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# Smart Energy Consumers: An Empirical Investigation on the Intention to Adopt Innovative Consumption Behaviour

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***Abstract*—**The aim of the present study is to investigate consumers' determinants of intention toward the adoption of Smart Grid solutions and technologies. Ajzen's Theory of Planned Behaviour (TPB) model is applied and tested to explain the formation of such adoption intention. An exogenous variable, taking into account the resistance to change of individuals, was added to the basic model. The elicitation study allowed obtaining salient modal beliefs, which were used, with the support of literature, to design the questionnaire. After the screening phase, data collected from the main survey were analysed for evaluating measurement model's reliability and validity. Consistent with the theory, the results of structural equation analysis revealed that attitude, subjective norm, and perceived behavioural control positively, which affected the adoption intention. Specifically, the variable with the highest estimate loading factor was found to be the perceived behavioural control, and, the most important belief related to each construct was determined (e.g., energy saving was observed to be the most significant belief linked with attitude). Further investigation indicated that the added exogenous variable has a negative influence on intention; this finding confirmed partially the hypothesis, since this influence was indirect: such relationship was mediated by attitude. Implications and suggestions for future research are discussed.

***Keywords*—**Adoption of innovation, consumers behaviour, energy management, smart grid, theory of planned behaviour.

## I. Introduction

THE aim of this study is to comprehend how consumers conceive smart city and what strategy could be followed in order to get daily acceptability of technologies belonging to a smart way of thinking urban life. The main objective estimates how attitude can become action and which variables are determinant in such behavioural pattern for potential smart consumers. That is studying which variables affect the attitude of consumers towards the adoption of smart behaviours in the use of energy and in particular, their attitude towards the adoption of externally driven patterns of consumption associated with use of smart grids [39].

Exasperated industrialization process engendered an urban situation in which liveability became the most important issue to ensure an acceptable human survival threshold. Smart city is the expression employed to characterize the set of solutions applied to urban contexts in order to make it more sustainable. Cities around the world are trying to make themselves smart applying different solutions. Despite these diversified approaches, there exists a common concept of what being smart means: it leads cities from a chaotic combination of technologies, to a concerted equilibrium of tools. In this sense, the research is usually focused on technological issues: smart system of transportations, implementation of sensors and smart grid are the most explored topics in this field of study. The concept of smart grid is born in order to solve several problems with current electricity grid, such as the huge diffusion of renewable energy systems (distributed generation) and the increasing electricity demand.

Smart grids are thought as electricity networks that can integrate information and communication technology (ICT) into the grid. They look different from the current electricity systems in important ways. They require a transition of current electricity systems that are characterized by centralized, fossil-fuel based facilities to one that can incorporate decentralized systems using more diverse energy sources as well as more price-sensitive and well-informed consumers [74]. Such transition would create electricity systems, which enable consumers to make, informed and empowered energy-related choices and make personal behavioural changes [28]. Therefore, the future electricity grid not only promises to be a radical technological, environmental and economic upgrade of the old system, it also will be more pervasive technology, influence the daily life of users [71], [68].

This study moves from the idea that smart cities need smart citizens: a city is made up by people, and people are those who should always interface with solutions found by researchers. Indeed, any technological innovation should be thought following two strictly linked lines of topics: one related to technological tools and the other involving investigations on who should accept adopt and use it [55], [89]. Albeit smart users play a fundamental role in making a city smart, research on smart city, smart grid and smart devices is developing faster toward technological innovation design than in the socio-behavioural context [91]. As for each innovation, which entails changes in users' life habits, one needs to know if and how such innovation can be accepted from potential users, also smart tools must be conceive to enable consumers to behave smart. The purpose of this paper is to understand the decisional process, which can lead consumer toward a smart behaviour; quantifying which variables are more influent in such decisional process, information can be used to promote smart behaviour and management strategies can be followed to plan smart city for smart citizens [76].

In order to reach the goal Theory of Planned Behaviour

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(TPB) [1], [2], [11] is applied to the case of study. Such consumer behaviour model allows describing rational process, which leads to a choice in terms of a good consumption [87]. Indeed, TPB, a more comprehensive version of the Theory of Reasoned Action [38], [67], allows examining the influence of personal determinants and social surroundings as well as non-volitional determinants on intention [42]. In particular, it could contribute to improving the prediction of customers' intention to choose Smart Grid solutions and technologies.

Overall, the current research aims to test the applicability of TPB in explaining electricity users' intention formation to adopt Smart Grid way of consumption. The specific objectives of this study are: 1) to identify salient belief items for each predictor construct of intention to adopt Smart Grid solutions and technologies (i.e., attitude, subjective norm, and perceived behavioural control), 2) to test relationships among study variables (i.e., behavioural beliefs, normative beliefs, control beliefs, attitude, subjective norm, perceived behavioural control, resistance to change and adoption intention). In the TPB model, this study further investigated the effects of users' inertia toward the adoption of new products or services. Since the TPB postulates rationality of actors, it is assumed energy consumer behaves in a rational manner: consumer decision process can be considered most likely cognitive, when decisions entail changes of daily life habits. Even though such hypothesis, the following study takes into account some non-rational component, which could be involved in the choice of innovative tools, adding a cause variable to ones that usually concern the TPB. This non-rational variable refers to boundaries due to human inertia that is resistance to change (RC). This study catches consumer's passive resistance to Smart Grid innovation through a survey on attitudes toward existing practices. Struggles made to obtain information on habitudinal practices and individual's need of cognition will be investigated. Then, results coming from correlation with behavioural intention highlights if and how consumer's resistance to change influences the intention of adopting Smart Grid innovation.

Theory of Planned Behaviour (TPB) is employed to design a survey. As suggested by [13] the set of new beliefs is obtained from an elicitation study conducted on a focus group representative of the research population. The questionnaire contains three sections of items related to: 1) belief constructs, 2) predictor constructs (Attitude, Subjective Norm, Perceived Behavioural Control), Resistance to Change variable and intention measures, 3) demographic information. Data have been collected on a *simple random sample* of citizens, using a self-administered questionnaire. Then, data are analysed through statistical techniques (Structural Equation Modelling - SEM) [52] and results are evaluated in order to study relationships among variables and to validate hypotheses; finally genuineness of cause-effect variables is verified.

