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The Challenge for Energy Saving in Smart Homes: Exploring the Interest for IoT Devices Acquisition in Romania

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Abstract: The Internet of Things (IoT) is a shift towards a digitally enriched environment that connects smart objects and users, aiming to provide merchants with innovative ways to communicate with customers. Therefore, the aim of this research was to identify the Romanian consumer's openness to technological autonomy and the degree of acceptance of IoT services and technologies to address the green deal principle of low energy consumption. This article investigated the factors that influence the decision to buy smart IoT devices and customers' perception regarding the security of the data generated in this process. Based on the Technology Acceptance Model (TAM), this research proposed an alternative model consisting of 18 items measured on a Likert scale in order to identify the factors that contribute to the perceived value of the consumer and the behavioral precursors impacting the decision to purchase IoT products. More and more products have built-in sensors and through the Internet connection generate valuable data from a managerial point of view in relation to the customer. Although these data are expected to be of great value to companies, the way they are used is not always transparent and can affect the purchasing decisions and the behavior of IoT products' customers. The findings of this paper aimed to better promote Smart Home IoT technologies and devices among Romanian people, making possible the control of consumption and the generation of energy savings.

Keywords: Internet of Things; sensors; technological autonomy; smart home; energy saving



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1. Introduction

The European Green Deal generates tangible and widely shared economic, social, and ecological benefits not only at the level of whole society, but also at the individual level, offering people the opportunity to buy IoT devices aiming at energy saving in their homes [1]. A recent study revealed the need, at the European level, of an integrated set of smart home policies that promote IoT devices and ensure that they meet the Green Deal's energy goals. A main challenge still remains, especially in countries from Central-Eastern Europe: users will not just buy IoT technologies for their homes; instead, learning the benefits and acceptance need to occur first. This is the premise of conducting a survey on the acceptance factor of IoT devices among Romanian users, offering complementary insights to another research, revealing that adoption of IoT-based smart home solutions has been too little addressed in Romania [2].

The dynamics of digital communication dramatically change the interaction between people and, more recently, the way we interact with products (devices with intelligent systems connected to the Internet). This is becoming increasingly important, given that in recent years this volume of data transmitted online is complemented by the interoperability of smart devices through the Machine to Machine (M2M) model. The communication channels through which intelligent objects perform these data exchanges are known as the Internet of Things (IoT) [3]. IoT technologies have a high degree of applicability in

the industrial and commercial field, changing economic systems globally and triggering a global revolution known as the fourth industrial revolution [4]. The IoT benefits merchants by addressing challenges related to resources, security, energy efficiency, and customer relations. Trab et al. [5] revealed how logistics can be streamlined in storage spaces and the application of labor protection rules using intelligent monitoring systems to reduce serious accidents. By integrating an IoT system based on communication between IoT-type objects, products are efficiently placed in the warehouse, which reduces transportation and storage time, thus reducing energy consumption and increasing security in the warehouse [6].

Using the smart phone, Rafsanjani et al. [7] proposed a support system called iSEA, which helps the user to save energy by providing real-time automated feedback on the position of people in the building. This system can be used in homes, but also in commercial buildings with more employees, saving up to 30% of energy consumption.

2. Theoretical Context and Hypotheses Development

The IoT concept was used in 1999 by Kevin Ashton at Procter & Gamble [8]. In this context, Stankovic [9] stated that most products developed in the future will benefit from IoT infrastructure to reduce costs, minimize resource consumption, and contribute to their efficiency to facilitate human comfort and safety. The IoT is already integrated into industries, smart cities, and processes related to consumer health and comfort, such as buildings with sensors to reduce energy consumption or to automate certain activities in order to make work more efficient. We also encounter homes, vehicles, and automated traffic lights that use sensors to increase safety [10]. However, Stankovic [9] argued that this is just the beginning of IoT deployment in society and believes that in the future there will be a transition point where the degree of digital integration of things around us will increase considerably. According to the study conducted by the insurance company Lloyd's, "Networked World: Risks and Opportunities on the Internet of Things", there will be over 20 billion objects connected to the Internet by 2025 [4].

