The Mutual Influence of Technology, Social Structure, and Public Ideology in Election Systems

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Role of Technology in the Democratic Election System

"Let each citizen remember at the moment he is offering his vote that he is not making a present or a compliment to please an individual - or at least that he ought not so to do; but that he is executing one of the most solemn trusts in human society for which he is accountable to God and his country." (1781, n.p.)

——*Samuel Adams*

The advancement in technology has brought society unprecedented changes, including the elections, which are endowed with sacred meaning in U.S. history. Their authoritativeness, fairness, and inclusiveness need to be guaranteed to effectively represent the spirit of the United States. Given the importance of the elections, the voting procedures of the elections have been gradually refined and improved along with the advancement in technology and social structure. However, nowadays, as cyber threats become more severe, widespread, and harder to detect, which in turn intensifies the distrust of the United States citizens in the result of the elections, the voting system needs to be improved to better defend against foreign attacks during elections and annihilate public's worry on election results. To better resolve the relationship between the advancement in technology and the evolution of voting methods, studying the progression of the election system in history would be helpful. Throughout U.S. history, the forms of elections have been modified and improved several times. For example, as summarized by Britannica(2021), the establishment of the electoral college "ensures that all parts of the country are involved in selecting the President of the United States." (n.p.)

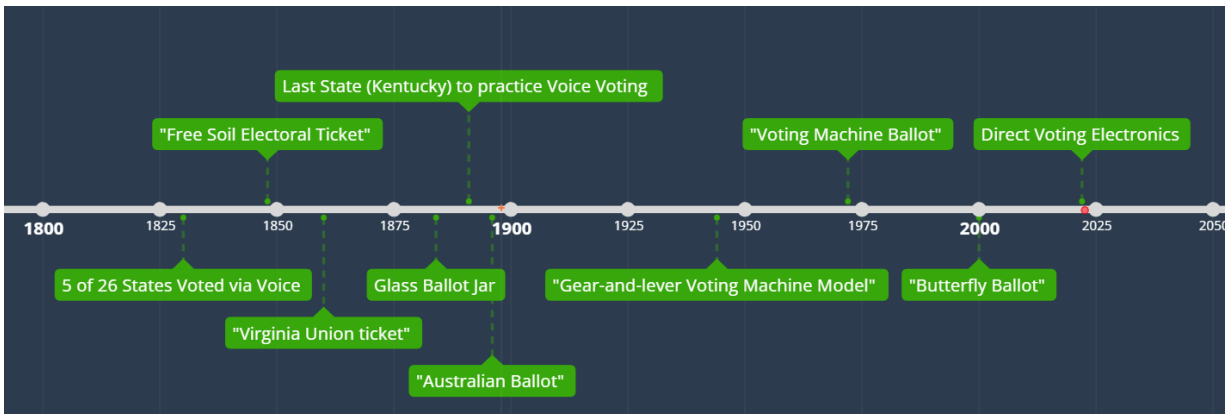

Figure 1: Timeline of Changes in Voting Methods. This timeline highlights several significant improvements in voting methods in U.S. election history. (Zhou, 2022)

As shown in Figure 1, the United States transformed from voice voting to paper ballots in the late 1800s. Then, mechanical voting machines were introduced to replace the shabby paper ballots. Until now, electronic voting machines are invented to provide accessibility to the disabled. Every transition in voting methods is a collective consequence of technological advancement, societal structure reformation, and public recognition awakening. These factors mutually influence each other. To better estimate the impacts of technology on society, an analysis of the relationship between the factors described above in the context of the STS framework, Pacey's triangle, will be presented.

History of the Election Systems

In the following section, the historical contexts of different voting methods are provided to help establish common knowledge in resolving the research question—the influence of technology in the election system.