In the following section, TPB and the conceptual framework that supports the research hypotheses are described. In the methodology section, procedures to identify belief items, to develop measures, and to collect and analyse data are illustrated. Finally, study findings, implications, and suggestions for future research are discussed in the results and discussion sections.

## II. Conceptual Framework

This study applies the Theory of Planned Behaviour (TPB) [15] to the electricity consumer behaviour; TPB has been already employed to study consumer adoption intention [86] and to analyze consumer behaviour for similar topics, such as green electricity [65]. A cause variable is added to the classical model. Such variable represents non-rational components, expressed by individual's predisposition to change his life habits [23].

### *A. Theory of Planned Behaviour (TPB)*

The Theory of Planned Behaviour (TPB) represents an extended model of the Theory of Reasoned Action (TRA). Both the TRA and TPB assert that behaviour is a direct function of behavioural intention [10]. Intention is the central concept in such theories; it is described as an individual's motivation in his/her cognizant plan/decision to exert an effort in performing a specific behaviour [1].

According to TRA, most human behaviours are predictable based on intention because such behaviours are volitional and under the control of intention [13]. That is, people make reasoned choices among alternatives, having a high degree of volitional control in their decision process. Because of its strong predictive power, TRA has been utilized as model to predict behavioural intentions and behaviours in the areas of marketing and consumer behaviours [61], [63], [81]. TRA suggests [13], [41] that behavioural intention is a function of two determinant factors, namely attitude toward performing the behaviour [8] and subjective norm. TPB also postulates that behavioural intention is a function of attitude and subjective norm. However, an additional dimension, perceived behavioural control is added to the TPB model to account for situations where an individual has less than complete control over the behaviour. According to Ajzen and Driver [12], perceived behavioural control reflects beliefs regarding access to the resources and opportunities needed to perform behaviour. Indeed, TPB expands the boundaries of TRA, a purely volitional control, by including a belief factor that concerns the possession of requisites, resources and opportunities to perform a specific behaviour [67]. Each of the determinants of behavioural intention, i.e. attitude, subjective norm, and perceived behavioural control, is, in turn determined by underlying belief structures. The beliefs concern the evaluation of the consequences of an action (behaviour), expressed with the product between the subjective probability measure and the consequence evaluation. Such beliefs are referred to as attitudinal beliefs, normative beliefs, and control beliefs, which are respectively related to attitude, subjective norm and perceived behavioural control.

The theory "postulates that a person's intention to perform (or not to perform) a behaviour is the most important immediate determinant of that action" [6], [7]. TPB allows modeling the behaviour of consumers with a cause-effect

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variable scheme, in which three cause variables are considered to be the determinants of behavioural intention. Each of the three variables (attitude, subjective norm and perceived behavioural control) is explained through an individual's beliefs related to that variable; in other words, beliefs represent of the subjective consequences evaluation, and they are the different aspects, which yield attitude, subjective norm or perceived behavioural control variables.

TPB has demonstrated good explanatory power across a range of decision-making contexts [16], [17], [21], [26], [46], [47], [50], [83]; one of the strengths of the TPB is that it is a parsimonious model that also allows for the inclusion of additional variables relevant to a specific behavioural context [30], [70]. The theory was widely employed in order to explain behavioural intention of consumers, such as reporting behaviour [64], exercise domain [80], food consumption [69], [90], [22], recycling behaviour [27], [88], engaging environmental activism [40], consumer adoption intention [18], [86].

TPB is applied to pursue the objective of this study that is predicting the consumer behaviour for smart grid adoption. Indeed, it provides a well-defined structure that allows through investigation of the formation of electricity consumer adopting intentions by simultaneously considering volitional and non-volitional factors. In the TPB model, this study further investigates the effects of individual's Resistance to Change (RC). Thus, the strength of the paths across high and low RC groups is compared. This is primarily based on the idea that consumers with high RC may have a different tendency in forming intention to adopt smart grid technologies and habits, as compared to low RC consumers. Resistance to Change is added as a variable, which causes behavioural intention.

In the following section, TPB is performed modelling consumer choice process through a cause-effect variables combination. If reliability of model is verified, results coming from correlation between variables allow understanding the structure of the path, which brings to the consumption choice.

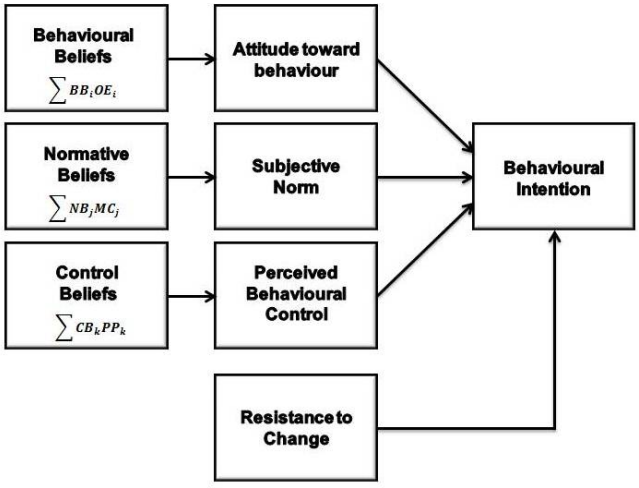



Fig. 1 Theory of Planned Behaviour (TPB) model with Resistance to Change variable

*B. Hypotheses Development*

TPB assumes attitude toward behaviour, subjective norm and perceived behavioural control are three conceptually independent determinants of behavioural intention. This section discusses how behavioural intention is related to its predictors, and how these antecedent variables are associated with belief constructs (see Fig. 1).

1. Attitude toward Behaviour

Attitude [4], [78] can be described as "the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behaviour in question" [2]. Attitude toward behaviour is believed to be a function of one's salient beliefs (i.e. behavioural beliefs (BB)), which represent the perceived consequences of the behaviour and his/her evaluation of the significance of the consequences (i.e. outcome evaluation (OE)) [36]. Ajzen and Fishbein [13] described BB as one's subjective probability that performing behaviour will lead to certain consequences. When determining whether to perform a specific behaviour person is likely to assess the benefits and the costs resulting from the behaviour [31]. An individual tends to possess a favourable attitude when the outcomes are positively evaluated and, thus, he/she is likely to engage in that specific behaviour [2], [31], [63]. In other words, an individual's positive attitude toward certain behaviour strengthens his/her intention to perform behaviour [2]. Attitude toward smart grid acceptance is evaluated through perceived advantages and disadvantages (beliefs) deriving from the adoption.