2.1. Ease of Use and Accessibility of IoT Products Aiming at Energy Saving

By equipping their homes with IoT technologies like RFIDs, people can track the activities in rooms and can make decisions that can save energy and money. Green IoT has already a significant impact on how people deal with problems in their daily life, making their lives easier and better, while responding to challenges of EU Green Deal [11]. The applicability of IoT systems aims to bring comfort to consumers, improving the quality of life and reducing the effort in repetitive processes [12]. Accessibility is defined as an easy way for the user to interact with a technological system [13] or the factor that determines the frequency and level of interaction with information sources [14]. The accessibility of a system is correlated with the ease of use perceived by users taking into account contextual features of the system interface [15].

The complexity of using IoT devices conferred by the mix of electronic components with software has led to academic research using extremely popular models [16]. The technology acceptance model (TAM) is among the most used, targeting different geographical areas and various applicability of IoT systems [17–19]. Using the TAM model [12], the concept of user experience was introduced, and used mainly in software solutions and web applications to validate the relationship with the ease of use of IoT systems. Ease of use perceived by the consumer is a determining factor that has a strong effect on a pleasant experience and intentions to use IoT products [12,20]. The ease of use, complexity, and quality of the product thus affect the user experience and accessibility. In the ease of interacting with certain applications on smart mobile devices, the ease of installation is outlined as a factor of accessibility. Installing a mobile application is considerably different from installing an IoT system. It is also important to check whether the transition to IoT technologies is made through dynamic adaptation, incorporating the proposed software architecture for adaptive IoT systems.

Saving energy in buildings is connected to measuring and controlling the IoT devices in an efficient way that takes into account each power level, as well as the interconnections among smart home devices [21].

It is also necessary to validate the energy efficiency of the solution in terms of the accuracy of matching services and IoT devices and the response to environmental changes. From the need to understand how ease of use and accessibility affect consumer behavior for IoT products, the following hypotheses arise:

Hypothesis 1. *The connectivity type of IoT products has a significant impact on accessibility.*

Hypothesis 2. *The shopping frequency of IoT products is influenced by their accessibility.*

Hypothesis 3. *The shopping frequency of IoT products is influenced by the level of consumers' expertise.*

Hypothesis 4. *The ease of installation of IoT devices is influenced by user know-how.*

Thanks to the ability to detect these smart products, the stored data can provide insights into the environment and context of use of IoT products. With improvements in processing power, device miniaturization, and network benefits of ubiquitous wireless connectivity, the Internet of Things is growing faster than ever [22]. The volume of smart products is soon expected to exceed the number of people connected. Businesses are already challenged continuously to keep up with technological advances. Considering the Internet of Things as the next wave in technological development and a new source of big data, companies face new opportunities as well as new challenges [22].

2.2. The Perceived Value by the Consumer on IoT Products Aiming at Energy Saving

The adoption of IoT systems is also enhanced by consumers' perception of the high added value of new technologies and unique ways of managing risk [23]. Although IoT is a broad field, there are few studies on consumer perception of IoT. In academic research, technical challenges or models of technology acceptance (TAM) are addressed. Based on these considerations, Ben Arfi et al. [4] found limitations in the analysis of important factors that influence users' perceptions of the benefits of IoT devices. In the case of TAM, the model could benefit from specific features related to the convenience and security of user data to analyze and contribute to increasing the level of adoption of IoT products by consumers. Additionally, the level of trust and risk perceived by the consumer are important for the usefulness of IoT technologies [4,18]. Due to the uniqueness of the IoT, the new technology must prove its usefulness and efficiency to convince users to adopt more complex techniques if they have a high level of know-how. Another model, the value-based adoption model (VAM), reveals both positive features of using a new technology, such as usefulness and satisfaction, and negative features that could be risky in relation to technology adoption, namely, increased level of technical detail or high usage costs [4,24]. Hsu and Lin [19] studied the perspective of consumer perceptions on IoT, the influence of the value perceived by the consumer while using IoT (network externalities) and the minimum value of the necessary resources that influence the benefits. Moreover, other empirical studies demonstrate that the benefits perceived by the customer in the use of technology have a stronger effect than the fears related to the confidentiality of information [4,19]. Taking into account the studies on the added value perceived by customers, this article proposes the following research hypotheses:

