The Business of Voting

Market Structure and Innovation in the Election Technology Industry

PENN WHARTON
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Executive Summary

Although it has been over sixteen years since the 2000 election, the pandemonium that emerged out of Florida that year still stands as a vivid reminder of what can happen when election systems falter.

That election experience invigorated efforts by technologists, academics, policy experts, and dedicated civil servants to improve election administration and shore up public confidence in the voting process. Enhancing the quality of election technology—the software and hardware upon which voting machines and other election administration equipment rely—has been a central part of that effort. One silver lining in the 2000 election was that it galvanized support for investing in the deployment of new electronic

voting machines across the country.

But, as documented by the Brennan Center for Justice at New York University in their 2015 study, *America's Voting Machines at Risk*, a new "impending crisis" in election technology is at hand. The voting machines purchased after the 2000 election are literally falling apart in jurisdictions in almost every state, many of which no longer have the funds necessary to purchase new ones. In many localities, the outmoded systems remain in place, despite the recognized dangers they pose to the integrity of the electoral process.

The question remains, then, of how to move forward with modernizing our election systems. While much of the discussion about the ills of our election technology have focused on the need for policy changes, this industry report approaches the topic from a different perspective, as a business problem. The findings here suggest that the impending crisis in America's election technology has not emerged solely from ineffective government action or insufficient public funding, but also from core attributes of the election technology industry itself.

Very little has been written previously about this industry, despite how critical it is to the functioning of our democratic processes. As this study initially got underway, it became clear that one of the most significant boundaries to conducting a useful analysis was the dearth and inaccessibility of industry data. The first goal of this report therefore is to compile a current set of facts about the election technology industry, including the market players, industry revenue and profitability, and the competitive dynamics among the relatively few vendors that manufacture and sell election systems.

The gathering of the industry facts facilitates the second purpose of the report: to provide an original analysis of the industry dynamics that can shed light on what has prevented the election technology industry from enjoying the robust level of innovation seen in other technology sectors. In the process, it also describes strategies that some election officials are pursuing to cope with the shortcomings of the current market:

- Buyer coalitions, which can give jurisdictions greater bargaining power for getting vendors to provide systems that are both better priced and more customized to their needs;
- Open source technology, which proponents believe may catalyze the development of new competitive markets in voting systems solutions;
- Modified certification processes, to support a move to modular voting systems built from less expensive commercial off-the-shelf components.

As the report explicates in detail, the real effects (and possible pitfalls) of these strategies are not yet fully known. But they are nevertheless reflective of the report's key contention: that a long-term solution to the election technology crisis is unlikely to be had until policymakers and market actors address the underlying business issues and take steps that catalyze changes in the structure of the election technology industry.

Introduction

A recent survey of voters and poll workers, aimed at exploring their impressions of the voting systems they had just used in the 2016 election, yielded some disconcerting results.

The research indicated that "one in five Americans who voted in the presidential contest [did] not trust that the national election results were accurately tabulated." Moreover, "one in three [had] concerns about the accuracy of the voting technology used at their polling place." While this still suggests that most people expressed overall confidence in the election process, an overwhelming number of voters—nearly 80 percent—nevertheless believed that it was time for the U.S. to upgrade its election systems, "and more than 80 percent [felt] these updates would not only increase trust in the system, but improve the overall election process and strengthen U.S. democracy."[1] A comparable survey administered by the Democracy Fund produced similar findings regarding the trustworthiness of current election systems: 38 percent of voters were "very" or "somewhat" concerned that "a voting machine miscalculated votes" during the election, and an almost equal percentage were concerned that "an electronic security breach or hack impacted the vote counts."[2] It seems that Americans are sensing the vulnerability of their election infrastructure more acutely than ever, and are wanting assurance that the machinery by which their votes are cast and counted embody the highest standards of reliability, accuracy, and overall functionality. This equipment is both literally and figuratively the "nuts and bolts" of America's democratic election process.