As stated by TPB, attitude (A) is calculated by multiplying the strength of each behavioural belief ($BB_i$) by the subjective outcome evaluation ($OE_i$) of the belief's attribute [90]:

$$A = \sum BB_i OE_i \quad (1)$$

2. Subjective Norm

Ajzen [2] defined subjective norm as "the perceived social pressure to perform or not to perform the behaviour. In other words, subjective norm is the perceived opinions of significant others who are close/important to an individual and who influence his/her decision-making [53]. Subjective norm is presented as a function of a person's normative beliefs (NB) about what salient referents think he/she should (or should not) do, and his/her motivation to comply (MC) to those referents [13]. Eagry and Chailen [36] described NBs as "perceptions of significant others' preferences about whether one should engage a behaviour". In other words, it concerns the probability of whether significant referents would approve or disapprove the behaviour. For what concerns the adoption of smart grid technologies, subjective norm, thus, represents the perceived social pressure to perform or not to perform the adoption. The important role of subjective norm as a determinant of behavioural intention is well documented in various contexts in marketing and consumer behaviour, e.g. [25], [31], [37], [62], [63]. The subjective norm (SN) is obtained by the strength of each normative belief ($NB_j$), multiplied by the person's motivation to comply ($MC_j$) with

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the referent in question [90]:

$$SN = \sum NB_j MC_j \quad (2)$$

3. Perceived Behavioral Control

Perceived Behavioural Control [5] can be described as "the perceived ease or difficulty of performing the behaviour" [2]. In particular, Perceived Behavioural Control assesses the perception of how well one can control factors that may facilitate/constrain the actions needed to deal with a specific situation. Perceived Behavioural Control is determined to be a function of control beliefs (CBs) that refer to one's perception of the presence/absence of resources/opportunities required to perform a specific behaviour, and his/her assessment of the level of importance of such resources/opportunities for the achievement of outcomes (i.e., perceived power (PP)) [14], [29]. A number of studies have demonstrated that people's intention/behaviour is positively influenced by their self-confidence in their ability to perform behaviour [25], [31], [34], [86]. It is expecting that when an individual holds little control over carrying out a certain behaviour because of the lack of availability of required resources (e.g. costs, time, knowledge), his/her behavioural intention will be lower in spite of the fact that he/she has positive attitude/subjective norm concerning the intended act. PBC is expected to play an important role in this study: the adoption of an innovative electrical consumption system involves resources/ opportunities in terms of knowledge that is needed information to assess the consequences of adoption, and time, necessary to change electrical consumption habits.

Perceived behavioural control (PBC) is the sum of the multiplication of each control belief ($CB_k$) with the perceived power ($PP_k$) of the particular control factor to facilitate or inhibit performance of the behaviour [90]:

$$PBC = \sum CB_k PP_k \quad (3)$$

4. Resistance to Change

Since smart grid will engender change in daily life habits of consumers, it can be considered as an innovation in electricity consumption practices regarding people investigated opinions. TPB "classical" model is integrated with the cause variable Resistance to Change (RC), which takes into account a relevant problem of innovation adoption process that is the inertia of users. Several theories in psychology explicitly deal with resistance to change [72], [75]. All these theories suggest that consumers have an intrinsic desire for psychological equilibrium. Any change imposed on their behaviour has the potential to disturb this equilibrium; the consumer, thus, more often opts for resisting the change than going through disturbing process of readjustment. In other words, resistance would seem to be a normal response of consumers when confronted with innovations. "Resistance to change may be defined as any conduct that serves to maintain status quo in the face of pressure to alter the status quo" [92] and is associated with the degree to which individuals feel themselves threatened by change. Considering the innovation adoption process, resistance to change occurs in its first stage that is initial response to innovations.

Resistance to change can be active or passive. Active resistance entails the active reaction of consumer to the idea of innovation; for example, an innovation may prompt a response of rejection, protest, or even active boycotting. This study investigates passive resistance to innovation as independent variable. By using some product repeatedly over a long period, a consumer forms habits: this leads to passive resistance. Sheth [82] defines this "the single most powerful determinant in generating resistance" and notes,

> "Perceptual and cognitive mechanism are likely to be tuned in to preserve the habit because the typical human tendency is to strive for continuously search of, and embrace new behaviours".

The most relevant cognitive mechanism behind such passive resistance to innovation is attitude strength toward the object of habit, which prevents one from being receptive to an innovation. Indeed, the greater the person's cognition need and the greater the efforts made to obtain relevant information on the object of habit, the stronger the attitudes. Strong attitudes toward existing objects contribute to resistance to change and may prevent consumers from being open to innovations. In this case, further processing of information about innovation may require that one should be open to change, or even change one's attitudes toward the habitudinal target. It means breaking the resistance to attitude change.

This study measures Resistance to Change quantifying how people are prompted to modify their life habits. The investigation is conducted in general terms: computing people passive resistance toward acceptance of any innovations allows understanding if adoption of smart grid way of consumption is felt as a relevant change of daily habits. Hence, the cause-effect relationship analysis gives information on how general resistance to change weighs on adoption intention: if the correlation is high, smart grid way of consumption should overcome human inertia before to be accepted.

5. Adoption Intention

Intentions have been defined in the TPB as the amount of effort one is willing to exert to attain a goal [2], "behavioural plans that enable attainment of a behavioural goal" [3], or simply "proximal goals". In essence intentions can be conceived of as a goal states in the expectancy value tradition that are the result of a conscious process that takes time, require some deliberation, and focuses on consequences [66]. The intention construct is central to TPB. Intentions assumed to capture the motivational factors that influence a behaviour and to indicate how hard people are willing to try or how much effort they would exert to perform the behaviour [21]. Hence, intention is a cognitive representation of a person's readiness to perform a given behaviour, and it is considered the immediate antecedent of behaviour. Although there is not a perfect relationship between behavioural intention and actual behaviour, intention can be used as a proxy measure of behaviour. Therefore, the variables in TPB model allow to determine the effectiveness of the implementation

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interventions even if there is not a readily measure of actual behaviour.

