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The effects of e-government evaluation, trust and the digital divide in the levels of e-government use in European countries

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ABSTRACT

Despite the significant amounts of public investment devoted to enhancing e-government over the last ten years, citizens' use of this service is still limited, posing a challenge to national governments. By analysing panel data derived from 27 European countries for the period 2010 to 2018, our work confirms that citizens' use of e-government services is influenced by supply-side e-government evaluations, citizens' trust in governments and the digital divide associated to income and education. Moreover, a longitudinal cluster analysis allows us to identify patterns of behaviour between the countries as regards the way those variables interact with the use of e-government services over time. Relevant practical implications derive from the research that can guide public policy in the area of e-government.

1. Introduction

Electronic government aims to make public institutions more transparent and accountable. The European Commission recognised the importance of digital transformation of the state as early as 2006 and is currently implementing the EU e-Government Action Plan 2016–2020 (EC, 2016). Since 2012 and on a yearly basis, it publishes the e-government benchmark reports which compare the penetration, and digitisation of e-Government services in 34 European countries (EC, 2018a).

According to Eurostat Statistics (EC, 2018b), only 57% of individuals aged 16 to 74 reported using the Internet for interaction with public authorities in 2018. Furthermore, since 2009, this share has risen by only 15% on average (EC, 2019). In this context, it is necessary to question the reasons for this low level of adoption of e-government.

The present work aims to answer two research objectives. The first aim is to verify whether certain characteristics of European countries can explain the use of e-government by citizens, in particular: supply-side e-government performance evaluations, citizen trust in their government, per capita income, education, age and rurality. The second aim is to identify patterns of behaviour across European countries as regards the way these characteristics interact with the level of e-government use over time.

On the one hand, it seems logical to expect supply-side aspects of e-government to be an instrument in enhancing citizen's perception of e-government and therefore affect usage levels. Recent decades have seen a growth in evaluations of e-government maturity, examples being West's assessment of e-government performance (2005, 2008), the United Nations E-government Development Index and E-Participation Index (UN, 2010,2012,2014,2016,2018) or the Digital Governance Index by Holzer and Manoharan (2016). Nonetheless, authors such as Codagnone et al. (2015) point out the weak relation between scores in supply-side benchmarking and the level of e-government adoption by citizens.

On the other hand, the extent to which government-to-citizen relationships are based on trust can affect overall public support for e-government. Works by authors such as Belanger and Carter (2008) and Tolbert and Mossberger (2006) have found that higher levels of trust in government correlate with more intensive e-government service use.

In addition, with the increasing availability of a variety of e-government functions, there is growing concern about why certain populations use some specific functions of e-government and others do not Nam (2014). The so-called digital divide refers to the unequal access of citizens to ICT, and uneven possession of skills and experience required for using it.

A rapidly growing body of empirical literature has evaluated the performance of e-government initiatives from the supply-side perspective (e.g. Glyptis et al., 2020; Das et al., 2017; Jho and Song, 2015; Zhao et al., 2014). Conversely, a relatively less number of studies have empirically examined the factors influencing citizens' adoption of e-

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Table 1
Research in e-government use in the last decade.

Paper	Godlfinch et al. (2009)	Reddick (2011)	Taipale (2013)	Park et al. (2013)	Nam (2014)	Zheng and Schachter (2017)	Ma and Zheng (2017)
Design	Cross-sectional	Cross-sectional	Cross-sectional	Longitudinal	Cross-sectional	Cross-sectional	Cross-sectional
Data	Primary data (survey) Australia and New Zealand 2009	Secondary data (Pew Internet and American Life Project) US 2009	Primary data (survey) Finland 2011	Secondary data (KoreanClick Stream Data). Korea Panel data 2003 to 2005	Secondary data (Pew Internet and American Life Project) US 2009	Secondary data (EU e-government Benchmark-User Survey) 32 EU countries 2012	Secondary data (EU e-government survey) 32 EU countries 2012
Analysis technique	logistic regression/ordinal logistic regression	logistic regression analysis	logistic regression analysis	multivariable regression	multivariable regression	ordinary least squares regression	multiple linear regression multilevel
Dependent variable	e-government attitudes and use	e-government use	e-government use	e-government use	e-government use	e-participation use	citizens' satisfaction with national e-participation
E-government performance evaluations	–—–	Citizen-demand variables (Significant +)	——-	e-information (significant +), e-petition (not significant) and e-participation (not significant)	Perceived value of service (Significant +), Perceived ease of use (significant +), perception of engagement with public officials (significant +)	Satisfaction to e-participation application (significant +)	e-Participation Index (UN) (significant (+)
Education	Significant +	Significant +	Significant +	—	Significant +	Significant +	Significant +
Location (rural vs urban)	Urban (significant +)	—-	Urban (Significant +)	—-	Suburban and urban residents (Not significant)	—	—
Age	Old (Significant -)	Not significant	Not significant	—	Not Significant	Young (Significant +)	Not significant
Trust in government	Significant -	Significant –	—-	—	Not Significant -	—	—-
Income	Significant + in New Zealand and in Australia partially	Significant +	Significant –	Not significant	Significant -	—	

government system. Table 1 shows some of the extant literature that has contributed to filling this gap in research during the last decade.

The works referred to in Table 1 contributed to identify the influential factors for e-government usage or satisfaction adopting a cross-sectional approach, with the exception being the longitudinal study by Park et al. (2013). As regards the predictors under study, Ma and Zheng (2017) and Park et al. (2013) considered supply-side measures for e-government performance evaluation, whereas Reddick (2011), Nam (2014) and Zheng and Schachter (2017) used demand-side (individual's perceptions) measures for e-government evaluation. Goldfinch et al. (2009), Reddick (2011) and Nam (2014) took different measures of trust in government. Additionally, all papers but Park et al. (2013) also considered demographic characteristics such as Age, Education, at the individual level. Most took into account the effect of citizens' income in e-government usage. The characteristics of the individuals' residential location (rural or urban) were also analysed by Goldfinch et al. (2009), Taipale (2013) and Nam (2014). In most cases, their findings advise against taking for granted the existence or the sign of the relationships between e-government use and typically used predictor variables.

From the consideration of previous research, the work presented in this paper contributes to understanding the determinants of e-government usage in the context of Europe, allowing us to tap into the large variations in e-government development and use across its member countries. In contrast to most studies, our work adopts a longitudinal approach, exploring recent data, which allows us to observe trends in e-government over the period 2010–2018. As Ingrams et al. (2018) suggest, longitudinal and multi-country analyses are vital to advance in research on e-government. To this end, a data panel was constructed on 27 European countries for the 2010–2018 period. The data are treated using a linear regression analysis for the entire period and a longitudinal cluster analysis at the start, middle and end of the period.

The article is structured as follows: following this introduction, Section 2 presents the theoretical framework of the determinants of the use of e-government by citizens and establishes the hypotheses. Section 3 describes the methodology used, while section 4 presents the results and section 5 the discussion. Finally, Section 6 gathers the main conclusions of the research.

2. Conceptual model and hypotheses development

2.1. e-government performance evaluations and citizens' use of e-government

According to the Technology Acceptance Model (TAM) (Davis, 1986), individuals' acceptance of information systems is influenced by two key variables, namely "perceived ease of use" and "perceived usefulness". Under this theoretical approach, citizen evaluation of e-government performance is significant in the decision to use the tools provided by e-government (Irani et al., 2012). Previous research has empirically demonstrated this idea, both in the specific area of e-government -e. g. Zheng and Schachter (2017), Ma and Zheng (2017)- and for the more general urban service technology -e.g. Sepasgozar et al. (2019)-.

Therefore, the design and promotion of e-government portals emerges as a strategic management tool to influence citizens' perceptions. According to Gracia and Ariño (2015), e-government quality is an observable consumer-oriented signal that can be used to communicate government's abilities and concerns about citizens' needs and demands. Moreover, it is exactly in this area where the published indicators on e-government performance come into play. According to Peña-López (2009), the comparability of these indicators means they are central to conducting cross-country comparisons of ICT development, monitoring the global digital divide and establishing policy-relevant benchmarks. In spite of this, authors such as Codagnone et al. (2015) highlight their analytical depreciation and lack of validity, whereas Ma and Zheng (2017) underline the inability of these indicators to predict user satisfaction.

