Pressing the Button for European Elections 2014: Public attitudes towards Verifiable E-Voting In Greece[1]

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Abstract. We present the initial set of findings from a pilot experiment that used an Internet-based end-to-end verifiable e-voting system and was held during the European Elections 2014 in Athens, Greece. During the experiment, which took place on May 25th 2014, a number of 747 people voted with our system in special voting stations that were placed outside two main polling places in Athens, Greece. The election mimicked the actual election that was taking place, which numbered forty political parties. After casting their ballot, voters were invited to complete a questionnaire that probed their attitudes towards e-voting. In total, 648 questionnaires were collected. We present a description of the experiment and a regression analysis of our results. Our results suggest that acceptance of the e-voting system was particularly high especially among the most educated, the technologically adept but also – somewhat surprisingly– older generations.

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1. Introduction

Even though the issue of electronic voting has attracted increased scholarly attention during the last decade, studies over the acceptance of such systems by the mass public and the factors behind individual-level variance in acceptance remain scarce. This paper aims to advance relevant literature by presenting individual-level correlates of attitudes toward electronic voting from Greece. In particular, we test the impact of sociodemographic and familiarity with technology on three key components of acceptance of an e-voting system, namely: a) the perceived easiness of the e-voting system b) participants' willingness to see the system being adopted for national elections and c) participants' attitudes to cast their vote remotely using an e-voting system. The trial was conducted in polling stations during the 2014 European Elections. Our results suggest that acceptance of the e-voting system was particularly high especially among the most educated, the technologically adept but also – somewhat surprisingly– older generations.

2. E-voting Evaluations

Available evidence on the public reception of an electronic voting system mainly comes from the United States and Latin America. Past research has shown that e-voting systems are viewed rather favorably by citizens who participate in the trials (Alvarez, Katz and Martinez 2009, Sherman et al. 2010). As for individual level-factors Sherman et al. investigated the impact of a number of characteristics for the case of the US in a convenience sample consisting of 105 volunteers who replied on advertisements. Their results illustrate that acceptance of the electronic voting system depends significantly on the extent to which participants had a basic understanding of the e-voting system (2010). On the other hand, Alvarez et al. (2009) studied acceptance of different e-voting devices in the case of Colombia using a non-representative yet extended sample consisting of 2294 respondents coming from three cities. Their results showed that acceptance of the system was particularly high, exceeding 80 percent of positive responses in perceived reliability of the system and 90 percent in perceived easiness. Nonetheless, highly educated and –surprisingly– the eldest age groups were more likely to regard the system as more reliable.

3. Short Description of the E-voting system DEMOS[3]

DEMOS is a remote e-voting system that supports end-to-end verifiability (i.e. the voter verifies that her vote was tallied properly) and voter privacy. The system builds on elements from the ADDER system (Kiayias et al. 2006) and incorporates techniques such as code-voting (Chaum 2001), secret-sharing homomorphisms (Benaloh 1986) as well as a number of novel features. Recall that in code-voting, the voters obtain a ballot that contains a list of the candidates, each of them associated with a unique vote-code, and vote by submitting the vote-code that corresponds to the candidate of their choice. Tallying takes place by combining cryptographic elements that relate to the submitted vote-codes. Our system comprises a number of cryptographic elements that include perfectly binding commitments and suitably designed zero-knowledge proofs. The complete description of the system is beyond the scope of the present paper; in this section we present a short overview of the system that will be sufficient to explain the way the experiment took place.

3.1 Setup

In the pre-election phase, an *election authority* (EA) generates double ballots that have a unique serial number and consist of two equivalent parts (**A** and **B**) containing all information needed to vote. Namely, in each part, every candidate is associated with a randomly generated vote-code, which is cryptographically paired with a *vote-code recording receipt* (Fig. 1). The double ballots are randomly distributed to the voters by EA. Next, the

[3] The complete description of the system is out of the scope of the present report.