Hypothesis 5. *Customer know-how significantly influences the perceived value of results from using IoT devices.*

Hypothesis 6. *The process optimization benefits related to IoT products significantly influences the value perceived by customers.*

Hypothesis 7. *The shopping frequency of IoT devices is significantly influenced by the perceived value of these technological products.*

2.3. Consumer Perceived Risk and Data Security of IoT Systems Aiming at Energy Saving

This new communication environment increases the risk that the personal information of users, but also the data generated by devices using IoT technology, will be easily accessed and used. By their heterogeneous nature, products designed to operate in the IoT network are prone to security and data vulnerabilities, unlike traditional products [25]. Customers' concerns about the use of IoT technologies are argued by highly promoted vulnerabilities targeting national and military secrets [25], privacy of images generated by IP cameras [26], but also mass orchestrated attacks using device networks. Moreover, some IoT providers do not provide clear information about the data being collected, meaning users do not have a clear view of the personal information collected by the provider, or if these data reach another entity [27]. These factors increase the distrust of potential users and prevent the integration of new technologies in several areas of activity. However, consumer privacy and the way businesses collect customer information is an important topic in digital marketing and e-commerce. As the volume of information stored and analyzed increases, organizations need efficient systems to facilitate an adequate level of communication with consumers. Enabling IoT solutions helps companies better understand customer behavior in order to develop appropriate marketing strategies. By adopting this type of solution, companies can improve the customer experience, become more effective, and adapt more quickly to market changes [28]. Therefore, based on validated findings from previous research on data security and perceived risk by consumers, this study proposes the following hypotheses:

Hypothesis 8. *Data security has a significant impact on the risk perceived by customers of IoT devices for energy saving.*

Hypothesis 9. *The shopping frequency of IoT devices focused on for energy saving is influenced by the risk perceived by customers.*

Hypothesis 10. *Data security has a significant impact on the level of accessibility perceived by customers of IoT devices for energy saving.*

Hypothesis 11. *Data security has a significant impact on the added value perceived by customers of IoT devices for energy saving.*

Hypothesis 12. *The perception of data security has a significant impact on the level of expertise required to interact with IoT devices for energy saving.*

The IoT has the ability to connect billions of devices and provide a smart real-world platform to collaborate and communicate with these devices over wireless or wired networks [11]. There are huge benefits to IoT systems, and there are still constantly many challenges, especially in terms of security and privacy. These issues are difficult to address because the IoT is a dynamic and heterogeneous system in nature [29]. One of the main concerns for managing IoT security issues is the access control model. This model not only limits access to authorized users, but also prevents authorized users from accessing system resources in an unauthorized manner [30,31].

Additionally, Shaikh et al. [32] proposed a dynamic risk-based decision approach using risk assessment. This approach assesses users' past actions to distinguish between good and bad user profiles. After the transaction is completed, the IoT system assigns reward and penalty points to users to determine access decisions.

