IS creators have studied the possibilities of utilizing models built in the field of psychology to describe intentions as a potential theoretical basis for research on the behavior of users of innovative systems. Martin Fishbein and Icek Ajzen (1975) formulated the Theory of Reasoned Action (TRA), which they later developed (Fishbein & Ajzen, 2010, 20) and modified into the Theory of Planned Behavior (TPB) (Ajzen, 2011). Korpelainen's review (2011) found that the Diffusion of Innovation (DOI), TRA, TPB, Technology Acceptance Model (TAM) (Davis, 1986; Davis, Bagozzi, & Warshaw, 1989; Venkatesh & Davis, 1996), and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003) are the most cited theories on technology acceptance (Nahotko, 2014, 54). These theories have their roots in cognitive psychology, which asserts that a small number of variables can explain a significant part of the variability of any behavior in any population. Specifically, these models indicate that the intention to exhibit a behavior is causally (though not necessarily rationally) based on the specific beliefs that people hold about those behaviors, and this intention can be the basis for predicting behavior.

The TAM provides for two forms of motivation for the use of technological innovation: extrinsic and intrinsic. Extrinsic motivation relates to the need to achieve a result separate from the technology itself, such as using technology to improve work efficiency. Intrinsic motivation leads to the use of technology for its own sake (Lin, 2007). Acceptance of technology is understood as the willingness of a group of users to use IT to perform the tasks for which it was designed to support (Dillon & Morris, 1998, 5).

Based on these assumptions, Davis (1985) proposed that user motivations should be explained using three main factors: perceived ease of use (PEU[4]), perceived usefulness (PU[5]), and attitude towards usage (ATU). Note that these constructs are comparable to the elements of the innovation diffusion theory described earlier: PEU with the complexity of innovations, PU with relative advantage, and ATU with the compatibility of the IS with the beliefs, values, and attitudes of the user influencing his/her behavior.

The model was also used by other researchers who introduced modifications (usually new variables), resulting in TAM becoming the basic model used to explain and predict the *acceptance* (use level) of IT systems. Despite these modifications, the original version of the TAM remains relevant for general applications where there is no need to consider application-specific variables. It has become so popular that it is quoted by most authors dealing with the issue of acceptance of ITs, although it is also criticized (Lee, Kozar, & Larsen, 2003; Chen, Li, & Li, 2011, 125).

4 PEU is defined as the degree to which a person believes that using a particular system will be effortless.

5 PU is defined as the degree to which a person believes that using a particular system will increase his/her productivity.

3. Theories integration: towards a unified model

In this part of the article, we will integrate the previously described models, namely MM and TAM, using the modeling method, which allows learning about complex systems and structures of the 'real world' by building their representations. Due to the similar goals and elements of the models, it is possible to identify their commonalities. On the other hand, because the models adopt different points of view (e.g. the user's perspective in TAM and the system designer's perspective in maturity models), they can complement each other in creating a comprehensive image of the IS and assessing its chances of success (achieving maturity). By integrating the models, we can also take into account the role of user needs and significant features of the IS itself, predisposing it to success, understood as its diffusion.

The process of integration concerns the highest level of modeling, i.e. merging phenomena related to the acceptance and maturity of IT. Therefore, the acceptance model used can be replaced by other similar ones without the need to change the general principles. For further discussion, the model known as TAM3 (Venkatesh & Bala, 2008) was chosen because in this variant of TAM the relationship between the level of IS acceptance and maturity is the most evident (Fig. 1). This model allows for external variables related to IS design features. The individual difference variable pertains to personal and demographic characteristics (e.g., age, gender, occupation, experience) that may influence the individual perception of PU and PEU. System characteristics are particularly interesting for assessing the maturity of the IS. These are important design features of the system that can help users understand its usability or ease of use. Social influence refers to various social processes and mechanisms that affect users' perceptions of the usable aspects of IS. It can be more or less voluntary (Zuiderwijk, Janssen & Dwivedi, 2015). These factors significantly affect the diffusion of innovation. For example, women pay more attention to evaluations from others than men (Venkatesh, Morris & Ackerman, 2000). The impact of social influence should decrease with experience, which forms the basis for making decisions about accepting the system (Baishya, Samalia, & Joshi, 2020). Facilitating conditions represent organizational support (organizational and technical infrastructure) that facilitates the use of the IS. Institutional support in the implementation and use of IS plays an essential role in this area, enabling the acquisition of appropriate skills and knowledge.

