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An Exploratory Study of Innovation Adoption in Estonia

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Abstract

The purpose of this paper is to extend innovation-decision process (IDP) research. Focusing at the individual level of analysis, the paper empirically describes the adoption of an innovation—the Smart identification (ID) technology—in Estonia. The paper opted for an exploratory study using both quantitative and qualitative approaches. To this end, 568 subjects completed questionnaires assessing aspects of the five innovation-decision stages. Hypotheses were tested simultaneously in iterative mediation and moderated mediation analysis. The analysis is modeled along the key aspects and phases proposed by Everett Rogers (2003). Consistent with Rogers' theory and as hypothesized, earlier stages of the innovation-decision process predicted later stages. However, Implementation did not predict Evaluation stage variables. The conclusions show that the IDP model is supported overall, and that additional work is needed to describe further the process of adoption in different social contexts, such as Estonia. It also identified that role and time are important explanators in innovation diffusion research. Practical implications and future research are suggested.

Keywords

Diffusion, Estonia, Innovation-Decision, Smart ID, Technology Adoption

1. Introduction

Innovation has been defined differently by many scholars. For example, innovation has generally been argued to be both the production of creative ideas and their implementation as the first and second stages respectively [1]. To economists, innovation is conceived as an outcome, while organizational sociologists see innovation from a process perspective [2]. To many management scholars [3], both earlier viewpoints should be considered with a focus on the adoption

process conditions and emerging patterns. In any case, these positions are evolving.

One of the most widely accepted definitions of innovation is that by Everett Rogers. Rogers, op. cit., said it is "an idea, practice, or object that is perceived as new by an individual or other unit of adoption". A unit of adoption could be an organisation, a society and also a target market [4]. The innovation-decision process, according to the diffusion of innovations theory of Rogers involves a technological innovation being communicated through particular channels, over time, among the members of a social system. A key characteristic of this process is that individuals participate in a series of actions related to decisions.

This robust decision factor classification framework of Rogers suggests that the adoption of an innovation by an individual, rests on three divisions: 1) antecedents (factors present in the situation prior to the introduction of an innovation); 2) process (information sources as stimuli), and 3) results (adoption or rejection of the innovation). Antecedents include factors pertaining to the actor's identity and perceptions of the situation, while process covers factors related to perceived characteristics of the innovation. Rogers in 2003 revised the original classification introduced in 1962 and rehashed in 1995 and focused on innovation decision process stages [5].

Rogers' (introduced in 1962, 1983, 1995, revised in 2003) theories have supported the innovation-decision as a multi-stage process through which a decision-making unit passes a number of selective steps. He argued that such processes occur both on the individual and organizational levels. He further posited that understanding the process perspective is relevant as the adoption of new technologies requires resources and efforts to shift towards a new behavior. He suggested therefore that, there was the need to analyze how a decision-making unit (which can be on the individual or organizational level) passes through the adoption process, and which factors ensure a smooth transition from one phase to another in the process. To Rogers, success along every phase can foster diffusion of innovations. He claimed that the process nature of innovation should be investigated through a research-based type of data gathering and analysis that seeks to determine the ordered sequence of a set of events [6]. However, [7] reported that many scholars ignore the proposed sequence.

Rogers in 1995, had identified five major categories of individual adopters: 1) Innovators 2) Early Adopters 3) Early Majority 4) Late Majority and 5) Laggards, based on his bell curve. The most striking feature of the innovation diffusion theory is that, for most members of a social system, the innovation decision depends heavily on that of the other members of the system.

Hall and Khan in 2003 argued that in the right circumstances, new technologies (or innovations) adopted by members of a community will spread by diffusion [8]. Hall, *et al.*, have asserted that diffusion itself results from a series of individual decisions to begin using a new technology, decisions which are often

the result of a comparison of the uncertain benefits of an invention with the uncertain costs of adopting it. Other scholars in the innovation diffusion stream have sought to develop models to aggregate innovation diffusion. Most of these models are based on a formulation of differential equations that specify the flow between mutually exclusive and collectively exhaustive subgroups such as adopters and nonadopters [9] [10], while more recent reviews have included [11]. All these scholars, especially Mahajan *et al.*, advocate an individual-level modelling approach to "study the actual pattern of social communication, and its impact on product perceptions, preferences and ultimate adoption". Goldenberg *et al.*, [12] modelled adoption as a probabilistic transition between two states that results either from spontaneous transformation or from word-of-mouth induced awareness.

While Nathan Rosenberg in 1972 asserted that the diffusion process is slow and the variations in the rates of acceptance of different innovations are wide, Hall *et al.*, op. cit. posited that although the ultimate decision is made on the demand side, the benefits and costs can be influenced by decisions made by suppliers of the new technology, confirming the other studies such as [13]. The resulting diffusion rate is then determined by summing over these individual decisions. Hall, *et al.*, op. cit., further noted that the most important thing to observe about this kind of decision is that, at any point in time the choice being made is not a choice between adopting and not adopting but a choice between adopting now or deferring the decision until later and that the reason it is important to look at the decision in this way is because of the nature of the benefits and costs.

Opinion dynamics in social systems has been given considerable place in the diffusion literature [14]. This idea stipulates that consumers develop preferences in a collective process of opinion formation. Under the same idea, refusal to adopt is increasingly weighted by neighbour agents as evidence against innovation, based on observed adoption behaviour [15]. Other approaches to modelling innovation decision are based on psychological rules rather than perfect rationality [16] [17] [18]. Social influence has been touched on extensively in diffusion research. There is evidence in the literature in this respect [19] [20] [21] [22] [23]. Many of these studies incorporate positive word-of-mouth mechanisms.

Although existing innovation decision models vary to some extent in their terminology, e.g. [24] [25] [26], the fundamental structure follows the process suggested by Everett Rogers (2003). Rogers has said that to understand the rate of adoption in any given situation requires analysing factors that facilitate or militate against adoption. These, he observed include: 1) Knowledge of an innovation 2) Persuasion or formation of an attitude towards the innovation 3) Decision to adopt 4) Implementation of adoption decision, and 5) Confirmation (referred to in this paper as Evaluation). The likely ensuing outcome of the full cycle is innovation diffusion. Nabih, *et al.*, op. cit. [26], observed that, "the acceptance and the continued use" of an innovation is the behaviour most com-

monly referred to in the definition of adoption.

There is again evidence in the literature about numerous technology adoption and acceptance theories over time [27]. Some of them include: 1) the Theory of Reasoned Action (TRA), which suggests that a person's intention to perform a behavior is determined by her/his attitude and the subjective norms; 2) the Theory of Planned Behavior (TPB) which extended the TRA and included a perceived behavioral construct; 3) the Technology Acceptance Model (TAM), which argues that the attitude towards using technology is influenced by the perceived ease of use and usefulness; 4) the theory of consumption values, and the five perceived values (functional, social, emotional, epistemic and conditional values) to explain how customers make market choices. In 1995, as noted earlier, Rogers introduced 5) the Innovation Diffusion Theory (IDT), which holds that the adoption rate of innovation depends on its relative advantage, compatibility, triability, observability and complexity, among other arguments. Rogers, op. cit., revised the theory in 2003. In the same year, 2003, 6) the Unified Theory of Acceptance and use of Technology (UTAUT) integrated constructs from the TRA, TPB, TAM, IDT, some motivational models, model of PC utilization and social cognition theory. By 2009, 7) the Green ICT Adoption Model (GITAM) was introduced.