EA uses the commitment scheme to create a table **T** where all ballot information is committed (the candidates are first encoded and then committed). The committed ballots are sorted according to their serial numbers and the parts **A** and **B** (e.g. 100**A** , 100**B**, 101**A**, 101**B**, 102**A**, etc.). Then, EA posts **T** on a public bulletin board (BB) and provides a *keyholder* (KH) with the de-commitment information and a *bulletin board authority* (BBA) with the list of pairs of vote-codes and vote-code recording receipts. At the end of the pre-election phase, the working tape of EA is destroyed and the EA will not participate any longer in the computation. Note that the KH functionality is distributed to a number of parties via standard secret-sharing to ensure better privacy. These parties will only be active once at the end of the election and need not be interacting with each other to complete their assigned task. Finally, the BBA functionality can be distributed to a number of parties for robustness and guaranteed output delivery.

3.2 Vote-casting

Vote secrecy in DEMOS is ensured by the random distribution of the ballots, so that the serial numbers are in no way linked with the voters. When each voter receives a double ballot, she chooses a random side for voting (the other one will be used for auditing). The double ballot idea for ensuring voting integrity was used in a number of previous systems (e.g., in the Scantegrity system, Chaum et al. 2008). Then, she sends to the BBA the vote-code for the candidate of her choice. This can be done by clicking a button in a user-friendly environment, or manually by typing the vote-code in case the voter does not trust her voting client. The BBA reads the vote-code and if it is valid, it produces the vote-code recording receipt that this vote-code is paired with. It provides to the voter the vote-code recording receipt that can check in her ballot that her vote was correctly recorded by the system. In more detail (refer to Fig. 1 for terminology), the voter can compare the vote-code recording receipt provided by the system to the vote-code receipt appearing next to the party and vote-code of his choice on the ballot's used facet and, thus, if both are identical, be certain that his vote was properly cast through the electronic voting system. An important feature of DEMOS is that choosing (randomly) one of the two ballot parts for voting, the voter generates (ideally) one bit of randomness that is posted on the BB.