Concerning this study, Behavioural Intention (BI) is the dependent variable of the model and it estimates consumer's intention to adopt smart grid technologies. Since the behaviour cannot be measured in terms of effective adoption because, actually, smart grid is not yet implemented in the urban context, consumer adoption intention represents the final level of the TPB. Granted that the more a person intends to carry out the intended behaviour the more likely he/she would do so [20], the assessment of smart grid adoption intention allows to capture the motivation factors needed to perform effective adoption.

6. Hypotheses

Based on the theoretical framework discussed above, the following seven hypotheses are proposed:

H1. $BB_iOE_i$ has a positive influence on attitude (where $BB_i$ is the belief that performing the behaviour has consequence $i$; $OE_i$ is the evaluation of consequence $i$).

H2. $NB_jMC_j$ has a positive influence on subjective norm (where $NB_j$ is the belief that important referent $j$ thinks he/she should conduct the behaviour; $MC_j$ is the motivation to comply with the referent $j$).

H3. $CB_kPP_k$ has a positive influence on perceived behavioural control (where $CB_k$ is one's perception of the presence/absence of resource/opportunity $k$ required to engage in the behaviour; $PP_k$ is his/her assessment of the significance of resource/opportunity $k$).

H4. Attitude has a positive influence on adoption intention.

H5. Subjective norm has a positive influence on adoption intention.

H6. Perceived behavioural control has a positive influence on adoption intention.

H7. Resistance to Change has a negative influence on adoption intention.

## III. Research Methodology

### A. Questionnaire Design

The questionnaire used in this study was composed of three sections: the first includes items designed to assess belief constructs, the second consists of predictor constructs (Attitude, Subjective Norm, and Perceived Behavioural Control), and resistance to change variable and intention measures and the third contains questions for demographic information.

These sections were preceded by a description of Smart Grid, which explained briefly, what Smart Grid is and how users are involved in the realisation of such smartness of the electricity grid.

Besides a fourth, section was included to collect demographic data of respondents.

1. Belief Constructs

The measurement items for salient beliefs and referents were developed from an elicitation study and a review of literature [51]. According to [9] and [13], there is no standard questionnaire for TPB. With regard to belief constructs, they insisted that formative research (i.e. elicitation study) and validation of the theory's belief constructs were needed prior to construction of the final questionnaire. They indicated that such an endeavour helps researchers construct a questionnaire that is adequate for a specific behaviour and population of interest.

A sample of twenty individuals representative of the research population was used to elicit readily accessible behavioural outcomes, normative referents and control factors. This focus group consisted of users with different ages, social positions, family status and occupations. The elicitation study was conducted through phone interviews in which respondents answer to open-ended eliciting questions designed to obtain the new set of items for belief constructs. Then, the refinement of the questionnaire was made through experts' reviews.

Subsequently, five individuals were asked to read and comment the questionnaire. The results of this pilot test revealed the instrument had an adequate level of reliability and question clarity. The questionnaire is composed as follows. 5 items with a 5-point Likert-type scale are employed to measure BB (1=*strongly disagree*, 5=*strongly agree*). Upon completion of the likelihood ratings, the corresponding questions were used to assess their evaluation of outcomes (e.g., "An electricity grid which allows me to be more conscious is" 1=*bad*, 5=*good* [33]). To measure NB, 2 items with a 5-point Likert-type scale (1=*strongly agree*; 5=*strongly disagree*) were developed. Respondents were also asked to indicate their MC for each referent (e.g., "Generally speaking, I prefer to do what my family thinks I should do", 1=*strongly disagree*, 5=*strongly agree*). Finally, 3 items with 5-point Likert-type scale were used to examine respondents' CB (1=*strongly disagree*, 5=*strongly agree*) and each item's perceived power (e.g., "To adopt SMART GRID's solutions and technologies, knowledge is:", 1=*extremely unimportant*, 5=*extremely important*). Based on Ajzen's [2] suggestion, all items for each belief were multiplicatively combined with their evaluative components using the expectancy-value approach [45] to obtain an overall level of each belief construct ($\sum BB_iOE_i$, $\sum NB_jMC_j$, $\sum CB_kPP_k$).

2. Measures of Other Constructs

This study adopted existing validated items to assess predictor constructs of adoption intention, and Resistance to Change [13], [86], [65], [88]. The wordings of the measure were slightly modified to be appropriate for this study. While attitude is assessed by a 5-point semantic differential scale, other constructs were all measured using a 5-point Likert-type scale (1=strongly disagree, 5 strongly agree). Multi-item scales were employed to measure these variables adequately capture the domain constructs [32], [73]. In order to avoid the problem of 'response set', three items were reverse scaled: so doing respondents that answer in the same way to every question are excluded from the analysed sample.

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### *B. Data Collection*

The data were collected in two stages during the period March to May 2015. In *stage 1*, elicitation interviews were conducted during March 2015 with sample of 20 Italian electricity users, selected using the *quota sample* to make sure that all relevant stratifications of the population were represented (in terms of age, gender, level of education and social position). The elicitation schedule requested to list advantages and disadvantages of Smart Grid solutions adoption, the people who would approve or disapprove the adoption and the factors, which would encourage or discourage such adoption. *Stage 2* was performed through the main purely paper-based survey. A self-administered, closed-ended questionnaire was distributed to citizens of Cosenza, a small city in the South of Italy, randomly selected in its urban area. Since Italy (as Europe) is mostly made by small-middle size cities, except some metropolitan contexts such as Rome, Milan or Naples, the test area can be considered as representative of the majority of Italian population of electricity users.

Respondents were randomly selected at the exit of shops and commercial centres. 168 questionnaires were collected, and a total of 96 usable responses were selected from participants, indicating a valid response rate of 57,14%. Of the 96 respondents 57,29% were male and 42,71% were female. Respondents' age groups and level of school education are showed in Table I.

TABLE I
CHARACTERISTICS OF SAMPLE

| | | Sample (N = 69) (%) |
|---|---|---|
| Sex | Male | 57,29% |
| | Female | 42,71% |
| Age | 18-29 years | 19,79% |
| | 30-39 years | 21,88% |
| | 40-50 years | 25% |
| | over 50 years | 33,33% |
| Level of school education | Middle school | 13,54% |
| | High school | 56,25% |
| | Graduated | 26,04% |
| | Post-graduation degree | 4,17% |

48, 96% of respondents live in Cosenza-Rende urban area, 51,04% is from Cosenza district towns. Finally 23,96% of respondents - the majority - were employees (freelancers 9,37% , unemployed 9,37%, students 7,29%, retailers 7,29%, entrepreneurs 3,12%).

