How Much Does an e-Vote Cost? Cost Comparison per Vote in Multichannel Elections in Estonia

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Abstract. We are presenting the results of the CoDE project in this paper, where we investigate the costs per vote of different voting channels in Estonian Local Elections (2017). The elections analyzed involve different processes for casting a vote: Early Voting at County Centers, Advance Voting at County Centers, Advance Voting at Ordinary Voting District Committees, Electronic Voting, Election Day Voting, and Home Voting. Our analysis shows how the administrative costs per e-vote (an electronic vote) are half the price of the second cheapest option (Election Day Voting), representing the most cost-efficient way of organizing elections, given the conditions of this Case Study. Otherwise, different forms of convenience voting have much higher costs, giving us subjects for further discussion on how to organize multichannel elections.

Keywords: Multi-channel elections · Calculation of costs · TDABC BPR

1 On e-Government, e-Voting and Calculation of Costs

Since McLuhan coined the notion of a global village [42] for the current Information Society [56] we adopted, naturalized and routinized the use of technology for several constituents of our daily life. The leap to an online world of Public Administration [36] had often been regarded as a potential cornerstone for managerial reform and creating future systems of governance [45]. In relation to this, e-government, following Yildiz [61] can facilitate better structures for interconnectivity, service delivery [5], efficiency and effectiveness [24, 50], decentralization, transparency and accountability. Citizens, already used to relating with others (friends, family and businesses) use online tools and consider the use of e-government measures as a normal step in the development of technology-based relationships [8].

Estonia is one of the pioneering and leading countries in adopting e-government tools [1, 27, 32, 51], thanks to the three layers forming the backbone of their government services: the X-road system, the electronic ID and the service provision eesti.

ee [41]. Amongst the causes for this success Kalvet [27] lists: (1) utilizing an e-commerce role model for the use of ICT in the public sector [55]; (2) the presence of enthusiastic and visionary civil servants who developed information systems in the public sector [63] and politicians focused on developing a program of e-government [17]; (3) a favorable legislative environment towards ICT; (4) stable funding for ICT expenditures; (5) the adoption of the Estonian ID-Card by public administration; and (6) cooperation between the public and private sectors, especially the banking sector *as a generator of expectations regarding e-government services and as a general catalyst for e-government* (p. 146). As a result, Estonia represents an ideal venue for observing different dimensions of e-related expressions such as e-government, e-voting, e-banking or e-commerce [30].

1.1   Convenience Voting and Electoral Complexity

The adoption of e-voting strategies can be inserted into the context of the battle against the consolidated tendency for a declining turnout [4, 39], which is challenging global understanding and the functioning of the democratic process. Some of the causes described for understanding this decline have been summarized as (1) the transition to a less competitive electoral scenario, (2) a generational decline in the will to participate in the political process and (3) a transformation of values that lead to political engagement [6]. The disengagement of citizens at elections threatens the correct functioning of democracy by unbalancing the distribution of power and representation between those who participate and those who do not [37], having spillover effects on the global legitimacy of the system of governance and its decision-making [9, 48]. Many governments and Electoral Management Bodies react by actively seeking out, testing and/or implementing improvements to traditional voting systems, presuming that a more convenient voting system will have positive impacts on the turnout at elections [57].

As a result, new systems for early or convenience voting had been proposed in a number of countries [31, 34], and administrative rules and procedures have been adapted to allow citizens to cast their vote at different moments in the election cycle [20], trying to increase the comfort of voters and ease voters' comfort [2, 7]. Administration of elections represents a necessary factor influencing voter turnout: an adequate voting system might not increase the number of voters, but an inadequate one will definitely decrease it. Although election administration differs from context to context, it is still commonplace that new voting channels cannot replace but can only complement existing methods of participation in elections due to the responsibility to provide a service to the entire electorate [19, 62]. However, the opportunity to rethink and optimize electoral administrative procedures when introducing these additional voting channels is often missed.