In this context, given that it has been shown that public expenditure on e-government should be associated with appropriate levels of citizen utilization, it is worth asking whether high scores in e-government performance evaluations are correlated with citizens' perceptions of ease of use and usefulness, and therefore, with their use of e-government. The first hypothesis in our research is derived from this question:

H1: A positive relationship exists between e-government evaluations from the supply-side and citizens' use of e-government.

2.2. Trust in government and citizens' use of e-government

Citizen trust in the public administration has been reduced worldwide due to recent events such as the current economic situation, corruption cases or disclosure of classified information. In the European context, citizens have been extrapolating their increasing distrust in national institutions to the EU institutions (Torcal and Christmann, 2018).

Trust in government represents confidence of citizens in the actions of a "government to do what is right and perceived fair" (Easton, 1965). It can be assessed by the extent to which citizens trust in public institutions to operate in the best interests of society and its constituents (see Kim and Lee, 2012). With the emergence of e-government, this has taken on the additional dimension of trust in government online services, while aspects of governance including privacy and control of information have increased in importance (Bannister and Connolly, 2011).

Studies such as that by Belanger and Carter (F. 2008) reached the conclusion that trust positively affects intentions to use an e-government service. In the same line, Tolbert and Mossberger (2006) found that higher levels of trust in government correlate with more intensive e-government service use and, at the same time, that those satisfied with such services are more trusting of government. Their results suggest that interaction through online may be especially important for increasing process-based trust and also that improving interactions could also include an expansion of participatory opportunities. Sternstein (2010) found that if citizens find e-government transparent, they are more likely to return to the website, recommend it, use it, and express more trust in the government agency.

Other studies as Nam (2014) reached the conclusions that for e-government service use, trust in government may be more important than trust in technology, given the gap between a higher level of trust in technology and a lower level of trust in government. Sweeney (2007) found that overall citizens more readily trust the functional aspects of e-government service—the technology—but are not as willing to trust the government itself, the actual provider of the service.

Thus, our second hypothesis is the following:

H2: A positive relationship exists between trust in government and citizens' use of e-government.

2.3. The digital divide and citizens' use of e-government

As previously explained, inequality in the access and possible use of e-government between different population groups is a reason for concern for governments and constitutes a challenge. The new technological tools of e-government may hold benefits for only some segments of the population. The Diffusion of Innovations Theory (Rogers, 2003) provides a solid theoretical background to support the explanatory importance of socio-demographic profiles in e-government use. According to the theory, early adopters of any technology innovation share common characteristics: they are young, well-educated, and have higher incomes. These characteristics coincide with those of e-government service users (Dimitrova and Chen, 2006).

Hence, our third hypothesis is as follows:

H3: A relationship exists between the digital divide and citizens' use of e-government.

This is a broad-based hypothesis, which we divide into more specific sub-hypotheses below.

The literature on the digital divide claims that Internet use relates to higher educational levels (Colesca and Dobrica, 2008; Taipale, 2013; UN, 2016). Furthermore, it is argued that people with higher incomes and education are more likely to be confident in their ability to understand how government runs and to get involved in an effective way (Zheng and Schachter, 2017). This leads to two Sub-hypotheses:

H3.a. A positive relationship exists between income and citizens' use of e-government

H3.b. A positive relationship exists between education and citizens' use of e-government

Age is another factor to be considered. Research on the digital divide points to older populations facing significant disadvantages in the use of e-government compared to younger people (Geana and Greiner, 2011; Friemel, 2014), suggesting our third sub-hypothesis:

H3.c. A negative relationship exists between ageing and citizens' use of e-government

Finally, rural population is often associated with lower levels of e-government usage and, subsequently, e-participation. There are large regional and rural/urban differences with regard to access to, and possession of, information technology (Amagoh, 2015). Accordingly, our fourth sub-hypothesis is:

H3.d. A negative relationship exists between rurality and citizens' use of e-government

3. Method

3.1. Data and measures

A cross-sectional and longitudinal study on data for the 2010–2018 period was used to test our hypotheses. The sample was selected from 34 countries included in the EC e-government benchmark reports (e.g. EC, 2018a). However, the lack of data to construct the data panel forced us to eliminate seven countries, specifically: Cyprus, Iceland, Montenegro, Romania, Serbia, Switzerland and Turkey. Thus, the final sample consisted of 27 countries, for which we compiled data from 2010, 2012, 2014, 2016 and 2018.

The values of both the dependent and independent variables were obtained from secondary sources. Table 2 shows the study variables, the indicators used to measure them and the source from which they were taken.

It should be noted that the data extraction was affected by a two-year time lag in some of the variables. This is because the independent variables EPI and HCI are published in the *t* year but their values are related to responses obtained in t-2 year. In consequence, and with the aim of maintaining a consistent time criterion, the data on the independent variables (Trust,% Rural,% Age > 65 years and GNIpc) were taken with a two-year time lag.

Certain comments should be made on some of the variables described in Table 2. In first place, for the dependent variable "percentage of individuals who reported having used the internet for interaction with public authorities" (hereinafter% Users), the data were obtained from European Commission (2018b) for the years 2010, 2012, 2014, 2016 and 2018. This variable considers the percentage of users to represent the general use of e-government, whether it be for searching for information, for consultation or participation. It also includes use of e-government services, although it is not possible to identify whether part of that use is non-voluntary as a result of the lack of alternative to access public services via traditional offer. In this regard, the work by Kumar et al. (2017) investigates the extent to which citizens are moving from traditional ways of using government services to using it electronically and how that experience influences their behaviour and the value given to e-government services.

For e-government evaluation, we used the e-Participation Index (EPI) as a measure of the offer of e-government in the different countries, as used also by Girish et al. (2012), Jho and Song (2015) and Ma and Zheng (2017). The EPI assesses the quality and usefulness of information and services provided by a country on national government portals for engaging its citizens in public policy through information and communication technologies. In 2014 the methodology applied to calculate this index was modified, being broken down into three stages (UN, 2014). In order not to lose the data available for this variable from 2010 to 2012, we used the global index value.

The Human Capital Index (HCI) consists of four components, namely: adult literacy rate; the combined primary, secondary and tertiary gross enrolment ratio; expected years of schooling; and average years of schooling. In 2014, the methodology for calculating this index was also modified, which might explain the significant changes in the values since that year. We are aware that it would have been advisable to use other variables related to the level of formation, skills and familiarity of citizens in the use of technologies. These data are not available for all the countries in the sample and for the whole period analysed, and for this reason they could not be included in the panel under study.

Regarding Trust in government, we used the indicator "Share of survey respondents indicating high confidence", for the years 2008 to 2016. These data, available at the country level, represent the population index of the country that has responded, in the survey conducted by Democracy Barometer, to express high confidence in its government. There is a lack of country-level data on the confidence that individuals have in e-government. For this reason, we have selected the indicator developed by the Democracy Barometer.

The variable Rurality was measured through the indicator% Rural

Table 2
Variables, indicators and data source.

Variable	Indicator	Source
Use of e-government	Percentage of individuals who reported having used the internet for interaction with public authorities (% Users)	EU (2018b) (Eurostat)
E-government evaluation	e-Participation Index (EPI)	UN e-Government Surveys (2010, 2012, 2014, 2016 and 2018)
Trust in government	Share of survey respondents indicating high confidence (Trust in government)	Democracy Barometer (2016)
Education	Human Capital Index (HCI)	UN e-Government Surveys (2010, 2012, 2014, 2016 and 2018)
Rurality	% Rural Population over total population (% Rural)	World Bank (2008, 2010, 2012, 2014 and 2016)
Age	Percentage of population over 65 years of age (% Age > 65)	World Bank (2008, 2010, 2012, 2014 and 2016)
Income	Gross National Income pc (GNIpc)	World Bank (2008, 2010, 2012, 2014 and 2016)

Table 3
Descriptive statistics for the study variables.