### *C. Data Analysis*

The explanatory factor analysis (EFA) was carried out using SPSS version 22 in order to examine whether the measured variables of each factor affecting the smart grid acceptance had been appropriately designed and answered, while Bartlett's unit matrix was checked to see whether the survey data was fit for factor analysis. To this end, Bartlett's test and Kaiser-Meyer-Olkin (KKMO) goodness-of-fit test were conducted. The Harman's single factor test was utilized for the implementation of Common Method Variance, and the Varimax method of orthogonal rotation was used for the factor rotation.

After EFA, the Structural Equation Modeling (SEM) analysis was performed by using LISREL 8.80 to test the hypotheses. The SEM analysis consisted of two steps: confirmatory factor analysis (CFA) and path analysis (PA).

Path analysis is an extension of multiple regressions. It allows for the analysis of more complicated models. In particular, it can examine situations, which there are several final dependent variables and those in which there are "chains" of influence [84]. CFA is used when a priori hypotheses about which items or variables are grouped together as manifestation of an underlying construct and wish to test how well the data match -or fit- the model.

While in path analysis one is limited to considering paths just among the measured variables, SEM allows to draw paths among the latent (that is, unseen but hypothesised) variables and thus, to examine the relation among them: this makes SEM particularly useful for modelling tests including several independent/dependent variables [85]. SEM combines aspects of multiple regression and factor analysis to assess a series of dependent relationships simultaneously [60], which is not possible using other multivariate techniques: each latent variable should have at least 2 (ideally 3 or more) measured variables associated with it. Thus, each latent variable is a small CFA in its own right, testing the hypothesis that the measured variables are in fact the measurable manifestation of the latent one. This provides the benefit in that the correlations among the measured variables are an indication of their reliability, and SEM can correct for this. Consequently, the relations among latent variables reflect their true correlations uncontaminated by measurement error.

Indeed, SEM is particularly useful for modelling tests including several independent/dependent variables and mediators/moderators [48].

## IV. RESULTS

### *A. Data Screening and the Measurement Model*

Prior to testing the measurement model, the collected data were screened to avoid any violation of the assumption of the general linear model. To establish construct validity and reliability, procedures from prior literature was followed [19], [49]. First an Exploratory Factor Analysis [43] was run using principal component analysis with Varimax rotation (SPSS version 22.0) to assess the unidimensionality of the measurement constructs; Bartlett's sphericity test and KMO's goodness-of-fit test were also conducted in order to evaluate the significance of correlation among variables and the suitability of data for factor analysis. Harman's single-factor test was performed to determine if common method bias was a significant problem. Cronbach's alpha values were then computed for each construct to assess their reliability and item-to-total correlation [35]. Confirmatory Factor Analysis based on LISREL 8.80 [56] allowed to evaluate construct validity and to estimate the measurement model.

Finally, Structural Equation Model (SEM) using the Maximum-likelihood estimation procedure linked with LISREL 8.80 software permitted to simultaneously test hypothesised structural associations between/among the set of

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eight latent constructs, assessing the causal relationships of the employed model [59], [79].

1. Explanatory Factor Analysis (EFA)

The value of Bartlett's sphericity test was 1517,75 ($sign.= 0.000$, $df = 378$), showing that the correlation of the variables was statistically significant. Further, the KMO value of 0,844 was a high goodness-of-fit, meaning that the raw data was suitable for factor analysis. Indeed, the closer the KMO value is to 1, the higher the significance the factor analysis has. Also, the minimum value should not be less than 0,5 and the value greater than 0,8 is good [54].

Common method bias was performed using Harman's single factor test. The output of this test is the Total Variance Explained: the instrument overcomes such test if it accounts less than 50% of all the variables in the model. Since from Harman's single factor test the total variance explained was 35,56%, the data can be considered free from significant common method bias.

The explanatory factor analysis in this study made use of the principal component analysis whose purpose was to minimize the loss of information and enable variables to have a minimum number of factors. The Varimax method was used for factor rotation. A Varimax solution yields results, which make it as easy as possible to identify each variable with a single factor. It consists of an orthogonal rotation of factor axes to maximize the variance of the squared loadings of a factor on all the variables in a factor matrix, which has the effect of differentiating the original variables by extracted factor. This is achieved if any given variable has a high loading on a single factor but near-zero loadings on the remaining factors, and if any given factor is constituted by only a few variables with very high loadings on such factor while the remaining variables have a near-zero loadings on this factor. Varimax rotation showed that three items related to three different constructs, had high loading values dispersed from factors grouping high loading values of other items of the same construct. Excluding such items, the concentration of the measured variables can be seen as good, since all other loading values were grouped and were more than 0,5. Furthermore, in order to test the internal consistency of the measured variables, Cronbach's $\alpha$ values were obtained to measure reliability. The range of the values is between 0 and 1, and generally, when the value is less than 0,3, the concentration between variables is weak, and when it is more than 0,7 the concentration between variables can be said strong. Cronbach's alphas of three variables (Behavioural Beliefs, Control Beliefs, Resistance to Change) were improved removing one item from each of involved constructs; two of them (Behavioural Beliefs, Control Beliefs) coincided with the dispersed high loading values observed in Varimax rotation. The values of Cronbach's alpha are showed in Table I.

The EFA and Cronbach's alpha evaluation allowed assessing and improving the measurement model highlighting the inconsistency of four items related to four different constructs -Behavioural Beliefs, Control Beliefs, Perceived Behavioural Control, and Resistance to Change. Such items were excluded from the further analyses, and the related variables became two-item constructs.

The measures obtained using the remaining items showed good level of internal consistency.

2. Confirmatory Factor Analysis (CFA)

CFA is used when a priori hypotheses about which items or variables are grouped together as manifestation of an underlying construct and wish to test how well the data match -or fit- the model.

The CFA has difference with the EFA in that it can model a form of hypothesis with theoretical knowledge or results and constrain some elements of the matrix. The reason to conduct CFA after EFA is that it can identify the outline of factor structure of the latent variables used in a research model and remove the measured variables contrary to the validity more thoroughly [57].

