Toward Digital Election in Indonesia: Cost Effectiveness Analysis of IVORI (Internet-Voting Republik Indonesia) as an e-Voting System

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ABSTRACT The election in 2019 was held simultaneously, where people directly elected the DPR, DPD, Provincial/ Regency/City DPRD, President and Vice President on April 17, 2019. All the changes in the implementation of elections in Indonesia since 1999, all of them are still carried out using paper. The history of the simultaneous elections in Indonesia in 2019, which were quite expensive, is a consideration for a more sustainable election process. Since the beginning of this century, internet voting has become the most straightforward and prevalent electoral reform adopted by many countries, with the goal of lowering voting expenses by enhancing convenience. This study aims to compare the Cost-Effectiveness Analysis (CEA) of conventional elections using paper ballots with digital-based elections using internet voting (I-voting) and we also developed a prototype of a digital election system called IVORI (I-Voting Republik Indonesia). The results show that elections using the I-voting system are proven to be 71% more cost-effective than conventional systems. IVORI is an internet-based digital election web application that offers two features, namely "VOTING" which will only be active on election day for voters who are eligible to vote and have been previously registered so that they can log in to the application using their ID number and voting station code and the "INFORMASI KANDIDAT" feature which can be accessed by voters during the candidate's campaign period which contains information about the background and work program plans of each candidate.

KEYWORDS *Cost-Effectiveness Analysis; Digital Election; I-Voting.*

INTRODUCTION

The emergence of technology can support the democratic process to become more possible and easily accessible within the framework of electronic democracy or e-democracy There are 5 basic applications in implementing e-democracy, namely e-Information, e-Service, e-Voting, e-Complaint, and e-Forum (Funilkul & Chutimaskul, 2009). With the increasing development of information and communication technology (ICT), it makes sense to apply it to the election process. The

implementation of an electronic election system is one of the popular issues in the implementation of e-democracy. This encourages the development of applications and their security in order to meet these needs (Valsamidis et al., 2018). The use of Electronic Voting Systems (EVSs) can occur through Direct Recording Electronic (DRE) voting systems and Internet voting systems. The use of Electronic Voting Systems (EVSs) can occur through Direct Recording Electronic (DRE) voting systems which usually require

a device for voting and cards to authenticate voter identity and internet voting systems which use devices, applications that use the internet for voting (Valsamidis et al., 2018). Some of the DRE systems that have been implemented are the DRE systems created by the company Trueballot, Inc. which are usually used by companies, organizations, universities and certain users for e-voting (TrueBallot, 2003). The Diebold AccuVote-TS DRE system in 2004 which was used in the US elections used hardware in the form of touch screens and authentication cards at certain polling places as well as software for voting (Bederson et al., 2003). The company SureVote in 2005 offered a DRE system in which users authenticate themselves and the right to vote using a numeric personal identification code and a numeric ballot code (Bederson et al., 2003). Not only does it provide a DRE system, the SureVote Company also offers an internet voting system. In the Netherlands, since 2006 voting has been carried out via DRE and in England trials with e-voting have been carried out in local elections in 2000, 2002, 2003, 2006 and 2007 (Pieters & van Haren, 2007). The browser-based Agile E-Voting system is a practical and voter-friendly e-voting system (Simhalu & Takeda, 2007). Global Election Company (2010) provides Election.com which is global election software that offers voting at polling places and remote electronic voting. Apart from being able to do it via DRE, the use of electronic voting through Electronic Voting Systems (EVSs) can also be done via the internet. The first Internet voting (I-voting) project in the US created to target elections was called VOI. The VOI project is aimed at residents who are far from where their voters

live and are abroad (Awad & Leiss, 2011).

In practice, the use of e-voting for elections contains pros and cons. On the one hand, elections that use e-voting with an internet voting system that can be done anywhere (for example via cell phone) can scalability reach long distances, but what is being debated is the difficulty of verifying that the voter is a genuine person and creates opportunities for buying and selling votes, resulting in there is a need for stricter security mechanisms in EVS Internet (Valsamidis et al., 2018). Nigerians are ready to use the e-voting system if it is adopted by the Nigerian Government with several considerations. The failure to implement postal elections in Poland has made the majority of Polish people prefer electronic voting (Musiał-Karg & Kapsa, 2021).