Now, studies over the years have focused on adoption of new technologies both generally [28] [29]; and more specifically: adoption of on-board information technology (IT) by firms in the trucking industry [30]; role of network effect in Automated Teller Machine (ATM) adoption by banks; education, consumer skills and learning in consumer adoption of electronic banking in the United States [31]; adoption of new technologies in agriculture [32] [33], education and learning [34] [35]; adoption of medical technology [36]; Supplier relations and adoption of new technologies [13]. More recent empirical studies have investigated determinants of adoption and non-adoption decisions. [37].

In the paper, the study location is Estonia, a Baltic country in Eastern Europe. According to the studies of [38], over the last two decades, the country has made tremendous technological progress. Every Estonian citizen or legal resident, irrespective of their location, has a state-issued digital identity. As a result, legal residents can authenticate their identity (ID) online without physical contact, use digital signatures, and access electronic services' portals using their ID cards, Mobile ID, Bank codes or PIN Calculators and the new Smart ID. The Smart ID technology, introduced in Estonia at the beginning of 2017, is a convenient new mobile application that works as an identification solution to securely prove online identity. According to Freedom House, 98% of the population have ID cards, 88% use internet regularly and 350 million digital signatures have been recorded [39]. It is worthy of note that the Smart ID is non-commercial, at least from the user end.

There is extensive research on the IDP as well as diffusion of innovations, as alluded to earlier, but not a single about Estonia.

This study seeks to:

- Extend what is known about the factors affecting adoption of new technologies,
- Identify the factors important either in facilitating or militating against adoption of the Smart ID technology by individuals in Estonia, and
- Propose recommendations to solving problems and reducing barriers to new technology adoption.

2. Research Hypotheses

In the paper, the author will investigate adoption of the Smart ID technology using the factors known to affect new technology adoption. Employing a mediation analysis in sub-models I to III (hypotheses 1 to 3) and moderated mediation analysis in sub-model IV (hypothesis 4), the author will investigate if "Role of individual" mediates the relationship between Knowledge, Persuasion, Decision, Implementation and Evaluation, as well as if Length of Stay (Time) moderates the likely relationship between Implementation and Evaluation through Role (see **Figure 1** for an overview of tested hypotheses).

The theory underpinning the model tested in this paper is grounded in the classical diffusion of innovations theory [40] [41] [42] [43] [44] introduced by Rogers and the works of Frambach & Schillewaert op. cit.; that the process nature of innovation should be investigated through a research-based type of data gathering and analysis seeking to determine the ordered sequence of a set of events.

The entire study is modeled along selected aspects and phases of the Innovation Decision Process (IDP) framework proposed by Everett Rogers. In the ensuing sections, each of Roger's key phases is reviewed and hypotheses stated. Indeed, there is some empirical support from several studies such as [45] [46] [47], showing that the innovation process as it unfolds over time is messy, reiterative, and often involves two steps forward for one step backwards plus several side steps. Does the IDP framework follow the order as posited by Rogers in the context of Estonia, which is an unexplored social system, in terms of the innovation decision-process framework? What are the factors that trigger accelerated adoption of new technologies such as the Smart ID?

Four sets of hypotheses were developed. First, the author hypothesized that the outcome would be consistent with Rogers' innovation-decision process model. Specifically, the expectation is that each of the stages of the IDP would predict subsequent stages and that knowledge levels would predict the extent to which the subjects had been persuaded in favor of the Smart ID innovation, which in turn, would predict their decision making, to implement the innovation. Decisions at post-implementation were then expected to predict self-reported implementation thereafter, which in turn would predict confirmation of the decision after dissemination. **Figure 1** summarises the Hypothesized Model.

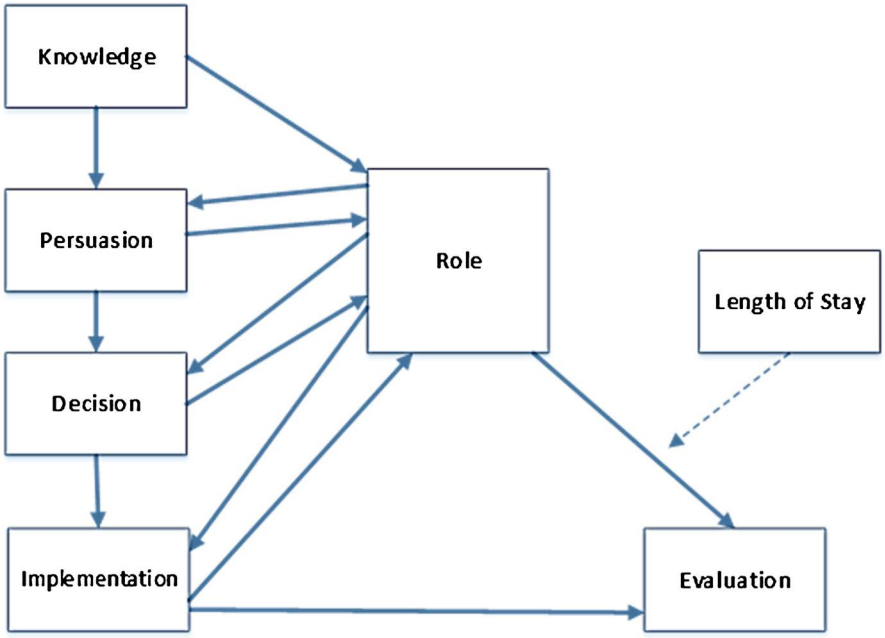

Figure 1. Hypothesized model.

2.1. Knowledge of an Innovation

Rogers, op. cit., had argued in 1995 that communication is the process by which participants create and share information with one another in order to reach a mutual understanding. To Rogers, what underlies the diffusion process is information exchange. The process he added involves: 1) an innovation (here the Smart ID technology), 2) an individual or unit of adoption that has knowledge or experience with using an innovation, 3) another individual or unit of adoption, without knowledge of the innovation and 4) a communication channel connecting the two units (2 and 3 above). He had in the same publication noted that, in connection with the categories of adopters, there are four main elements in the diffusion of innovations, which are 1) the innovation 2) communication channels 3) time and 4) a social system.

In Rogers' model, Knowledge is the first stage in the IDP framework and suggests that, when an individual is exposed to an innovation's existence and gains some understanding of how it functions, knowledge occurs. It has been argued that spreading an innovation can have the most powerful effect on adoption and consequent diffusion. For example, Hauser *et al.*, in 2007 summarised research on innovation from a marketing perspective and agreed. Rogers further argued that knowledge of innovations influences attitudes to new innovations. Meanwhile, research has shown that strong interpersonal ties are usually more effective in the formation and change of strongly held attitudes and that such attitudes are developed through communication exchanges about the innovation with peers and opinion leaders in the adoption chain. To eliminate a deficit of awareness of an innovation, mass media channels have been suggested as the most appropriate. A generalisation that mass media channels are relatively more

important at the knowledge function, and interpersonal channels are relatively more important at the persuasion function has been made by Rogers and Shoemaker [48]. Communication has been seen as a convergence of meaning achieved by symbolic interaction, with the product of the convergence process being adoption, rejection, modification or creation of an innovation [49]. In any case, Rogers and Kincaid in their previous works observed that interpersonal networks are the most important in the diffusion process while mass communication channels play a significant role in diffusion. Lippman *et al*., investigated the impact of three types of informational returns to scale (cheaper, faster and better) and concluded that the decision to adopt or otherwise is made later when information is cheaper, and the change in timing is unsignable in the case of faster arrival of information, and that only more accurate (better) information leads to earlier innovation decisions [50]. According to Kaplan [51], awareness should motivate the individual to seek further information about the innovation attributes and thereby proceed to the persuasion stage. Based on these arguments, the first hypothesis is stated as follows:

H_1 There is a significant positive relationship between Knowledge of new technologies and Persuasion to adopt mediated by Role of individual.

