Interdisciplinary Description of Complex Systems 22(1), 129-141, 2024

SELECTING A SUITABLE FRAMEWORK FOR MODELLING THE SPREAD OF THE HUNGARIAN EID CARD

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DOI: 10.7906/indecs.22.1.8
Regular article

Received: 3 September 2023.
Accepted: 19 January 2024.

ABSTRACT

The aim of this article is to select an applicable framework for modelling the spread of the Hungarian eID card, as an innovation, among the Hungarian population. Using the concepts of the selected theory, a basic model is also outlined, which can serve as a foundation for further research.

Keeping the characteristics of the Hungarian eID card in mind, this article compares the various technology acceptance theories. Considering the specialties of the identity document, the Diffusion of Innovations is the most suitable framework for examining the spread of the Hungarian eID card and its electronic functions in Hungary.

Through the outlined model, the factors preventing the spread can be identified, and new research directions can also be determined. With the further development of the model, a diffusion plan can be created that would greatly facilitate the spread of the examined electronic identification document.

KEY WORDS

electronic ID document, technology acceptance, diffusion research, electronic signature, information security

CLASSIFICATION

ACM: J.1, J.4, K.4.m

JEL: L86, O33, O52

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INTRODUCTION

The eIDAS regulation [1] defines a uniform model for the application of electronic ID cards in the European Union. Governed by the Hungarian Government Decree 414/2015. (XII. 23.) the so-called 'eSzemélyi' ID card (in the following: Hungarian eID card) is the Hungarian equivalent of the eIDAS-defined ID card [2].

Among other things, the eID card is suitable for storing personal digital certificates and identification numbers. Several use cases can be mentioned like electronic signature of documents (e.g. motor vehicle or real estate sales contracts), authentication in e-government services and so on. To take full advantage of the benefits of the card, one needs a computer and a card reader device connected to it (can be replaced with a smartphone and the 'eSzémélyiM' mobile application) [3].

Somogyi and Nagy [4] state that the Hungarian Act CLXVI of 2012, in conformity with EU Council Directive 2008/114/EC, defines the following financial services as critical infrastructure: Commerce, payment and clearing of monetary assets and liabilities, Security of banks and credit institutions and Cash management.

Over time and with the increasing number of use cases citizens will probably depend on electronic trust services and electronic signature services to a similar extent as they do on various financial services (e.g. bank card use) today. However, this would require electronic trust services and electronic signature services to be considered as critical infrastructures in Hungary, which unfortunately is currently not the case according to the Act CLXVI of 2012 [5].

Nowadays, electronic information systems have a growing presence in the Hungarian public administration increasing the expected digital and computer literacy skills from all citizens. The situation however can easily seem complicated to users, since the use of the eID card has many technical requirements. As a result, basic computer usage skills are not enough, but further knowledge is necessary, e.g., the basics of electronic signature.

Nyári [6] shows in previous research on the topic that Hungarian citizens seriously suffer from a lack of information related to the eID card and its possibilities. This may be because they do not receive the necessary informative materials and information, even though such materials are abundantly available on the information portal about the identification document.

The purpose of this article is to find a suitable framework for modelling the phenomenon of the Hungarian eID card. The selected framework can be used in further research in order to explore the factors hindering the spread of the usage of the eID card and to develop solutions that facilitate the broadening of its use.

The framework for modelling the examined phenomenon must have the following properties:

- the phenomenon must be modelled among an entire social group not only in a scope of an organisation,
- the model must take into account the way of communication related to the phenomenon,
- the focus of the model must be on a technological novelty,
- the time course of the phenomenon must be considered as well.

In the recent decades, researchers have used several different methodologies to measure the acceptance of various technologies. In the following literature review section, the basic properties, similarities and differences of these methodologies are presented as well as the pieces of research conducted with them.

LITERATURE REVIEW

Hungarian eID cards with a chip are suitable for storing various data, for example: digital certificate for electronic signature, ICE (In Case of Emergency) telephone numbers, address data, identification numbers like social security number, fingerprint, etc [3].

The main areas of use of the eID card are electronic identification, public transportation, receipt of mail, travel document (within the EU) and electronic signature (e-signature). Regarding this study, however, the most important use case is the electronic signature. According to the edict governing the Hungarian eID card only private individuals can use the eID card for personal matters, i.e. it cannot be used for corporate affairs [2].