Together, these four variables determine the level of technology maturity. However, the mere level of technology maturity is not sufficient for success. To achieve success, the sufficiently strong motivation of users is also necessary, which, of course, to some extent, results from the design features of the system, but not exclusively. We must also take into account the characteristics of individual users of the IS.

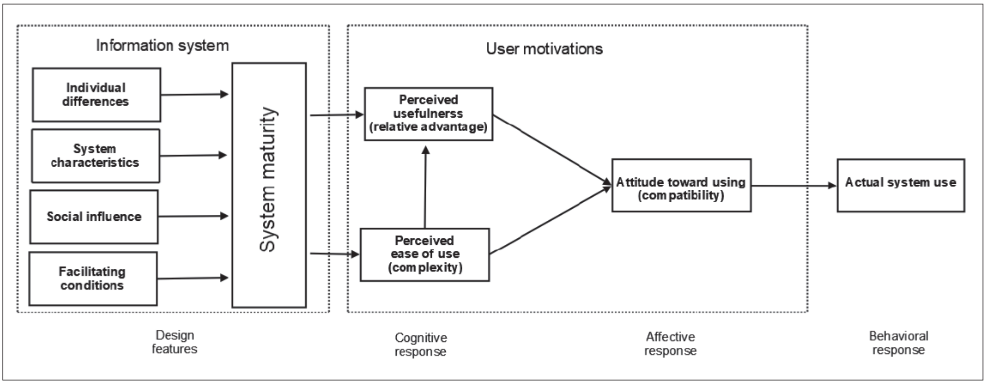

Fig. 1. The TAM3 model, taking into account the features of the IS affecting its maturity.
Source: own elaboration based on (Davis, 1985, p. 24; Venkatesh & Bala, 2008).

The maturity of IS, which are a type of social system, is strongly related to the concepts of innovation, improvement, and excellence (Mettler, 2011), described above. These relationships can be explained based on the work of Rogers (2003) and Utterback (1971), who examined conditions that increase or decrease the likelihood of acceptance of a technology, idea, product, or service.

According to the model of Utterback and Abernathy (1975), the development of each innovation follows the S curve (see the graph on the left in Figure 2). Innovation usually arises as a result of many small successive improvements to a product, service, process, or organizational rules. Over time, innovation goes through many successive levels of maturity. The stage of shaping disruptive innovation is particularly interesting when dominant solutions (i.e., commonly recognized standards or practices) become recognizable and used by the majority of members of the target group of users. Dominant solutions do not have to be perfect or even better than others; what is essential is that the acceptance of innovation becomes maximum (see the right side of Figure 2).

In the development of maturity models, recognizing the state (stage) of innovation is crucial, especially when the model has a prescriptive function. For innovations introduced to the market, the level of their maturity may be completely unknown, as there is no dominant solution in this area yet. The proposed improvement activities, although very useful at this stage, are often made based on intuition and previous, sometimes inadequate, experience, which is one of the reasons for mass innovation failures at this stage. In the case of mature innovations, their level of maturity and thus also the essential characteristics are known, but the possibilities for improvement are insignificant. Therefore, they can be considered artificially forced as they do not bring significant benefits. Similar reasoning can be applied to the diffusion of innovations, presented in the right-hand part of Figure 2. After reaching the maximum innovation diffusion point, further improvement and pushing for a more mature product do not bring the expected results; on the contrary, they can lead to creative destruction and missed opportunities related to a new innovation introduced to the market.

When defining the level of maturity for a specific IS, it is necessary to reach a compromise between the state of uncertainty as to the success of the innovation and its actual diffusion, the measurement of which helps estimate the probability of the innovation's success. Such careful behavior when applying the MM makes it easier to obtain credible, but not too obvious, conclusions, which can help plan specific improvement actions.