2.4. IoT Consumer Behavior and Specific Communication Strategies

The emerging IoT technologies that have been launched in the last years have influenced current marketing tactics and tend to become the way brands build their strategies in the years to come. Artificial intelligence assistants, such as Amazon Alexa, Apple Siri, or Google Assistant, have the potential to influence customer behavior, anticipate user needs, and collect useful user information to provide a personalized experience. Through the IoT

network, devices use the knowledge gained about the consumer to plan and make regular purchases, suggesting advantageous offers. The high efficiency of recommendation algorithms, the public's trust in virtual assistants, and the openness to the use of IoT increase the consumer appetite of customers [33]. According to recent studies, virtual assistants are used by 20% of the adult population of the United States and have the potential to replace the communication interfaces now monopolized by tablets, laptops, and smartphones. It is anticipated that the number of homes in which this technology will be used will increase to 275 million by 2023, an increase of 1000% compared with 2018, with only 25 million homes [34]. With the spread of these technologies, organizations will have to adapt their marketing tactics to take full advantage of the new IoT systems. The main advantage of IoT integration in marketing tactics is the personalization of brand interaction with consumers. Virtual assistants can hold personalized conversations, similar to human ones, and can offer a marketing offer suitable for that user through the data accumulated and analyzed via IoT by the device [34]. At the same time, the research carried out by Ingemarsdotter et al. [35] outlined that the use of IoT in business models for services attracts more customers due to the personalization of services.

Although integrating IoT into a business strategy may allow more information to be collected and used, managing the collection and analysis of a large amount of information can be a challenge. This level of data management requires a structured system for defining the qualitative requirements that the data collected must meet. Another obstacle to IoT integration is the difficulty of developing software and hardware for interoperability, adaptability, and the ability to upgrade. The ability of organizations to plan in detail how products evolve from generation to generation is limited in the context of the use of IoT technologies due to the unique nature and lack of studies on this issue at present. Additionally, the attitude and perception of consumers about IoT technologies is a decisive factor in the success of their integration into business strategies. Ingemarsdotter et al. [35] suggested that businesses in certain areas, such as the food industry, refuse to implement IoT-type solutions due to reluctant customer behavior. When trying to change the status quo with a new technology, the phenomenon of resistance to innovation among consumers appears [36]. Customers, accustomed to certain products, may reject the integration of new technologies, the innovative nature being in this case a barrier. Ciesielska and Li [37] stated that the failure of IoT integration is due to the neglect of consumer requirements, high installation costs and, last but not least, addressing privacy issues.

The applicability of IoT in e-Healthcare includes remote monitoring of patients, increasing the level of communication between patient and healthcare professionals, reducing costs and increasing efficient time management in critical situations [4,38,39]. Collecting critical data in the cloud using IoT devices or even mobile phones can help determine the severity of motor complications, digital assessment of patients diagnosed with Parkinson's treatment [40], and other chronic diseases.

3. Research Methodology

3.1. Initial Conceptual Framework and Data Collection

The IoT system connects billions of heterogeneous devices in a dynamic way; therefore, existing access approaches and the decision to transition to the sphere of IoT systems vary depending on various factors that users or companies take into account. To analyze these factors, empirical research was conducted to identify customer behavior, the risks they face, and the factors that contribute to the decision to buy IoT devices.

The market of IoT products in Romania is an emerging one, the companies that sell such products outlining a growing turnover in the last five years. Instead, the technical documentation of these products is somewhat limited; Costea-Marcu and Militaru [41] analyzed patients' perceptions of IoT medical devices using the TAM model.

The data from this exploratory (pilot) study were collected by sending invitations to fill in an online questionnaire to over 15,000 customers of an IoT devices online store in Romania, Cleste.ro. Finally, 242 responses out of 315 received were validated.

The questionnaire was discussed with a panel of tech companies' managers within a qualitative study, which revealed that the intention of management is to find out the technological factors that influence customers' decision to purchase IoT products for energy saving, adapted to the TAM model. This process ended with validation of 18 items, listed in Table 1, each measured on a five-step Likert scale, ranging from "Strongly disagree" (1) to "Strongly agree" (5).

Table 1. Items included in the initial conceptual framework.