Nyári [6] conducted focus group interviews about the aspects of trust towards the electronic signature technology. Members of the 18-30 age group were represented in the first group, and members of the 31-65 age group in the second one. Grounded Theory analysis was performed on the collected data using the open coding approach. The resulting codes were then grouped into categories using axial coding, and finally a core category was created to combine the categories.

The analysis pointed out that lack of trust is not the main obstacle to the spread of electronic signatures in Hungary. Although it appears as an inhibiting factor, but the fundamental problem is caused by the fact that citizens are not aware of the possibilities of the Hungarian eID card, which is due to the lack of communication, lack of information and lack of use cases related to the identity card. So, the problem is seemingly a question of communication [6].

Several frameworks can be used to examine the acceptance of technology. According to Oliveria and Martins [7] the most used theories include Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), Technology Acceptance Model (TAM), Technology-Organization-Environment (TOE), Unified Theory of Acceptance and Use of Technology (UTAUT) and Diffusion of Innovation (DOI).

Some of these frameworks place focus on organizational rather than individual level. Awa, Ojiabo and Orokor [8] state that TPB and TAM are more suitable for understanding technology adoption among individuals. According to Oliveria and Martins [7] TPB, TAM and UTAUT are at individual level, as opposed to TOE, furthermore DOI can be applied on organization and individual level as well.

For this research topic, the frameworks that examine the willingness of individuals to accept technology are most suitable, since the organizational level cannot be interpreted in the use-cases of the electronic identity card of Hungarian citizens due to the national legal context mentioned above. Given the nature of this research, those frameworks that are not suitable for examining the individual level will be excluded.

In the Theory of Reasoned Action (TRA) behavioural intention is the main motivator behind behaviours, and it is a function of attitudes and subjective norms toward the behaviour in question. Analysing attitudes and subjective norms can lead to an understanding as to whether the tested person will perform the intended action [9, 10].

Theory of Planned Behavior (TPB) was created in 1985 by Ajzen [11] based on Theory of Reasoned Action (TRA) by Ajzen and Fishbein [9]. According to Ajzen [12] TRA can be looked at as a special case of TPB. TRA does not consider that certain tasks may be beyond the ability (unanticipated events, insufficient time, money, or resources; lack of requisite skills and so on) of the tested subjects, so TPB is extended with control which expresses the extent to which the examined person has influence over undesirable events. Madden, Ellen and Ajzen [10] state that, practically speaking, perceived behavioural control is the level of confidence of being able to perform the behaviour. It influences both behaviour intention and the behaviour itself.

According to Ajzen [12] TPB is formulated on a very general level whereas Technology Acceptance Model (TAM) is an extension of TPB focusing on acceptance of technology. As a result, the TPB and the TRA methods are no longer dealt with, as they may be too general for the purpose of this research.

TAM was created by Davis [13] in 1986 stemming from the TRA. It models the degree to which users of an information system accept and utilize the technology in question. According to Davis [13] perceived usefulness (U) and perceived ease of use (EOU) are the two primary impressions that influence users' attitude towards using a computer system.

Practically speaking a user decides whether to accept a technology based on two questions:

- Does it enhance my job performance (Perceived usefulness)?
- Is it easy enough for me to use (Perceived ease of use)?

The TAM methodology has been continuously developed and supplemented over the past decades by researchers. TAM2 was created by Venkatesh and Davis [14] in 2000. The extended model refines the original U and EOU from the perspective of social influence and cognitive instrumental process [15].

According to Venkatesh and Davis [14] the additional aspects are the following:

- subjective norm – this is kept consistent with TRA, basically, it is the user's impression as to whether his/her acquaintance would perform the same task,
- voluntariness – practically, the potential adopter's judgment of the extent to which an innovation is adopted out of their free will,
- image – defined by Moore and Benbasat [16] based on research on Diffusion of Innovation, image is the perception of the degree to which performing a task will influence the potential adopter's status in his/her social system,
- job relevance – 'an individual's perception regarding the degree to which the target system is applicable to his or her job',
- output quality – a subjective perception how well the system is able to perform specific tasks,
- result demonstrability – also defined by Moore and Benbasat [16] it is the extent to which the system produces concrete and relevant results for the individual's job.