	% Users	EPI	Trust in government	HCI	GNIpc ($)	% Age >65	% Rural
Mean	47.16	62.86	52.37	76.6	36,202	14.33	26.03
Typical Deviation	18.68	25.43	20.99	22.9	20,292.87	5.57	12.06
Max.	88 (Denmark 2018)	100 (Netherlands 2014; UK 2016; Finland 2018)	87.86 (Finland 2010)	97.4 (Belgium. 2018)	104,540 (Norway 2016)	22.71 (Italy 2018)	50.37 (Slovenia 2010–2018)
Min.	10 (Bulgaria 2010)	2.63 (Bulgaria 2012)	−17.86 (Poland 2016)	29.3 (Malta 2010)	6040 (Bulgaria 2010)	2.3 (Norway 2014)	2.10 (Belgium 2018)
N	135	135	135	135	135	135	135

population over total population; the variable Age was measured through the variable% of population over 65 years; and the variable Income has been measured through the indicator Gross Nationale Income pc. All of them have been obtained from the World Bank database for the years 2008, 2010, 2012, 2014 and 2016.

Table 3 shows the descriptive statistics for the variables for the period 2010–2018.

Starting with the % users, a general increasing trend is observed throughout the period, presenting an average value of 47.16%. The highest percentage is reached by Denmark in 2018 (88%) in contrast to Bulgaria (10%) in 2010.

As for EPI, a generally increasing trend is also observed, being the countries with the lowest starting values, therefore, those with the greatest room for improvement, those experiencing the greatest increases. Having said that, the strongest variations take place between 2010–2014 (e.g. Slovakia, Italy, Greece, Luxembourg) compared to 2014–2018 (e.g. Croatia, Czec Republic, Slovenia and Denmark). The maximum values (100) are reached by Netherlands in 2014, UK in 2016 and Finland in 2018, while the minimum (10) is recorded by Bulgaria in 2012.

The percentage of citizens who show confidence in their government fluctuates between −100% and 100%, with an average value of 52.37%. Confidence generally decreases in most countries. The maximum value is presented by Finland (87.86%) in 2010 and the minimum value by Poland (−17.86%) in 2010.

As for the level of education, measured through the Human Capital Index, it reaches an average value of 76.6, on a scale from 0 to 100 points. However, as a result of the change in calculation methodology referred to above, between 2010 and 2014 all countries experience increases, while between 2014 and 2018 there are slight variations. As extreme values of this indicator we find the maximum in Belgium with 97.4 points in 2018, compared to the lowest represented by Malta in 2010 with 29.3 points (before the change).

Throughout the period analysed, the percentage of population over 65 years of age is on average 14.33%. This percentage ranges from 2.3% in Norway 2014 to 22.71% in Italy 2018. The values of this variable show a general decline in 2014, and a recovery in 2018.

In terms of revenue, the average GNIpc stands at $36,202, peaking in Norway in 2016 ($104,540) and its lowest in Bulgaria in 2010 ($6040). The variations experienced show that the economic crisis affected the countries in the sample differently.

Finally, the percentage of the population living in rural areas has an average value of 26.03%. Overall, the percentage declines in most countries over the period. The country with the maximum value is Slovenia in 2018 (50.37%), while Belgium records the minimum in 2018 (2.1%).

3.2. Data analysis

The hypotheses were tested using a multiple linear regression analysis and a cluster analysis. The multiple linear regression was conducted on 135 observations for the 2010–2018 period. All the independent variables were included as there were no high correlations between them. Regarding the goodness of fit, the R^2 and adjusted R^2 statistics revealed the explanatory capacity of the model (0.692 and 0.678, respectively).

For the cluster analysis, we applied the hierarchical cluster method. The variables were standardized by z-score transformation and Euclidean distances with Ward's method of clustering were used. Similarly to other studies that use cluster analysis in e-government or open government data research (e.g., Holzer et al., 2010; Pina et al., 2010; Silal et al., 2019; De Juana-Espinosa et al., 2019), the cluster analysis applied allows countries to be grouped together to construct types that should reflect the percentage of Internet users related to the independent variables. To investigate the groups of countries over time, a cluster analysis was run using data from 2010, 2014, and 2018.

4. Results

Table 4 shows the results obtained with the linear regression model applied to the complete panel, with a confidence level of 95%.

The results reveal a significant association between the use of e-government and evaluation of the offer of electronic government, level of education, level of trust in governments and the population's per capita income, with the highest beta coefficient corresponding to GNIpc (0.506). The percentage of rural population and that of the population aged over 65 years were non-significant.

For the cluster analysis, the grouping variable was percentage of users. The number of clusters was determined using dendrogram analysis, with three clusters being chosen as the optimum number. The countries included in the three clusters at the beginning, middle and end of the period are those shown in Table 5.

CL1 represents the lowest percentage of user values. The countries grouped in this first cluster across all three periods, were Bulgaria, Croatia, Czech Republic, Greece, Italy and Poland. CL2 groups the countries where the user percentage values are intermediate. The countries that remained in CL2 across all three periods were Austria, Germany, Ireland, Slovakia, Slovenia, Spain and the United Kingdom. Finally, the countries that fell in CL3, that of the highest user percentage values, across all three periods, were Finland, Luxembourg, Netherlands, Norway and Sweden.

In addition, between 2010 and 2014 seven countries moved from cluster, showing and important increase in the use of e-government: Belgium (92%), Hungary (50%), Malta (64%), Portugal (105%), Latvia (135%) moved from CL1 to CL2, whereas France (27.08%) and

Table 4
Multiple linear regression analysis. Dependent variable (% Users).

	B	Sig.	Lower limit	Upper limit
EPI	0.189	0.005	0.043	0.235
Trust in government	0.314	0.00	0.169	0.389
HCI	0.286	0.00	0.137	0.330
GNI pc	0.506	0.00	0.00	0.001
% Age >65	0.086	0.165	−0.121	0.699
% Rural	0.049	0.428	−0.112	0.262

Table 5
Clusters identified at the beginning, middle and end of the period.

2010			2014			2018		
CL1	CL2	CL3	CL1	CL2	CL3	CL1	CL2	CL3
Belgium	Austria	Finland	Bulgaria	Austria	Denmark	Bulgaria	Austria	Denmark
Bulgaria	Denmark	Luxembourg	Croatia	Belgium	Finland	Croatia	Belgium	Estonia
Croatia	Estonia	Netherlands	Czech Republic	Estonia	France	Czech Republic	Germany	Finland
Czech Republic	France	Norway	Greece	Germany	Luxembourg	Italy	Greece	France
Greece	Germany	Sweden	Italy	Hungary	Netherlands	Poland	Hungary	Latvia
Hungary	Ireland		Lithuania	Ireland	Norway		Ireland	Luxembourg
Italy	Slovakia		Poland	Latvia	Sweden		Lithuania	Netherlands
Latvia	Slovenia			Malta			Malta	Norway
Lithuania	Spain			Portugal			Portugal	Sweden
Malta	United Kingdom			Slovakia			Slovakia	
Poland				Slovenia			Slovenia	
Portugal				Spain			Spain	
				United Kingdom			United Kingdom	

Denmark (69.39%) evolved from CL2 to CL3. All of them presented levels of use that were initially higher than the average of their cluster. Use increased in all countries except in Italy, despite the extraordinary raise in its EPI (265.98%).

Between 2014 and 2018, five countries changed their cluster, as result of a relevant raise of their levels of use: Greece (44%) and Lithuania (25%), which moved from CL1 to CL2, and Estonia (42.59%) and Latvia (46.81%), which started being in CL2 to end in CL3. The first two presented the higher initial values of use for their cluster, whereas Estonia and Latvia were higher than the average of their cluster. Use increased in all cases with the exception of Bulgaria, Poland and Slovenia.