The Estonian e-vote remote online voting system, in use since 2005, turns Estonia into the only country in Europe (if not in fact the world) to use this without restriction in all types of elections [54]. The Estonian I-voting project was established in order to sustain and increase voter turnout by creating an additional and convenient voting channel that would be in coherence with efficient use of the infrastructure already in existence [28]. Estonian e-voting systems can be considered a successful and widely

used voting mode (over 30% in the last three elections) but with an unequal impact in different subpopulations [52].

The adoption of multi-channel electoral systems poses a set of new challenges to be considered by public administrations, including additional workloads for electoral administrations, increased vulnerability from double voting, increased length of voting periods or difficulties derived from overlapping voting periods [59]. Previous research studies to evaluate multichannel elections [34, 60] indicated the three main areas of concern: (1) multiple-channel elections increase the complexity for election administrations; (2) the increase in complexity requires business process reengineering of electoral processes; and (3) it involves analyzing the cost of introducing new voting channels. This situation addresses a different dimension in the debate on elections, how to achieve the desired social goals with a reduced economic impact.

1.2 Cost Accounting

The analysis of the costs arising from running elections has attracted researchers' and practitioners' interest, but a large share of the research already conducted on this issue had been focused on the costs for candidates and campaigns [22, 26, 47], the costs for voters [14, 16, 23, 46] or the costs of public information systems [12, 40]. Other projects that addressed the topic revealed (1) the increase in the cost of elections all over the world [44], (2) the need to define different kinds of electoral costs and the analytical scope of the methodology [38], (3) the need to include costs incurred by adding new voting channels, either high one-off costs (e-votes) or transaction costs (postal voting) [35] and (4) the need to overcome the reduced level of transparency and limited opportunities for scrutinizing certain voting modalities [13]. A clear and successfully proven methodology for facing this challenge is still lacking [58], permitting the calculation of costs of multichannel elections overcoming the previous difficulties, amongst others, (1) the lack of depth in approaches for calculating costs based on the assessment of administrative costs through electoral budgets and their division by the number of voters participating [18], the difficulties of uncovering hidden costs and dealing with different accounting systems and governance structures [10, 38] or difficulties relating to the choice of methodology of directly questioning the source (levels of response, overall quality of responses) [25]. Three main problems can summarize the access to the costs of elections: (1) the difficulties in accessing election costs [11], as many democratic governments are not obliged to divulge this information; (2) the difficulties in recovering hidden costs from budgets; and (3) the difficulties of allocating the costs of public infrastructures to the organization of the election.

2 Methodology

For developing the research methodology, we referred to a broader research field of governmental cost accounting and business-oriented methodologies adapted for calculating administrative management costs. Our goal not only relates to detecting potential inefficiencies in the electoral process or to raising awareness of the costs [43], but also, in particular to deliver comparative results of the costs of different voting

channels, in order to enrich the existing literature on e-voting and electoral analysis. To achieve this, our proposed methodology relies on the use of (1) Business Process Reengineering (BPR) [3, 21] for facilitating workflow analysis of complex systems (elections); and (2) Activity-Based Costing (ABC) [15, 33] for calculating costs per service/unit produced by the electoral system (votes), in particular, the use of Time-Driven ABC (TDABC) [29], which reduces the volume of data required for conducting the ABC analysis of (1) the practical capacity of resources committed and the costs involved and (2) unit times for performing transactional activities.