According to the TAM focused literature review by Marangunić and Granić [15] the framework is rather popular in many fields including information systems, health care information systems, clinical information systems, digital libraries, Internet-based information systems and e-learning systems.

Ward [17] states that many studies prove the connection between U, EOU and system use. Since the creation of TAM research indicate that U is 50% more influential than the other factor. Imposing new technologies by corporate management or organizations though affect the users' attitude towards innovations negatively.

Lovosova [18] used TAM to examine the usage of the national Electronic Health Record system among the healthcare professionals of Estonia finding that in that particular case the key motivator was imposing the usage of the system by law, but TAM variables Perceived Ease of Use and Perceived Usefulness had a correlation on user behaviour.

Venkatesh, Morris, Davis and Davis [19] formulated the Unified Theory of Acceptance and Use of Technology (UTAUT) model in 2003 based on the empirical evaluation and comparison of eight existing models (Theory of Reasoned Action, Technology Acceptance Model, Motivational Model, Theory of Planned Behavior, Combined TAM and TPB, Model of PC Utilization, Innovation Diffusion Theory and Social Cognitive Theory).

There are eight key concepts in UTAUT, four core determinants of intention and usage, and four moderators of key relationships. The main concepts and their relations are shown in Figure 1.

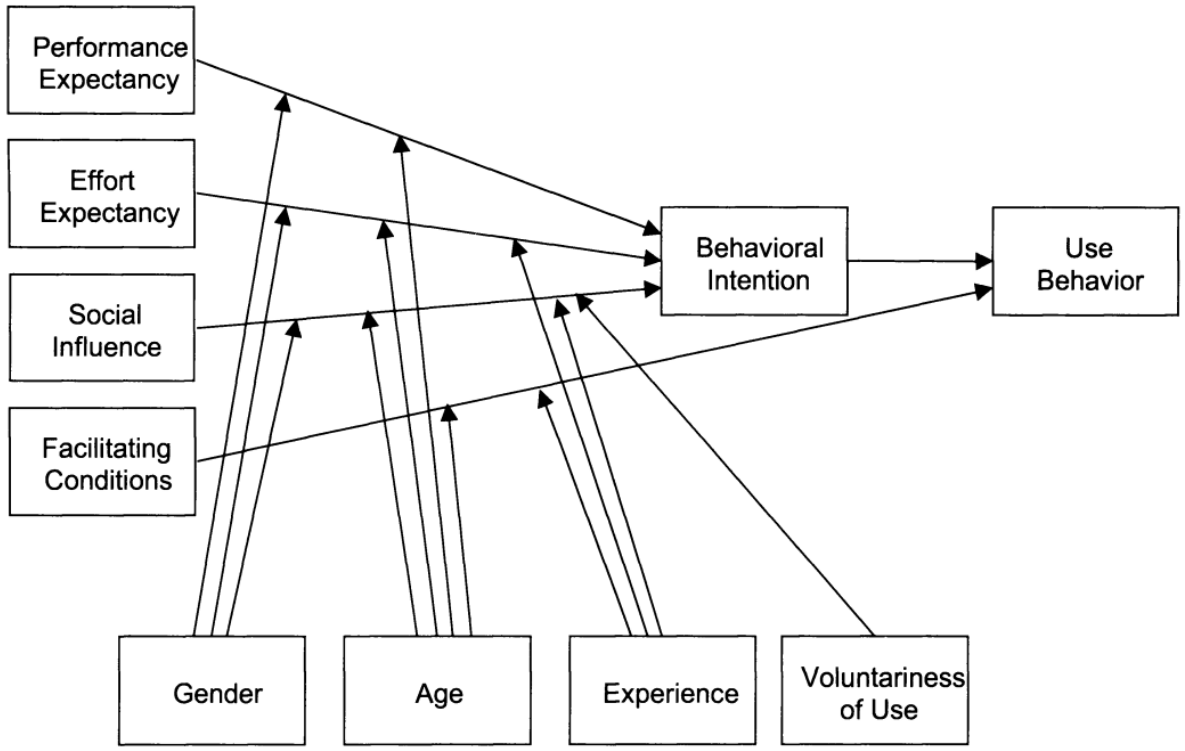

Figure 1. UTAUT [19].