Using Table 5, we computed the frequency with which each country appeared in each cluster. The following table, Table 6, shows the predominant three groupings (hereinafter referred to as Low cluster, Medium cluster and High cluster), including in each of them the countries that appeared in that cluster in more than one of the three moments of time under study: 2010, 2014 and 2018. It was decided to position Latvia in the Medium cluster as it appeared in a different cluster in each of the analysed years. Finally, an analysis of variance (ANOVA) was conducted to confirm the existence of significant differences between the clusters, with a confidence level of 95%.

In Table 6, it can be seen that all the countries in Low cluster, with the exception of Italy and Greece, are from Eastern Europe, while High cluster is formed by countries from Northern Europe together with France and Luxembourg. The other countries, including Spain, United Kingdom, Portugal, Ireland and Belgium form the most heterogeneous group, the Medium cluster, corresponding to the intermediate scores. It is worth noting that Ireland, Spain and the UK are positioned in the Medium cluster due to their mean scores on e-government use, despite their values on the EPI being notably higher than the mean in their group.

Next, using the absolute mean values, we conducted a cross-sectional analysis of the clusters at the beginning (2010), middle (2014) and end of the period (2018).

Fig. 1 shows the independents variables' mean values in each cluster for 2010 year. In this figure, similar to Figs. 2 and 3, central hexagon adopts value 0 and each one more concentric hexagon increases its value ten units. The scale to measure the variables variation runs from 0 to 100.

In Fig. 1, it can be seen that, at the beginning of the period, the countries included in the Low cluster present lower mean values showing relative disadvantage on all the variables compared to those in the Medium cluster, with the exception of% Rural, which is slightly lower in the Low cluster, and HCI, which is similar. A comparison of the Medium cluster and the High cluster reveals a similar disadvantage for the countries in the Medium cluster, with the striking exception of EPI, whose score is 56.72 points, compared with 43.42 points in the High cluster. Thus, it is worth underlining that in the countries in the third cluster, which present the highest use values (62.8%), the offer of electronic government is more modest at the beginning of the period, compared to the Medium cluster and only a little higher than in the Low cluster, where% Users is much lower (20%).

Fig. 2 shows the mean values by cluster at the middle of the period, in 2014. It can be seen that, four years later, the countries in the High cluster, where e-government use is higher, also exhibit the best mean values in performance, trust, income, education, younger population and urban population. The same trend is observed if we compare the Medium cluster with the Low cluster, the latter having the lowest scores. It is also worth underscoring that the Medium cluster no longer leads in terms of evaluation of the e-government offer, being surpassed by the High cluster.

At the end of the study period, in 2018, Fig. 3 confirms that the countries in the High cluster present the highest mean values in all the variables, followed by those in the Medium cluster and finally the countries included in the Low cluster.

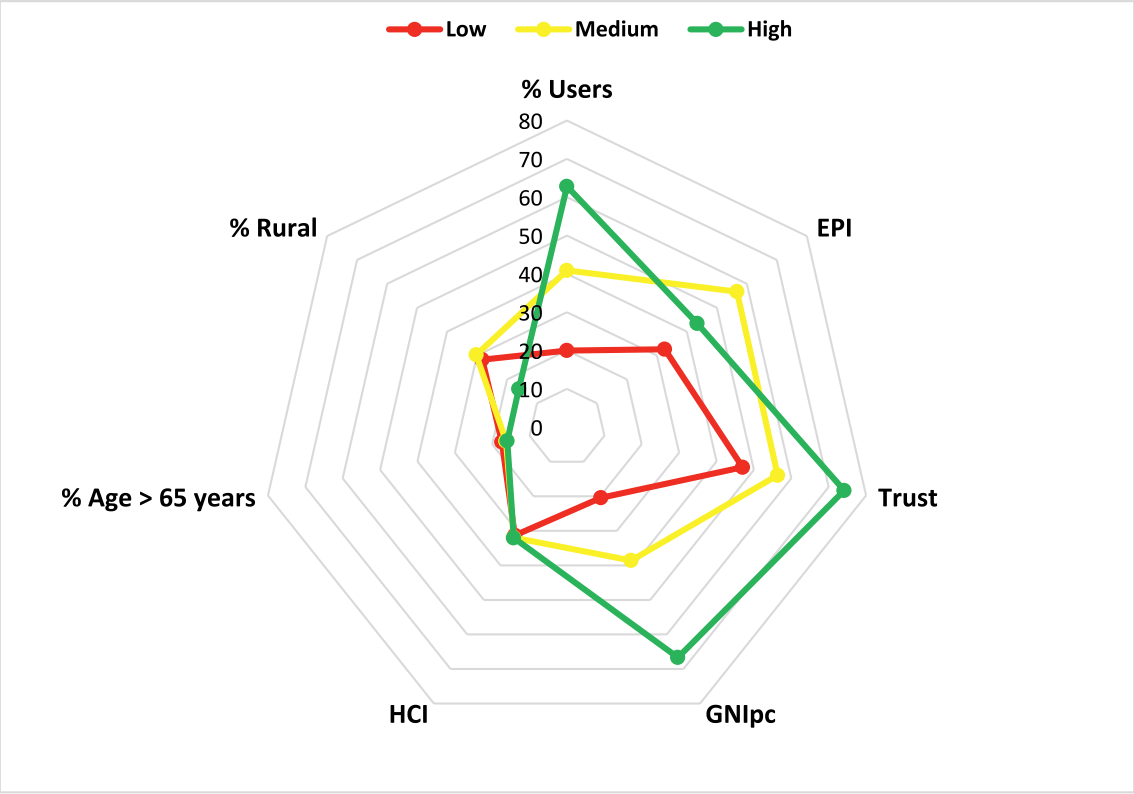
In short, and with the two exceptions in 2010 already mentioned, it can be concluded that as we move from the Low cluster to the Medium cluster and then to the High cluster, the percentage of e-government users increases, accompanied by a more attractive offer of e-government, higher levels of trust in governments, higher per capita income and education and a younger and less rural population. These results support the three hypotheses proposed.

That said, if we analyse the overall evolution of the variation in the variables between 2010 and 2018, interesting findings emerge.

In relation to the first hypothesis, it should be noted that, as shown in Graph 1, while the value for EPI grows rapidly across the period and for all three clusters (151.81% in Low cluster; 51.38% in Medium cluster and 114.95% in High cluster), the increase in use of e-government is much slower (45% in Low cluster; 22.05% in Medium cluster and 23.6% in High cluster). However, it is worth underlining that the largest variation in the number of users is found in the countries with the lowest percentages in 2010. It can be appreciated, therefore, that investments and improvements in e-government from the supply side

Table 6
Predominant clusters over the complete period.

Low cluster	Bulgaria, Croatia, Czech Republic, Greece, Italy, Lithuania, Poland
Medium cluster	Austria, Belgium, Estonia, Germany, Hungary, Ireland, Latvia, Malta, Portugal, Slovakia, Slovenia, Spain, UK
High cluster	Denmark, Finland, France, Luxembourg, Netherlands, Norway, Sweden



2010	Low cluster	Medium cluster	High cluster
% Users	20	40.9	62.8
EPI	32.62	56.72	43.42
Trust	47	56.37	74.16
GNIpc	20,425	38,581	66,672
HCI	31.32	31.96	32.03
% Age > 65 years	17.4	16.31	15.97
% Rural	28.25	30.26	16.04