Construct	Indicator Label	Indicator	Item from Questionnaire
Accessibility	AC1	AcquisitionFrequency	I often shop on Cleste.ro
	AC2	EasyInstall	Ease of installation is a key factor in selecting IoT devices for energy saving
	AC3	EaseUse	Ease of use is a key factor in selecting IoT devices for energy saving
	AC4	CloudSolutions	I believe that cloud solutions are a good option for storing data generated by smart devices
Cost	C1	CostBenefitAnalysis	I perform a cost/benefit analysis before purchasing IoT devices for energy saving
	C2	Budget50Euros	I consider that I can afford a budget of about 50 euros for the purchase of IoT devices for energy saving
Perceived Value	PV1	AddedValue	I believe that the use of IoT devices for energy saving adds value to my work
	PV2	ProcessOptimization	I believe that the use of IoT devices for energy saving contributes to the optimization of processes
	PV3	EnergyConsumption	I believe that the use of IoT devices for energy saving leads to a decrease in energy consumption
	PV4	LifeQuality	I believe that the use of IoT devices for energy saving contributes to improving the quality of life
Perceived Risk	PR1	DataSecurity	I believe that the data generated by my smart devices is secure
	PR2	SecurityBreach 6Months	The smart systems used may be affected by a security breach in the next 6 months
	PR3	MitigateRisksSystemAccess	Using an intelligent access control system contributes to home security (mitigates risks)
Know-how	KH1	ExpertiseLevel	I think I need to have a high level of expertise to interact with IoT devices for energy saving
	KH2	IoTProject6Months	Do I intend to develop a project that includes the Internet of Things (IoT) in the next 6 months?
	KH3	Industry4.0Projects	I was involved in projects that involve automation of industrial processes (Industry 4.0)
	KH4	ProductsVariety Cleste.ro	The online store Cleste.ro has a wide range of devices for energy saving
	KH5	IoTSmartHouses	I am interested in IoT devices for energy saving in the field of smart homes

After an analysis of the data using SPSS, which can be seen in Table 2, we selected the nine factors that were used to strengthen the conceptual model. These are highlighted in green color in the table, the other factors not being useful in subsequent statistical analyses.

Ease of installation is one of the nine factors that were used in building the conceptual model. The majority of respondents (76.19%) agreed that this is a determining factor in the selection of IoT devices for energy saving. Given the predominantly positive response of

people to this question, we can understand why this factor was relevant in building and consolidating our predictive model.

Table 2. Descriptive analysis using SPSS ($n = 242$).

Item	Average	Std. Deviation	Skewness	Kurtosis
AcquisitionFrequency	2.5	0.93	0.418	−0.023
ProductUtility	1.08	0.276	3.05	7.366
EasyInstall	1.98	0.864	0.749	0.436
EaseUse	1.91	0.828	0.916	1.079
CloudSolutions	2.5	1.117	0.605	−0.295
IoTAppsMobilephone	0.54	0.5	−0.15	−1.994
NumberDevices	12.88	19.985	3.247	10.812
CostBenefitAnalysis	1.86	0.878	1.25	1.912
Budget50Euros	2.06	0.923	0.971	0.998
AddedValue	1.87	0.776	0.71	0.572
ProcessOptimization	1.79	0.783	1.009	1.578
EnergyConsumption	2.05	0.893	0.704	0.382
LifeQuality	1.79	0.775	0.824	0.664
DataSecurity	2.61	1.069	0.415	−0.598
SecurityBreach 6Months	2.26	0.922	0.825	0.81
MitigateRisksSystemAccess	2.21	0.99	0.937	0.735
ExpertiseLevel	2.37	0.907	0.584	0.107
IoTProject6Months	2.17	1.016	0.628	−0.283
Industry4.0Projects	3.24	1.338	−0.208	−1.217
ProductsVarietyCreste.ro	2.07	0.794	0.928	1.437
IoTSmartHouses	1.91	0.833	1.207	2.508
Age	43.1	13.567	0.367	0.464

It is important to note that one of the relevant accessibility factors for IoT customers is their desire to shop using smart mobile devices and tablets. Of the 242 respondents, the majority (46.79%) answered in the affirmative to the question “Do you shop on your phone/tablet?”. Mobile e-commerce applications are becoming increasingly popular for online shopping and easy access to data and products for IoT and DiY (do it yourself) devices offers customers flexibility but also integration with existing IoT systems.