According to Venkatesh, Morris, Davis and Davis [19] the four core determinants are the following:

- Performance Expectancy – basically, the same as the Perceived Usefulness in TAM, the degree to which an individual believes that a system is helpful regarding his/her job;
- Effort Expectancy – very similar concept to the Perceived Ease of Use in TAM, it expresses the degree of ease of the system usage;
- Social Influence – it stems from the Subjective Norm concept of TRA expressing the degree to which a user of a system believes that his/her acquaintances would use the same system;
- Facilitating Conditions – rooting in the Perceived Behavioural Control concept of TPB it expresses the degree to which individuals believe that the necessary technological and organization infrastructure is in place for the system in question.

As Figure 1 shows the first three core determinants (Performance Expectancy, Effort Expectancy and Social Influence) have a direct effect on Behavioural Intention and through that an indirect effect on Use Behaviour. The fourth, Facilitating Conditions has a direct effect on Use Behaviour. And the four moderating factors influence the effects of the core determinants on the Behavioural Intention or the Use Behaviour [19].

In 1962 Rogers [20] published the 1st version of 'Diffusion of Innovation' theory (DOI or Innovation Diffusion Theory – IDT) aiming to model the spread of new ideas and technologies. In this context diffusion is a process of communicating an innovation to the members of a social group. The key factors of the diffusion are Innovation (the innovation itself), Communication Channels, Time and Social System (including the potential adopters).

According to Rogers [20] the innovation can be anything that is considered new by the potential adopters (an idea, a practice and so on). The perceived characteristics of the innovation under consideration by potential adopters greatly influence the rate of the spread. It is important to emphasize that the following properties should always be interpreted in the context of what is perceived by potential users. The main characteristics of innovation are:

- relative Advantage is meant to express the extent to which the innovation is more advantageous compared to the currently used, usual practice,

- compatibility refers to the extent to which the innovation is similar to the already known and regularly used practices of potential adopters,
- complexity expresses the extent to which potential adopters consider the innovation in question to be complicated and difficult to understand,
- trialability is the extent to which the examined innovation can be tested without consequences,
- observability expresses the extent to which the results of the application of the innovation are visible to other potential adopters [20].

In order to diffuse, the Innovation must be transferred between potential adopters, Communication Channels are the media for that. Mass media channels such as TV, radio and the Internet can reach many people, but interpersonal communication channels can be much more effective in spreading innovations. The greatest challenge is the diversity of people in terms of knowledge, beliefs, education, socioeconomic status etc. [20].

Obviously, Time is needed for any new technology to be adopted, so time is also a part of the model. Every potential adopter needs to go through a so-called 'Innovation Decision Process', in which he/she decides whether to adopt the innovation in question. This goes from the first knowledge of the innovation to the adoption or rejection of it. According to Rogers, the spread of an innovation always follows the pattern of the so-called S-shaped curve [20].