The red line in Figure 2 (left side) indicates the Garner Hype cycle (Jayasundra, 2021). This model describes the development of technological innovation in five stages: technology trigger, peak of inflated expectations, trough of disillusionment, slope of enlightenment, and plateau of productivity. The most interesting phase is the third one, the trough of disillusionment, when early adopters begin to look more soberly at the possibilities of innovation, getting rid of the excitement and hype that are very strong in the second phase. This is a breakthrough moment when many adopters of technology may become more attached to it or abandon it. In the third stage, many IT users, including enterprises and entire industries, abandon the new technology, recognizing that negative opinions indicate that the technology is approaching the end of its life. According to this model, innovation develops from excessive enthusiasm of the first users, through disappointment, to final realism. This model, together with the Rogers model, provides the basis for distinguishing factors that determine the success of innovative technology.

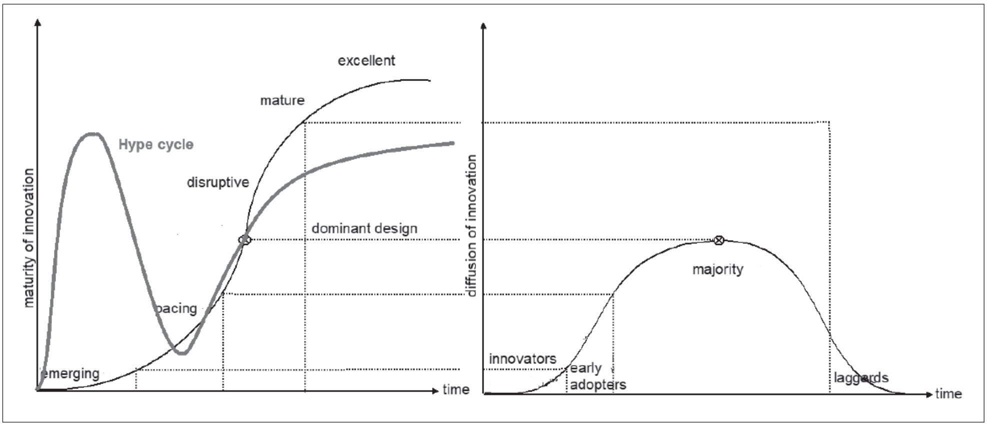

Fig. 2. Relations between maturity, perfection, and diffusion (acceptance) of innovation

Source: Prepared by the author based on (Mettler, 2011; Lajoie & Bridges, 2014).

Successive levels of maturity should lead to a state called organizational excellence, which includes the excellence of its IS. Such an IS is part of an environment that ensures continued operational success, understood as functioning in the best interest of both the system and its users. Maturity is therefore one of the conditions for achieving excellence. Paradoxically, as shown in Fig. 2, achieving perfection in the use of a particular technology carries with it the potential for failure: it means the declining stage of its application, as it is soon replaced by other innovative solutions, initially not as perfect, but with functionalities previously unavailable. This innovation matures in subsequent stages of development, again striving for perfection.

It can therefore be said that maturity means organizational capabilities that must grow over time to enable the efficient operation of the IS (achieving success), while excellence means achieving and maintaining the highest level of information services, accepted by both the creators of the system and its users. The MM is thus a step-by-step roadmap to excellence (Looy, De Backer & Poels, 2011). The maturity models of ISs typically describe the standard behavior of a person or organization at a certain number of predefined levels of maturity for each of several dimensions and procedures considered useful to achieve the next level of maturity (the assumed goal). It follows that maturity refers to the organization of the system, while excellence refers to the results obtained from that organization. Maturity models are used to increase the organizational capacity of the system to meet the information needs of users. Reaching excellence consists of achieving the assumed results by improving organizational efficiency. However, in these activities, the preferences of users related to the degree to which they are ready to accept new ITs meeting their information needs should not be forgotten.

4. Towards practice: completeness of RDS maturity models in the light of TAM

The relationships between the diffusion of IS innovation, its acceptance, and maturity presented in the previous subsections have been experimentally tested using the example of research data services (RDS). RDS is a relatively new and innovative type of information activity that has already piqued the interest of many authors of MM in this area. This diversity makes it possible to compare them with each other and with other types of models. The growing role of research data in science, which is becoming increasingly data intensive, collaborative, and computer-based, has led to the need for new methods of data collection and representation to improve computer support and online, open community development (Murray-Rust, 2008).