Based on this, a model was developed with the following steps:

1. Conducting electoral process modeling based on the analysis of electoral legislation and publicly available internal instructions, complemented with interviews with stakeholders and on-site observations.
2. Creating a list of activities based on findings from Step 1. Select only those activities which are organized differently depending on the voting channel.
3. Identifying resource pools and determining costs assigned to each resource pool.
4. Attributing costs to activities (attribute directly if possible; attribute by proportional time in other cases) in order to receive total cost per activity.
5. Calculating the practical capacity of resources (we set it at 80% of the theoretical full capacity in line with the standard established in accounting research).
6. Dividing total cost per activity by the practical capacity, to receive cost per minute per activity.
7. Dividing time spent on every activity by output to receive cost per output (in our case, per vote or ballot paper) per activity[1]. Multiply this number by the unit cost of a resource pool in order to receive the cost per vote or ballot paper per activity. Total the cost per vote cast for all activities considered, in order to receive the cost per vote used per voting channel.
8. Comparing costs per vote cast for different voting channels.

3 Case-Study

3.1 Case Selection

As was mentioned above, Estonia has a leading position in the development of e-government and I-voting tools, having aroused the interest of many scholars trying to understand the adoption of these tools by citizens [1], its impact on electoral turnout [53] or internal processes in the I-voting system [40], leading many to consider Estonia as a critical case in any relevant research on e-democracy.

Administration of Estonian elections is rather complex, permitting the multichannel analysis proposed. Voters are simultaneously offered multiple voting channels (Fig. 1). However, not all the voting channels are active during every election (voters residing

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[1] In traditional TD ABC the time per item of output is estimated. However, as is the case with elections, we know precisely how much time is spent on every activity, we receive time per item of output in the manner described above.

outside Estonia cannot participate in Local Elections) and some of the voting channels, when occurring, overlap both in their periods, like advance voting at county centers, advance voting in ordinary Voting District Committees and Internet voting.

Two more elements endorse developing a case study in Estonia. Firstly, the fact that Estonian elections by and large use the existing infrastructure, providing an excellent opportunity to test analytical methodologies directed towards delving into hidden costs. Secondly, the involvement of the Estonian Electoral Management Bodies (State Electoral Office) in developing the case study and also the interests of Estonian administration in implementing a similar cost calculation methodology to the one proposed in this research by 2020.

With this background, Estonia has been selected as the first case for us to test our methodology and model. For this analysis, we focus on the most recent elections in Estonia which happened to be the Local Elections taking place in October, 2017.

3.2 Case Description

Estonian local elections took place from October 5–15, 2017, and offered voters seven different voting channels. Overall, it provided a turnout of 586,519 voters (53.3% of the electorate), including 120,888 early and advance voters (20.6% of turnout) and 186,034 e-voters (31.7% of turnout). 279,597 voters cast their votes on Election Day (47.7% of turnout). The results do not represent a big change from previous local elections in terms of overall turnout, following the series of declining turnouts starting in 2009, but indicate a consolidation of the use of e-voting (31.7% of votes cast) and the popularity of voting in county centers (40% of all early and advance votes were cast in 28 county centers, compared to only 60% of advance votes cast in 549 ordinary polling stations).

In order to conduct the cost analysis, we divided voting channels occurring in relation to time of voting:

- *I-voting* (10th to 4th day before Election Day).
- *Early Voting* (10th to 7th day before Election Day).
- *Advance Voting* (6th to 4th day before Election Day).
- *Election Day Voting*.

  In relation to the voting location, we consider:

- *Supermarket Voting* - Voting organized in county centers (Early, Advance and Election Day Voting).
- *VDC Voting* - Voting organized in ordinary Polling Stations – Voting District Committees (VDC) according to the Estonian legal system (Advance and Election Day Voting).
- *I-voting*.

  This division is based on the following criteria: (1) The differentiation between voting organized online and voting at physical locations (Early, Advance and Election Day Voting) is due to the obvious organizational differences and, as a result, activities and costs involved; (2) voting organized in county centers and voting organized in ordinary VDCs are analyzed separately due to a significant difference in the number of locations (28 county centers compared to 549 ordinary VDCs), staff involved (3–6

Voting Channels for voting in Estonia	
1)	Early voting at county centers
2)	Advance voting at county centers
3)	Advance voting at ordinary VDCs
4)	Custodial voting
5)	Electronic voting
6)	Election day voting
7)	Home voting
Voting Channels for voting from abroad	
1)	By Post
2)	At the Diplomatic Missions
3)	Electronic voting

Fig. 1. Voting channels in Estonia.

members of staff per ordinary VDC and, at least 8 officers per county center), and voting channels offered in these locations (Early Voting is only organized in county centers). Home voting is considered as a subtype of Election Day Voting and, as a result, it is included in this category of our analysis. To analyze it separately, further observations would be required to accurately establish travel time and average number of voters per polling station.