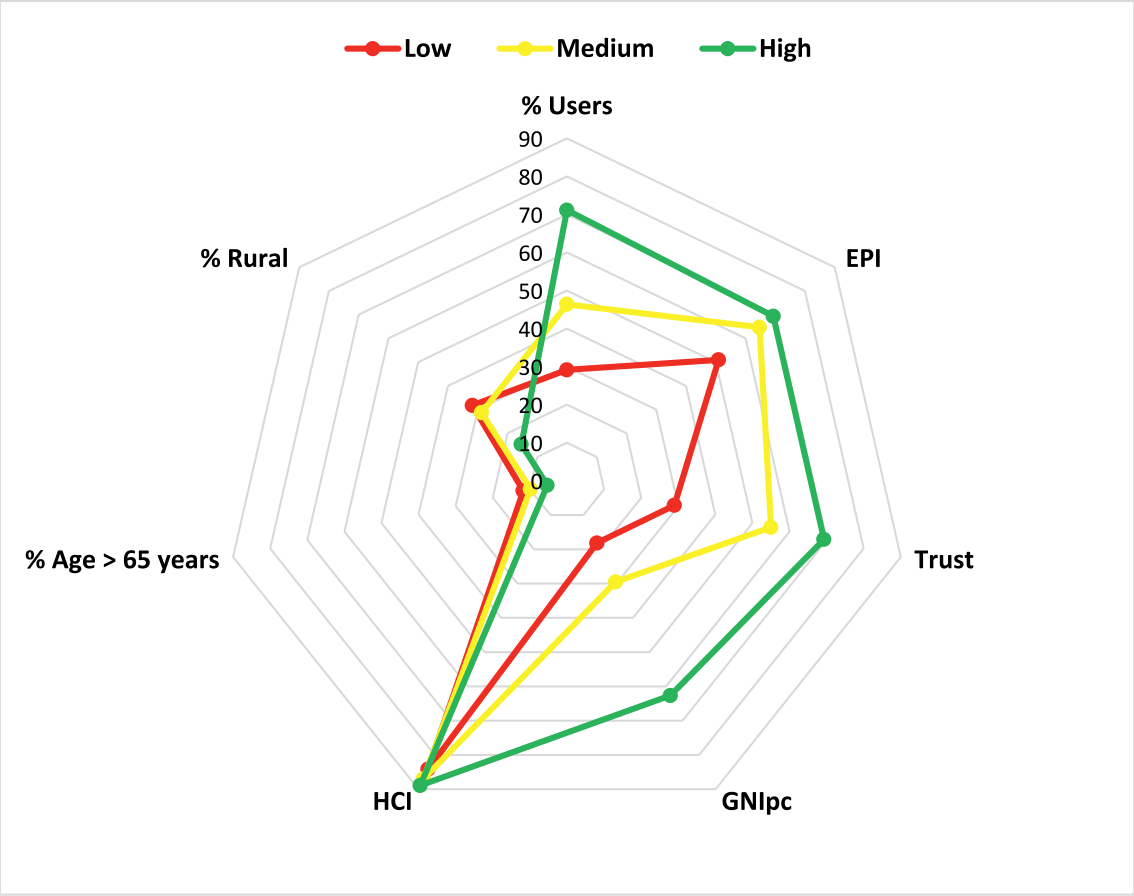
Fig. 1. Mean values for the clusters at the beginning of the period, 2010. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.).

are easily implemented but do not obtain a proportional response in demand for e-government. Despite this detail, our cross-sectional analysis and linear regression analysis, where EPI emerges as an explanatory variable of the model, lead us to confirm the first hypothesis.

As regards the second hypothesis, it has previously been shown that the higher the percentage of e-government users, the greater is citizens' trust in the government. Nonetheless, as shown in Graph 2, while% users increases on average by 30.22% in all three clusters, trust declines by 48.40% in the Low cluster, 14% in the Medium cluster and 11.42% in the High cluster, along the study period. It is interesting to note that, as we move from the Low cluster to the High cluster, e-government increases in both supply and demand, and the decrease in trust is considerably lower, which could be interpreted as a benefit derived from e-government in citizens' perception of their governments. Consequently, the results of the cluster and regression analyses, where the variable "trust in government" obtained a significant beta coefficient, allow us to corroborate the second hypothesis.

With respect to Sub-hypothesis 3a, Graph 3 shows, in first place, the rates of variation in GNIpc across the panel, with an increase in income in the Low cluster of 36%, compared to a drop of 2.47% in the Medium cluster and 34.02% in the High cluster. This might reflect the differing effects of the worldwide economic crisis in the different European countries. The digital divide paradigm holds that higher income levels are associated with higher e-government use. This relationship can be observed and confirmed by comparing the per capita income values in absolute terms at the beginning, middle and end of the period (Figs. 1, 2 and 3). In addition, the GNIpc variable is significant in the regression analysis. Thus, we can confirm the existence of a digital divide according to per capita income level.

As for Sub-hypothesis 3b, Graph 3 also reflects that the Human Capital Index rises across the 2010–2018 period in all the clusters, with this increase being slightly higher in the Medium cluster than in the Low cluster and in the High cluster compared to the Medium cluster. It is worth remembering that the HCI score rose sharply from 2014, due to a change in the calculation methodology, increasing from 2010 values of 31.32, 31.96 and 32.03 in the Low cluster, Medium cluster and High cluster, respectively, to values of 84.13, 86.97 and 88.89 in 2014. In addition, as explained from a cross-sectional perspective, at each



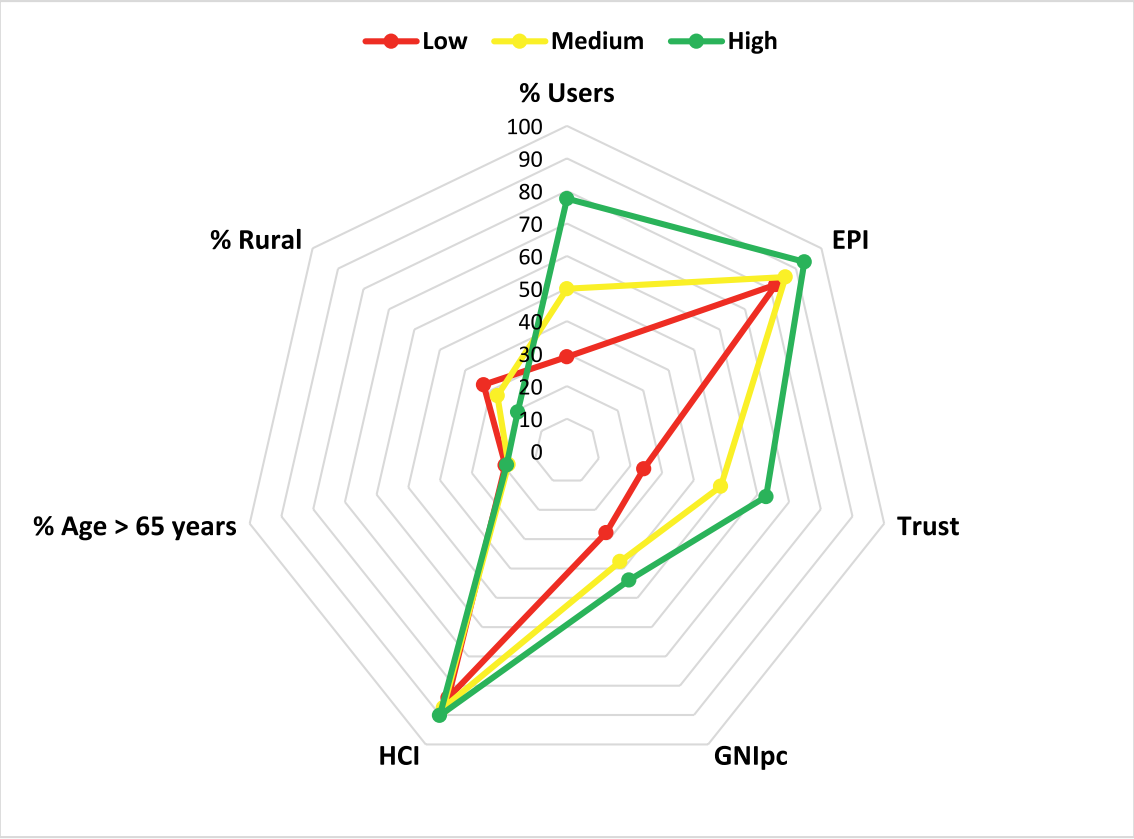
2014	CL1	CL2	CL3
% Users	29.14	46.38	71.14
EPI	50.98	64.71	69.36
Trust	28.98	55	69.29
GNIpc	18,161.43	29,512	62,662.85
HCI	84.13	86.97	88.89
% AGE > 65 years	11.78	9.84	5.31
% Rural	31.77	28.7	15.34

Fig. 2. Mean values for clusters at the middle of the period, 2014. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.).

moment of analysis, 2010, 2014 y 2018, it can be stated that the cluster with the highest percentage of e-government use is also that with the highest education level (Figs. 1–3). All this, in combination with the results of our linear regression analysis, which presented a significant positive beta coefficient for HCI, allows us to confirm the existence of an association between digital divide and education level.