From voice voting to paper ballots

In the early 1800s, voice voting was one of the official voting methods in the elections. Professor J. Alex Halderman (n.d.) from the University of Michigan described the voice

voting process in detail:

> The voter is going to call out the candidate he wants to vote for and those are going to be announced loudly enough for everyone standing around to hear especially for the clerks sitting in the background to hear and they're going to write down on a sheet of paper the voter's name and his choice. (n.p., para. 1,)

It is notable that this voting method is inaccurate and lacks confidentiality. The voting process is not rigid enough to establish the authority of an election. Other than the inaccurate nature of voice voting, the ratification of the 15th, 16th, and 17th Amendments to some extent stimulates the transition from voice voting to paper ballots. As the three Amendments granted more legal voters to participate in the election, voice voting was not capable of efficiently handling the voting process. As society realized the importance of keeping records during the voting process, paper ballots were introduced. The awakening in social recognition prompted the development of technology. As depicted in Figure 2, a ballot jar was designed to store votes from voters. The jar was made transparent to show voters that no alteration would be made during the voting process. Ellery Foutch(2022), an American journal, described the glass jar as "[a] key design of transparency, of allowing the observation of votes as they were submitted, preventing the subterfuge of hidden recesses and pre-filled ballots." (n.p.) The paper ballots addressed the issue of inaccuracy in vote counting, however, the privacy of voters remained a problem: through the transparent

Figure 2: Glass Ballot Jar. This is a glass ballot jar with a lockable wooden housing. (National Museum of American History, n.d.)

jar, everyone could see others' votes. To further improve the integrity of the election process, Australian Ballots were first introduced in 1892.

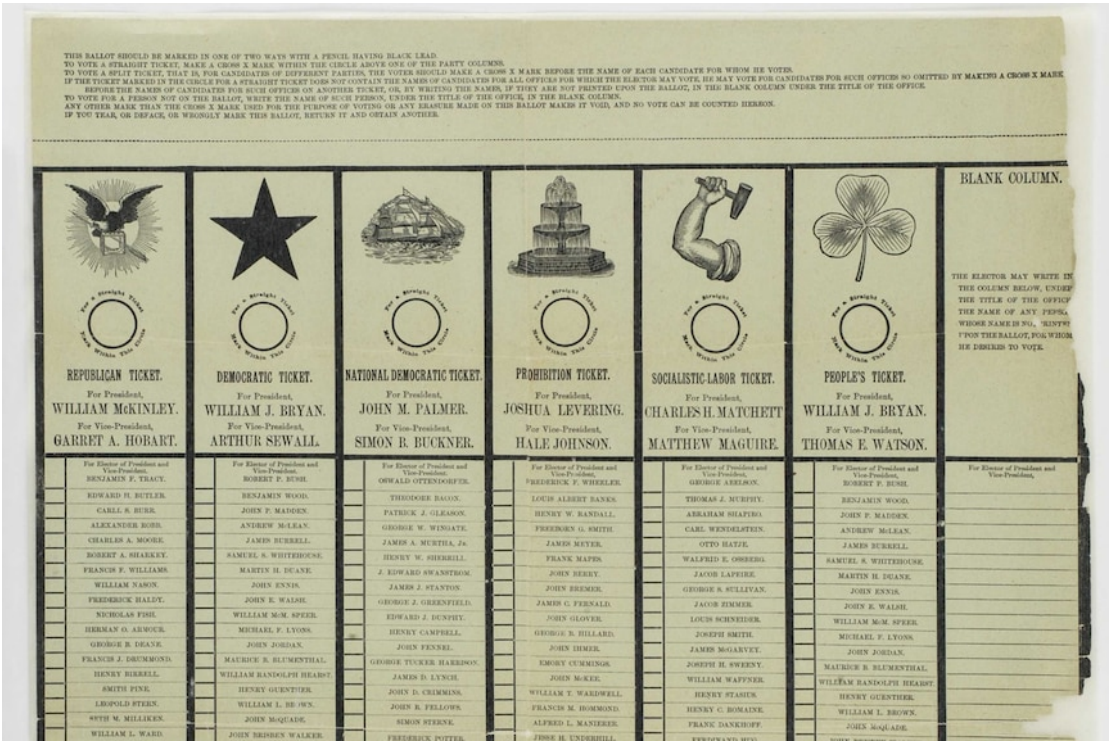

Figure 3: Australian Ballot. This is a picture of the Australian Ballot that once used in the election of 1896. (Wiggins, 2020)

"The secret ballot was designed to stop one problem made possible by these very public election days — voter intimidation. [Since] [i]t's much harder to intimidate or bribe someone if you can't see who they end up voting for." (Wiggins, 2020) As shown in Figure 3, the ballot was designed to be more detailed and harder to snoop. As a result, Australian Ballots elevated the confidentiality of the elections to a new standard since it achieved privacy for voters as well as left a reference to address possible disputes on election results.