CFA using maximum likelihood estimation with the 96 cases was conducted to assess the underlying structure of the variables in the model. Specifically, all measures were assessed for unidimensionality, reliability, and construct validity.

The measurement model fit indices fell within the recommended parameters ($\chi^2/degrees\ of\ freedom = 1{,}24$; $root\ mean\ squared\ error\ of\ approximation\ (RMSEA) = 0{,}05$; $p - value = 0.009$; $normed\ fit\ index\ (NFI) = 0{,}91$; $confirmatory\ fit\ index\ (CFA) = 0{,}98$) as suggested by [49].

Results obtained from the Confirmatory Factor Analysis are showed in Table II: loading values and t-values related to each item, the values of Cronbach's alpha, Composite Reliability and Average Variance Extracted related to each construct are displayed. All factor loadings exceeded the minimum value of 0,40, and the t-values of the indicators were greater than 2,0, in support of convergent validity [19] and unidimensionality.

The results related to Composite Reliability (CR) and Average Variance Extracted (AVE) are not satisfying for some of the constructs. Indeed, CR is greater than 0,60 for the majority of the scales, except for Perceived Behavioural Control (PBC) variable. Consequently, also AVE does not exceed the recommended threshold (0,50) for the same construct (PBC). Moreover, Control Beliefs (∑CB*PP), Subjective Norm (SN), and Resistance to Change (RC), exhibit low values of AVE, but very close to the limit value of 0,50 [24]. PBC items need to be revised for further studies; nevertheless, for other variables, the slightly low values of AVE can be due to the small sample size.

After the test for the reliability of latent variables, the discriminant validity should be checked. If AVE1 and AVE2 of two latent factors were greater than the coefficient of determination, i.e., the square of their correlation coefficient, the two factors can be said to have discriminat validity between them [57], [58]. Evidence of discriminant validity was found because square root of AVE for each construct (except for PBC) was always greater than the correlation coefficients shared among constructs [44]. Overall, the majority of the measures possessed adequate reliability and validity. The correlation coefficients, means and standard

deviations and square root of AVEs for latent variables are listed in Table III.

TABLE II
MEASUREMENT SCALES

| Factor/item | Standardized factor loading | t-values |
|---|---|---|
| **Behavioural Beliefs (α=0,79; CR=0,80; AVE=0,50)** | | |
| Consciousness of own consumption | 0,7 | 7,31 |
| Energy saving | 0,86 | 9,67 |
| Lower price electricity | 0,68 | 7,1 |
| Usability of energy service[a] | | |
| Supporting environmental sustainability | 0,56 | 5,52 |
| **Normative Beliefs (α=0,88; CR=0,88; AVE=0,78)** | | |
| Opinion of family | 0,9 | 10,33 |
| Opinion of friends | 0,87 | 9,83 |
| **Control Beliefs (α=0,61; CR=0,64; AVE=0,48)** | | |
| Knowledge on SMART GRID | 0,53 | 5,23 |
| Get savings on electricity bill | 0,83 | 8,13 |
| Electricity grid accessibility[a] | | |
| **Attitude toward adoption (α=0,93; CR=0,93; AVE=0,68)** | | |
| Adopting SMART GRID's solutions and technologies would be: | | |
| Favourable-Unfavourable | 0,71 | 7,81 |
| Positive-Negative | 0,87 | 10,48 |
| Appropriate-Inappropriate | 0,81 | 9,43 |
| Useful-Useless | 0,89 | 11,02 |
| Advantageous-Disadvantageous | 0,82 | 9,69 |
| Desirable-Undesirable | 0,85 | 10,22 |
| **Subjective Norm (α=0,72; CR=0,71; AVE=0,46)** | | |
| Opinion of important people | 0,68 | 7,15 |
| Opinion of influencing people | 0,75 | 8,17 |
| Endorsement of important people | 0,58 | 5,96 |
| **Perceived Behavioural Control (α=0,54; CR=0,36; AVE=0,22)** | | |
| Perceived power on the adoption decision[a] | | |
| Perceived ability needed to adopt SMART GRID | 0,44 | 3,39 |
| Having resources, time and knowledge needed to adopt | 0,5 | 3,69 |
| **Resistance to Change (α=0,58; CR=0,63; AVE=0,47)** | | |
| Tendency to test new product[a] | | |
| Tendency to not change own habits | 0,79 | 5,71 |
| Tendency to use unknown products or services | 0,56 | 4,6 |

AVE = average variance extracted; α = Cronbach's alpha; CR = Composite Reliability
[a] Item dropped during scale purification

As can be observed from Table III, hypothesised correlations among variables (BB-A; NB-SN; CB-PBC; A-AI; SN-AI; PBC-AI; RC-AI) are all statistically significant. While, high correlation coefficients related to variables that should be not correlated (such as SN-PBC) were verified to be free from the phenomenon of multicollinearity using SPSS 22.

*B. Structural Model and Hypotheses Testing*

Structural model is shown in Fig. 2. Such model has good fit statistics ($\chi^2 = 333{,}62$; $df = 239$; $p - value = 0{,}0005$, $\frac{\chi^2}{df} = 1{,}4$; $RMSEA = 0.065$; $CFI = 0{,}96$; $NFI = 0{,}89$; $IFI = 0{,}96$) and contains a good explanatory power for behavioural intention ($R^2 = 0{,}84$).

Table IV details the results of hypotheses testing. The estimates of standardised coefficients showed that the linkages between $BB_iOE_i$ and attitude ($\beta = 0{,}29$; $p < 0{,}01$), between $NB_jMC_j$ and subjective norm ($\beta = 0{,}86$; $p < 0{,}01$), and between $CB_kPP_k$ and perceived behavioural control ($\beta = 0{,}72$; $p < 0{,}01$) were all positive and significant. Therefore, Hypotheses 1-3 were supported. The results also revealed there were positive influences of attitude ($\beta = 0{,}45$; $p < 0{,}01$), subjective norm ($\beta = 0{,}11$; $p < 0{,}01$), and perceived behavioural control ($\beta = 0{,}61$; $p < 0{,}01$) on adoption intention. Thus, Hypotheses 4-6 were supported.