In addition to the questions whose answers were evaluated on the Likert scale, questions with semi-open choice answers were also asked about the categories of IoT products that customers want to purchase in the next year. Smart house was in the top of preferences for 78.55% of respondents. This category can indirectly contribute to the interconnection of mobile devices, following the qualitative analysis showing that to operate or configure an IoT system for smart homes requires a smartphone.

The initial conceptual model for the present study was based on the TAM model. We used Confirmatory factor analysis (CFA) to analyze four latent variables: Accessibility, Perceived Value, Perceived Risk, and Know-how. However, following the feasibility analysis (Table 3), the initial model was modified. Items associated with the variables Perceived Risk (0.68) and Know-how (0.47) were removed from the model, with values below the minimum recommended threshold (greater than 0.7, according to Peterson [42]).

Table 3. Reliability analysis using Cronbach α .

No.	Variable	Cronbach α	Number of Items	Decision
1	Accessibility	0.872	2	Validated
2	Perceived value	0.845	4	Validated
3	Perceived risk	0.685	2	Rejected
4	Know-how	0.474	3	Rejected

3.2. Validated Conceptual Framework

The new validated model satisfies the recommended values, which allows the examination of the path coefficients in order to test the hypotheses of this study. At the same time, hypotheses **Hypothesis 1**, **Hypothesis 4**, **Hypothesis 5**, and **Hypothesis 8** cannot be analyzed within the new conceptual model presented in Figure 1.

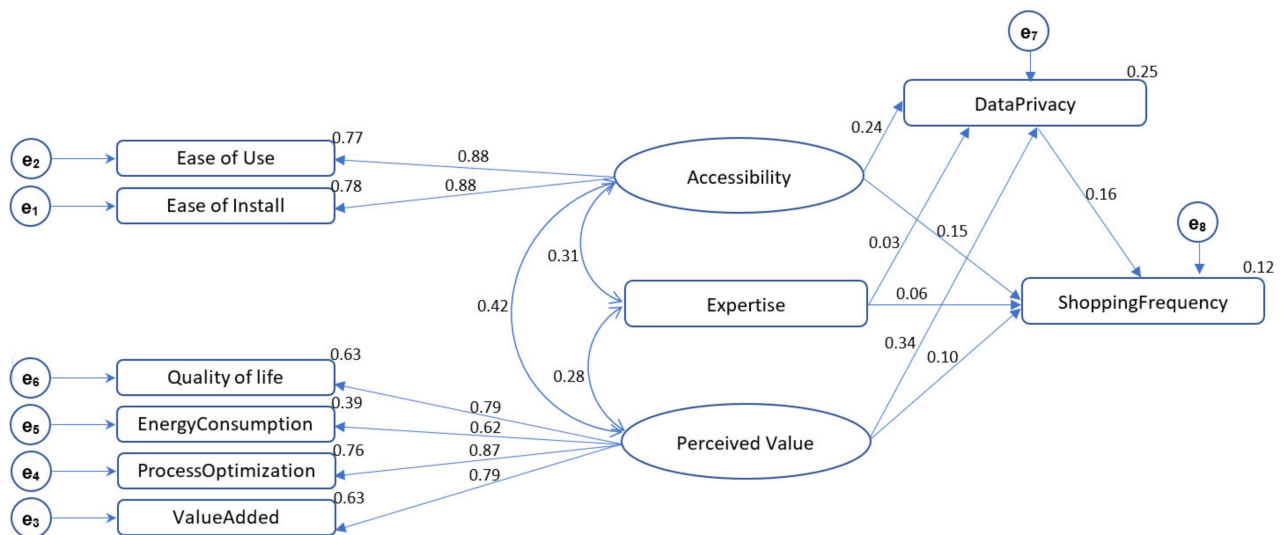


Figure 1. Validated conceptual framework. Source: Smart PLS 3 software report.