With respect to Sub-hypothesis 3C on population age, Graph 3 reveals an increase in the percentage of persons aged over 65 years across the study period, in all three clusters, with the highest increase being in the High cluster, followed by the Medium cluster and then the Low cluster. This evolution might be generated by the positive association between life expectancy and wealth in the countries, given that the High cluster exhibits the highest levels of per capita income. In addition, by means of the cross-sectional analysis previously conducted for each moment of time (Figs. 1, 2 and 3), it was observed that the percentage of older adults exhibited a certain negative association with e-government use. This association was highest in the Low cluster, where use was lowest, and lowest in the High cluster, where e-government use was highest, with the exception of 2018, where the percentage of older adults was slightly higher in the High cluster (18.99) compared to Medium cluster (18.46). However, it should be stressed that these variations between groups were very small. This, together with the results of the linear regression analysis, which revealed the non-significance of this variable, means we cannot confirm the relationship between the age of users and the percentage of e-government users.

Finally, with regard to Sub-hypothesis 3d, the variation in percentage of rural population does not show a homogenous behaviour across the three clusters. Graph 3 reveals that the rate of variation increases in



AÑO 2018	Low cluster	Medium cluster	High cluster
% Users	29	49.92	77.62
EPI	82.14	85.86	93.33
Trust	24.25	48.48	62.79
GNIpc	27,786	37,629.23	43,988.75
HCI	84.13	87.5	90.15
% AGE > 65 years	19.44	18.46	18.99
% Rural	32.76	27.33	19.34

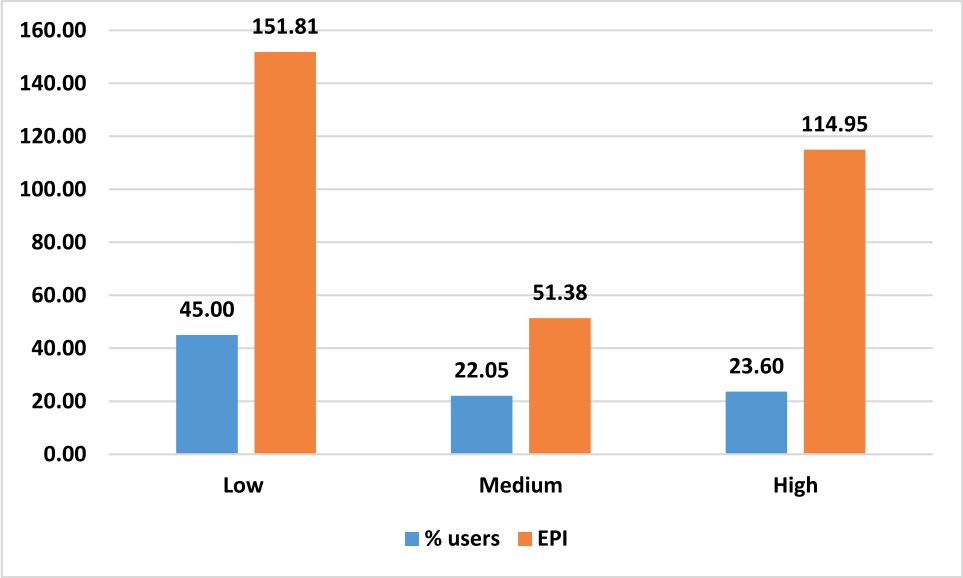
Fig. 3. Mean values for clusters at the end of the period, 2018. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.).

the Low cluster by 15.96%, declines slightly in the Medium cluster by 9.68% and increases in the High cluster by 20.57%. There appears to be no association between this trend and that of the percentage of e-government use, which rises in all three clusters along the study period. Nonetheless, the cross-sectional analysis for 2010, 2014 and 2018 coincides, albeit weakly, with the inverse relationship between belonging to rural environments and use of e-government suggested under the digital divide paradigm, given that in Figs. 1–3 it could be seen that clusters with a lower rural population percentage in absolute terms also presented the highest levels of e-government use. The weakness of this association, in conjunction with the non-significance of this variable in the regression analysis means that evidence for a digital divide as a result of rural populations cannot be said to be conclusive.

Table 7 presents a synthesis of the acceptance and/or rejection of the proposed hypotheses:

5. Discussion

Based on the results of both our regression analysis, which demonstrated a significant positive relationship (beta = 0.235) between the use of electronic government and supply-side e-government performance evaluations, and the cluster analysis, the first of the proposed hypotheses can be accepted. This is consistent with the postulates of the TAM, according to which the perceptions of individuals influence the level of e-government use. This positive relationship corroborates the conclusions of previous studies such as those by Reddick (2011) and Nam (2014). Moreover, Ma & Zheng (2017) confirmed the influence of EPI on citizen satisfaction with e-participation services. Zheng and Schachter (2017) found that greater citizen satisfaction with e-participation services results in greater use of, and participation in, such services. In addition, Park et al. (2013) evidenced a significant positive relationship between e-government use and e-information services used as a variable to evaluate supply-side e-government content.



Graph 1. Growth rates for % users and EPI between 2010 and 2018 by cluster.

A more in-depth analysis of our results shows that, despite an increase in the percentage of e-government users and scores on EPI over the study period, these increases are not proportional. Tolbert and Mossberger (2006) already detected this gap between e- government availability and usage even in advanced countries. According to the UN (2012) report, this gap means that many potential benefits of e-government are concealed and have not been fully realized. In this sense, coinciding with Teerling & Pieterson (2010), it is our opinion that governments should make an effort to promote e-government, developing a citizen-oriented communication strategy that focuses on increasing citizens' awareness of these services and informing them about the benefits of e-government.

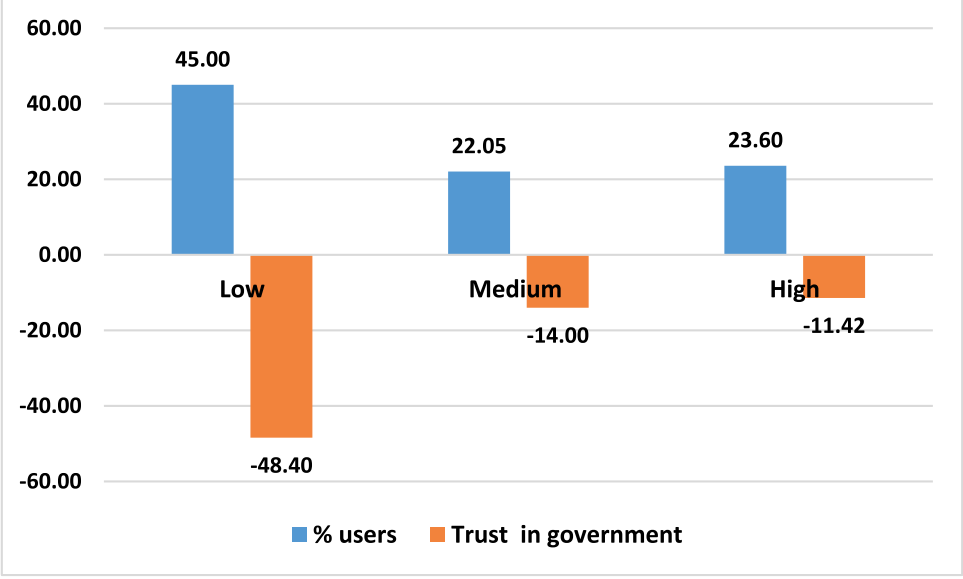
Regarding the second hypothesis on the relationship between the percentage of e-government users and the level of trust in governments, it was observed that the higher the level of trust in a government, the higher is the use of e-government services and vice versa.