Early voting in county centers is a relatively new voting innovation in Estonia, and it implies that for four days from the 10th to 7th day before Election Day, voters could vote at any of the county centers regardless of the voting district of their residence. In 2017 local elections, 28 county centers were open throughout the country. Half of them were situated in shopping malls, expecting a significant increase in turnout by making the voting process more convenient.

Another important feature of Estonian elections is that early, advance and e-voters are not permitted to override their votes on Election Day. The principle of the precedence of ballot paper voting allows e-voters to override their e-vote with a paper vote but only during the period of early and advance voting, not on Election Day.

3.3   Time Frame, Processes and Activities

As our focus is on cost variation between the different electoral channels present in the Estonian electoral system, we considered the processes occurring in one particular period of the election cycle: the election period [34] (Fig. 2). In Estonia the election period starts 90 days before Election Day with "Informing EU citizens of their right to vote" and finishes three days after the Election Day with the "Resolution of complaints on electoral management". The activities and processes occurring before and after the election period would not add differences to the costs analyzed amongst voting channels, as the activities occurring are the same for every channel.

Based on the analysis of electoral legislation and publicly available internal instructions, complemented by interviews with municipal secretaries responsible for organizing elections, members of EMBs, members of the National Electoral
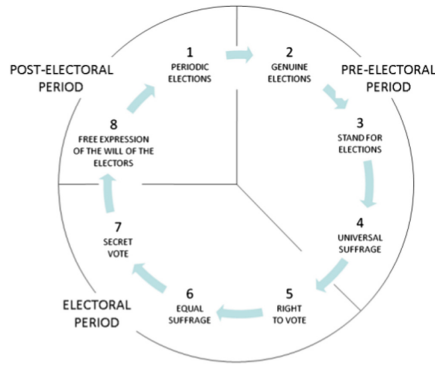
Fig. 2. The electoral cycle [34].

Committee, and the I-voting auditor, as well as multiple on-site observations across the country, we mapped the electoral processes occurring in the time frame under consideration. Overall, we identified 31 processes with 177 activities among which we selected only major processes which are organized differently, depending on a voting channel which constitutes the third step of our analysis. These processes are as follows:

1. Organization of the voting place.
2. Voter identification.
3. Processing votes.
4. Counting votes.

These four major processes consist of different sets of activities depending on voting channel and voting location. There are 22 activities for I-voting, 8 activities for early and advance voting, and 7 activities for election day voting, all of which will be described in more detail in the following section. This represents our list of activities for TD ABC analysis. During the third step of analysis, we identified the following resource pools: labor costs, printing costs, stationery costs, transportation costs, rental costs, costs of equipment and depreciation costs. We assigned costs to those pools based on electoral budgets available, information derived from procurement contracts, interviews, observations and estimates. In order to assign costs we also considered: the ratio of activities consumed by different voting channels to avoid double counting; the number of times an activity is repeated during the electoral period; the time spent in conducting a certain activity; the number of people participating in a certain activity; and the final number of votes cast through every voting channel. For calculating time, we derived data from log files, on-site observations, legislative regulation and interviews. For the fourth step, labor and transportation costs were attributed directly to activities; other costs were attributed based on the proportion of time every activity consumes. Finally, the steps from the fifth to eighth step were calculated according to the model.