However, the industry that provides the hardware and software for the election process has been scarcely studied and often is opaque, even to election administrators, policymakers and representatives at other governmental and non-governmental organizations that support or directly participate in the election process. Previous reports on the state of election administration in the United States have stressed the importance of providing a modern, efficient and responsive process for the voter. These reports also have documented the limitations of existing voting machine technology and the opportunities for new technology

1 "New Study: 2016 Voters and Poll Workers See Improved Technology as Key to Restoring Trust in U.S. Voting System," *Business Wire*, December 6, 2016, http://www.businesswire.com/news/home/20161206005515/en/Study-2016-Voters-Poll-Workers-Improved-Technology.

2 "Election Security and the 2016 Voter Experience," *Democracy Fund Blog*, December 2, 2016, http://www.democracyfund.org/blog/entry/election-security-and-the-2016-voter-experience.

to improve election administration.[3] However, the implementation of these new technologies and processes ultimately relies on the actors that design, manufacture, integrate, and support voting machines and the associated technological infrastructure, which we collectively refer to in this report as the "election technology industry."[4]

The role of industry structure in shaping the delivery of election services has been examined before. For instance, a 2001 study[5] by the CalTech/MIT Voting Technology Project—conducted in the aftermath of the voting problems that arose during the 2000 Presidential Election—noted that a sustainable business model for the industry was critical for encouraging innovation in high-integrity voting systems that can better manage the complexities of the electoral process. However, a decade later, the same authors noted that, aside from some changes in funding and purchasing patterns, not much is different within the industry, and in some respects, the changes that have occurred are not necessarily conducive to increased innovation that could significantly improve the voting experience.[6]

In addition to extending the business analysis provided in the CalTech/MIT study, this report builds specifically on two other recent publications. In January 2014, the bipartisan Presidential Commission on Election Administration (PCEA) issued a comprehensive investigation of "The American Voting Experience," drawing insight from public hearings, interviews with stakeholders, and data from a survey administered by the CalTech/MIT Voting Technology Project to thousands of local election officials. The report identified an "impending crisis" in America's election infrastructure from the "widespread wearing out of voting machines," and advised reforming the standard-setting and certification process for those machines to facilitate innovation in the production of new, secure, and reliable technology and equipment.[7] The Brennan Center for Justice at New York University School of Law gave fuller treatment to the nature and extent of this impending crisis in its widely cited study, *America's Voting Machines at Risk*. In addition to echoing the PCEA's call for streamlining the certification process, the Brennan Center offered a series of additional recommendations to policymakers and election officials to help extend the life of current voting machines, efficiently identify when they start to malfunction, and plan for the purchase and implementation of new election systems.[8] Despite the alarms that these reports have sounded, though, little has happened to deploy this next wave of election technology.

3 The Presidential Commission on Election Administration, *The American Voting Experience: Report and Recommendations of the Presidential Commission on Election Administration* (2014), https://law.stanford.edu/publications/the-american-voting-experience-report-and-recommendations-of-the-presidential-commission-on-election-administration/. See also "Keep the Faith," *U.S. News & World Report*, April 25, 2016, http://www.usnews.com/news/articles/2016-04-25/voting-reform-is-one-of-americas-biggest-challenges; Governing Institute, *Modernizing the Election Process: A Watershed Moment in Government* (2015), http://www.governing.com/papers/How-Tablets-Can-Transform-the-Voting-Experience-and-Election-Process-1474.html.

4 Because of data availability, in this report we often generalize trends we find in voting machine acquisition and market trends to the more general election technology industry, which, as noted, includes other products.

5 CalTech/MIT Voting Technology Project, *Voting: What Is, What Could Be* (2001), http://vote.caltech.edu/reports/1. See especially Section II: Cost and Public Finance of Elections.

6 Stephen Ansolabehere and Ronald Rivest, *Voting Equipment and Ballots*, September 2013, http://web.mit.edu/supportthevoter/www/files/2013/09/Voting_Technology_SDA_RLR.pdf, p. 7-8.

7 *The American Voting Experience*, p. 62-67.