From paper ballots to voting machines

As the world becomes digitalized, new voting methods are invented. Electronic voting methods are gradually becoming dominant in election offices. For example, direct recording

electronic (DRE) voting machines are a form of paperless voting method. The options of candidates will be displayed on the screen as depicted in Figure 4 and the voter can vote for candidates by selecting the corresponding choices. (AvanteTech, n.d.) The invention of electronic voting machines prevents physical human interference, such as destroying and altering ballots, during the elections. Also, voting machines are equipped with headphones for the disabled to cast votes much easier. However, the invention of DREs brings concerns: “First, a claim that the architecture of DREs made it impossible to tell whether they had been tampered with; second, a belief that DREs were simply more prone to error than other voting systems; and third, a suspicion that DREs had been rigged to favor Republican candidates.” (Stewart, 2011, p.358)

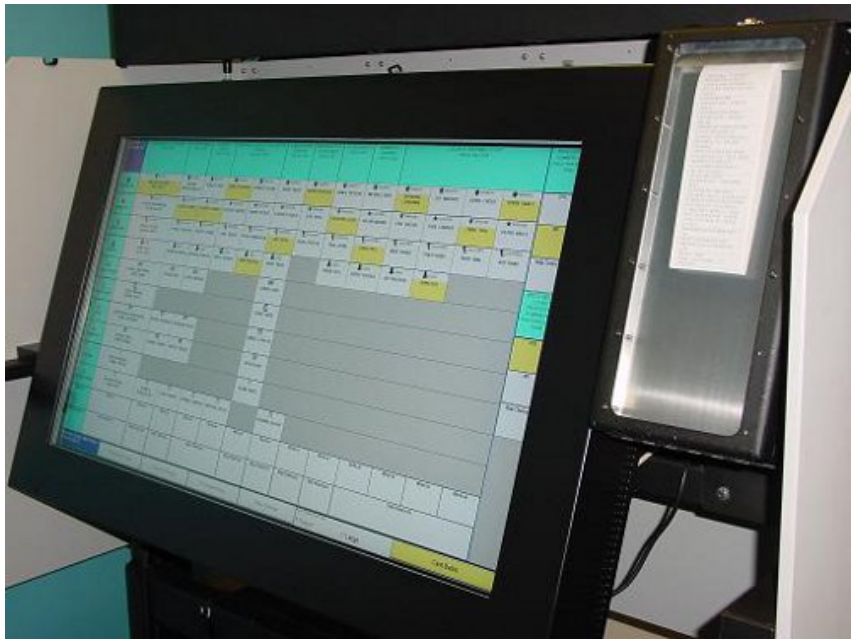

Figure 4: Direct Recording Electronics Voting Machine. This is a picture of the screen of a DRE. (AvanteTech, n.d.)

In this digitalized era, the realization of potential cyber threats among the public would again facilitate the development of the democratic system. The following part provides a thorough analysis of the influential factors that contribute to the advancement of elections.

Analysis Methodology

Pacey's Triangle

The evolution of election systems involves the participation of multiple parties, including the judicial system, the federal government, the citizens, the state governments, as well as the technology. To better evaluate the relationships and the contributions of these factors to the