2.2. Persuasion to Adopt an Innovation

Persuasion is the second stage in the IDP and occurs when an individual forms a favourable or unfavourable attitude toward the innovation. [52] theorized that early adopters are willing to take the risk of adoption without gaining information from their social systems and therefore, tend to be risk takers in this light. To them, consumers differ in terms of their reliance on others for information and assistance when making new innovation decisions. Research has shown that product characteristics can affect adoption decisions [53]. One of the key characteristics, which has been influential in consumer adoption of innovation is network externality, aside innovation newness, compatibility, feature richness and perceived risks. Recent studies have suggested that persuading opinion leaders is the easiest way to foment positive attitudes toward an innovation. Rogers, op. cit. explains that the types of opinion leaders that change agents should target depend on the nature of the social system. Social systems have been characterized as heterophilous or homophilous [43]. On one hand, heterophilous social systems tend to encourage change from system norms. In them, there is more interaction between people from different backgrounds, indicating a greater interest in being exposed to new ideas. It has been argued that these systems have opinion leadership that is more innovative because these systems are desirous of innovation, whereas, homophilous social systems tend toward system norms. Most interaction within them is between people from similar backgrounds. People and ideas that differ from the norm are seen as strange and undesirable. These systems have opinion leadership that is not very innovative because these systems are averse to innovation. Opinion leadership is the degree

to which an individual is able to influence other individual's attitudes or overt behaviour informally in a desired way with relative frequency. Katz [54] made a connection between media, opinion leaders and opinion followers while Rogers posited that the structure of a social system can facilitate or impede the diffusion of innovations in the system. This argument is further stretched with the view that, a group with similar attributes such as language, beliefs, education and social status, experience better transfer of new ideas. Lustig and Koester noted that members outside the original social system, whose norms, values and adoptive behaviours violated the original were likely to form some resistance to the new [55]. Markus [56] wrote "innovation spreads when others either observe the early adopters and imitate them to replicate their profits or communicate with early adopters and are persuaded or induced to adopt". Fill [57] added that "testimonies from those who have experienced the product become very important" while Gouws *et al.*, and Florea [58] noted that positive perceptions of relative advantage, compatibility, complexity, triability and observability are processes necessary in order to proceed from the Persuasion stage to the Decision stage of the innovation-decision process, in agreement with Rogers. Following the above arguments, the second hypothesis is:

H_2 There is a significant positive relationship between Persuasion to adopt new technologies and the Decision to adopt, mediated by Role of individual.

2.3. The Innovation Decision

Rogers, in 2003, in the fifth edition of his publication, Diffusion of Innovations [43], noted that innovation decisions are of several types. These include: 1) optional innovation-decisions, 2) collective innovation decisions, 3) authority innovation-decisions. (pp. 28-29) and 4) contingent innovation-decisions (p. 30). In any case, decision is the third stage in the IDP framework and occurs when an individual engages in activities that lead to a choice to adopt or reject the innovation. The innovation-decision is made through a cost-benefit analysis where the major obstacle is uncertainty. The argument is that people will adopt an innovation if they believe that it will, all things considered, enhance their utility. So, they must believe that the innovation may yield some relative advantage to the idea it supersedes. That means an appraisal of the disruptive nature of the new technology to other functioning facets of daily life, level of uncertainty attached to the innovation, workability of new innovation or technology and what new challenges the new could introduce to daily life. It is an accepted position among diffusion scholars that since people are on average risk-averse, the uncertainty will often result in a postponement of the decision until further evidence can be gathered. But the key is that this is not the case for everyone. Each individual's innovation-decision is largely framed by personal characteristics, summed into their technology orientation and this diversity is what makes diffusion possible. The personal characteristics of individuals and interaction of the

various segments illuminates the spread and its consequent effect. Consumers at this stage refine their perception of an innovation and decide whether to adopt or reject it [59]. The decision stage results in an intention, although not yet to concrete behavior. On the contrary, in the implementation stage, intentions transform into actual behaviour [60].

Another dimension to innovation diffusion theory is social setting. In 2003, Rogers said "an innovation's incompatibility with cultural values can block its adoption (p. 241), adding that the knowledge-persuasion-decision process sequence proposed in the model of the innovation-decision process may be somewhat culture-bound and that in some sociocultural settings, the knowledge-decision-persuasion sequence may occur frequently, at least for some innovations" (p. 179). For these reasons, the third hypothesis set out to prove the following:

H_3 There is a significant positive relationship between Decision to adopt and Implementation of innovation mediated by Role of individual.

2.4. Evaluation of Innovation: Role as a Mediator, Length of Stay as Moderator

Empirical evidence from several studies have shown that respondents sought information after they had made the decision to adopt and before. At the Evaluation stage, the individual seeks reinforcement for the innovation decision already made but may reverse this decision if exposed to conflicting messages about the innovation. This has been referred to as *Discontinuance* [43]. The Evaluation (confirmation) stage continues after the decision to adopt or reject for an indefinite period of time [61] [62]. Throughout the confirmation stage, the individual seeks to avoid a state of dissonance or to reduce it if it occurs. In this stage, consumers seek reinforcement of their adoption or rejection behaviour.

Individuals are the most important element in the diffusion process according to the IDP model. Role of individual is a key in the adoption chain. In the IDP generally, Role is seen from the technology orientation of an individual or one's placement in the social system. In this paper, Role of individual extends additionally to undertakings of each individual in the study that could significantly impact the outcome of the adoption decision. User roles cannot be neglected in technology adoption. Roles have been known to predict attitudes towards innovation adoption [63]. Intention-based models have been successful in investigating attitudes as mediators between beliefs and intentions [64] [65]. The attitude towards adopting a particular system is formed by individual beliefs about the consequences of adopting a particular system and the evaluation of the resulting consequences [66]. Similarly, user attitudes influence the adoption of new technologies [67]. The present study will investigate whether Role of individual mediates the adoption relationships in H_1 to H_4.

Time is another important element in the diffusion process. In fact, most oth-

er behavioural science research is timeless in the sense that, the time dimension is simply ignored. Time is an obvious aspect of any communication process, but most (non-diffusion) communication research does not deal with this explicitly. Perhaps, it is a fundamental concept that cannot be explained in terms of something more fundamental. According to Rogers, time does not exist independently of events, but is an aspect of every activity [43]. The inclusion of time as a variable in diffusion research is one of its strengths (p. 20). Time has been considered intrinsic to the process of communicating, even more so if the concept being communicated is unknown to the audience.

The study also investigates whether Length of Stay in Estonia moderates the proposed relationship between the Implementation and Evaluation decisions, suggesting that this relationship is weak when there is strong Length of Stay. Specifically, the author will investigate whether Length of Stay moderates the already proposed indirect relationship between Length of Stay, Role of Individual and Evaluation, so that when the Length of Stay is strong, the proposed indirect relationship from Implementation via Role to Evaluation will be weaker. Against this backdrop, the fourth hypothesis is stated as follows:

> **H_4** The indirect association between Implementation and Evaluation through Role is conditionally dependent upon levels of Implementation, so that the relationship between Role and Evaluation is only present when Implementation is weak.

3. Method

3.1. Procedure and Sample

A survey was developed, and measurements were validated through initial pilot data collections using selected samples. The initial sample count was 9, purposefully selected to check theoretical saturation. The results of the initial pilot led to a regrouping, re-alignment and recomposing of the number of standardised inventories. The author then implemented the survey online, using a general sample to test the hypotheses. The following subsections provide the details of the measurement development and implementation.