RDS is provided as part of Research Data Management (RDM) performed in science institutions in various organizational configurations, but usually with the participation of the library, which plays a more or less leading role in this respect. These activities include typical information tasks such as documentation, organization, storage, and sharing (Kim, 2021), but their specificity is related to the subject of these activities, which are research data. The need for RDM arises from the desire to ensure the availability and reuse of mass-produced research data. However, as in the case of all products of scientific activity, such as publications, scientists are experts in substantive research activities, but they do not necessarily have knowledge about managing information and data sets created in research processes and they do not need to have it. In the context of research data, this results in the need to organize a relatively new type of information services, namely RDS. These services cover a spectrum of RDM activities, including training and advice for researchers in the field of data management plans (DMP), required by research funding agencies. Creating a DMP requires educating researchers on good data management practices, which is often carried out as part of training courses organized by libraries.

Thanks to the digital and networked environment, indirect research results, such as research data, can be made visible and disseminated (Dempsey, 2017). A very important area of activity is the creation and operation of specialized IS, research data repositories, which have diverse organizational bases and institutional legitimacy. These repositories usually have a three-tier architecture consisting of file-based data storage, a metadata database, and a web interface facilitating access to data (Curdt & Hoffmeister, 2015). Repositories are a tool to facilitate data curation for their dissemination and reuse. Interoperable metadata collected in repositories for documenting and describing research data is an essential tool for proper data curation.

The area of issues related to research data is diverse and can be studied from many points of view, such as economic, social, technical, institutional, operational, political, and legal (Zuiderwijk, Janssen & Dwivedi, 2015). Due to this diversity of solutions in the RDM area, RDS maturity models are also created from different perspectives (Nahotko, 2022, 15). The RDS MM mentioned below were included in the research described later, and the variety of goals of these models was considered an advantage of this juxtaposition, as it made it possible to take into account the different points of view of their creators. From the point of view of the main application of RDS MM, the models used in the study can be divided into the following.

- Models created in the library community:
  - Cox et al. (2017) pointed to the urgent need to create mature services and research data activities, as very few extensive RDS have been found. Initially, library responses are focused on 'compliance' in response, for example, to funder mandates. Libraries, for the research community, should also create 'capacity' in areas such as RDM training. The authors foresaw the need for increasing requirements for re-engineering of organizational structures and business processes in the future. Libraries that

have a long tradition of playing the trusted stewardship role for traditional (printed) materials can now create new data repositories in a similar way.

- Cox et al. (2019) expanded and modified the earlier model. Four levels of development remained, but the lowest was marked as zero. Audits and surveys may be undertaken at this level. Level 1 (compliance) includes formal policy combined with advisory services. Level 2 (stewardship) is associated with the creation of a repository and associated services. At the top level (transformation) library services are being transformed for support high-level analytic services.
- The model Kouper (2017) was based on empirical analyzes services of ARL[6] libraries. In order to develop strong and mature RDS a library needs to have the following: a mission consistent with institutional mission; services matching user needs; qualified and dedicated staff; strong relationships with other units on campus and with other institutions; established policies that guide data collection, sharing, and use. Based on these themes, eight key areas of maturity were formed: leadership, services, users and stakeholders, research life cycle support, governance, cost and budgeting, cross-unit collaboration, and human capital. Compared to the CMM, the number of maturity levels has been reduced from five to three.

– Models used in the research process: Qin, Crowston & Kirkland (2014) proposed CMM for the RDM model, a modification of CMM key elements: key practices, key process areas, maturity levels, and generic processes, for RDM needs. In effect CMM for RDM includes five chapters describing five key process areas for RDM: data management in general; data acquisition, processing and quality assurance; data description and representation; data dissemination; repository services and preservation. In each chapter, key data management practices are organized into four groups according to the CMM's generic processes: commitment to perform, ability to perform, tasks performed, and process assessment (combining original measurement and verification). For each area of practice, the document provides a rubric to help projects or organizations assess their level of maturity in RDM.