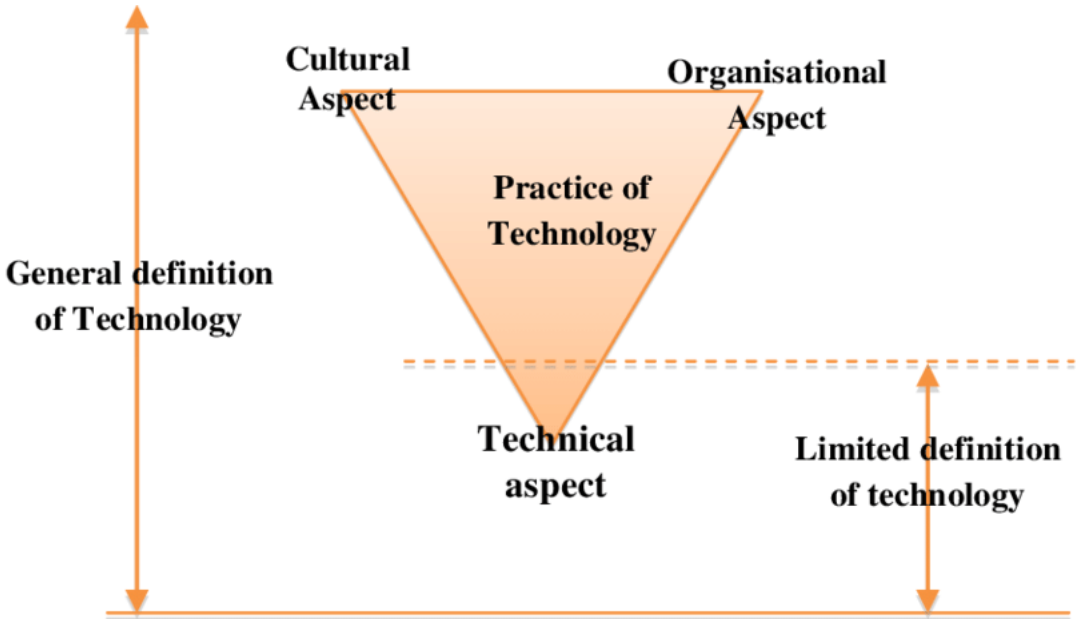

Figure 5: Pacey's Triangle. This is a visualization of the content of Pacey's Triangle. (Karman, n.d.)

advancement of election systems, Pacey's triangle, as depicted in Figure 5, would be a suitable STS framework. Pacey's triangle incorporates both tangible and intangible elements within the society, aiming to explain the underlying reason for the development of a certain object. Specifically, the three components that are included in Pacey's triangle are the technical aspect, organizational aspect, and cultural aspect. In *The Culture of Technology,* Arnold Pacey (1983) claims, "…technology is seen as a part of life, not something that can be kept in a separate compartment." (p.3) He emphasizes the inseparability of technology and

social context. This characteristic of technology makes Pacey's framework more suitable to be applied in the election system—a system that serves the democratic society. Particularly, to better fit this STS framework in evaluating the topic of election systems, I will establish correspondences between factors in elections systems and elements in Pacey's triangle: the institutions involved in the election system will be categorized into organizational aspects in Pacey's triangle; the citizen and public's attitude and view of election system will be categorized into cultural aspect; the technology that supports voting system will be categorized into technical aspect. To better observe the pattern of mutual influence between technology and the election system, I intend to apply Pacey's triangle framework in different periods throughout election history, particularly at timestamps that signal a significant transition in the voting method.

Technological Determinism and Technological Momentum

In addition to Pacey's triangle's analysis at a specific time, technological determinism and technological momentum provide an alternative perspective. More significantly, these two frameworks can be integrated into a broader version that discovers the relationship between technology and society. The integrated version of the framework will be applied to the election system to explain the overall development trend of the system.

Technological Determinism

Merritt Roe Smith, a famous American historian who was awarded Pulitzer Prize in History in 1977, suggests that "the belief in technology as a key governing force in society dates back at least to the early stages of the Industrial Revolution." (1994, p. 2) Indeed, the

claim holds when viewed from a historical perspective since the rapid emergence of technology greatly influences people's way of living. For example, the invention of the steam engine during the Industrial Revolution provided an unprecedented power source to supply engines, enabling people to travel farther than before. However, the contrast between the "soft view" and "hard view" within this framework diverges its application. The "soft view" "holds that technological change drives social change but at the same time responds discrimin atingly to social pressures."(1994, p.2) In contrast, the "hard view" "perceives technological development as an autonomous force, completely independent of social constraints." (1994, p.2) Both views are applicable in different scenarios depending on the relationship between technology and societal conditions.