3.2. Instruments

The questionnaire was composed of a number of inventories, including scales measuring Knowledge, Persuasion, Decision, Implementation and Evaluation. The survey was modelled along the Innovation-Decision Process by Everett Rogers [42] [43]. The questionnaire was made up of 14 items grouped and adapted based on the Innovation-Decision Process Model and Innovation Diffusion Theory (IDT).

Knowledge was measured on two items, Awareness of Smart ID technology (Likert scale: Not Aware at all = 1; Very Aware = 5). How did you learn about the Smart ID, was assessed with "from own research", "from social media", "from peers, family and friends", and "from banks and other stakeholders".

Persuasion was assessed in two ways. Respondents were asked to indicate their preference for logging into e-services' platforms in Estonia. The options included "Mobile ID", "ID Card", "Bank Code Cards", "PIN Calculator" or "Other". Respondents were also asked on a 5-point Likert response scale ranging from 1 (Not difficult at all) to 5 (Very difficult), to indicate the degree of difficulty with migrating from their known platforms to the new Smart ID technology.

For Decision, respondents were asked to select from the following, which best described their technology orientation: 1) "sceptical of new technologies and use them only when I have to", 2) "usually one of the last to use new technologies", 3) "I use new technologies when most people I know do", 4) "I like new technologies and use them before most people I know" and 5) "I love new technologies and among the first to experiment and use them". Innovators fall into the item one group as being venturesome and enjoying being on the cutting-edge, while early adopters, early majority, late majority and laggards fall into groups two, three, four, and five respectively, and as represented in the scale.

Implementation was assessed on two items: "Have you used the Smart ID technology already" measured using a 2-scale response, 1 (Yes), 2 (No). Based on the influence of time on the decision and also the Dissonance theory (Leuthold, op. cit.), where a decision is reversed, the author assessed how long respondents had used the Smart ID technology for (1—"less than a month", 2—"1 to 2 months", 3—"3 to 6 months" and 4—"6 to 12 months").

Evaluation consisted of three core items describing the different forms of outcomes in relation to faster access to e-services, increased convenience to e-services portals and safer access to e-services. Responses were given on a frequency scale from 1 to 5, (where 1 represents "Strongly Disagree" and 5 "Strongly Agree").

Length of stay in Estonia consisted of 1 ("Less than a year"), 2 ("1 to 2 years"), 3 ("3 to 5 years") and 4 ("more than 5 years"). Role consisted, 1 ("student only"), 2 ("employed (worker) at an organisation only"), 3 ("student, but employed"), 4 ("Other"). Gender, Age and Education levels were used as control variables in the statistical analyses.

The measures were developed, refined and ultimately validated during the pilot test phase in July 2017. They are based on the IDP framework and IDT by Everett Rogers. Data from 9 samples were used to validate the scales for the final measurement model. During this item development process, each measurement model was assessed by looking at the reliability of the indicators, the internal reliability of the measurement scales and the discriminant validity of the indicators. In completing each assessment of the measures, any items with questionable validity were reviewed for face validity (to ensure that they were not essential to the meaning of the construct); if they were non-essential, the author removed them and re-ran the partial least squares (PLS) analysis. Some items were carefully reworded for clarity, and another group was then asked to respond to the

revised items, and the author then subjected their responses to the same PLS analysis. This process was repeated until the author was satisfied with the properties of all the measurement items.

3.3. Survey Implementation

The participants in this study are residents of Estonia. The questionnaires were distributed from August to November 2017 via email and also social media in Estonia. Altogether, 568 responses were returned (excluding the pilot sample). 46.5% of the respondents were students, of which 15.5% were employed concurrently. 43.7% of the respondents were workers only, and the remaining 9.8% were uncategorised. For demographics, the average age of the respondents was 21.5 years (SD = 0.79), varying from 18 to more than 45 years and 73.2% of the respondents were men (N = 416). Regarding their level of studies, 14.1% of the sample lacks university studies. Participation was voluntary. Anonymity and confidentiality were guaranteed. Permission was sought from closed-membership group administrators and in some cases, university student and other association representatives, including resident groups, to access members and distribute the survey questionnaire. The survey was then implemented through online media resources, particularly the online provider Facebook Groups using Google Forms. Descriptive information concerning the 568 subjects who completed the survey, is shown in Table 1.

3.4. Statistical Analyses

In order to properly assess the path coefficients in the research model, the author first examined the indicator reliability, internal consistency reliability, discriminant validity, and convergent validity of the reflective measurement model to ensure they are satisfactory [68].

The author first utilised the PLS technique—specifically, Smart PLS version 3.0.M3 [69]—to analyse the data. Given the sample size and the complexity of

Table 1. Subject demographics.

N = 568		N	Percent
Age	18 - 24	88	15.5
	25 - 34	360	63.4
	35 - 44	64	11.3
	More than 45	56	9.9
Gender	Female	152	26.8
	Male	416	73.2
Education	High school/Vocational training or equivalent	80	14.1
	Undergraduate degree or equivalent	144	25.4
	Graduate degree or equivalent	304	53.5
	Doctoral degree or equivalent	40	7.0

the theoretical model, the use of PLS is appropriate [70]. The analysis confirmed the measurement model. The results are reported.

The author confirmed the measurement model first, through PLS by testing for item and scale reliability, internal consistency, and convergent/discriminant validity.

After examining the outer loadings for all latent variables, some items were removed because their outer loadings were smaller than the 0.4 threshold level suggested by [71]. After reviewing the model from a face validity basis and re-running the model to ensure there were no differences in the structural model results, the author decided to remove the indicator variable LRNG (Learning about Smart ID) from the Knowledge construct and LENGTH_UD (Length of use of Smart ID) from the Implementation construct in an effort to capture as much of the meaning of the constructs as possible without distorting the model. These alterations resulted in an increase of Average Variance Extracted (AVE) and composite reliability (CR) of their respective latent constructs. All retained indicators had outer loadings higher than 0.7 [72] [73] (**Table 2** shows the outer loadings).

To assess scale reliability and internal consistency, the author considered the CR score and the AVE. For adequate reliability, the CR score should be greater than 0.70 in exploratory research or 0.80 in more mature streams of research (Fornell, op. cit.). All of the CR scores exceeded 0.85. In addition, all AVE scores exceeded the recommended level of 0.50 suggested by [74]. The AVE was calculated by averaging the R-squared values of the reflective constructs. The CR and AVE and Cronbach's Alpha (CA) scores for the factors are shown in **Table 3**.

Prior research suggests that a threshold level of 0.60 or higher is required to demonstrate a satisfactory composite reliability in exploratory research (as suggested by [73]). The Composite Reliability (CR) values for the Evaluation (EV)

Table 2. Outer loadings.

Construct (Latent variables)	Outer Loading	>0.7	Single item
MD <- PRSN	1.000	Yes	√
LoS <- Length of Stay	1.000	Yes	√
LoS * Al_UD <- Moderating Effect	1.000	Yes	
TO <- Decision	1.000	Yes	√
e-serv_CONV <- Evaluation	0.871	Yes	
e-serv_FSTR <- Evaluation	0.925	Yes	
e-serv_SFR <- Evaluation	0.837	Yes	
AWR <- Knowledge	1.000	Yes	√
Al_UD <- Implementation	1.000	Yes	√
Role <- Role	1.000	Yes	√

PS: MD = Migration difficulty; PRSN = Persuasion; LoS = Length of stay; TO = Technology orientation; e-serv_CONV/FSTR/SFE = e-services logon evaluated as convenient/faster/safer; AWR = Awareness; Al_UD = Already used Smart ID.