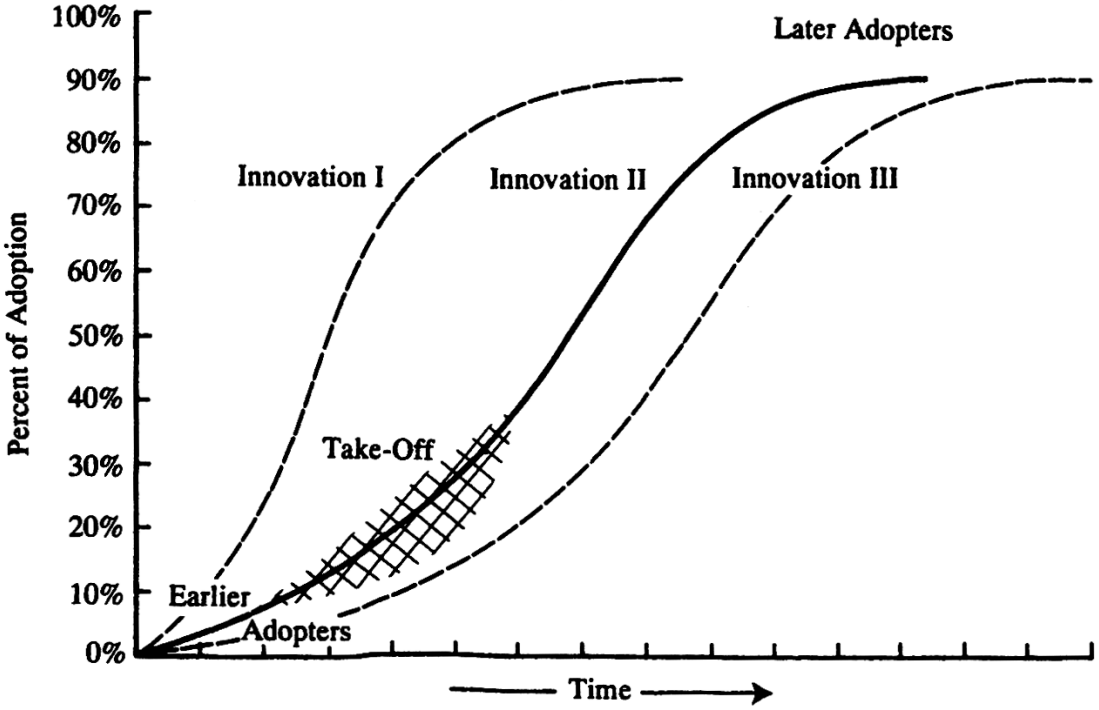

Figure 2. Diffusion process, source [20].

Finally, Social System is 'a set of interrelated units that are engaged in joint problem solving to accomplish a common goal' whose members include potential adopters as well. Adopters can be individuals or organizations depending on the nature of the innovation in question. Adopters can be categorized by the willingness of adoption (from the most to the least willing) as follows: innovators, early adopters, early majority, late majority and laggards [20].

According to Rogers [20] a 'Change Agency' is an organization that is somehow interested in the spreading of the innovation under investigation, and 'Change Agents' are the people who actively participate in promoting the innovation.

Opinion Leaders are those members of the Social System who can influence the opinions of other individuals to a large extent [20].

If the adoption rate of the innovation in question reaches the so-called 'Critical Mass', the diffusion process becomes self-sustaining, and there will be less and less need for the contribution of change agents [20].

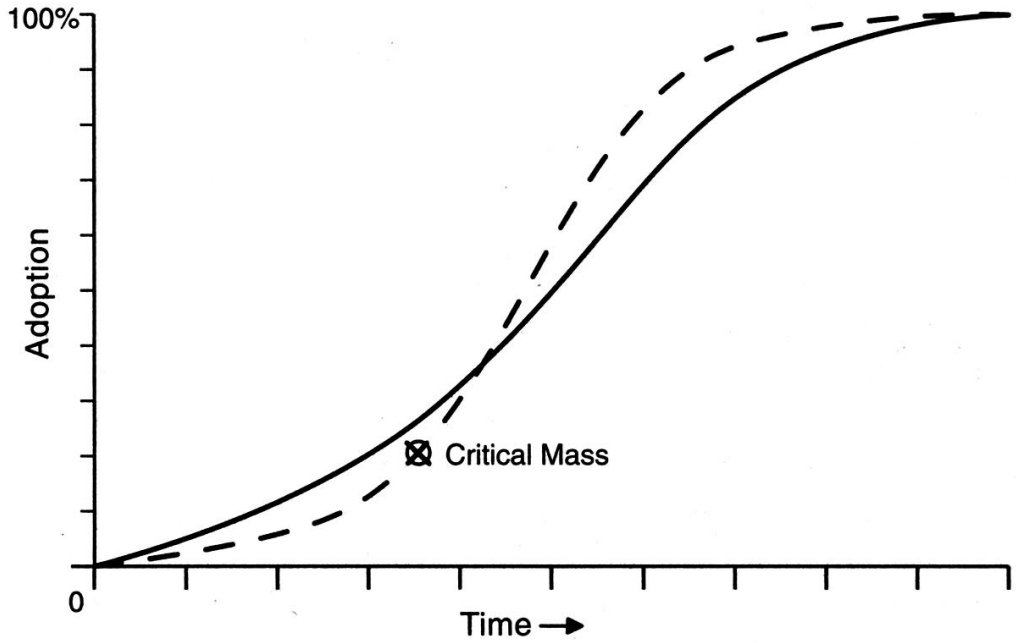

Figure 3. Critical Mass, source : [20].