4. Findings

As previously mentioned, the Cronbach alfa reliability analysis altered the conceptual model. By replacing the latent variables, Perceived Risk and Know-how, with exogenous variables Expertise Level and Data Security, the results of the indicators associated with the fit of the model meet the conditions documented in Table 4.

Table 4. Indicators related to fit model.

Indicator	Recommended Threshold	References	Value in the Validated Framework
Degrees of freedom	<3	Hayduck, 1987 [43]	1.855
Asymptotic significance coefficient (p -value)	<0.05	Hair et al., 2006 [44]	0.011
Goodness of fit index (GFI)	>0.8	Scott, 1995 [45]	0.969
Adjusted Goodness of fit index (AGFI)	>0.8	Scott, 1995 [45]	0.930
Comparative fit index (CFI)	>0.9	Bagozzi and Yi, 1988 [46]	0.979
Root-mean-square error (RMSE)	<0.08	Bagozzi and Yi, 1988 [46]	0.060

To ensure compliance with the statistical integrity of the conceptual model developed in this research, it is necessary to comply with the parameters set out in Table 4, where the recommendations suggested in the literature for the values generated by the SPSS Amos software are presented. For the degrees of freedom of the chi-square test, a value lower than three is recommended [43], our model obtaining a value of 1855. For the value of the asymptotic significance coefficient p -value (0.011), we note that it was below the minimum allowable threshold of 0.05. The Goodness of fit index (GFI) and the Adjusted goodness of fit index (AGFI) follow the recommendations presented by Scott [45], both indicators showing values higher than 0.8. The conceptual model also respects the limits imposed by Bagozzi and Yi [46] for the comparative fit index (CFI) and the Root-mean-square error (RMSE).

The results of the structural model showed that the link between the variables Data Safety and Accessibility was significant ($p < 0.001$), this hypothesis not being initially listed (visible in Table 5), but it is important to mention it in this context. This hypothesis

was marked with the indicator **Hypothesis 13!**, the same being done for **Hypothesis 14!**, **Hypothesis 15!**, and **Hypothesis 16!**.

Table 5. The results of the proposed research framework (** $p < 0.001$; !—for the hypotheses identified in the conceptual framework).

Hypothesis	Item		Variable	Estimate	S.E.	C.R.	p	Result
Hypothesis 13!	DataSecurity	<—	Accessibility	0.237	0.1	3.341	***	Validated
Hypothesis 11	DataSecurity	<—	PerceivedValue	0.342	0.123	4.814	***	Validated
Hypothesis 12	DataSecurity	<—	ExpertiseLevel	0.034	0.072	0.552	0.581	Rejected
Hypothesis 10	EasyInstall	<—	Accessibility	0.88	0.105	5.843	***	Validated
Hypothesis 14!	EasyUse	<—	Accessibility	0.88	0.092	10.404	***	Validated
Hypothesis 6	ProcessOptimization	<—	PerceivedValue	0.872	0.078	14.286	***	Validated
Hypothesis 15!	EnergyConsumption	<—	PerceivedValue	0.623	0.094	9.577	***	Validated
Hypothesis 16!	LifeQuality	<—	PerceivedValue	0.791	0.078	12.723	***	Validated
Hypothesis 2	ShoppingFrequency	<—	Accessibility	0.153	0.095	1.978	0.048	Validated
Hypothesis 3	ShoppingFrequency	<—	ExpertiseLevel	0.06	0.067	0.915	0.36	Rejected
Hypothesis 7	ShoppingFrequency	<—	PerceivedValue	0.096	0.12	1.208	0.227	Rejected
Hypothesis 9	ShoppingFrequency	<—	DataSecurity	0.159	0.062	2.225	0.026	Validated

The results of the validated research model are presented in Table 5 where the validated hypotheses (**Hypothesis 11**, **Hypothesis 6**, **Hypothesis 2**, **Hypothesis 9**) from the 12 initially listed can be found.