Table 3. Reliability estimates and validity coefficients.

	CA	CR	AVE	1	2	3	4	5	6	7	Discriminant Validity met?
1. KNWL	1.000	1.000	1.000	**1**							Yes
2. PRSN	1.000	1.000	1.000	−0.403	**1**						Yes
3. DC	1.000	1.000	1.000	0.503	−0.221	**1**					Yes
4. IMPL	1.000	1.000	1.000	−0.586	0.517	−0.263	**1**				Yes
5. EV	0.908	0.910	0.772	−0.067	0.007	0.302	−0.031	**0.879**			***Yes***
6. Role	1.000	1.000	1.000	0.232	0.051	0.170	−0.165	0.174	**1**		Yes
7. LoS	1.000	1.000	1.000	0.198	−0.144	−0.077	−0.208	−0.187	0.271	**1**	Yes

DV criteria [Square root of AVE > LVC] Square root of AVE values is shown on diagonal. Non-diagonal elements are the latent variable correlations (LVC); KNWL = Knowledge; PRSN = Persuasion; DC = Decision; IMPL = Implementation; EV = Evaluation; LoS = Length of stay.

construct are shown to be 0.910, indicating high levels of internal consistency reliability [75]. All other constructs recorded a value of 1, because they had single indicator (item) variables and do not imply perfection as a result.

Bagozzi and Yi, op. cit. suggests an AVE threshold level of 0.5 as evidence of convergent validity. Since all constructs retained met discriminant validity and other reliability tests, they are kept in the model to maintain content validity with high levels of convergent validity.

The author performed two tests for discriminant validity. First, the author examined the cross-loadings of the items to ensure that: 1) each item loaded more highly on its own construct than on any other construct; and 2) there were no items that loaded more highly on a construct than the items intended to measure that construct. All measures passed both tests. Second, the author compared the square root of each construct's AVE to the correlations between that construct and all other constructs to ensure that the square roots of the AVEs exceeded the other correlations. By the Fornell-Larcker [72] criterion, to establish discriminant validity, the square root of average variance extracted (AVE) of each latent variable should be larger than the latent variable correlations (LVC). All measures passed this test as well. The square roots of the AVEs are in bold on the diagonal in Table 3. Discriminant validity is met for this study because the square root of AVE for KNWL, PRSN, DC, IMPL, EV, Role and LoS are much larger than the corresponding LVC (1 - 7).

In addition to checking the measurement model, the structural model was evaluated. Collinearity assessments showed all Variance Inflation Factors (VIF) were within the threshold of < 5 (Hair, op. cit.) except for the EV construct items which were above the threshold due principally to the three indicator variables on that construct. Model fit results were also positive: SRMR = 0.03; NFI = 0.805; Chi square = 516.884.

For common methods bias (CMB) test, the author performed Harman's one-factor test as described by [76] and found that the measures loaded on one factor with an eigenvalue greater than 1 and that, that one forced-factor extracted explained 19.49% of the overall variance.

4. Results

In order to test the hypotheses, regression analyses were conducted using PROCESS SPSS by Hayes [77]. A 5000-sample bootstrapping method was used with bias-corrected confidence estimates. Bootstrap data resampling procedures establish confidence intervals (CIs) set to 95% for testing the statistical significance of indirect effects. Knowledge was entered as the independent variable, Persuasion as the dependent variable in sub-model I, Persuasion was entered as independent variable, Decision as the dependent variable in sub-model II, Decision was entered as independent variable, Evaluation as the dependent variable in sub-model III, Implementation was entered as independent variable, Evaluation as the dependent variable in sub-model IV, with Length of Stay as Moderator Variable. In all sub-models I, II, III and IV, Role was entered as Mediator Variable. Control variables were Age, Gender and Education levels. Models 4 and 14 of PROCESS SPSS were employed respectively.

Descriptive statistics and intercorrelations among the study variables are displayed in Table 4. Results indicated that the four tested hypotheses were clearly confirmed. Figure 2 displays the model and results.

4.1. Hypothesis 1: Relationship between Knowledge and Persuasion mediated by Role

First, it was found that Knowledge was positively associated to Persuasion ($B = -0.30$, $t(563) = -4.91$, $p < 0.001$). It was also found that Knowledge was positively associated to Role ($B = 0.29$, $t(563) = 5.94$, $p < 0.001$). Lastly, results indicated that Role was positively related to Persuasion ($B = 0.17$, $t(290) = 3.16$, $p < 0.001$). Results of the mediation analyses (conditional indirect effects) confirmed the mediating role of Role in the relationship between Knowledge and Persuasion ($B = 0.05$, CI = 0.02 to 0.09). In addition, results indicated that the direct

Table 4. Descriptive statistics and intercorrelations among the study variables.

Means (M), Standard Deviation (SD), and Correlations												
	M	SD	1	2	3	4	5	6	7	8	9	10
Education	2.53	0.82										
Age	2.15	0.79	0.153**									
Gender	1.73	0.44	0.084*	0.117**								
Role	2.04	0.93	−0.123**	0.372**	−0.007							
LoS	2.21	0.92	0.299**	0.224**	0.174**	0.271**						
Knowledge	3.46	0.71	−0.004	0.059	0.305**	0.215**	0.130**					
Persuasion	2.09	1.12	−0.181**	−0.159**	−0.232**	0.051	−0.144**	−0.243**				
Decision	3.90	1.10	−0.066	0.097*	0.408**	0.170**	−0.077	0.336**	−0.221**			
Implementation	1.26	0.44	−0.162**	−0.117**	−0.281**	−0.165**	−0.208**	−0.505**	0.517**	−0.263**		
Evaluation	3.82	1.12	−0.134**	0.083*	0.048	0.166**	−0.179**	−0.061	0.006	0.287**	−0.029	

NB: **Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

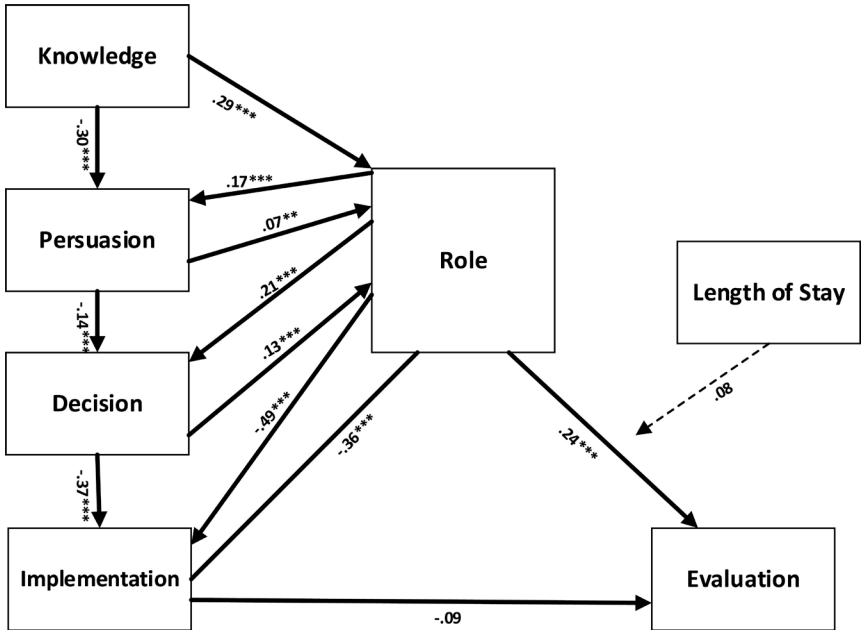

Figure 2. Final path figure.

effect of Knowledge on Persuasion became significant (B = −0.35, t(563) = −5.82, p < 0.01) when controlling for Role, thus suggesting partial mediation.