Although the adoption of technology and innovation are drivers of i-voting, on the other hand, the perception of inconvenience and insecurity are barriers to the intention to use and actually use technology in the election process (Omotayo & Adekunle, 2021). The effectiveness of using technology in conducting elections does not always increase voter participation. The results of research conducted on elections in Estonia stated that older voters or those with less access to technology would have difficulty using the application (Ehin et al., 2022). In addition, the implementation of the i-voting system faces the challenge of potential cyberattacks that can cause a sense of insecurity and become a barrier to the intention to use and actually use technology in the election process (Omotayo & Adekunle, 2021), so governments that use this system

need to consider the protection and security of technology from cyberattacks. Public trust is a key element in the adoption and use of new technology in elections (Mcknight et al., 2011). Therefore, governments that will use the i-voting system need to provide a lot of education to the public regarding the security and accuracy of its use to provide a sense of trust to the public.

Internet voting became the most cost-effective voting channel offered to voters in the 2017 Estonian local elections (Krimmer et al., 2018, 2021). Since the beginning of this century, internet voting has become the most straightforward and prevalent electoral reform adopted by many countries, with the goal of lowering voting expenses by enhancing convenience. However, no ideal case study for internet voting exists, as the technology has been implemented with different regulations across various nations (Goodman & Stokes, 2020). E-voting show more cost effective compared than paper ballots based on several factors including initial investment, poll worker training, maintenance, operational costs, and educational voter materials. Initial investment in technology infrastructure (such as voting machines and software), these costs are spread over multiple elections. Paper ballots may seem cheaper initially, but their cumulative costs over several election cycles can exceed those of electronic systems (Wadowski et al., 2023).

As a democratic country, the reform period was the starting point for the implementation of the first elections in Indonesia which were held in 1999. Continuing in the 2004, 2009, 2014 election period, the people received the authority to directly elect people's representatives who would sit in the DPR, DPD and DPRD and to vote directly. President and Vice President, but with different election dates between national elections (President and Vice President) and local elections (DPR, DPD and DPRD). The idea of simultaneous elections began to emerge in 2013 through a request for a judicial review of Law no. 42 of 2008 concerning General Elections in article 3 paragraph (5), article 9, article 12 paragraph (1), paragraph (2), article 14 paragraph (2), and article 112. As a state institution that has the authority to conduct material tests, the Constitutional Court (Mahkamah Konstitusi/ MK) decided on the request for material review by issuing decision Number 14/PUU-XI/2013 and it could only be implemented in the nearest election, namely the 2019 Election (Arrsa, 2014).

Simultaneous elections were realized in the 2019 election period where the people directly elected DPR, DPD, Provincial/ Regency/City DPRD, President and Vice President on April 17 2019 at one time with the aim of minimizing the state budget for elections and political costs for election participants, money politics and streamlining government work schemes (Rohmah, 2019). In the 2019 election, the realized election budget was IDR 17,209,744,147,344 from the budget ceiling given to the KPU of IDR 18,579,230,309,000 whose management and accountability followed the APBN mechanism (KPU, 2020). The realization of the 2019 election increased by 69.58% from the realization of the 2014 election (KPU, 2020 ; KPU, 2014). Quoting Hasil Kajian Lintas Disiplin atas Meninggal dan Sakitnya Petugas

Pemilu 2019 by Fisipol UGM that data from the Indonesian KPU on May 4 2019 stated that the number of 2019 Election Officials who died was 440 people, while 3,788 sick officials (FISIPOL UGM, 2019).