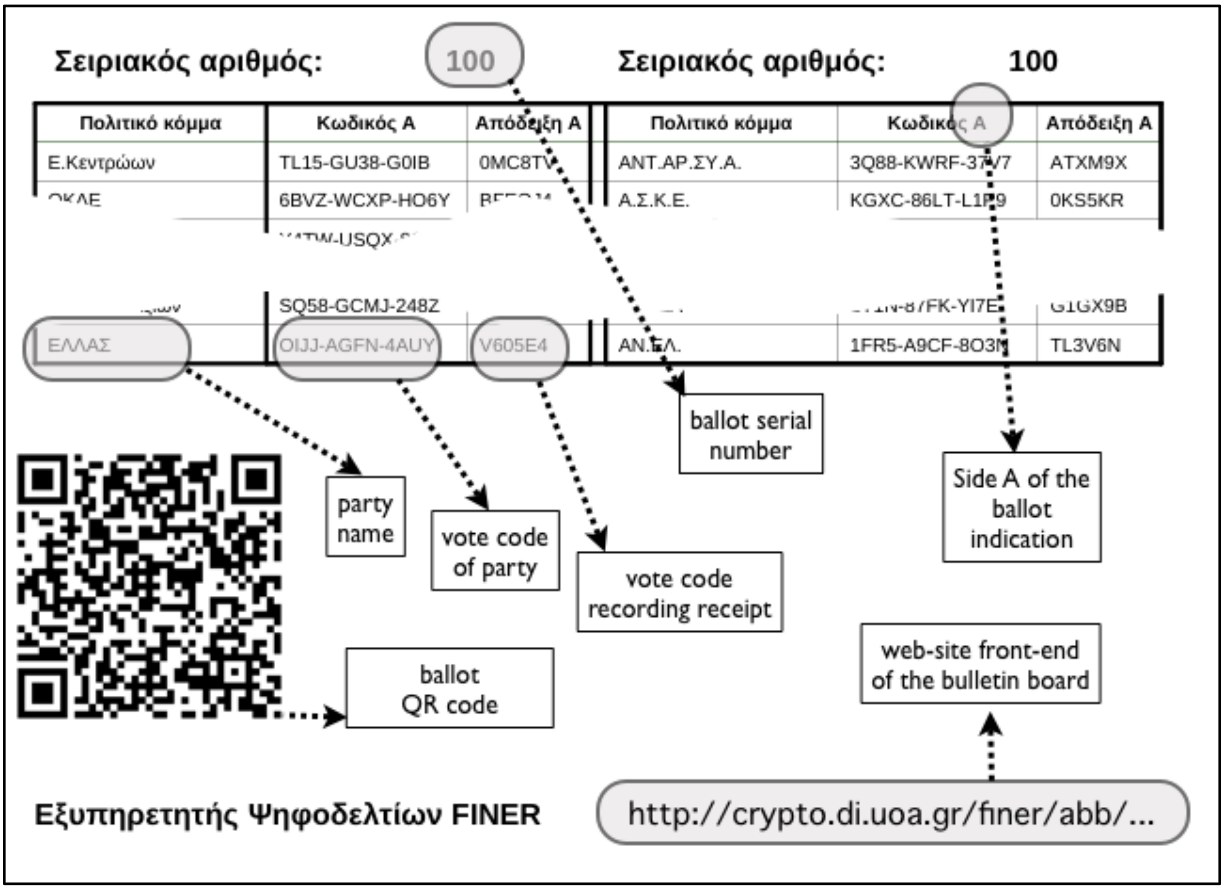


Figure 1. Facet (A) of a paper ballot.

3.3 Vote Tallying and Verifiability

After the voting phase has ended, the tally is computed as follows:

1. The BBA marks properly all commitments that correspond to the voted options (see also Fig. 2 for screenshot of this view).
2. The KH reads from the BBA the voted options and provides all the necessary de-commitment information and zero-knowledge proof information.

3. The BBA adds homomorphically all the marked commitments and opens their sum, which is the election result in encoded form. Finally, it publishes the encoded election result. We note that the result can be efficiently decoded by any party, without the possession of a secret key.
4. Additionally, BBA opens all information for the ballot parts that were used for auditing (Fig. 2) allowing the verification of the correspondence between vote codes and parties.

E2E verifiability in DEMOS is achieved (with high probability)[4]:

1. Because any observer can extract the election result and verify the ZK proofs.
2. By the auditing of the ballots: the voter can verify that her ballot was not altered by a malicious party by checking that the perfectly bound opening of the ballot part used for auditing matches the part that the voter obtains. Observe that the malicious EA can guess the facet that will be audited only with 1/2 probability. This implies that the probability of altering *t* votes without being detected decreases exponentially in *t*.

[4] We stress that the security analysis of the system is not the purpose of the present paper. However we do present some elements from the analysis in order to give the reader a feel of how the system works. A complete security analysis of our system is the subject of upcoming work.