Oliveria and Martins [7] state that DOI can be applied on organization and individual level as well. The theory has been applied in various fields like e-business and e-procurement so far.

Rogers [20] also states that diffusion research programs were conducted in many fields like agricultural science, healthcare, marketing etc.

SELECTING A SUITABLE FRAMEWORK

As stated earlier, the aim of this paper is to find an applicable framework for modelling the spread of the Hungarian eID card. A suitable model can provide a solid basis for further research on the factors hindering the spread of the electronic functions of the Hungarian eID card, among others.

Considering the characteristics of the Hungarian eID card, a framework with the following properties must be selected:

- can be applied on individual level,
- it focuses on technology or innovation,
- it considers the time factor and the communication aspects of the topic.

TRA and TPB are essentially psychological behaviour models with a long history but are not specifically designed to examine the acceptance or spread of technologies. Although the foundations of the first two theories are used by several other models, like TAM, on their own these frameworks are too generally formalized in order to efficiently use them in further research on this topic.

TAM as its name suggests, focuses on the acceptance of a technology that is available to and known by the users. But acceptance cannot be measured in cases where the technology was not spread to its potential users. Considering that Hungarian citizens do not have enough information regarding the possibilities of the national eID card, a framework with capabilities of modelling the communication aspects is needed.

Although UTAUT combines the best attributes of eight other models, but Communication Channels are not taken into consideration as opposed to DOI.

Based on the requirements above the suitable frameworks can be narrowed down to one framework, Diffusion of Innovations, so in the following this methodology will be in focus.

See the reasons of excluding other frameworks summarized in Table 1.

Table 1. Excluding frameworks from the current research.

Framework	Reason of exclusion
Technology-Organization-Environment (TOE)	Cannot be applied only on individual level
Theory of Reasoned Action (TRA)	Formulated on a too general level
Theory of Planned Behavior (TPB)	Formulated on a too general level
Technology Acceptance Model (TAM)	Does not take 'Communication Channels' into consideration
Unified Theory of Acceptance and Use of Technology (UTAUT)	Does not take 'Communication Channels' into consideration

The Hungarian eID card phenomenon can be best modelled as a diffusion research problem by applying the concepts of the Diffusion of Innovations framework.

APPLYING THE CONCEPTS OF THE DIFFUSION OF INNOVATIONS FRAMEWORK TO THE HUNGARIAN EID CARD PHENOMENON

As stated above, the DOI framework basically divides diffusion into four main elements: Innovation, Time, Communication Channels and Social System. In the next section, it will be discussed how the Hungarian identity document can fit in the concepts of the DOI.

INNOVATION

According to Rogers [20] even a relatively old technology can be considered as an innovation in the scope of a Social System, when it is new to the members. The Hungarian eID has been available to citizens since January 1, 2016, but the chip has only been mandatory since August 2021 [3].

Based on the statistics provided by the Hungarian Ministry of Interior Deputy State Secretariat for Data Registers, only a very small percentage of those entitled have requested the electronic signature functionality of the document over the years, so the ID document and its electronic functions can be considered as an Innovation [21].

The eID card as an Innovation may seem somewhat complex, since several software and a card reader (or an NFC-capable mobile device to replace it) are required for its use. In terms of its Compatibility, it is quite different from the paper-based signature solution used by citizens as a daily routine.

Unfortunately, citizens do not have the opportunity to try out or observe the solution without consequences before applying for it, so the situation is not very favourable in terms of Trialability and Observability.

As an advantage of its use, it can be highlighted that time and paper can be saved by using electronic signatures, but it depends on the individual judgment of the citizens as to what degree of Relative Advantage this represents for them compared to the usual solution.

SOCIAL SYSTEM, ADOPTERS AND CHANGE AGENTS

The concept Social System requires the least explanation. In this diffusion research, Social system means the entire Hungarian society.

All Hungarian citizens are required to have a photo identification card (however, this can also be a driver's license or passport) and citizens from the age of 14 are entitled to apply for an eID card with an electronic signature function. Essentially, the set of citizens defined above corresponds to the concept of Potential Adopters in this case [2].

In further research Opinion Leaders should be identified regarding the eID card in order to actively and effectively facilitate the spread of the benefits of the card.