The support found for these hypotheses indicated that consumers' intention toward adoption of SMART GRID solutions and technologies is positively associated with their evaluation of the consequences of the adoption, perceived social pressure from important referents, and perceived control over the barriers for the adoption of smart technologies. In addition, as can be seen in Fig. 2 the estimates standardised coefficients showed that the direct effect of perceived behavioural control on adoption intention was greater than attitude and subjective norm. Subjective norm has the lowest standardised coefficient: such finding is consistent with previous study on smart grid adoption intention, which employs the TPB [65].

The variable added to the basic model (RC), is revealed indirectly correlated with adoption intention: the variable attitude has a mediating role in the relationship between resistance to change and adoption intention. Such finding is highlighted by the correlation matrix (Table III): looking at the row related to resistance to change it is possible to observe that the greatest correlation coefficient for such variable corresponds with attitude. SEM analysis confirmed this high correlation; indeed, the standardised coefficient value between RC and attitude is significant and the goodness-of-fit indexes of this model were highest than the ones found with the hypothesised direct relationship between RC and adoption intention. The negative sign confirmed the negative influence of RC on adoption intention, which is mediated by attitude: the greatest the inertia of consumers, the lowest the attitude, and, hence, the lowest the adoption intention. The path between RC and AI was eliminated and the one between RC and A was added.

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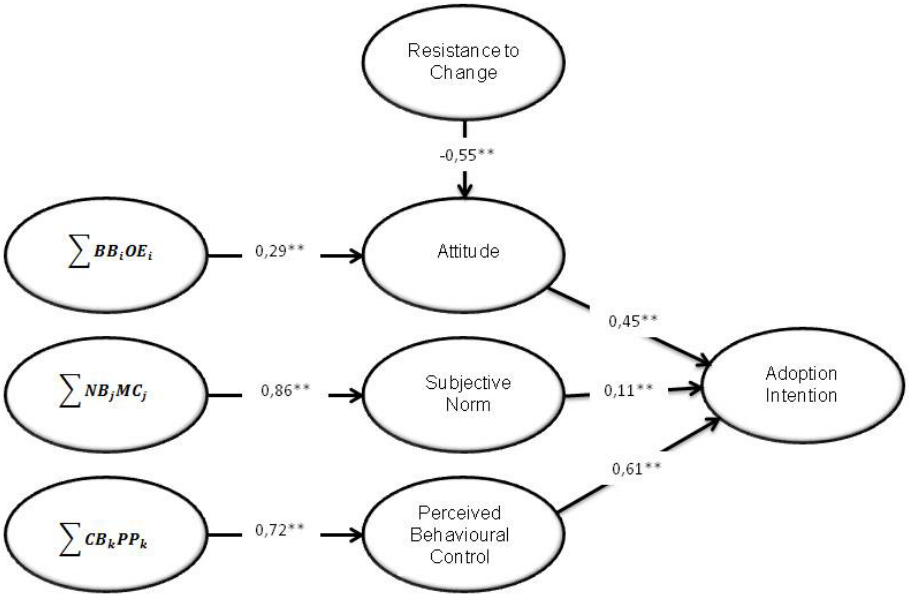



Fig. 2 Final model. $**P < 0{,}01$. Note. BB = Behavioural Beliefs; OE = Outcome Evaluation; NB = Normative Beliefs; MC = Motivation to Comply; CB = Control Beliefs; PP = Perceived Power

TABLE III
CONSTRUCT SUMMARY STATISTICS: MEASURE CORRELATIONS, RELIABILITY COEFFICIENTS, AND SQUARE ROOT AVE

| Measure | ∑BB*OE | ∑NB*MC | ∑CB*PP | A | SN | PBC | RC | BI | $AVE^{1/2}$ |
|---|---|---|---|---|---|---|---|---|---|
| ∑BB*OE | 1 | | | | | | | | 0,71 |
| ∑NB*MC | 0,32** | 1 | | | | | | | 0,89 |
| ∑CB*PP | 0,58** | 0,50** | 1 | | | | | | 0,7 |
| A | 0,29** | 0,37** | 0,43** | 1 | | | | | 0,83 |
| SN | 0,39** | 0,63** | 0,55** | 0,60** | 1 | | | | 0,67 |
| PBC | 0,27** | 0,20* | 0,33** | 0,25* | 0,47** | 1 | | | 0,47 |
| RC | -0,73 | -0,15 | -0,14 | -0,38** | -0,34** | -0,94 | 1 | | 0,68 |
| BI | 0,43** | 0,41** | 0,58** | 0,66** | 0,63** | 0,42** | -0,37** | 1 | 0,79 |
| Mean | 16,15 | 3,94 | 5,6 | 3,69 | 3,39 | 3,36 | 2,96 | 3,43 | |
| SD | 3,68 | 2,32 | 2 | 0,93 | 0,85 | 0,93 | 1,09 | 0,97 | |
| CR | 0,8 | 0,7 | 0,8 | 0,9 | 0,7 | 0,6 | 0,6 | 0,8 | |

TABLE IV
STRUCTURAL EQUATION MODELING RESULTS - FINAL MODEL (N=96)

| Paths | Coefficients | Hypotheses |
|---|---|---|
| $BB_iOE_i \rightarrow A$ | 0,29** | H1: supported |
| $NB_jMC_j \rightarrow SN$ | 0,86** | H2: supported |
| $CB_kPP_k \rightarrow PBC$ | 0,72** | H3: supported |
| RC → A | -0,55** | Added path |
| A → AI | 0,45** | H4: supported |
| SN → AI | 0,11** | H5: supported |
| PBC → AI | 0,61** | H6: supported |
| Goodeness-of-fit statistics: $\chi^2$=333,62; df=239; p=0,00005; $\chi^2$/df=1,4; RMSEA=0,065; CFI=0,96; NFI=0,89; IFI=0,96 | | |

BB = Behavioural Beliefs; OE = Outcome Evaluation; NB = Normative Beliefs; MC = Motivation to Comply; CB = Control Beliefs; PP = Perceived Power; RC = Resistance to Change; A = Attitude; SN = Subjective Norm; PBC = Perceived Behavioural Control; AI = Adoption Intention.
$**p < 0{,}01$

## V. DISCUSSION AND CONCLUSIONS

The present study tested the suitability of TPB in explaining electricity users' intention formation toward the adoption of smart grid solutions and technologies. Bearing in mind that this study is work in progress, most of the objectives can be considered achieved. Specifically, salient belief items for each predictor construct, which are particularly appropriate in the adoption of a smart way of consumption, were identified through a focus group and literature review. In the analysed TPB model, the first six hypotheses were supported. However, resistance to change was found indirectly correlated with adoption intention, through the mediation of attitude. Thus, the last hypothesis was not supported just because the path RC-AI was thought to be direct and not mediated. This found is coherent with theory: the intention to adopt a new way of consumption is negatively influenced by the inertia of the user, which acts on his attitude toward the adoption.