4.2. Hypothesis 2: Relationship between Persuasion and Decision Mediated by Role

First, it was found that Persuasion was positively associated to Decision (B = −0.14, t(563) = −4.10, p < 0.001). It was also found that Persuasion was positively associated to Role (B = 0.07, t(563) = 2.06, p < 0.001). Lastly, results indicated that Role was positively related to Decision (B = 0.21, t(562) = 4.31, p < 0.01). Results of the mediation analyses (conditional indirect effects) confirmed the mediating role of Role in the relationship between Persuasion and Decision (B = 0.01, CI = 0.00 to 0.03). In addition, results indicated that the direct effect of Persuasion on Decision became significant (B = −0.16, t(563) = −4.63, p < 0.01) when controlling for Role, thus suggesting partial mediation.

4.3. Hypothesis 3: Relationship between Decision and Implementation Mediated by Role

First, it was found that Decision was positively associated to Implementation (B = −0.37, t(563) = −3.75, p < 0.001). It was also found that Decision was positively associated to Role (B = 0.13, t(563) = 3.76, p < 0.001). Lastly, results indicated that Role was positively related to Implementation (B = −0.49, t(562) = −3.6, p < 0.05). Results of the mediation analyses (conditional indirect effects) confirmed the mediating role of Role in the relationship between Decision and Implementation (B = −0.06, CI = −0.13 to −0.03). In addition, results indicated that the direct effect of Decision on Implementation became significant (B = −0.37, t(563) = −3.75, p < 0.01) when controlling for Role, thus suggesting partial mediation.

4.4. Hypothesis 4: Relationship between Implementation and Evaluation Mediated by Role, Moderated by Length of Stay

The author explored the conditional indirect effect of Implementation on Evaluation through Role for three values of Length of Stay: one standard deviation below the mean, and one standard deviation above the mean. It was revealed that Length of Stay enhanced the indirect effect of Implementation on Evaluation in low values of Length of Stay (B = −0.92, CI = −0.11 to −0.02), average values (B = 0.00, CI = −0.15 to −0.04), and high values (B = 0.92, CI = −0.21 to −0.05), through increased Length of Stay. It can be observed from the coefficients that the higher the levels of Length of Stay, the lower the effect of Implementation on Evaluation through increased Role. Both the low and high confidence intervals for the conditional indirect effects of Implementation on Evaluation at values of Length of Stay recorded negative values below zero. Therefore, the moderation is significant at high values of Length of stay and at low and average values of Length of Stay. The results indicated that the direct effect of Implementation on Evaluation became non-significant ($p > 0.05$) when controlling for Role, thus suggesting full mediation.

5. Discussion

Using a sample of 568 subjects in Estonia, this study has provided support for the validity of the IDP framework in explaining the relationships between some antecedents, Knowledge, Persuasion, Decision, Implementation and Evaluation. However, Implementation stage variables did not predict Evaluation stage variables, as expected and hypothesized. The sequence or order of the innovation-decision process, as being based on sociocultural settings, is indeterminable, specifically in this study context. Time, from when the innovation becomes available to when it is adopted by the individual, which is the most common question asked in adoption and diffusion studies, was also not established entirely. At the time of this study, 40.8% of the respondents preferred the new technology as login option, among a varied set of options available, suggesting that they had used the Smart ID technology, and this was barely six months after the Smart ID had been rolled out. The study has implications for the innovation diffusion research stream and for managerial practice. The author discusses each.

5.1. Implications for Research

The study was designed to test the Innovation-Decision process model. Research exists on how some factors accelerate the rate of new technology adoption, however, this study puts the spotlight on the Estonian context.

The main aim was to test a model to explain the process by which adoption of new technologies occur. In light of the findings from the research, the author can say that Role of individual is a mediator variable so that an individual's disposition influences their adoption of new technologies, and communication is

key in the adoption chain, notwithstanding the kind of innovation or invention. Further, social networks of adopters are identified as a critical factor for innovation adoption, especially during the stages of information exploration and decision-making [38]. Additionally, major factors that influence the innovation adoption process, such as characteristics of the adopter, which include individual role; quality of innovation management and incentives for innovation adoption, were confirmed. Attributes such as innovation culture was noted to be strengthened by experiencing successful innovation adoption in agreement with [78]; German *et al.*, [79] who argued that this culture is transformed and modified by many external and internal changes, such as advancement of technology, policies, social institutions or systems and past innovation experiences, which are also influenced by, and consequently serves as an influencer of an individual's role or disposition in terms of innovation adoption.

In agreement with Rogers, op. cit., the innovation-decision sequence of knowledge-persuasion-decision, was confirmed. In the Estonian social setting, the sequence, based on the number of adopters in this study, confirms that the study subjects first had knowledge of the Smart ID, were persuaded to, based on factors such as ease of use and convenience, among others, to migrate to the new platform easily. Based also on the study, there was no indication that the IDP process sequence in actual fact, followed the knowledge-decision-persuasion pattern. In line with earlier research on the adoption and diffusion of computer-related systems, e.g., [80] [81], Knowledge of an innovation has a positive influence on persuasion to adopt (hypothesis 1). In this connection, other subject data gathered, based on the study results, revealed that 46.5% of individuals in the study learnt about the new Smart ID technology through their banks and other state-managed portals. 26.8% learnt about the Smart ID through peers, family and friends while via social media recorded was 9.9%, not confirming opinion leadership as originally posited by (Rogers, op. cit., p. 249) in the IDP framework.

In line with literature [82], the results revealed that 16.9% of individuals in the study learnt about the Smart ID through their own research. This group constitutes innovators, who are venturesome types who enjoy being on the cutting edge. Innovators imagine possibilities of an innovation and are eager to give it a try. Early adopters use data provided by the Innovators' Implementation and Evaluation to make their own adoption decisions. Early Innovators here are individuals who learnt about the Smart ID via peers, family and friends (26.8%) and individuals who learnt about the Smart ID via social media sources (9.9%). These two groups make up most individuals with a high technology orientation.

Prior research has highlighted the importance of peer-to-peer conversations and peer networks which have been tested in more than 6,000 research studies and field tests and reported as the most reliable in the social sciences. The study results regarding peer-peer communication was confirmed. The Bass Forecasting Model [83] for example, which illustrates how word-of-mouth and mass

communication becomes more influential over time, is confirmed. Peer communication is paramount in the adoption decision. Much of the social system does not have the inclination or the capability to remain abreast of the most recent information about innovations, especially in homophilous social systems, where there is a tendency towards system norms, and interactions between people are mostly from similar backgrounds, and opinion leadership by people outside this bracket is low. When others in a network advocate and explain how an innovation can be implemented in practice and what impact it will have, this significantly impacts on the adoption decision (in agreement with [78]).

It must be noted that there are several electronic services authentication options available in Estonia. A decision to research and find information about an innovation by an individual is therefore a confirmation of that individual's high technology orientation. Additionally, the population of Estonia is about 1.3 million, suggesting a densely homogenous social setting and possibly homophilous [39].

The author looks across this study's three research focus so that the study's contributions can be placed into perspective and reflect on future research initiatives that will deepen understanding. **Figure 2** shows the results of the test of the model.