The main Change Agency is the Hungarian Government itself; Citizens' Administrative Bureaus can also be considered as Change Agencies. The main Change Agents are Government Customer Service Representatives who help citizens with the application for the eID card.

Nyári [6] pointed out that improvements could be made in this area, and that Government Customer Service Representatives should make a greater effort to promote the electronic document during the application process.

According to Somogyi and Nagy [4], great emphasis should be placed on education and training to increase the IT security awareness of employees in the financial sector. Similarly, the use of electronic identification documents and electronic signatures also require sufficient awareness and training on the part of citizens.

TIME

The timeframe of this innovation starts on January 1, 2016. The identity document in question has gone through some alterations over the years. At first the chip was optional, but since August 2021 it is mandatory. In the spring of 2022, the 'eSzemélyiM' mobile application was released making it possible to replace hardware card readers utilizing NFC and WIFI capable mobile devices [3].

The innovation and its use cases continue to develop, since January 2023, a new role-based authentication solution has been available in connection with the electronic signature function of the Hungarian eID card, which allows users to supplement electronically signed documents with an attribute certificate that includes their position in an organization. This is however only available for governmental employees for now [22].

As a result of the amendment of Act C of 2021 [23], a further important development is expected in 2024, when it will be mandatory for citizens to use electronic signatures in real estate transactions. However, it is feared that the prerequisites for this will not be available neither on the technical nor the human side. The preparation of citizens for this change should have already started with the publication of advertisements and educational materials, but currently there is no information whatsoever on the eszemelyi.hu portal [3] referring to this new use case.

With the introduction of newer and newer use cases, society will increasingly rely on the services provided by electronic trust providers and electronic signatures. Taking the electronic signature service to the appropriate security level will become important, so including it to the critical infrastructures in Hungary would be necessary.

Unfortunately, according to the aforementioned statistics by the Hungarian Ministry of Interior, the number of citizens applying for the electronic signature functionality has not increased significantly over the years, as shown Table 2 below.

The data available on the website present the annual number of new eID documents broken down according to the various services that can be requested (e.g., electronic signature function). For the sake of simplicity, we considered the requests as completely new claims (rather than replacing lost/damaged documents). The cumulative amount of the new requests

is also shown in Table 2. However, this is a maximum estimate, meaning that this is the maximum number of valid cards with an electronic signature function. Data also show that there were 11 016 399 eID card requests among the full population of 9 689 010 during the years. This is normal as it covers requests to replace lost/damaged/expired cards [21, 24].

Table 2. New eID cards per year [19].

	2016	2017	2018	2019	2020	2021	2022	July 2023
New eID cards with eSignature	67 348	122 520	37 523	25 509	20 743	16 246	27 980	17 313
Sum of eID cards with eSignatrue	67 348	189 868	227 391	252 900	273 643	289 889	317 869	335 182

The rate of adoption is very low, even with the aforementioned simplification applied, what's more the annual increase has fallen compared to the initial values (2016 and 2017). In order to reach the Take-off stage and the Critical Mass on the S-shaped curve the annual increase should drastically boost up in the next three to four years. The Critical Mass would be at around 1.5-2 million eID cards with electronic signature function.