3.4   Description of Processes and Activities Analyzed

Organization of the voting place for Election Day Voting consists of many activities from the delivery of ballots, ballot boxes and other equipment to putting the seal on all paper ballots allocated to a polling station. Moreover, the organization of voting places for Advance Voting requires additional equipment and particular skills from the staff. For Electronic Voting, setting up the voting place is no less complicated. For an e-voter, the voting place is the voting application through which a voter casts a vote. However, the supporting infrastructure without which e-votes could not be cast includes: an electronic ballot box (which is a vote storage server), vote forwarding server and the log server [49].

The process of voter identification differs significantly for the different voting channels. During the Election Day, voter identification occurs based only on the printed voters list. During Advance Voting, those polling places allowing voters from outside their place of residence (county centers) conduct voter identification with the help of the electronic voter registers which are updated daily. Therefore, such voting locations must have computers with access to an updated electronic voter register. For voter identification in I-voting, the voter identifies himself/herself with an ID card used via a card-reader in the voter application. Based on the information retrieved from an ID card, the voter application gives a voter an appropriate list of candidates. To cast a vote, a voter puts a digital signature onto the ballot. Alternatively, identification may be completed with the help of digi-ID or mobile-ID.

Processing votes is the least complicated activity for Election Day Voting, as all votes are stored in ballot boxes, and no additional steps are required before the count. Otherwise, processing votes cast during Advance Voting requires transportation of votes from outside the Voting District (VD) to the appropriate VD/County/National Electoral Commission. For this purpose, votes should first be sorted according to their VD. This process also requires delivering votes belonging to this VD. Processing e-votes takes place with the help of an electronic ballot box. All other activities associated with it such as removing the information on a voter from a vote take place during the counting process.

Counting votes depends on the format of votes cast: manual counting of paper votes and automated counting of e-votes. All paper votes in Estonia are counted manually, at least two times. No equipment such as scanners is used in the counting process. However, counting advance votes and election day votes also differ from one another. To count advance votes, first votes should be removed from their envelopes. Then, the second stamp should be stamped on every ballot paper. Finally, advance votes are mixed with election day votes and counted together.

Now, when the differences in how four major processes are organized for every voting channel are explained, we move to the description of different sets of activities constituting those processes for every voting channel.

Regarding **Internet-voting**, we consider such activities as: auditing the I-voting system; organizing seminars and training sessions for observers, the media and all those interested in I-voting (activities aimed at building trust); conducting the

penetration test of the I-voting system; monitoring the network; activities concerning harmonization between I-voting and paper-based voting (printing and transportation of e-voters' lists, manual transfer of e-voters into printed voter lists); counting and recounting of votes (these processes are automated, but by law require certain numbers of officers to be present); storage and destruction of e-votes, voter ID cards, and hard drives. Hence, calculating I-voting costs also considers such **cost pools** as transportation and printing costs, alongside labor costs and depreciation costs which take into consideration the expected life span, initial costs of I-voting system acquisition and the cost of updates and replacement.

Regarding **voting organized in ordinary polling stations**, we consider the following activities: delivery of equipment before voting starts (voting booths, ballot boxes, stamps and others); setting up a voting place (installing voting booths, setting up signs giving directions, setting up tables for voting district committee officers); stamping ballot papers before voting (as in Estonia, every ballot must have a stamp from the voting district where it would be issued to a voter); voter identification during voting days; counting ballot papers; transportation of ballot papers for recounting; recounting. Therefore, among the **cost pools** we consider labor costs, transportation costs, printing costs, stationery costs, rental costs for equipment (mainly renting printers and laptops which polling stations need for advance voting and election day voting, but also rental of voting booths as according to our estimation based on interviews and observation, around 25% of VDCs must hire voting booths for elections as they do not possess their own ones).