Regarding the first research focus ("Extend what is known about the factors affecting adoption of new technologies"), the conclusion is that, based on the subset of the constructs from within the framework that the author tested, the IDP framework does indeed provide useful guidance to researchers. As the findings reveal, Knowledge influences Persuasion ($p < 0.01$), providing strong support for H_1. Obviously, future research initiatives would be appropriate on both sides of the IDP construct. On the left side, it would behove future researchers to expand the examination of antecedents to include other individual factors such as need for the new technology versus awareness and selective communications and, additionally, organisational/societal factors such as cultural context against native or individual cultures of subjects, norms and values of the society. On the right side, a few different outcomes should be considered: for example, there is no evidence to support a direct relationship between Implementation and Evaluation. Consideration of the IDP framework at other levels of analysis (group, organisational, societal) would also be appropriate. Regarding H_2, the author finds strong support for the hypothesis about the effect of Persuasion on Decision to adopt mediated by Role (H_2; $p < 0.01$). Decision directly influences Implementation mediated by Role (H_3; $p < 0.01$). The author found that there is no significant interaction by Length of stay (time) on the adoption relationship between Implementation and Evaluation (H_4; $p > 0.05$) even though the tests revealed that Length of Stay, in a moderating capacity, enhanced the indirect effects in the adoption relationship between Implementation and Evaluation, mediated by Role of individual, suggesting that subjects who stayed longer in Estonia, were more likely to evaluate (EV) their implementation (IMPL) decisions based on their undertakings (students, workers and other

roles). Role of individual has an effect on Knowledge of an innovation, Persuasion or forming an attitude towards an innovation, Decision to adopt, Implementation of adoption decision and its Evaluation thereof (H_1-H_4), confirming prior research that the IDP process consists of a series of summed individual actions and choices in dealing with the uncertainty inherently involved in the decision to adopt or reject a new technology (Rogers op. cit., p. 163). This suggests that an individual's role could have a crucial influence on their innovation adoption choices. Many studies maintain the original unit of analysis at the individual level even though they studied organisational level adoption (e.g. [84] [85]. In some studies, constructs are measured with a combination of organisation level and individual level indicators, e.g. [86] [87]. Organization theorists suggest that the explanation of collective phenomena must eventually be grounded in explanatory mechanisms involving individual action and interaction [88] [89] [90]. Some researchers have attempted to adapt the variables in individual-oriented frameworks and use them at the organizational level. [91] adapted perceived ease of use and perceived usefulness [92] in their use of the Technology Acceptance Model (TAM) of Davis (1986). Recent innovation researchers [93] [94] developed a unified model of technology acceptance. [95] also contributed to the study of technology adoption, regarding the readiness of individuals. [96] addressed propensity of use, combining the evaluation of attitudes and beliefs of people who may or may not be users of technologies, using as analysis, inhibiting and facilitating drivers.

Regarding the second research focus ("Identify the factors important either in facilitating or militating against adoption of the Smart ID technology by individuals in Estonia"), future research could profitably consider a more specific and extended model that tests the adoption relationship between Knowledge and Persuasion. This is important as according to Rogers, op. cit., the diffusion process commences with communication channels and messages, awareness and learning [43].

Regarding the third research focus ("Propose recommendations to solving problems and reducing barriers to new technology adoption in such contexts"), this is discussed expansively in the ensuing section.

5.2. Implications for Practice

While many of the findings of this study will be of greater import to researchers than practitioners, there nevertheless are three areas that have implications for managers.

First, the concept of cost-benefits analysis based on Rogers' [42] innovation diffusion theory, where the major obstacle is uncertainty should also be explored. The first of these is relative advantage, which is the degree to which an innovation is perceived as better than an idea it supersedes by a particular group of users, measured in terms that matter, like economic advantage, social prestige, convenience, or satisfaction. It has been argued that the greater the perceived relative advantage of an innovation, the more rapid its rate of diffusion is likely

to be. Further, compatibility with existing values and practices is another quality which must be met. These broadly include individual roles which ought to be considered carefully (numerically and via other dimensions) by the change agent before rolling out an innovation. This is the degree to which an innovation is perceived as being consistent with the values, past experiences, and needs of potential adopters. An idea that is not compatible with the values, norms and practices of prospective adopters will not spread as rapidly as an innovation that is compatible. Simplicity and ease of use is another quality which goes together with "triability". This is the degree to which an innovation is perceived as difficult to understand and use according to Rogers, op. cit. New ideas that are simpler to understand are adopted more rapidly than innovations that require the adopter to develop new skills and understandings as argued by Rogers. Triability is also the degree to which an innovation can be experimented with on a limited basis [42]. This represents less uncertainty to the individual who is considering it. This is reflected in the Migration Difficulty (MD) aspect of the Persuasion (PRSN) construct in this paper. Diffusion-style campaigns should consciously attempt to utilise peer networks, for example, using opinion leader techniques or various "viral marketing" methods. These methods which are becoming increasingly popular aim to recruit well-connected individuals to spread ideas through their own social networks. In that case, Innovators' information will serve as leverage providing early and late adopters with Evaluation information from Innovators' early adoption decisions and therefore increase the domino effect [42]. Since most individuals learnt about the new technology from banking and other state portals, service providers or change agents, in this case, the innovation supplier ought to make use of the Evaluation information of Innovators and increase communication meaningfully. In general, the two facets of the cost-benefit analysis argument of relative advantage and ease of use, were confirmed in this study, validating findings from earlier studies, e.g. [97] [98] [99] [100]; about compatibility [101] [102] [103]; and also triability [104] [105].

Second, it is instructive to note that a good understanding of user segment needs is crucial to diffusion of new technologies. Ziemer [106] investigated diffusion models for forecasting technological innovations and suggested that further insights into diffusion models can be obtained by examining trends in both the noncumulative adopter distribution and its rate of change, in a bid to answer the question of how the Bass adopter distribution can be used for developing adopter categories. It is a commonly known concept among diffusion scholars that the various user segments are static and cannot be changed. Therefore, innovation managers should first, track down Innovators and make them their first followers, if possible invite them to be partners in the improvement or re-design of the innovation, where need be. Early adopters will leap in once Innovators have been captured and the benefits of the innovation have become apparent. It is imperative to offer strong support for a limited number of early adopters to try a new idea while maintaining relations with regular feedback. A set of design strategies (endorse, curate, integrate, economize, play and refresh)

have been formulated for technology adoption [107] with a view to promoting adoption of new technologies. Dickerson *et al.* [108] reported that adopters of personal computers were older and had higher income, more education and higher status occupations, consistent with most empirical studies in the diffusion theory literature [10]. This could not be confirmed in this study. However, only 14.1% of the respondents lack university education, confirming high education levels, while the age of the respondents rather showed a relatively young population (between 18 and 45 years). Studies of technical ideas such as innovations indicate that the key attributes of technical innovations differ markedly from those that influence the diffusion of other innovations [109] and studies of policy ideas as innovations indicate that their socio-political aspects are critical diffusion drivers [110] [111].

Third, regarding early adopters, evidence exist in the literature that mainstream advertising and media stories featuring endorsement from credible, respected individuals in social systems, such as Estonia could markedly impact adoption rate. An exploratory case study in Italy suggested that early adopters play multiple roles in the diffusion process [112]. These studies suggest that for late adopters, who are conservative pragmatists, who hate risk and are uncomfortable with new ideas, the innovation manager or change agent should focus on promoting social norms common to that channel, rather than just product benefits and keep emphasizing the risks of being left behind. Laggards, as the last user segment, hold out a bit until later. They usually defer adoption decisions as they see a high risk in adopting certain products or behaviours. It is important to maximise their familiarity with the innovation. Overall, the most important for the business manager or adoption agent or innovation supplier is to when designing change projects, know the percentage that have already taken up the innovation. That figure tells the business manager the segment to address next by providing great insights into design issues and communication measures.