Results from Table 5 highlight that perceived value of IoT devices aiming to reduce energy consumption has a powerful impact on process optimization, energy consumption optimization, and life quality, but influences to a lesser extent the shopping frequency. This issue suggests the need to better promote these IoT devices among Romanian users through interactive marketing channels. Furthermore, considering the fact that data security and accessibility are the main drivers of shopping frequency, IoT devices' retailers should reconsider these factors while redesigning their value proposition.

The adhesion to the recommendations of the model measurements ensures not only the validity of the conceptual model created but also the ability to compare our results with published research using similar measurements. Here, it is necessary to specify how relevant it is that the research carried out be easily replicated and follow standards already established in academia and industry.

5. Conclusions, Implications and Future Agenda

Home appliance automation via IoT devices enables wireless sensors and networks to reduce energy consumption. In the context of European Green Deal, IoT devices are already technology enablers that drive both the digital transformation of all pillars of the society as well as sustainable growth. This study was not focused on a quantitative approach to measure the impact of IoT devices on energy consumption decrease. It was developed with the aim to offer an overview on how to better promote IoT devices focused on energy consumption among the potential consumers who are willing to turn their houses into smarter ones, considering that managing energy consumption of buildings in a smart way through of acquisition of IoT devices enables reducing energy costs.

The diversity of application areas of IoT devices for energy saving brings vast benefits to many aspects of consumers' lives in the digital environment, but also in activities related to the comfort of home or professional activity. These benefits are found in the validation of the conceptual model by validating the hypothesis "**Hypothesis 6**: The benefit of process optimization brought by IoT products significantly influences the value perceived by customers"; we can say that there is a significant correlation between process optimization and the value perceived by IoT clients. At the same time, the management of data generated in relation to IoT devices for energy saving proves to be a critical issue by validating the hypothesis "**Hypothesis 11**: Data security has a significant impact on the added value perceived by IoT customers". The theoretical implications of this study contribute to

strengthening the contribution of data security generated by IoT products, in the value perceived by the consumer, but also the impact they have in the purchase of such products.

We see the presence of IoT in a multitude of industries and business models, including logistics, security, infrastructure, traffic organization and the field of autonomous transport, monitoring of industrial processes, and the use of resources to save electricity. All these sectors will be radically changed in the next period, in this process being generated a huge volume of valuable data. Properly processed data can be a significant competitive advantage if managed efficiently. The managerial implications of this study are materialized in the impact of IoT products on consumers' perception of value and their purchasing decision. Ensuring a transparent framework on how these data are used and managed can contribute to the frequency of purchases of IoT products, streamline energy consumption, and improve the quality of life in general (**Hypothesis 9**, **Hypothesis 15**, **Hypothesis 16**).

Although the conceptual model developed and presented in this research managed to identify and incorporate the items to validate the proposed hypotheses, it has some limitations. First of all, it was not possible to integrate key elements in this conceptual model, such as Cost-Benefit Analysis and Product Utility, thus modifying the structure of the TAM model. Our approach was based on a different conceptual analysis, partially addressing the level of acceptance of IoT devices in Romania. The fact that we had to deviate from the initial confirmatory factor analysis (CFA) model shows that the data used in this research were not numerous enough to represent a solid basis for the development of complex conceptual models that provide us with insights into dynamic mechanisms advanced between buyers and IoT products. At the same time, the sample was conducted on customers who use online commerce to purchase electronic and IoT products, which limits their ability to interact and fully understand the benefits of IoT products regarding energy optimization, especially in the areas of business and development.

In future studies, it is desired to expand the database for a larger sample and also add new items to improve the results related to Perceived Risk Factors and Know-how. The qualitative analysis showed a particular interest in specific IoT products for smart homes and cities, and a representative sample would help to understand the technological acceptance for such devices. Moreover, decision-making factors can be identified in the acquisition process and integrated on mobile devices.

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