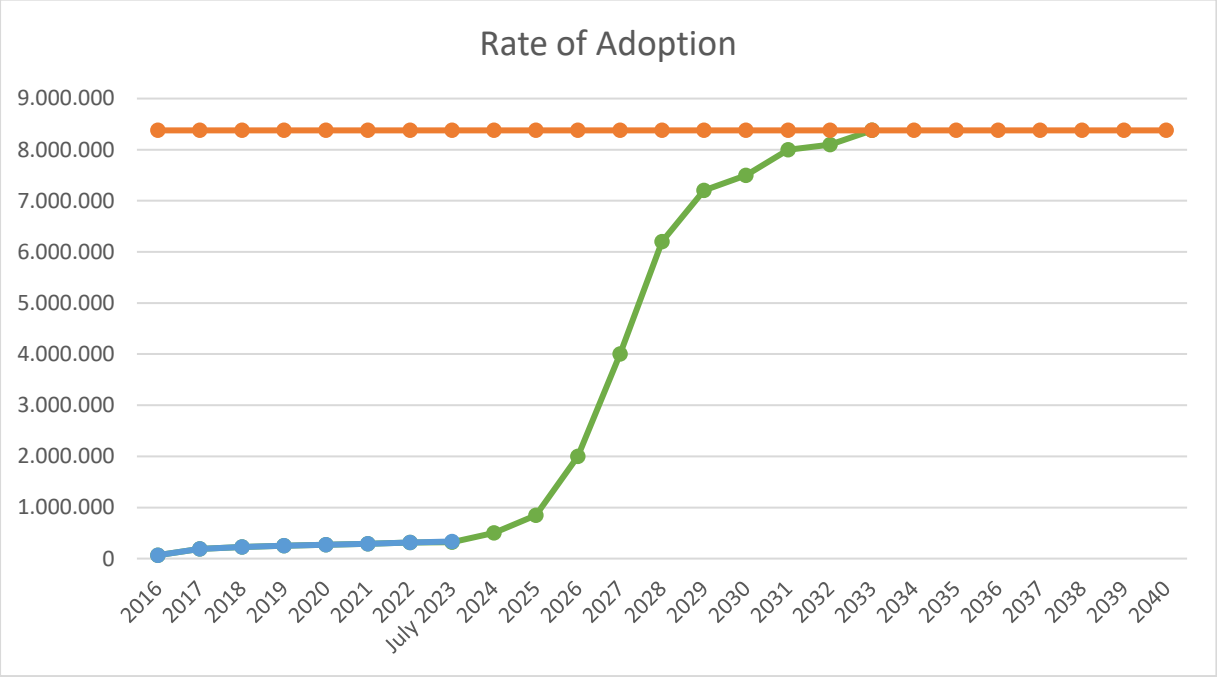

Figure 4. Hungarian eID card Rate of Adoption.

In Figure 4 the blue line shows the requests from previous years until the end of July 2023, the orange line shows the number of eligible citizens (calculated from Hungarian population data for 2022 [24], considered constant 8 377 302 for the entire period), and finally the green shows the S-shaped curve of diffusion estimated based on the data so far.

COMMUNICATION CHANNELS

On one hand there are no TV, radio or internet commercials promoting the Hungarian eID card whatsoever. On the other hand, the eSzemelyi.hu information portal contains all the information necessary to learn about the capabilities and use of the document. It also presents the possible use cases of the document in sufficient detail, except for the soon-to-be-compulsory use case of real estate sales [3].

However, Nyári [6] in 2022 stated that citizens do not have enough information about the document, nor are they aware of the above-mentioned information portal. The participants in the research also highlighted that the use of the document could be embedded in the story of TV series and movies in order to further promote it.

SUMMARY

As more and more use cases appear for electronic signatures, electronic trust service providers and electronic signatures should be considered as critical infrastructure, and this should be reflected in the Hungarian legal environment as well. Defining best practices and security measures for the protection of the infrastructure in sectoral recommendations would be highly advisable like the case of the financial sector as Somogyi and Nagy [4] point out.

The risk analysis of the Hungarian electronic identity card and the electronic signature – as a further research direction – would be vital for the development of adequate infrastructure protection.

There are many theories to examine the adoption of technologies, which utilize different criteria. However, we can only examine the acceptance of technologies if they are already available to potential users. The phenomenon of the eIDAS compliant Hungarian eID card needs a different approach, since its electronic functions are not well known among citizens. It should be considered as a diffusion research problem utilizing the Diffusion of Innovation framework.

The Innovation in question is somewhat complex and less compatible with the solutions currently used by Hungarian citizens. The diffusion process is still in the early phase, since the number of eID cards has not reached the Critical Mass yet.

Based on the annual increase so far, the number of the new e-signature requests should grow drastically for the S-shaped curve to form. In order to start on the S-shaped curve, the electronic functions and benefits of the eID card should be promoted through educational and advertising campaigns. These are absolutely necessary so that the innovation can reach citizens as soon as possible and that they can use it with confidence. Furthermore, gradual introduction of additional use cases would also speed up the spread of the innovation.

The Diffusion of Innovations theory is fully suitable for modelling the Hungarian eID card phenomenon. The basic model outlined in this article needs to be further refined in order to facilitate the wide spread of the eID card. A diffusion plan must be developed to achieve the most efficient and fastest spread keeping the importance of education and IT security awareness in mind.

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