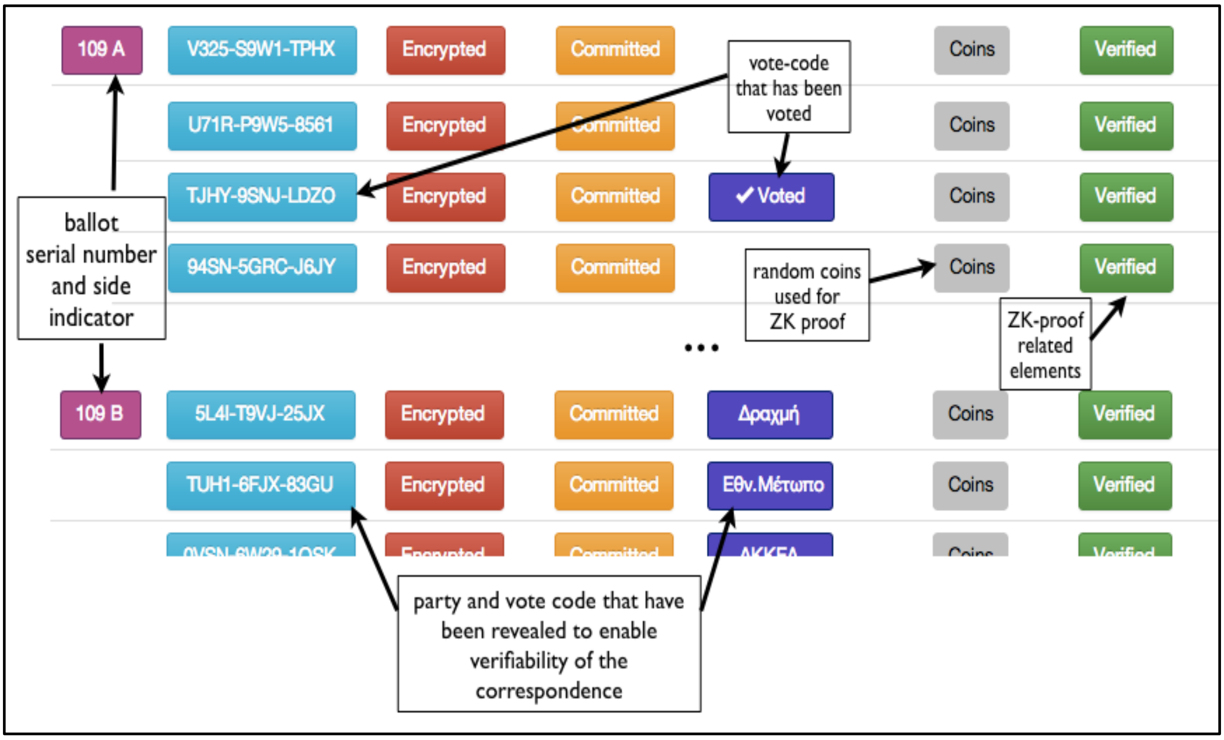


Figure 2. The verification and tally bulletin board.

3.4. The Pilot Implementation of E-voting DEMOS

In our pilot experiment, each participant received a paper ballot where in each facet, besides the lists of candidates, vote-codes and vote-code recording receipts, there was a *QR code*, which, if scanned, lead to a web rendering of the ballot, with an easy to use interface, where candidate parties appeared in buttons the user can click on. In the trial of the system presented below, voters used tablets with cameras to scan paper ballots and voted electronically through the interface described above. Furthermore, since all voters voted on site, issues of vote-selling or coercion that are typically linked with remote voting were not raised or examined[5].

[5] Still voters were informed about the functions of the pilot system and its potential application for remote i-voting and, as presented further in the analysis of the distributed questionnaire findings, they were asked whether they would use it to vote from home for national elections. Our system accepts further enhancements to (partially) deal with the issue of coercion that are out of scope for the present exposition.

As mentioned above, the system provides for the capability of verification of the integrity of the tallying process, a feature that reinforces transparency, as well as reliability and accountability. In our pilot experiment, by using their ballot's unique serial number, voters could trace their ballot and check (a) that their vote was properly marked as "voted" and (b) that in the unused version of the ballot all selection codes correspond to the proper candidate parties that were shown in the paper version of the ballot. This covers one of the two parts of the E2E verifiability check of DEMOS. Note that the complete check requires also the verification of zero-knowledge proofs that may be done by external observers (including any voter if they wish to do so). This aspect was not tested on our trial (i.e., no third party zero-knowledge verifiers were commissioned).

4. The Pilot Experiment

The trial was conducted on two different polling stations for the 2014 European Elections in the premises of two public schools in highly populated municipalities in the greater Athens metropolitan area. While the actual election procedure was being held inside the school buildings, a set of desks was placed right outside within the guarded courtyard and next to them there were banners that informed the public regarding the trial that was taking place. In each site, two tablets were placed on the desks supported by an elevated Plexiglas stand that allowed for the insertion of the A4 paper ballot underneath (containing the serial number of the "electronic envelope", the codified candidate parties, the *vote-codes* corresponding to them, their *vote-code recording receipts* and the QR code).