An analysis of the evolution over time of all the variables in conjunction reveals, on the one hand, a clear generalized decline over the years in levels of trust in government. On the other hand, we observe that the sharpest decline in trust is found in the countries in the first cluster, where e-government use is lower, with the fall being less dramatic in countries in the third cluster, where e-government use is more widespread.

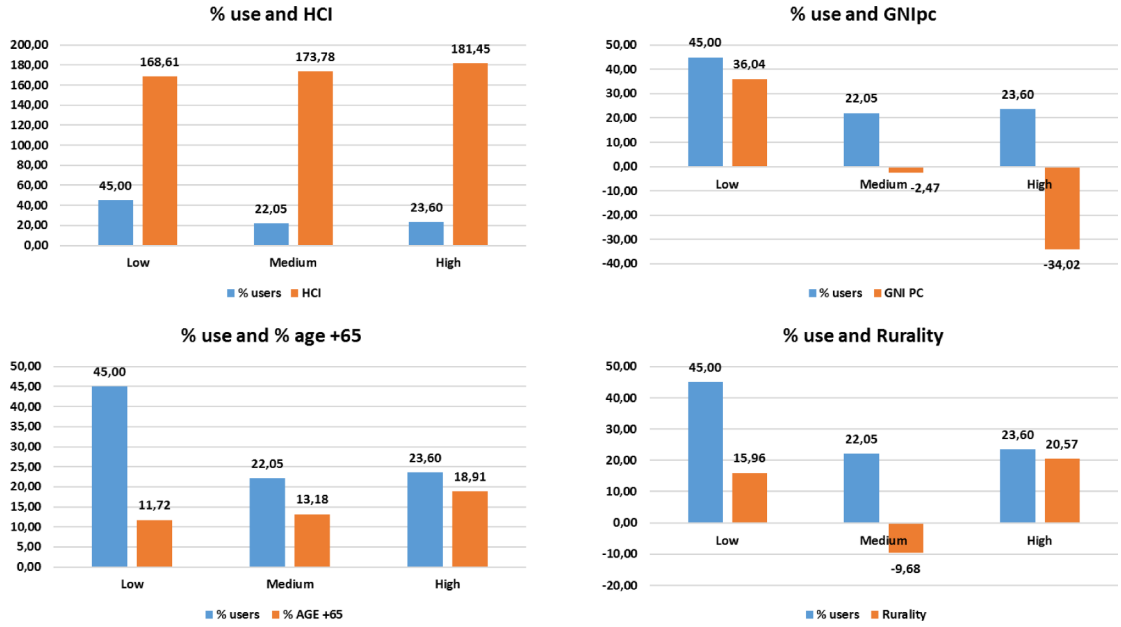
The confirmation of our second hypothesis, however, is not in line with the findings of studies. Thus, Goldfinch et al. (2009), for example, reported a significant negative relationship between e-government use and trust. Reddick (2011) found a significant negative relationship between citizen trust in federal government and participation in public policies. Nam (2014), finally, held that the relationship between the trust of citizens in government and e-government use is non-significant.

With regard to the results for the third hypothesis on the relationship between e-government use and the existence of a digital divide, we can confirm a positive association between e-government use and educational level and per capita income.

For Sub-hypothesis 3a, the regression analysis also reveals a significant positive relationship between this variable and the dependent



Graph 2. Growth rates for % users and trust between 2010 and 2018 by cluster.



Graph 3. Growth rates for % users and digital divide between 2010 and 2018 by cluster.

variable, and again, the highest percentage of e-government use is found in countries with the highest per capita income. This positive relationship was also identified in the studies by Goldfinch et al. (2009) and Reddick (2011). However, this finding is contradicted in the studies by Taipale (2013) and Nam (2014). Finally, Park et al. (2013) found no significant relationship between per capita income and the number and length of Internet visits.

As regards the relationship between education and e-government use (Sub-hypothesis 3b), our results support this association, which is consistent with the findings of Goldfinch et al. (2009), Reddick (2011), Nam (2014), Taipale (2013), Zheng and Schachter (2017) or Ma and Zheng (2017).

For Sub-hypothesis 3c, we found no conclusive evidence to support an association between e-government use and population age, which is in line with the findings of Reddick (2011), Taipale (2013), Nam (2014) and Ma & Zheng (2017). Other studies, such as those by Goldfinch et al. (2009) and Zheng & Schachter (2017) conclude that younger populations are more frequent users of available electronic government services.

Finally, regarding the notion that rural or urban environments have an impact on e-government use (Sub-hypothesis 3d), we found no conclusive evidence. While the cross-sectional analysis reveals greater use of e-government services in countries with lower percentages of rural populations, this variable was not found to be significant in the regression analysis. This runs counter to the findings of Nam (2014). Goldfinch et al. (2009) argues that e-government use is significantly higher in urban areas compared with rural areas, while Taipale (2013) also reports that the higher the percentage of rural population, the lower is citizen e-participation in government services.

The above discussion helps us to answer the first of our research objectives.

With regard to the second research objective, we have been able to observe that the 27 European countries included in our study are grouped in three large blocks regarding their levels of e-government use: Low cluster, Medium cluster and High cluster. Throughout the rest of the section, we will connect our results with those obtained by the E-government Benchmark Report (EC, 2018a), hereinafter referred to as the Report. It should be noted that this report refers only to data from the year 2016 and that it uses indicators for measuring the use and supply of e-government other than those of our work. These indicators are Penetration (P), which can be described as the extent to which use of the online channel is widespread among users of government services; and Digitisation (D), described as the digitisation level of the back- and front office. The Report classifies the European countries in four clusters: non-consolidated e-government (low D and P), unexploited e-government (low D and acceptable level of P), expandable e-government (low P and high D) and fruitful e-government (high P and D). Despite this, we find many similarities between the groups identified in that Report and the clusters we have reached in our research.

With regard to the Low cluster, interesting findings can be derived

Table 7
Synthesis of the results of testing the research hypotheses.

HYPOTHESES		RESULTS
H1: A positive relationship exists between e-government evaluations from the supply-side and citizens' use of e-government.		Acceptance (+)
H2: A positive relationship exists between trust in government and citizens' use of e-government.		Acceptance (+)
H3: A relationship exists between the digital divide and citizens' use of e-government.	*H3a: A positive relationship exists between income and citizens' use of e-government*	Acceptance (+)
	H3b: A positive relationship exists between education and citizens' use of e-government	Acceptance (+)
	H3c: A negative relationship exists between ageing and citizens' use of e-government	Non-conclusive results
	H3d: A negative relationship exists between rurality and citizens' use of e-government	Non-conclusive results

from our study. For example, it is striking that it is in the first cluster that e-government use most increases (45%) over the study period, as well as e-government supply measured by the EPI (151%), representing a considerable mismatch between the two growth rates. It is also worth noting that the decline in trust in government is also highest in the first cluster (48.4%). At the same time, the countries included in the Low cluster coincide, for the most part, with those classified by the Report in the group of countries with non-consolidated e-government, as low-performing in penetration, with the only discrepancy being Lithuania, considered by the Report as a country with high levels of both penetration and digitisation. For this country, according to our results, it is from 2016 when the use is close to 40%, with an EPI level of 80.34%. For previous years, Lithuania shows use values not exceeding 28%. For this reason, Lithuania jumps to cluster 2 in 2018 and not before, having experienced a growth in use by 104% over the period 2010–2018. In addition, the report identifies the countries that underperform in penetration compared to countries with a similar environment, specifically the Czech Republic and Italy, which are also included in our Low cluster.