One of the reasons is because the average workload is high before, during and after the day of the election, ranging from 20-22 hours on the day of the election; 7.5 to 11 hours to prepare TPS; and 8 to 48 hours to prepare and distribute invitations. One of the costs of holding elections is the massive budget for paper use. According to the chairman of the KPU for the 2017-2022 period, Arief Budiman, in kumparanNEWS (22/01/2020), the use of paper in the 2019 elections was 978,471,901 sheets of paper for inner paper ballots, 58,889,191 sheets of paper for covers, and 130,746,467,309 sheets of paper for forms (Ananda Teresia, 2020).

The history of the 2019 simultaneous elections in Indonesia which still use paper and are quite expensive is a consideration for a more sustainable election process. This study aims, firstly, to compare the cost-effectiveness analysis of conventional elections using paper ballots with digital-based elections using internet voting. The second objective which is also a novelty of this study after the cost analysis, we also developed a prototype of a digital election system called IVORI (I-Voting Republik Indonesia) which can encourage the implementation of elections in Indonesia to be more effective, in terms of cost, time, and energy.

Materials and Methods

The main focus of this research is on designing workflows that can minimize operational costs, increase effectivity, and ensure voter security and anonymity. The ultimate goal is to provide concrete recommendations that can be used as a basis for the government or the General Election Commission (KPU) in improving the effective general election process.

This research begin by identifying the budget and challenges faced by conventional general elections in the previous year, calculate cost effectiveness analysis of conventional election and comparing with I-voting election system. We tried to adapt the Cost Effectiveness Analysis (CEA) calculation which is usually carried out to measure the effectiveness of health programs for use in this research by dividing the net cost value by the outcome (Centers for Disease Control and Prevention, 2021). Then, we conducted a literature study to identify the latest technology and practices used in electronic elections that involve the use of electronic means for voting (Krimmer et al., 2007). After understanding existing conventional general elections, we designed a digital electronic general election system workflow using the internet that is effective and safe. This include technology infrastructure planning and data protection aspects.

E-Voting Republic of Indonesia (IVORI) is designed as a web-based general election platform that utilizes an internet connection. This application also has an end to end encryption mechanism where every data sent encrypted. IVORI uses the principles of privacy, speed and accuracy. The principle of privacy because it offers voting results that are transparent but remain anonymous, the principle of speed and accuracy because vote

recapitulation can be obtained more quickly and precisely.

The results of this research lead to the preparation of recommendations for the government covering the technical implementation of a more effective and secure digital election system. In addition, we are consider regulatory and policy aspects that need to be changed or strengthened to support the introduction of these digital systems. It is hoped that these recommendations can guide policy makers in efforts to improve the integrity and effectivity of general elections in the country.

DISCUSSIONS

Costs of Conventional Elections

Cost represents the worth of all inputs utilized in producing goods or services, encompassing both direct expenditures (explicit costs) and indirect expenditures (implicit costs). Explicit costs are direct financial payments, whereas implicit costs are the opportunity costs associated with using resources that could have been used in alternative ways (Pindyck & Rubinfeld, 2018). The costs we mean in this study include costs for the procurement of election processes such as procurement of paper ballots and properties, transportation, officer training, officer fees. The costs of conducting elections over time have increased throughout the world (Montjoy, 2010). The following is the election budget data in Indonesia from the last 2 periods, namely the 2014 election and the 2019 election.

From Table 1 below, the budget ceiling for the 2019 election increased by 44.27% from the budget ceiling for the 2014 election. In line with the total realization of the election budget in 2019, it increased by 69.58% from the realization of the 2014 election budget. Ideas Simultaneous elections, which are expected to be more cost efficient, actually require a larger election budget. Due to limited data, we cannot find details of the allocation of the budget realization and only find the total budget from the elections in each period as a whole.

Table 1 Election Budget for 2014 and 2019

Election Period	Budget Ceiling (IDR)	Realization (IDR)	% Realization
2019	18,579,230,309,000	17,209,744,147,344	92.63
2014	12,877,434,291,000	10,148,353,335,461	78.81

Source: Laporan Kinerja KPU Tahun 2019; Realisasi Anggaran Tahapan Pemilu 2014 Tahun Anggaran 2014 (processed data)

Election Participation

From Table 2 below, the % realized number of voters in the 2019 presidential election increased by 12.39% from the realized number of voters in the 2014 presidential election.