– Models related to specific fields of science, like environmental protection: Peng et al. (2015) identified nine key components that are relevant to scientific data stewardship, which compose the maturity matrix. They are: preservability, accessibility, usability, production sustainability, data quality assurance, data quality control/monitoring, data quality assessment, transparency/traceability, and data integrity. For each component, a five-level progressive maturity scale is defined to assess stewardship practices applied to individual datasets, representing the Ad Hoc, Minimal, Intermediate, Advanced, and

6 ARL – Association of Research Libraries (USA and Canada – https:// www.arl.org).

Optimal stages. This model ensures digital environmental data users needs, who are asking for data to be dependable in terms of quality and production sustainability, to come from credible, secure, and authoritative sources, to be easily and publicly accessible online, and to be easily usable in a standard-based common data format with relevant documentation.

– Models tailored to the needs of the selected country, like Canada: Fry et al. 2021 proposed MAMIC, the RDM Maturity Assessment Model in Canada. The model has two roles: first, to ascertain whether or not the different areas of the research data life-cycle are being supported; and second, to understand who is responsible for the different areas. The model consists of four tables for different categories (institutional policies and processes, IT infrastructure, support services, and financial support), and each category contains specific elements to assess. The assessment is calculated based on a 5-level scale, with the highest rating representing strong maturity for the element and lower ratings indicating possibilities for improvement (or gaps).

The research described below aims to demonstrate the possibility of evaluating the quality of RDS MM in terms of the completeness of their structure. As mentioned in the second part of the article, MMs are matrices of maturity levels and assessment dimensions, which are the areas subject to assessment at each of the distinguished levels. The first step was to compile a list of these features for the existing RDS MM. These matrices for each examined RDS MM are summarized in Table 1. Individual RDS MM were assigned their dimensions, ranging from three to nine, and levels, depending on the model, from three to five.

According to the TAM3 model (shown in Figure 1), the features of an information system that affect its maturity, and subsequently the decisions of its users regarding its usage, are individual differences, system characteristics, social influence, and facilitating conditions. Subsequent research aimed to assess the degree to which these features were taken into account in the structures presented in Table 1. To accomplish this, the dimensions (shown inside the matrix) included in selected RDS maturity models (matrix rows) were assigned to the features of the information system from the TAM3 model (compare design features in Fig. 1) in matrix columns. The result of this assignment can be seen in Table 2.

The primary challenge encountered during assigning dimensions of MMs to TAM3 design features was the lack of unambiguous definitions for dimensions and the arbitrary terminology used by the authors of the RDS maturity models. To match dimensions to design features, it was often necessary to refer to the descriptions of each element or action/process that can be performed at each subsequent maturity level, that is, the content of the maturity model matrix. However, also these descriptions sometimes did not provide clear definitions. Among the MMs used, only MAMIC contained explicitly defined dimensions. Additionally, it was found that some activities and processes were repeated in different dimensions of the same maturity model (cf. Peng et al., 2015), which further complicated the process of clearly defining dimensions and assigning them to the appropriate design features. Analysis was also necessary to isolate dimensions that were named differently in different models but described the same or similar features of the RDS.

Tab. 1. Models used in the study

No.	**Model name and author (date)**	**Key areas (dimensions)**	**Levels (quantity and names)**
1	**2**	**3**	**4**
1	Cox et al., 2017	Policy and governance Service (advisory/technical) development Staff deployment and skills	Level0 None Level1 Basic Level2 Developing Level3 Extensive
2	Cox et al., 2019	Policy Services Support	Level0 None Level1 Compliance Level2 Stewardship Level3 Transformation
3	Kouper, 2017	Leadership Services Users and stakeholders Research life cycle support Governance Cost and budgeting Cross-unit collaboration Human capital	Basic: Foundation building Intermediate: Organization and standardization Advanced: Monitoring and optimization
4	Qin, Crowston, Kirkland, 2014 (CMM for RDM)	Data management in general Data acquisition, processing and quality assurance, Data description and representation Data dissemination Repository services and preservation	Level1: Initial Level2: Managed Level3: Defined Level4: Quantitatively managed Level5: Optimizing
5	Peng et al., 2015	Preservability Accessibility Usability Production sustainability Data quality assurance Data quality control/monitoring Data quality assurance Transparency/traceability Data integrity	Level1: Ah hoc, not managed Level2: Minimal, managed limited Level3: Intermediate, managed defined, partially implemented Level4: Advanced, managed well-defined, fully implemented Level5: Optimal, level4 + measured, controlled, audit

1	2	3	4
6	Fry et al., 2021 (MAMIC)	Institutional policies and processes IT Infrastructure Support Services Financial Support	Level0: Does not exist or do not know
			Level1: The element is not formalized or is ad hoc
			Level2: Element is under development
			Level3: Element is operationalized and launched
			Level4: The element is robust and focuses on continuous evaluation

Source: own study.