Four assistants in each site conducted the trial. Assistant A was responsible for calling one out of every four voters that had already participated in the conventional elections, to participate in the e-voting procedure. In case of refusal, Assistant A called the next one and took note of the refusal. Assistant B accompanied the participants to the desks with the tablets, where the other two Assistants were handing them the ballot and helping them scan it under the tablet. Then, keeping a distance to ensure privacy, Assistants C and D, would, if asked to by the participant, offer clarifications or guidance on the use of the e-voting system and the optional electronic completion of the subsequent questionnaire.

Figure 3. The configuration of the pilot experiment.

Before leaving, participants were given two leaflets, one containing information about the e-voting system function and features, with emphasis on its procedural safeguards for transparency, verifiability, accountability, reliability and security, and another containing a set of simple directions for the successful completion of the verification procedure.

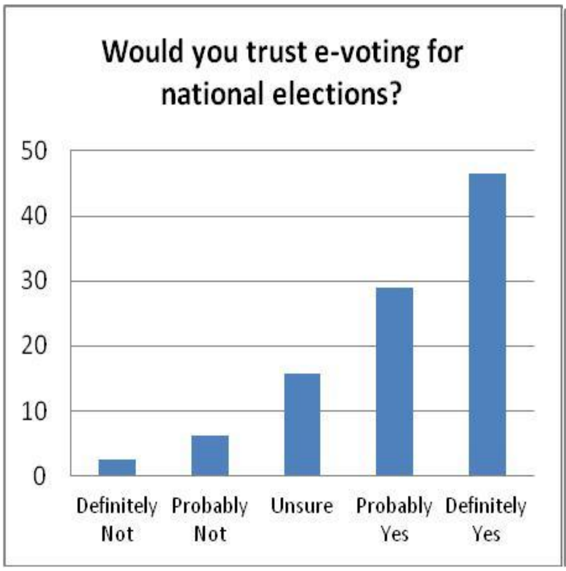
A total of 747 people participated in the e-voting trial, while 648 of them filled in the relevant questionnaire that followed the actual e-voting procedure. Table 1 reports the demographic details of the sample. The average participation rate was 61.5% in both sites, i.e., about 6 out of 10 voters of the actual voting procedure agreed to participate in the e-voting pilot. The website of the project, (whose address was only publicized in the paper ballots), received 231 unique visits (i.e., a rate of about 30% of the total people that participated) during the next two days. In addition, 21 participants (about 2.8%) chose to make use of the verifiability process and actually locate their ballot assigned to them. It is worth noting that while the verifiability turnout may seem small we consider it satisfactory for our experiment as the verifiability aspect was very briefly explained to each voter (none of which showed any familiarity with this level of secure e-voting design) and the voters were aware of the fact that the pilot election was not binding in any way (and hence one would expect a lower interest in verification than it would have been in case the election was binding). Furthermore, the actual election results were available through other means to all voters (e.g., via regularly conducted exit polls with results broadcasted in the national TV). It is also worth noting that even with as little as 21 verification checks (if done properly) our system would have been capable of providing a reasonable level of election integrity.

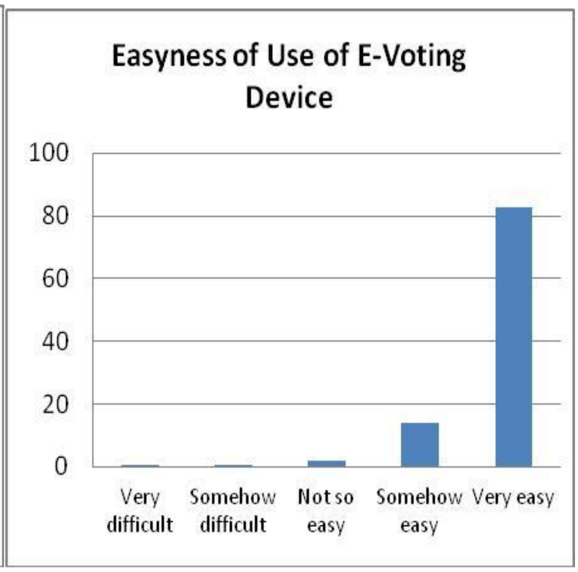
	Percent
Gender	
Male	50.9
Female	49.1
Age	
15-24	12.8
25-34	16
35-44	24.5
45-54	22.8
55-64	15.9
65 or older	7.8
Level of Education	
Up to six years	2
Six to nine years	3.3
High school graduate	19.3
Some college	13.3
Higher education graduate	41.5
Postgraduate education	20.7