Table 2 Election Participation in 2014 and 2019

Election	Number of Voters (People)	Realization of Voting Rights Users (People)	% Realization
2019 Presidential Election	192,770,611	158,012,499	81.97
2019 DPR Election	192,770,611	157,475,230	81.69
2019 DPD Election	190,779,466	156,715,892	82.15
2014 Presidential Election	193,944,150	134,953,967	69.58
2014 DPR Election	185,826,024	139,573,927	75.11

Source: Laporan Kinerja KPU Tahun 2019 (processed data)

Cost Effectiveness Analysis of Conventional Elections

Table 3 Cost Effectiveness Analysis of Conventional Elections

Election Period	Budget Realization (IDR)	Realization of Voting Rights Users (Person)	CEA
2019	17,209,744,147,344	158,012,499	108,913.8154

From table 3 above, we try to calculate CEA by dividing costs and outcomes in the form of realization of voting rights users. From this conventional election, the CEA value is 108,913.8154, where this value will be compared with the CEA value for elections using the I-voting system in table 6.

Estimation of Election Costs with I-voting System

We use prices from three election voting service provider website for estimates the cost of internet voting, with details of costs in Table 4 below.

Table 4 Details of Election Costs with the I-voting System

Website	Voter Capacity (People)	Estimated Cost ($)
https://electionbuddy.com/	100,000	299
https://electionbuddy.com/	1,000,000	80,000
https://www.associationvoting.com/	5,000	299

Source: ElectionBuddy, n.d.; Election Runner by Eko Internet Marketing, n.d.; AssociationVoting, n.d.

From these three websites, there are different prices and voter capacities. Then, to make it easy to compare, we tried to estimate the costs with the same number of eligible voters as in 2019, which is 192,770,611 for the presidential election, the details are in Table 5 below.

Table 5 Details of Election Costs using I-voting System with the Number of Voters in 2019 for the Presidential Election

Website	Voter Capacity (People)	Estimated Cost ($)	Estimated Cost (IDR)
https://electionbuddy.com/	192,770,611	576,384	9,050,959,945
https://electionbuddy.com/	192,770,611	15,421,649	242,166,152,363
https://www.associationvoting.com/	192,770,611	11,527,683	181,019,198,891

Source: ElectionBuddy, n.d.; Election Runner by Eko Internet Marketing, n.d.; AssociationVoting, n.d. (processed data)

From Table 5 above, the highest estimated cost for using internet voting is on the website https://electionrunner.com/ amounting to IDR231,324,733,200.00 (with the rupiah exchange rate against the dollar amounting to IDR 15,703.00 on October 15 2023 at 13.28) for the same number of eligible voters as in 2019 for the presidential election, namely 192,770,611 people. Let's use this largest value as the value that we will calculate in the Cost Effectiveness Analysis (CEA) calculation.

Cost Effectiveness Analysis of Elections with I-voting System

Table 6 Cost Effectiveness Analysis of Elections with the I-voting System

Election Period	Estimated Cost (IDR)	Realization of Voting Rights Users (Person)	CEA
2019	242,166,152,363	158,012,499	1,532.575928

From Table 6 above, the CEA value for elections with the I-voting system is 1,532.575928, a value 71% lower than the CEA value for conventional elections of 108,913.8154 as shown in Table 3 above.

Comparison of Cost Effectiveness Analysis

From the table above, the results show that elections using the I-voting system are proven to be 71% more cost-effective to implement than conventional systems.