In the Medium cluster, there is a lower discrepancy between the growth rates of the percentage of e-government use and the EPI compared to those in the Low cluster, arguably a result of the fact that the starting values on the EPI were higher in the Medium cluster. Some countries in this cluster have a highly developed set of e-government services in terms of EPI but fall in this cluster due to an intermediate level of use. It is worth mentioning the case of the UK, which, according to the Report, shows high levels of Penetration but underperforms in Digitisation, which makes it classified within the group of countries qualified as Unexploited e-government. These results do not seem to coincide with ours. Based on the analysis carried out during the whole period 2010–2018, UK shows intermediate levels of use: until 2014 it only raises it by 7.5% and in the second period it rises by 23.26%, reaching a value of 53% of use, which does not allow it to jump to the High cluster. This occurs even though its e-government offer is high, as it starts from the second highest value of EPI after Spain and both end the period with the highest value of their cluster, 98.31.

In a similar vein, the report identifies Estonia as the best-in-class in terms of both indicators, while our study positions it in the Medium cluster, since that is the cluster where it was located in 2010 and 2014, having increased it usage level in 45.95% along that period. From 2014 to 2018 Estonia's usage level grows another 42.59%, changing to cluster High. In terms of EPI, this country starts the period with the second highest value of its cluster (68.57) and it raises it up to 91.01 Despite this fact, in 2018 Estonia presents the lowest value of EPI in cluster High, with the exception of Latvia (68.54).

In addition, the countries included in the High cluster coincide with those identified in the Report as high performers in penetration, with the exception of Luxembourg, which is classified in the group of Non-consolidated e-government countries with values close to but below the European average. It is worth noting that our results, although placing Luxembourg in cluster High, also show that this country presents the lowest usage level of its cluster at the beginning of the period (60%) and, while improving it along the years, it does not reach the mean value in 2018 (76.72%). Similarly, its initial EPI value (17.4) is one of the lowest of the 27 countries studied, and its extraordinary growth (447.37%) keeps it just above the average of cluster High in 2018 (93.33).

On the other hand, it has been observed that most countries remained in the same cluster during the whole period (for instance, Bulgaria in the Low cluster, Spain in the Medium cluster or Sweden in the High cluster). However, other countries have experienced an inter-cluster movement. These cases are discussed below.

We would like to start by highlighting the case of Denmark, which in 2010 is located in the Medium cluster, moving on to the High cluster in 2014 where it remains. It starts from values higher than the average of the Medium cluster in practically all variables. In 2014 and 2018 its level of use is the highest of the High cluster (83%; 88%), having shown a growth of 79.58%. As for EPI, in 2014 it was below the average (54.9%), but it rises it by 82%, so that in 2018 Denmark -along with Finland- steal the leadership from the Netherlands, reaching the value of 100. In this sense, UN e-government Survey (2018), indicates the effort of the Danish government to maintain the e-government offer at levels above 99% and percentages of use close to 90%, which makes this country occupy the first place in the world in terms of e-government. According to UN (2014), since 2012 the entire public sector in Denmark provides access to an enormous amount of information and services. It paves the way for an efficient user interface with effective streamlining of public sector departments. En 2012, the electronic invoicing saves taxpayers €150 million and businesses €50 million a year. The example of Denmark illustrates the importance of citizens' and businesses' perceptions of the economic benefits of using e-government by generating cost savings without sacrificing the quality of services.

Next, we will refer to some of the countries that were initially in the Low cluster and moved to the Medium cluster in 2014 (Hungary, Malta, Portugal and Latvia, having this country ended the period in the High cluster) or in 2018 (Greece). The experience of these countries shows the existence of a positive relationship between the investment in the e-government offer and the level of use by citizens, reinforcing the first hypothesis of our work.

Latvia, Hungary and Malta have been classified as emerging countries, advancing to 32 positions in the world e-government rankings. Their investment effort makes them different from other countries with similar GDPpc figures but whose e-government offer is much more modest (UN, 2014). In this sense, our results reflect how, throughout the period, they experienced significant growth in their GNIpc (90%, 91% and 78%), which was accompanied by improvements in EPI (152.5%, 125.3%, and 147%) and usage (245%, 71.42%, 76%). For instance, the UN (2014) refers to the case of Malta. As part of the e-government strategy to enhance citizen communication with the government, Malta provides timely notifications and alerts citizens to government services of interest through multiple delivery channels. These services are updated continuously to provide the latest information on governmental and also provides citizens with news regarding ongoing and new e-government initiatives. This example shows that the multi-channel nature of e-government is key to increasing citizens' exposure to the offer of digital public services and thus promoting their use and exploitation.

On the other hand, although in a context of economic austerity, most of the governments has not had an impact on their level of e-government spending. This can be attributed to their support for e-government implementation as a key strategic tool to achieve wider public governance goals that support economic recovery and serve citizens. This finding is in line with Glyptis et al. (2020) for the Cypriot context. From our study, it is interesting to highlight the case of Portugal, whose revenues fall 5.75% between 2010 and 2014, while its e-government offer increases 138.43% and its use grows 105.26% in the same period, which makes it jump to the Medium cluster. Likewise, Greece has intensified its effort to offer services that had previously been off-line (UN, 2018). Between 2010 and 2014 this country is the hardest hit by the crisis, suffering an 18% drop in pc revenue, followed by a 50.37% drop in confidence. At the same time, its EPI climbs 212.68% and its use rises 161.54%. In the second study period, its use increased again by 44.12%, which justifies its passage from the Low cluster to the Medium cluster in 2018.

There are other countries that being in the Medium cluster in 2014 moved to the High cluster in 2018. This is the case of Estonia, France and Latvia. Estonia, as it was previously mentioned, represents an important growth in its e-government offer. According to UN (2018), since

2014 Estonia has implemented systems for on-line voting (I-voting or online voting) already existing in the Netherlands or Sweden. Generally, it should be noted that the countries located in the High cluster are not only those with the best levels of use and EPI, but also those that have most improved their e-government offer in order to encourage citizen participation in public affairs.

6. Conclusions

In response to our first research objective we can affirm that, in the light of our results, the level of citizens' use of e-government services in Europe is influenced by the quality of the national offer of such services, the levels of citizens' trust in governments and the digital divide generated by populations' per capita income and citizens' level of education. Besides, as an answer to our second research objective, our findings reveal the existence of patterns of behaviour between the 27 European countries as regards the way those variables interact with the use of e-government services over time.

The following practical implications can be derived from the study:

- Government investment in e-government can contribute to raising the use of e-government but such growth cannot be expected to be proportional. At the same time, not all countries have capitalised equally on their investment in e-government in terms of its use. This evidences the existence of other factors that influence use. In this regard, it is a requirement that citizens perceive the economic benefits of using e-government to interact with their governments. Only a citizen-centric e-government policy, accompanied by an appropriate communication and promotion strategies, can help balance the levels of supply and demand.
- Despite financial austerity, countries have opted to invest in e-government as a key strategic tool to achieve wider public governance goals, support economic recovery and serve citizens. At the same time, countries that have experienced strong growth in their level of wealth have also directed their efforts toward investing in e-government, obtaining returns on use by citizens.
- Government should strive to boost citizens' trust in their actions, and our findings suggest that encouraging e-government use might contribute to this goal. The use of e-government cannot prevent a decline in confidence, but it does appear to have an attenuating effect. This relationship appears to be bidirectional, as greater levels of trust seem to encourage greater use of e-government facilities.
- Public investment in e-government projects will only achieve cost-efficiency by bridging the digital divide and guaranteeing equitable usage of e-government by all citizens. In this sense, our study confirms that public policymakers should take action to assure less affluent and educated citizens are also benefiting from e-government functions, in order to reduce the differences in e-government use across countries in Europe. In this sense, it has been shown that the High cluster countries are characterized by a clear commitment to e-participation, as a tool for citizen empowerment.

Some limitations to our study should be underlined, particularly related to the availability of data at the national level for the construction of the panel. It would have been desirable to have a variable that measured the level of confidence in e-government and technology by citizens in each country. Similarly, we have not found adequate data on the level of ICT training and skills. it has also not been possible to differentiate between the voluntary use of e-government and that which is forced due to the non-existence of a traditional offer. Other variables, such as the use of social media, could not be considered either.

In future works, we would like to transfer our methodology to other contexts different from Europe.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.techfore.2020.119973.

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