Technological Momentum

As suggested by Thomas P. Hughes (1994), "Technological momentum offers an alternative to technological determinism and social construction. [It] infers that social development shapes and is shaped by technology." (p. 102) This framework provides a more comprehensive approach to illustrate the role of technology in society. Different from technological determinism, technological momentum focuses on describing the trend of the development of technology over time.

Application of Pacey's Triangle in Different Periods

In the transition from voice voting to paper ballot

The shifting from voice voting to paper ballots represents a significant improvement in voting since it greatly improves the privacy, security, and authoritativeness of the election

system by providing evidence that can be traced afterward if any dispute arises. As evaluated by Marco Steenbergen, “All of these [voice voting] methods were open to manipulation, intimidation, bribery, and corruption, and for these reasons, the British colony of South Australia introduced a secret, pre-printed single ballot paper in 1856.” (2006) The accuracy of the voice voting is solely dependent on the integrity of the vote-counting officer. For instance, the votes from the voters may be ignored or misheard because of the noises in the voting scene. Also, there is no record of the actual choice of the voters. If there is a dispute regarding the result, evidence can neither support the winner nor the loser. So, the process is susceptible to external factors that cannot be controlled by either the voter or the voting officials.

To better understand the underlying driving force that promotes the shift from voice voting to paper ballots, I fit the influential factors into Pacey’s triangle. In Pacey’s framework, it would be appropriate to attribute voting institutions, including vote-counting jurisdictions, vote-counting officials, and all relevant personnel, into the category of “organizational aspect” since they are the organizer, as well as an established systematic entity in the context of voting. Then, the opinions, views, and perspectives of citizens can be well fitted into the “cultural aspect”. Lastly, the methods that support the election system falls into the “technical aspect”.

The dynamics within the triangle are complicated, as any two aspects exert mutual influences. In this beginning stage of the election system, the will of the public occupies the dominant role that decides the development and the direction of the other two aspects. During this period, citizens realize the lack of confidentiality in the current system. As a result, the

appeals from the public motivate the reform of electoral institutions. To satisfy the need for security, integrity, privacy, and authoritativeness of elections, the institutions introduce paper ballots, which can be deemed as a new technology since it is invented by South Australia to specifically serve the elections.

Therefore, the relationship between these three aspects can be articulated by the analysis above: the appeal of the public initiates the expansion of Pacey's triangle, resulting in the development of organizational reformation and technical development to respond to the request from citizens.

In the transition from the paper ballot to the voting machine

The shifting from the paper ballot to the voting machine involves more advancement in technical aspects in Pacey's triangle than in the shift from voice voting to the paper ballot because electronics are introduced. However, the intention of bringing electronic voting into use is different from the reason for bringing paper ballots. The primary actant that drives the adoption of electronic voting machines is electoral institutions which aim to improve the efficiency and accuracy of the vote counting process. Indeed, according to Sanjay Kumar in his "Analysis of Electronic Voting System in Various Countries", "[electronic voting machine] eliminates the possibility of invalid and doubtful votes…makes the process of counting of votes much faster than the conventional system…reduces to a great extent the quantity of paper used thus saving a large number of trees making the process eco-friendly." (2011) The outcomes of the adoption of the electronic voting system (EVM) greatly favor

election-related institutions with a huge improvement in the efficiency and integrity of the election system.

When analyzing the transition in this period, the organizational aspect becomes a dominant factor that spurs the development of the other two. This reveals the difference in essence between the organizational aspect and the cultural aspect: in certain cases, the organization can view an issue from an overarching perspective whereas the cultural aspect only represents a collection of individual wills, lacking the integrated view. To elaborate, a voter, to large extent, is satisfied with the level of security and privacy of

paper ballots. However, when viewing from the angle of an election institution, the great number of voters and the complicated nature of paper ballots reduce the efficiency and the accuracy of the vote-counting process considerably. Therefore, the need for a faster voting system is suggested by the institution. The electronic voting system is the technology's response to the appeal from the organizational sector. Then, the introduction of EVM also benefits the citizens in numerous ways. For example, EVM facilitates the accessibility of the voting process. The design of the voting machine incorporates voice guidance for illiterate citizens and braille for people who are visually impaired. The factors in Pacey's triangle are not only driving the improvement of each other but also enjoying the benefit brought by those advancements.