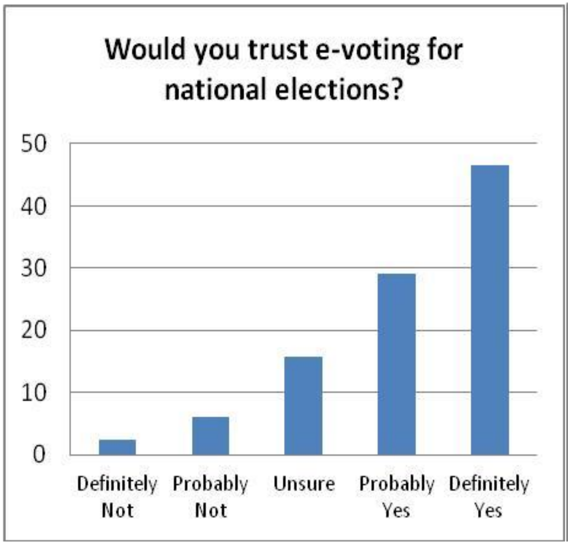
Table 1: Demographic Composition of Athens Sample

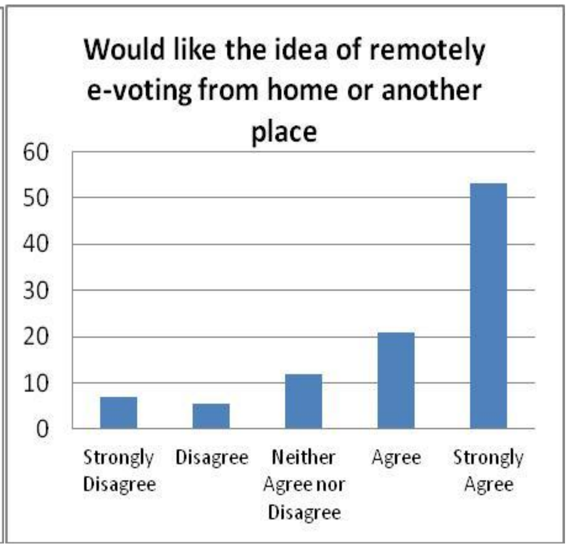
4.1 Statistical Analysis Results

We measured respondents' attitudes toward e-voting through a number of items. Attitudes toward the device were highly positive (Graphs 1-4). Starting with overall satisfaction, nearly 90 percent of respondents answered that they were "somewhat" and "very" satisfied with the electronic voting experience. Moving on to the perceived difficulty of using the e-voting device, 82.7 percent of respondents found its use "very easy", while only 1.2 percent answered that they faced problems using the device. Apart from easiness of use and satisfaction, we measured trust and attitudes toward the adoption of remote electronic voting for national elections. Respondents' attitudes were again very positive: 47 percent of the sample said they would trust an e-voting device such as the one they used for the conduction of European elections, while less than one in ten (8.6 percent) appeared negative toward such an implementation. As for attitudes toward remote electronic voting, roughly three out of four respondents were somehow or very positive toward the prospect of being able to vote in national elections from home with a use of a similar device, while only 12.4 percent appeared dismissive toward this prospect.