Regarding **voting organized in county centers**, we consider all the same activities as for voting organized in ordinary polling stations, with one additional activity, which is processing of advance votes from outside the voting district: two members of staff for every county center are obliged to transport votes from outside their voting district to the National Electoral Commission, then, collect home votes, and transport them back to their county. That is how the exchange of votes from outside cast during the advance voting period is currently organized. Another thing to consider is that counting advance votes always requires more resources than counting election day votes, even when it occurs in the same voting settings, because it requires the additional activities which are removing ballots from envelopes and putting a stamp of an appropriate VDC onto a ballot paper for votes cast. In our model, we take this into consideration. Regarding **cost pools**, we consider labor costs, transportation costs, printing costs, stationery costs, and equipment rental costs. Early voting in county centers requires allocating additional voting booths, ballot boxes, envelopes, laptops and printers for those who decide to vote in a different voting place than their own. Such voting places should also have printed lists of candidates available on request for all voting districts. Such voting districts should also have at least part of their staff trained and able to operate laptops with electronic voter registers and printers.

4   Results and Costs

The use of TDABC analysis allowed us:

– to consider the different pools of administrative costs incurred during the management of local elections in Estonia, including (a) wages, (b) depreciation, (c) transportation, (d) rental, (e) printing and (f) stationery costs;
– to track the electoral expenses incurred by the different protagonists involved in managing elections, including (a) Local Municipalities, (b) State Electoral Office, (c) Estonian Information System Authority (RIA) and (d) others;
– and to allocate those costs to the voting channels, (a) Early Voting at County Centers, (b) Advance Voting at County Centers, (c) Advance Voting at Ordinary VDCs, (d) Electronic Voting, (e) Election Day Voting (including Home Voting) at County Centers and (f) Election Day Voting (including Home Voting) at Ordinary VDCs.

Through process modeling (BPR) we could understand the internal steps for every voting channel and estimate the unused capacity for every model (see Fig. 3). As a result, the TDABC analysis of existing voting channels allows us to allocate numbers to some aprioristic ideas regarding how the costs rise or decline. In particular, the combination of a reduction of use for certain voting channels due to a decline in its popularity but deployment of the same structures and resources (workforce, number of polling stations and working hours), leads to an increase in cost per vote. In particular, our data permits stating that certain forms of Advance Voting have large amounts of unused capacities resulting in low cost-efficiency (higher cost per vote cast) compared to other voting channels.
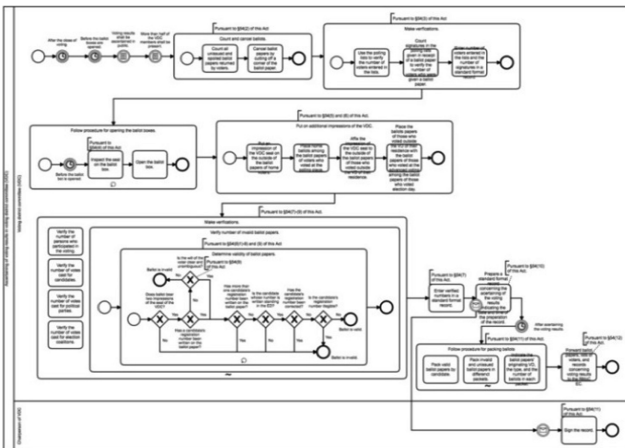
Fig. 3. Model of the activity "Ascertaining voting results in a Voting District Committee".

The analysis conducted shows (Fig. 4) that for the Local Elections in Estonia (2017), the most expensive voting channel was Advance Voting in Ordinary VDCs (3) for which the costs considered constituted 20.40 euros per ballot paper. Next comes Advance Voting in County Centers (2) with 6.24 euros per ballot paper and Early Voting in County Centers (1) with 5.07 euros per ballot paper. Regarding Election Day Voting (6), the costs considered constitute around 4.50 euros per vote cast with almost no difference between county centers and ordinary VDCs. I-voting (5) represents the cheapest option carried out in the 2017 Estonian elections, with 2.30 euros per e-vote cast.