Analysis of the contemporary voting system

As the DRE is adopted by the majority of the jurisdictions during the elections in the United States, controversies on the confidentiality of these machines have been raised to the

public's attention. "Although e-voting systems were developed to make voting easier and to boost voters' confidence in the election process, security, robustness, and privacy issues remain major challenges." (Choi & Kim, 2012, p. 434, para. 2) For instance, according to Kohno, several security concerns ranging from unauthorized privilege escalation and improper use of cryptography to vulnerabilities to network threats are all concerns regarding the security of the system. (2004) In addition to the cybersecurity concerns, the physical concerns regarding the lifespan of voting machines also play an important role. In the article "Voting Machines at Risk in 2022" published by Brennan Center, Turquoise Baker and Lawrence Norden claim, "Today, 24 states, home to over 41 million registered voters, use machines first fielded more than a decade ago as their principal voting equipment." (2022, para. 6) Applying Pacey's triangle to the contemporary voting system, the technical aspect and the organizational aspect in a large extent determines the outcome of cultural aspect. Specifically, in this scenario, a negative impact on the cultural aspect is exerted by the other two.

From Social Determinism to Technology Determinism

According to the analysis using Pacey's triangle above, it is notable that there is a trend that society gradually shifting from social determinism to technology determinism. Specifically, at the early stage when the improvement between generations of technology is not that great, the needs of the society largely determine the direction of technological development. The trend is partly because the fulfillment of people's requirements is not that hard. However, as the gap between generations of technology expands, the influence of technology transcends civil factors, endowing technology with a more influential role in

human development. This phenomenon can be observed in the development of the election system. The step between the paper ballot and EVM is reasonably large, as people's understanding of electronics in 1973, the invention year of the first EVM, remains obscure and limited. The security concerns of EVM are not realized until the 21st century. However, the influence of EVM is profound during the twenty years in between. As a result, only modifications, or "technological fixes", can be applied to the established system to meet the requirements of the public or to resolve the concerns raised by the public rather than subvert, or reconstruct, the current system. The history of the development of the election system signifies a change from social determinism to technological determinism. As the influence of technology becomes greater and greater, the role of technology correspondingly becomes more and more significant, endowing it more dominant power not only in the interaction between aspects of Pacey's triangle but more importantly, in people's daily life.

Conclusion

In this paper, I integrate Pacey's triangle, technological determinism, and technological momentum to evaluate the role of technology in election systems. I summarize the transition of voting methods at different times throughout U.S. history to provide a context of where technology plays a determinant role in the election systems. Then, by applying the frameworks listed above, I first analyze the influence of technology at specific periods. To provide a unique perspective, I observe the overarching trend of voting evolutions. As a result, the analysis displays a gradual shift from social determinism in the early stage to technological determinism in the relatively well-developed stage. Nowadays, I suggest that the election system is currently in the "technological fix" stage, where particular fixes are

needed to be applied to the current established voting system to meet a more secure standard. And the public's worry about the fallacies of election systems can thus be eliminated. The analysis of the development history is also useful to predict the public's reaction to a more advanced electronic voting technology—homomorphic encryption of ballots. This proposed voting method enhances transparency and defends the current system against potential attacks from malicious third parties. Scrutinizing in the setting of Pacey's Triangle, this development in the technical aspect would be bound to bring benefits to the other two aspects.

Though the analysis produced in this paper is not comprehensive since there are innumerable internal and external factors that drive the change of the voting system, the result provides a possible interpretation of the role of technology in modern society. The observed development pattern can be applied to a broader scope because people's lives in this heavily digitalized era are greatly determined, and guided, by the forms of different technology.

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