Table 7 Comparison of Cost Effectiveness Analysis

Jenis Pemilu	CEA
Conventional	108,913.8154
I-voting System	1,532.575928

Discussion of Cost Effectiveness Analysis

A Cost Effectiveness Analysis (CEA) comparison between conventional paper ballots and internet voting (I-voting) revealed that I-voting was significantly more cost-effective, with a CEA value of 108,913.8154 for conventional and 1,532.575928 for I-voting, making I-voting 71% more cost-effective. This significant cost difference indicates that I-voting requires fewer resources due to savings in printing, staffing, and logistics. In addition, I-voting offers increased scalability and accessibility, allowing more voters to participate with minimal additional costs. However, the implementation of I-voting poses challenges such as ensuring security, building a robust digital infrastructure, and addressing the digital divide. Despite these challenges, the overall environmental benefits and cost-efficiency make I-voting an attractive option for future elections, provided these issues are adequately addressed to maintain public trust and equitable access.

In the calculation of I-voting cost, we only calculate the estimated costs for making applications for the I-voting system, this excludes estimates for TPS costs and incentives for election officials. However, we assume the value will be lower than the costs

for conventional elections because current election logistics costs can only be made for the construction of TPS booths and the number of election officers at each TPS with the I-voting system can be reduced by half from the number of election officers at each TPS in conventional system.

After comparing the cost-effectiveness analysis of conventional elections using paper ballots with digital-based elections using internet voting, the results prove that elections with i-voting are more cost-effective than conventional elections. Our next goal is to develop a prototype of a digital election system called IVORI (I-Voting Republik Indonesia).

The Design of IVORI

IVORI web application is designed as an example of a concept with the potential to enhance effectivity in elections. The recommendations we provide take into consideration key elements in elections that can be implemented as a foundation for further development. In this context, we emphasize the importance of ensuring an effective and valid voter registration process by using e-KTP cards and direct facial photos as security mechanisms. This is crucial to ensure that only eligible voters can use the application. In addition to two-factor authentication.

The entire design is intended to be adaptable and improved based on previous election experiences, illustrating a sustainable approach to improving the electoral process. We also recommend an effective public education campaign to ensure a better understanding of how to use "IVORI" in elections. Overall, these recommendations serve as a guide for digital voting application developers in creating an effective and secure system.

Pra-voting

Before the voting day starts on the IVORI web application, people who are eligible to vote will be asked to go through a series of registration phases in the IVORI application as in Figure 1.
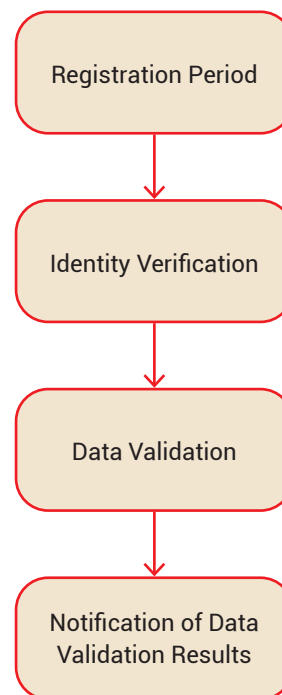

Figure 1. Registration Process

Phase 1: Registration Period

The use of IVORI web application begins with a registration period, which takes place two months before the election period commences. In the first registration phase, prospective voters are required to enter information such as their NIK (Nomor Induk Kependudukan - Population Identification Number), Family Card Number (KK), Full Name, Email, Mobile Number, and Password. After completing the form, registrants will

receive a confirmation via SMS equipped with a One-Time Password (OTP) mechanism for verification. If a registrant fails to enter the OTP three times, they must wait for 24 hours before trying again.

Phase 2: Identity Verification

In the second phase, registrants are asked to provide more detailed information, including their date of birth, address as per their identification documents, current address, and to upload a facial photo, an e-NIK card photo, and a photo of their face alongside the e-ID card, taken directly from the application's camera.

Phase 3: Data Validation

The third phase involves the Election Committee team that will validate the information provided by the registrants. This team will verify the authenticity of identification documents and ensure information consistency. The aim is to ensure that only eligible and qualified residents can access the "IVORI" application.