Tab. 2. RDS maturity model dimensions

Design features Maturity models	**Individual differences**	**System characteristics**	**Social influence**	**Facilitating conditions**
Qin, Crowston, Kirkland, 2014 (CMM for RDM)	–	Data acquisition, processing and quality assurance Data description and representation Data dissemination Repository services and preservation	Data management in general	–
Peng et al., 2015	Usability	Preservability Accessibility Usability	Production sustainability Data quality assurance Data quality control/monitoring	Transparency/ traceability Data integrity
Kouper, 2017	Users and stakeholders	Services Research life cycle support	Leadership Governance Cross-unit collaboration	Cost and budgeting Human capital
Cox et al., 2017, 2019	–	Services	Policy and governance	Staff skills
Fry, 2021, (MAMIC)	–	IT Infrastructure	Institutional policies and processes	Support Services Financial Support

Source: own study.

The data presented in Table 2 shows that not all design features of the IS are represented equally in the MMs. The RDS maturity models focus the most on system characteristics, with 11 dimensions dedicated to technical features of the RDS. In second place is social influence, with nine dimensions related to RDS management, leadership, policies, and cooperation at various levels. Facilitating conditions appear 7 times, covering issues such as human resources, finance, and support services. Individual differences dimensions, which include issues related to RDS users, appear only twice.

Overall, this means that the RDS MMs prioritize the technical features of these services and their functioning in the information environment, with less emphasis on the problems of users' needs, particularly their individual needs. The most evenly distributed dimensions in relation to design features were found in the Kouper (2017) and Peng et al. (2015) models, which filled all design features of the TAM3 model. At the other end of this continuum is the Qin, Crowston, and Kirkland (2014) model, where the dimensions concern only the two most frequently used design features: system characteristics and social influence. Perhaps this is due to the conviction that the technical features of IS properly designed are sufficient for its acceptance. Models such as TAM and research using them prove otherwise.

It should be emphasized that the differences shown here do not necessarily result from mistakes made by the authors of maturity models. On the contrary, they may be the result of adjusting the model to the needs and tasks for which it was designed. The matrix presented in Table 2 indicates those design assumptions that were considered the most important by the authors of the MM. Knowledge of this choice makes it easier to decide on the use of a specific MM based on the design priorities set during its creation. In other cases, the analysis may support the process of updating and modifying the MM to supplement its structure.

Comparing the dimensions of RDS MMs with the design features of the TAM3 technology acceptance model reveals deficiencies in the structure of the former. These deficiencies may have resulted from design decisions or insufficient consideration of the features of the RDS information system. In any case, the comparison presented in Table 2 allows for the identification of gaps in the proposed RDS MM that should influence design decisions. Method used to create the Tab. 2 can be treated as a universal tool for evaluating all types of MM, all types of IS, allowing their creators to consciously direct attention to selected areas, recognizing others as less useful in a specific application. The mere creation of a new, better MM was not the goal of the author of the article because it is very dependent on the field and area of application. Therefore, two, even significantly different, MMs in the same area can both be useful due to the practical needs for which they were created.

5. Conclusions

Models that represent the level of novelty and complexity of IT systems are necessary to understand technology acceptance and its maturity and often ambiguous relationships between them. Both of these indicators, in turn, influence the successful and sustainable application of an innovative information system. Understanding the motivations of stakeholders to accept or reject technological innovations is critical in determining the success of a particular technology in the market. Moreover, it is important to understand how technological innovation reaches maturity for organizational management decisions.