5.3. Limitations

There are several potential limitations to this study; however, only four of them are discussed. First, the model is not exhaustive because of the large number of antecedents and outcomes that might be included across the entire IDP framework. As was noted above (under "Implications for Research"), much additional work should be done to include additional constructs. Even so, these findings should be taken neither as confirmation nor refutation of other studies but, rather, as exploratory results that warrant attempts at replication.

Second, although going beyond what has been traditionally examined in most diffusion research papers, this study relies on self-reported rather than measured behaviours. It is conceivable that individuals may misreport their own behaviours, either due to cognitive constraints or in an attempt at self-justification.

Third, although the author's developed measures for several constructs proved to have both convergent and discriminant validity, the items for all constructs

were created for this study with some inspiration from prior studies, especially the IDP framework and IDT. These items should be viewed not as comprising fully validated scales but, rather, as exploratory contributions to a growing research stream. Future researchers will no doubt wish to refine the author's items and purify the scales to fit specific social contexts and situations. It is worthy of note that there are myriad established psychometric approaches available, but the measures used in this paper are purely for exploratory purposes again. Also, the data used in the analysis for this study are from one point in time. Future research may examine whether and how the relationships among the constructs have evolved over time.

Finally, the use of an Estonian-based sample could be considered a limitation by introducing methodological biases. However, to the author's knowledge, there are no international organisations that provide cross-cultural, random samples from multiple continents, so construction of a worldwide sample would require merging datasets collected through disparate means. Thus, to secure an international sample using a similar sampling technique would be very difficult. Further, the statistical procedures performed on the data are not conclusive and the same research should be repeated including some aspects not either mentioned or included in this specific exploratory study.

6. Conclusions and Recommendations

In this paper, the author has attempted to ascertain the validity of one suggested framework—IDP, as proposed by Everett Rogers *et al.*, (2003)—and to consider some of the implications associated therewith.

This study should be viewed most directly as an "informing event" for future work. The author hopes that other researchers will join in as the author attempts to unravel some of the important (and, in many cases, under-studied) relationships inherent in this complex research domain.

The main contribution of this study is three-fold:

First, the extension of and/or addition to innovation adoption frameworks will advance innovation diffusion research and practice and depict the dynamic and interactive nature of technology adoption processes; the actors involved and their interactions in the adoption processes. Second, innovation agents and suppliers should intensify efforts at understanding different user segments in varied social contexts, as noted in this study. This means channeling resources towards social and market research activities to appreciate consumer needs and preferences in-depth and developing feedback mechanisms to integrate findings. This will provide greater and targeted insights to innovation dissemination strategies; address appropriately, design and communication measures; improve technology product and service offerings; and most paramountly, the user experience. Third, one of the key barriers to new technology adoption is communication or its lack thereof, as confirmed in the study. Awareness and learning about new technologies are crucial to speed up adoption and its consequent diffusion, as

confirmed in the study. Innovation agents and suppliers especially the banks, and state agencies, need to optimise their use of social media channels as dissemination avenues while utilising the peer and family and friends' networks noted in the study creatively, to drive home new technology adoption. To the innovation supplier/agent, web presence alone without engaging, on-brand social media channels and responsive content strategy to manage digital assets, will not yield the needed results for all stakeholders.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Appendices

Survey Questionnaire

Adoption of Smart ID Technology in Estonia

Thank you for your willingness to answer this survey, which focuses on your experiences with and opinions about new technology adoption in Estonia. The information you provide will be used for academic purposes only and reported in a study under the auspices of the Estonian Business School, Tallinn. The primary goal of the study is to better understand your experiences with new technology in Estonia. Your answers are confidential.

For purposes of this survey, new technology refers to "Smart ID platform, its applications and associated devices"
Smart-ID is a convenient new mobile application that works as an identification solution to securely prove online identity.

Please submit your survey responses as soon as possible . It should take 3 - 5 minutes to complete the survey.

Your time and participation is deeply appreciated. Thank you.

* Required

1. **1. What is your role?** *
   Mark only one oval.
   - ◯ Student
   - ◯ Employed at an organisation
   - ◯ Student but employed
   - ◯ Other

2. **2. When it comes to technology generally, what best describes you?** *
   Mark only one oval.
   - ◯ I am skeptical of new technologies and use them only when I have to
   - ◯ I am usually one of the last people to use new technologies
   - ◯ I usually use new technologies when most people I know do
   - ◯ I like new technologies and use them before most people I know
   - ◯ I love new technologies and among the first to experiment with and use them

3. **3. The new Smart ID technology has made e-services** *
   Mark only one oval per row.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Faster	◯	◯	◯	◯	◯
Convenient	◯	◯	◯	◯	◯
Safer	◯	◯	◯	◯	◯

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Adoption of Smart ID Technology in Estonia

4. **4. What is your preferred application for logging onto e-services platforms in Estonia?** *
Mark only one oval.

- ◯ Smart ID (mobile application for authentication)
- ◯ Mobile ID (mobile phone as a form of secure digital ID)
- ◯ ID Card (state-issued ID card which provides access to all e-services)
- ◯ Bank Code Card (pre-generated bank codes printed usually on a card)
- ◯ PIN Calculator (A small offline device which generates a new code every minute)
- ◯ Other

5. **5. How aware are you of Smart ID tools and technology?** *
Mark only one oval.

	1	2	3	4	5	
Not Aware at all	◯	◯	◯	◯	◯	Very aware

6. **6. How did you learn about the new Smart ID technology?** *
Mark only one oval.

- ◯ From my own research
- ◯ From social media
- ◯ From my peers, family and friends
- ◯ From Banks or other new technology stakeholders (e.g., state portal)

7. **7. Have you used the new Smart ID technology already?** *
If your answer to this question is NO, skip the next question.
Mark only one oval.

- ◯ Yes
- ◯ No

8. **8. How long have you used the new Smart ID technology?**
Answer this question only if your response to the previous question was YES.
Mark only one oval.

- ◯ less than a month
- ◯ 1 - 2 months
- ◯ 3 - 6 months
- ◯ 6 - 12 months

9. **9. Which of the following mobile operating systems do you use the Smart ID service on?** *
Mark only one oval.

- ◯ Android
- ◯ iOS
- ◯ Other

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Adoption of Smart ID Technology in Estonia

10. **10. How difficult was it to migrate (download, install, learn etc.) to this new Smart ID technology?** *

Mark only one oval.

	1	2	3	4	5	
Not difficult at all	◯	◯	◯	◯	◯	Very Difficult

11. **11. What is your gender?** *

Mark only one oval.

- ◯ Female
- ◯ Male
- ◯ Prefer not to say

12. **12. What is your age?** *

Mark only one oval.

- ◯ 18 - 24
- ◯ 25 - 34
- ◯ 35 - 44
- ◯ More than 45

13. **13. What is your highest level of education?** *

Mark only one oval.

- ◯ High School/Vocational Training or equivalent
- ◯ Undergraduate degree or equivalent
- ◯ Graduate degree or equivalent
- ◯ Doctoral degree or equivalent

14. **14. How long have you lived in Estonia?** *

Mark only one oval.

- ◯ Less than 1 year
- ◯ 1 - 2 years
- ◯ 3 - 5 years
- ◯ More than 5 years

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