Graphs 1-4: Distribution of Post-test Respondent Attitudes toward E-Voting

Even though the acceptance of e-voting was quite high in the sample we have reasons to expect that the aggregate distribution masks significant individual-level variation. A number of scholars have argued that the use of electronic voting could possibly create a turnout gap between technologically adept and novices (Norris 2004, 2005, Gibson 2005). Hence, the argument goes, as the old and less educated are least adept in using technology these population segments will be less likely to vote using an electronic voting device and consequently they may be more skeptical toward the introduction of e-voting devices, and especially remote e-voting devices. In order to investigate whether these trends are evident *after* respondents have used electronic voting devices we construct three linear regression models, measuring the impact of sociodemographic characteristics (age cohort, gender, level of education) and Internet use (through a dummy variable separating non-Internet users from the rest of the sample) on (a) difficulty using the e-voting device (Model A) (b) trust in e-voting for national elections (Model B) and (c) attitudes toward the prospect of voting from home or another place using a remote electronic voting device (Model C).

	Model A		Model B		Model C	
	Easiness of use		Trust		Attitude toward Remote Electronic Voting	
	b	S.E.	b	S.E.	b	S.E.
Male	0,00	0,04	0.01	0.08	-0.07	0.09
Age cohort						
15-24						
25-34	-0,05	0,08	0,50***	0,14	0,53**	0,17
35-44	0,05	0,07	0,73***	0,13	0,60***	0,16
45-54	-0,09	0,07	0,79***	0,13	0,66***	0,16
55-64	-0,08	0,08	1,02***	0,14	0,67***	0,18
65 plus	-0,30**	0,11	1,17***	0,20	0,83**	0,24
Education	0,03**	0,02	-0,01	0,03	-0,01	0,04
No internet access	-0,42***	0,10	-0,07	0,18	-0,09	0,22
Easiness of Use			0,59***	0,07	0,69***	0,09
Adj. R_2	0.12		0.16		0.11	
N	624		620		618	

Table 2: OLS Regression of Easiness of Use, Trust toward E-Voting and Attitudes toward remote e-voting. *(Entries are unstandardized OLS coefficients. Standard errors are reported in the second column.* **: $p < 0.05$; ***: $p < 0.01$)

Beginning with variation in individual-level variation in the difficulty of using the e-voting device, results suggest that educated respondents found it easier to use the device. On the other hand, perceived difficulty was significantly increased for participant categories that are less likely to be familiar with technology, namely respondents aged over 65 years and those who do not use the Internet. Model B reports the respective OLS regression results on trust of e-voting for national elections, using the same independent variables as Model A plus the item measuring perceived difficulty. Results suggest that, all else equal, facility with the e-voting device is associated with general trust toward e-voting, as those who found the use of the electronic voting device easy were more likely to trust the implementation of an electronic voting for general elections. What is striking however is that, all else equal, older aged cohorts appear significantly more trustful toward electronic voting compared to younger age cohorts. This finding that seems paradoxical at first has also appeared in other countries (Alvarez et al. 2009) and can be attributed to the fact that younger respondents who are more knowledgeable on issues of technology are more likely to be aware of possible security threats than older and less technologically familiar respondents (Alvarez et al. 2009). Surprisingly, level of education[6] on the other hand is not associated with trust toward electronic voting. The lack of impact of the level of education is against previous findings (Alvarez et al. 2009) and needs to be further investigated. Moving on to Model C, which measures variation in attitudes toward remote electronic voting, results suggest that the extent to which one finds remote electronic voting a good idea mainly depends on age and perceived difficulty of using the electronic voting device. Again, as was the case with trust toward e-voting, older respondents appear more positive toward remote electronic voting. What is more, participants who found the use of the e-voting machine easy were significantly more likely to respond that they would like to be able to vote remotely with an e-voting device. Yet it should be noted that the explanatory power of all three models, as indicated by the adjusted R^2 is rather low, meaning that there exist additional latent factors that account for variation in attitudes toward electronic voting in Greece.

[6] It should be noted that the insignificance of education persists with alternative codings as well as when perception of e-voting difficulty and internet use are removed from the model.