The SEM allowed to determine the loading of each belief on its latent variable and, indirectly, on the adoption intention (see Table II).

Four behavioural beliefs were determined from elicitation phase: one of them, coinciding with the usability of the electricity grid, was revealed to be not significant, while the energy saving is the most important of this group of beliefs. Looking at salient referents, family showed to have a bigger weight than friends. Concerning control beliefs, the

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accessibility to the grid was found to be not significant, if compared with the other beliefs.

Through SEM, the predictive constructs were validated for intention. Particularly, it was found that latent variables of beliefs were positively and significantly correlated to their predictor constructs (attitude, subjective norm and perceived behavioural control), and these lasts with the adoption intention. The examination of the estimated standardised regression coefficients indicated the effects of antecedent variables on adoption intention were asymmetrical. In particular, the findings revealed that perceived behavioural control had a greater level of influence on SG adoption intention than subjective norm and attitude. This implies that, to enhance smart grid adoption intention, it could be effective for energy managers to increase positive perceived control. As the study results indicated, generating strong positive control beliefs would contribute to enhancing perceived control. The need of information on Smart Grid is highlighted by such finding: PBC and control beliefs are the variables related to perceived possessed knowledge on the product or service object of the survey. Since it is likely that Smart Grid was unknown for respondents, the need of information was determinant in formation of adoption intention. Because of this study, the importance of consumer education and public relations of the smart grid can be confirmed [77]. The analysis shows that the understanding of the smart grid improves the perceived control and, thus, the adoption intention. Consumers need to be able to understand reasons, benefits, and impacts of the smart grid deployment. The importance of spreading information on Smart Grid before asking users to adopt its technologies is one key of a successful implementation of the smart electricity grid. By doing so users, becoming more confident with their energy consumption and conscious of their key role in getting savings on the electricity bill, can be more available to adopt SG solutions and technologies.

Attitude was found to be also a significant determinant variable of adoption intention. This means that enhancing positive attitude through the behavioural beliefs can incite users toward the adoption. It is interesting to observe that environmental sustainability is the less important behavioural belief, among the ones considered: this means that consumers are less motivated to adopt SG solutions if the matter is the environmental sustainability. Getting energy savings, becoming more conscious of own energy consumption and purchase lower price electricity are the most significant behavioural beliefs.

The low significance of subjective norm as determinant of adoption intention is consistent with findings of previous studies on the application of TPB to adoption of new products and services [86] and on SG [65]. The relationship might be based on the argument that, in the absence of adequate information on SG, significant referents might think that a decision to adopt its solutions and technologies was unwise. For example, someone with a limited knowledge on SG, may incur the disfavor of family members who would think that it could involve changes in electricity consumption habits not supported by the certain opportunity to get energy savings and, thus, money savings.

This study extends previous research on TPB by investigating the influence of resistance to change of consumers. It was proposed a fourth cause variable of adoption intention, that is resistance to change of users, due to their behavioural inertia in changing own life habits. Findings indicated that such variable did not have a significant influence on adoption intention if directly linked with it; RC negative influence is significant if mediated by attitude variable. This result implies that such behavioural inertia in change own life habits is strongly related to attitude, when decision-making involves electricity consumption.

This study provides both theoretical and managerial implications for comprehending the determinants of users' intention toward the adoption of SG solutions and technologies. The results showed that TPB including the variable resistance to change had a strong predictive power for adoption intention, indicating its applicability to the domain of smart electricity users' conscious decision-making. That is, the findings provide a solid theoretical basis for the study of adoption of "smart" behaviours in the field of energy consumption.

## VI. Limitations and Further Researches

While the present study has combined a number of innovative methodological elements from psychology and economic analysis of consumer behaviour related to smart tools associated with smart cities, it is also subject to a number of limitations that can serve as starting points for further research.

The limited number of observations caused some problems in the phase of data screening and validation of measurement tool. Since the literature suggests that the main survey should involve a number of observations, which has to be at least five times the number of items, using 38 items questionnaire, the present research needs a minimum of 190 observations to obtain definite and conclusive results. For this reason, the study is considered a pilot survey of future research. Indeed, one result is the necessity to revise some of the items (particularly for PBC constructs) in order to overcome the incongruities identified in the CFA and to get solid results from the main survey.

The second limit is due to the geographical restriction of the sampling. The survey was conducted selecting respondents randomly in the urban area of Cosenza. Despite this city can be considered representative of most middle size cities around Europe, in further researches surveys could involve respondents of different geographic areas; for example, it would be interesting to compare results of the present study with the ones gotten from respondents living in different urban conditions, such as metropolitan areas.

The third limit is related to the purely paper-based survey. Since this kind of survey does not allow to use any type of graphic element, and the availability of respondents and their attention in filling questions are strongly conditioned by the length of the questionnaire which looks static and annoying. Further research could evaluate the possibility to conduct an

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online survey.

The fourth limitation concerns the hypothesis of the behavioural model employed in this study. Indeed, TPB is based on the hypothesis of a rational decisional process of consumers and it requires that individuals are motivated to perform a given behaviour. This assumption may be particularly problematic when studying consumer adoption behaviours [86]. SG was unknown for respondents and this conditioned the answers, specifically for items related to PBC. Furthermore, there was also the difficulty to cannot represent SG as a specific service or display some particular product. Hence, the stronger relationship of PBC construct with adoption intention can be explained with the expected importance that the non-volitional factor could have when decision involves something does not have any correspondence in consumers' imagination. When the implementation of SG will be started users will be more informed, allowing future studies to analyse changing in the relationship of determinants with adoption intention, and it will be possible to test the final part of the model through observation of users behaviour.

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