Phase 4: Notification of Data Validation Result

The fourth phase involves notifying registrants whether their identification documents have been successfully validated or not. If the documents are not successfully validated, registrants will be asked to provide clarification or upload the correct documents. Once users are validated, they will have access to "Informasi Kandidat" features from various upcoming elections. This will serve as a reference for them to decide to whom their voting rights will be granted. However, it is important to note that the voting feature can only be accessed during the actual election period.

Voting Day

Following the registration period, users can utilize IVORI web application during the general election. The voting feature is only active during the actual election period. During this time, all users will be automatically logged out of the application.

On the day of voting, people who are eligible to vote will come to the polling station (TPS) to carry out the election process by bringing their respective smartphones and will go through a series of phases as shown in Figure 2.
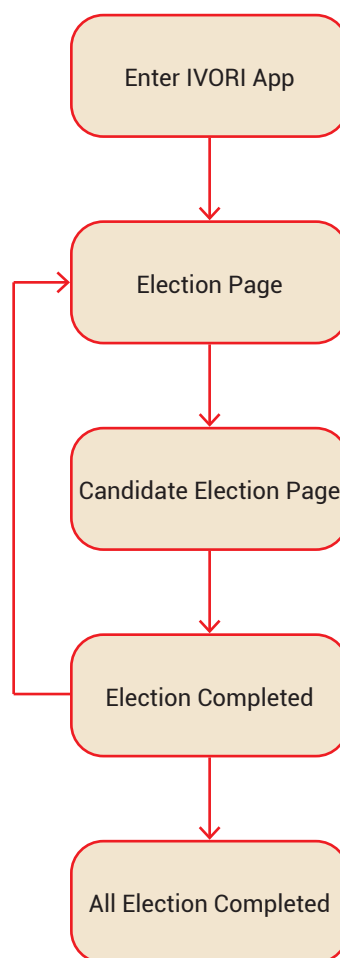

Figure 2. Election Process

Phase 1: Enter IVORI App

To participate in the election, they must log in again after the automatic logout. After re-logging in during the election period, users will have an active login session for 10 minutes. If the session exceeds 10 minutes, the system will automatically log them out.

In each polling station (TPS), a TPS code will be made available, distributed to the election committee at the polling stations through the election committee's application.

The process begins with users opening the application and entering their NIK and password to log in. After a successful login, they will be directed to the OTP input page sent via SMS and the TPS code located at the polling station. During the voting process, users have an active session of 10 minutes to vote for candidates. If the session exceeds 10 minutes, users will be automatically logged out of the application.

Phase 2: Election Page – All Election Completed

The voting feature consists of several pages. First is the election list page, where all the available elections, such as the national presidential and vice-presidential election, DPR, DPD, and DPRD elections, will be displayed.

The second page is the list of candidates for the selected general election. Users can view the competing candidates in the election and select their preferred candidate. After selecting a candidate, users will receive a pop-up notification informing them that they have successfully participated in the general election, with the chosen candidate being (candidate's name), and the voting data has been stored in the KPU database. If there are more general elections to participate in, users can return to the election page to make additional selections. This process ensures an e effective and secure participation during the general election period. The voting process will be repeated until all types of elections are completed by the voter.

CONCLUSION

A comparison of Cost Effectiveness Analysis (CEA) between conventional paper ballots and internet voting (I-voting) shows that elections using the I-voting system are proven to be 71% more cost-effective than conventional systems. The overall cost-efficiency and environmental benefits make I-voting an appealing option for future elections, as long as these concerns are effectively managed to maintain public trust and ensure equitable access.

IVORI (I-Voting Republik Indonesia) is a prototype of an internet-based digital election web application that we developed.

IVORI offers two features, namely "ELECTION" and "CANDIDATE INFORMATION". The ELECTION feature will only be active on election day. Voters who have met the requirements to vote and have previously registered will enter the application using their NIK and TPS code. Meanwhile, the

Candidate Information feature can be accessed by voters during the candidate's campaign period, which contains information about the background and work program plans of each candidate who will run for office so that the public can get to know the candidates more comprehensively.

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