Conclusion

Electronic voting systems are deemed as a cost-effective alternative for conducting elections, having a promising potential for the quality of democratic representation especially among distinct social groups that may face difficulties accessing polling stations. Yet studies investigating the acceptance of e-voting by the general public remain scarce. This paper advanced the literature on electronic voting by presenting evidence on attitudes toward electronic voting from Greece. Three main conclusions can be drawn from the analysis. First, our results point to the conclusion that acceptance of electronic voting could be fairly high in the general population, bringing additional evidence to confirm previous research by Alvarez et al. (2009) and Sherman et al. (2010). This finding however should be interpreted with caution as the sample was skewed in regard with age and level of education, compared to the general Greek population. An additional parameter that may have boosted positive responses is that respondents took part in the trial after having tried the e-voting device. Second, the aggregate distribution of preferences toward e-voting masks significant individual-level variation: Citizens who are already familiar with technology, those who found e-voting easy and older age cohorts were significantly more likely to be supportive of its implementation in national elections. These results appear to substantiate the worry that the advent of electronic voting could possibly create a gap between segments of the population who are familiar with technology and those who are not. On the other hand gender and education were unrelated to e-voting preferences. Third, sociodemographic characteristics and familiarity with technology account only for a small portion of the total variation in acceptance of electronic voting. Future research could shed more light to the pattern of attitudes toward e-voting from a comparative perspective and further investigate latent parameters that may have an impact on attitudes toward e-voting.

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APPENDIX

It is of some interest to note that the answers collected by our e-voting sample seem to be divergent from the actual election result. Still, the divergence factors, far from being exorbitant, may be interpreted considering the following factors.

First, it should be made clear that the comparison between real and e-voting results is not direct. That is to say that e-voting results are can only be compared not to the ones of the voting stations at which our pilot implementation took place, but to the overall results noted at the municipalities where our e-polling stations were situated. This is due to the fact that we are not able to gather from the pertinent authorities the final accurate results coming out of the voting stations we had chosen for our exit poll. However, we consider that this approach does not seriously affect the comparative image portrayed below (Table 3).

	Pilot	Real results	Positive divergence	Negative divergence
SYRIZA	31,8	29,8	2,0	
ND	18,8	21,4		-2,6
Golden Dawn	4,5	7,4		-2,9
Elea	6,3	6,9		-0,6
Potami	10,8	8,4	2,4	
KKE	4,0	6,8		-2,8
ANEL	2,5	3,2		-0,7
Other	21,3	16,1	5,2	

Table 3 : Voting results from the pilot e-voting research compared to the real final overall elections results of the relative municipalities.

Second, the observed divergences do not outreach the limit of +/-3%, with the exception of the "Other Parties" which are not analytically presented here since they represent 35 different small parties that failed to reach the 3% threshold on a national level. This threshold is provided from law in order for a party to win a European Parliament seat. The divergence at this case was greater than 3%, reaching at the e-voting exit poll a 5,2% more than the actual result.

Finally, third, the above divergence, as well the (smaller) ones referring to the parties which are analytically presented, may be adequately interpreted by looking more closely at the age groups represented in our sample and comparing them to the age groups which took part in the election. The following Table (Table 4) accounts for the age structure of the electorate.

	Pilot	exit poll results	Over-representation	Under-representation
18-24 y.o.	12,8	7,2	5,6	
25-34	16,1	12,9	3,2	
35-44	24,5	18,5	6,0	
45-54	22,8	21,9	0,9	
55-64	16,0	19,3		-3,3
65+	7,8	20,2		-12,4

Table 4: Age Structure of the the pilot e-voting sample compared to that of the electoral body as referred to the 'official' exit poll of the elections day.

Voters under 54 are over-represented to an overall 15,7%, while older voters (of 55+ y.o.) are under-represented. This divergence could be interpreted as unwillingness to participate in the electronic voting trial. Thus, based on the above evidence, we conclude that the deviation of the pilot sample is within what one may have reasonably expected given the bias of the sample. The statistical validation of this claim is beyond the scope of the present study.