Voting Channel	Cost per ballot (in Euro)
Early Voting in country centres	5,07
Advance Voting in country centres	6,24
Election Day Voting in country centres	4,61
Advance Voting in VDC	20,41
Election Day Voting in VDC	4,37
I-Voting	2,32

Fig. 4. Costs for the different voting channels for Estonian Local Elections (2017).

5   Discussion and Conclusions

This research has a double and complementary goal to take one step forward in the approach to costs involved for elections. First of all, we aim to use an innovative method in order to count the costs of voting systems to be used in multichannel elections, proving the suitability of its use. Secondly, we aim to put our method into practice in a real electoral context, promoting reflection of the costs of different voting channels and their efficiency.

Regarding the methodological dimension, the methodology we proposed could and should be used in different case studies, should be adapted to the context, or in further elections in the Estonian context, in order to allow more general conclusions to be reached. Accordingly, the results we obtained are valid for the case study we analyzed (Local Elections in Estonia, 2017).

The proposed methodology allowed us to assess with greater accuracy the administrative costs of running elections. The definition of direct and indirect costs incurred by the different protagonists that occur in the organization and development of elections gives a more realistic view of electoral costs, improving previous approaches based on assessing costs by adding up shares of total costs collected from electoral budgets. Secondly, the TDABC methodology allows a more accurate allocation of costs of voting channels, revealing the activities with the heaviest drain on resources that trigger the cost expenditure, facilitating further reflection in the drive for efficiency.

Finally, the use of observation as the main strategy for collecting data allows us to surpass some traditional limitations of calculating electoral costs. Amongst other things, previous researches pointed out the limited access to data on electoral costs and the lack of ability to track expenses as the main constraints for a better fit for analyses. Moreover, this observational approach allows replicating research in other contexts where the availability of information on electoral costs is poor but observation of the electoral process is allowed. In order to test the assumptions derived from our observations, the approach was complemented by a significant number of interviews with polling officers and staff, members of local electoral councils, National Electoral Commission, State Electoral Office of Estonia and other agencies involved in elections. The support of Electoral Management Bodies when providing information and experience-based opinions improves the validity and credibility of the results.

Regarding the cost analysis, we can raise some general statements regarding the Estonian Local Elections (2017): (1) E-voting is the cheapest voting channel proposed in the electoral context analyzed due to the tool's acceptance by citizens and reduced costs involved in deployment. The cost per e-vote cast is half the cost of the second cheapest option; (2) Election Day Voting represents the second cheapest option per vote due to the fact that it is a frequently used voting channel and even with the increased amount of resources deployed; (3) Early and Advance Voting channels are more expensive due to the length of deployment and the lower number of participants that use these channels by comparison; (4) Advance Voting in Ordinary VCD is by far the most expensive channel, at around 18.00 euros per vote more expensive than the cheapest voting channel.

Costs per vote are correlated with resources invested and the popularity of the voting channel. In the search for convenience for voters, e-voting seems to be a good bet in terms of efficiency and success amongst voters, refocusing the debate on suitability to other dimensions (trust, security). The consolidation and success of e-voting in the Estonian electoral context, and its consequent cost efficiency clearly contrasts with other voting channels that consume more resources without achieving such high levels of success. Even so, we would like to stress that the results presented are valid for the elections analyzed, and that a change of voters' electoral behavior in further elections could impact on the distribution of costs by changing them substantially. To better understand electoral costs, this research should be repeated in the same electoral context allowing a comparison between elections.

Finally, the use of TDABC methods in this research, and in future research studies, may have practical implications in terms of rethinking the way elections are organized and formulated; consequently, less efficient voting channels try to maintain the conditions to allow voters to cast their votes in a convenient way but have less impact on reducing public expenditure. Multi-channel elections including e-voting, such as the one analyzed, represent a different and complex reality that can challenge the viability of some paper-based voting channels, especially those with higher unused capacities that reduce the efficiency of the tool.

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