The models and theories used in the article are complementary and both the user (outcomes) and the system's (input/output) characteristics must be considered for a successful IT implementation. Maturity models primarily focus on the characteristics of IT, but the technology user and their needs should always be taken into account. Technology acceptance models, on the other hand, start from the user's needs but cannot disregard the technical features of innovative solutions. Otherwise, a technologically mature system may not be accepted by the targeted users. Therefore, combining both points of view gives the best results. What is more, their consistent use makes it easier to assess the usefulness of each of the tools, which was presented in the article on the example of RDS.

This indicates that the theories and models outlined in the article share many common features, making them easily combinable. Their combined use enables a multifaceted assessment and analysis of new ITs, allowing for a more accurate determination of the technology's stage in its life cycle and the probability of success in the next stages. Additionally, they complement each other by presenting different perspectives on the same processes and issues. The greatest benefit thus lies in their integrated use, which enables a multilateral analysis of the current IT situation and forecasting its development, affecting the level of acceptance. Such multifaceted analyses could also help to minimize errors during the implementation of new ITs, which are often associated with significant financial losses.

At every level of RDS maturity, the service developers should take into account users' views on their technological and psychological ability to use RDS, which is one of the most important factors allowing the development of beliefs, attitudes, intentions, and final acceptance of RDS, which can be estimated by such IT acceptance models as TAM. It is therefore important to take into account auxiliary factors that increase users' technological and psychological capacity to use RDS. Online services should be flexible, easy to navigate and download, and completely accessible. The maturity of RDS is not only in their extensive functionality. Technological assistance for users should be ensured, which gives hope for an increase in their mental motivation to use RDS.

The presented results may have practical implications for project management teams and for management strategies development for future RDS implementations, taking into account the perspective of RDS users on their usefulness and ease of use. In terms of RDS development, research may have practical implications for future planning and design of RDS solutions in relation to the main determinants of their implementation in organizations such as libraries. RDS solutions should take into account the role of the maturity of these services in the institutions providing them.

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Integracja modeli dojrzałości i akceptacji technologii informacyjnych: przypadek RDS

Abstrakt

Cel/Teza: W artykule przedstawiono trzy metody ewaluacji innowacji technologicznych, ze szczególnym uwzględnieniem innowacji technologii informacyjnych, takich jak systemy i serwisy informacyjne. Metody te obejmują ocenę dojrzałości, dyfuzję innowacyjnych technologii informacyjnych oraz ich akceptację przez użytkowników. Celem jest wskazanie na komplementarność tych metod, co czyni właściwym ich zintegrowane stosowanie.
Koncepcja/Metody badań: Wykorzystano dwa rodzaje teorii uwzględniających punkt widzenia zarówno twórców technologii informacyjnych (modele dojrzałości technologii), jak i użytkowników (modele akceptacji technologii). Podjęto próbę wskazania podobieństw pomiędzy tymi modelami umożliwiających ich łączne stosowanie. Zaprezentowano łączne stosowanie tych modeli na przykładzie modeli dojrzałości serwisów danych badawczych (RDS). Przeanalizowano sześć modeli dojrzałości RDS dostępnych w literaturze przedmiotu, badając ich kompletność przy użyciu modelu akceptacji technologii (TAM).
Wyniki i wnioski: Wykazano możliwość integracji modeli stosowanych do oceny SI. Przedstawione podejście badawcze pozwoliło na ocenę badanych modeli dojrzałości z punktu widzenia potrzeb użytkowników RDS, wpływających na poziom ich akceptacji. Wyniki wskazują, że istniejące modele dojrzałości RDS niewystarczająco uwzględniają potrzeby i punkt widzenia użytkowników tych serwisów, utrudniając ich akceptację.
Oryginalność/Wartość poznawcza: W artykule zaprezentowano nowy punkt widzenia na ocenę systemu informacyjnego służący integracji dwóch, stosowanych dotąd metod oceny SI: modeli dojrzałości i modeli akceptacji innowacyjnych technologii informacyjnych. Zaproponowano połączenie obu metod dla uzyskania bardziej spójnego i uniwersalnego narzędzia badawczego.

Słowa kluczowe

Akceptacja systemu informacyjnego. Dojrzałość systemu informacyjnego. Innowacyjność systemu informacyjnego. Usługi danych badawczych. RDS.

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