8 Brennan Center for Justice at NYU School of Law, *America's Voting Machines at Risk* (New York, 2015), https://www.brennancenter.org/sites/default/files/publications/Americas_Voting_Machines_At_Risk.pdf.

Whereas the PCEA and Brennan Center reports approach this problem principally from a public policy perspective, this report focuses on the business side. Its primary motivation is to describe the industry practices and competitive dynamics of the election technology industry. These dynamics contribute, in part, to limiting both innovation in the development of more secure and reliable voting machines and the spread of best practices throughout the industry. They have hampered the formation of sustainable long-term strategies for the deployment of new technological solutions that could both yield profits for vendors and provide a favorable cost-benefit tradeoff to their customers. Moreover, a lack of understanding of the industry's competitive dynamics may impede the formation of effective public policy aimed at improving the way in which the industry functions.

Part of the challenge in understanding the election technology industry is that it is difficult to compile even basic facts about it. The industry earns an estimated $300 million in revenue annually (out of the estimated $1 billion spent on election administration overall in the US).[9] This figure is small compared to the size of federal IT expenditure, estimated to be about $80 billion per year,[10] or even state IT expenditure (about $30 billion per year).[11] The industry is dominated by three firms that are moderate in size and neither publicly nor independently held, limiting the amount of information available in the public domain about their operations and financial performance. Meanwhile, the customer base is highly fragmented, with election technology decision-making dispersed across more than 10,000 county election officials.[12] This combination of small market size and limited publicly available information renders aggregate market information scarce. One objective of this report is simply to compile (or generate where necessary) a consistent set of current industry facts that can be utilized to better understand the industry as it exists today.

The second objective of this report is to characterize the issues faced by customers, vendors, and regulators that explain the problematic state of the industry and to identify practices for addressing these issues. While our perspective throughout the report is primarily descriptive rather than prescriptive, our research also has documented some innovative strategies that could address some of the challenges that have persisted in the industry. Some of these strategies have been profiled elsewhere (as we cite later in the report). However, they take on a new light when viewed as a response to, or remedy for, concerns about market structure, as is reflected in our discussion.

9 The international market is less clear. The three major vendors in the American market also do some business internationally. Dominion Voting Systems is based in Canada and has done business in the Philippines and Mongolia, and Election Systems & Software does business in Canada. According to data collected by the ACE Electoral Knowledge Network, a number of major European democracies obtain or produce 91-100% of their election technology domestically. This is true of other major democracies as well, including Canada, Japan, South Korea, Pakistan, and Brazil. Some of these countries do not yet utilize electronic voting widely and use manually marked paper ballots paid for by the state, various authorities, or political parties.

10 Office of Management and Budget, *Analytical Perspectives, Chapter 17: Information Technology* (2017), https://obamawhitehouse.archives.gov/omb/budget/Analytical_Perspectives. See Chart 17-1.

11 Chris Cotner, *State IT Budget Analysis and Forecast for 2015: Changes and Opportunities on the Horizon*, Deltek White Paper (2015), http://more.deltek.com/State-IT-Budget-Forecast-2015.

12 As discussed within the report, acquisition practices vary nationally. Some customers acquire on a state-level, others on more intermediate levels, whereas many states have a highly dispersed acquisition scheme.

We will begin this report by examining the present state of the voting technology industry, the vendors that are currently competing in the market, and the conduct of regulators and customers that affect the dynamics of the industry. We then will explore some of the existing barriers to innovation, as well as discuss alternative approaches that might facilitate greater innovation by changing the incentives of vendors and strengthening the market position of their customers.

State of the Industry

Warranted or not, the election technology industry has faced considerable criticism from a number of fronts.

Election officials have long complained that the technology is too costly, limited in capability, outdated, and insufficiently flexible to address their local needs.[13] At the same time, election officials are unsure of how else to obtain good value for their expenditures on election systems, due to the limited number of choices and their own internal challenges in contracting for and managing information technology investments. Voters and their representatives in government, often prompted by news of high-profile voting problems, also have raised concerns about the reliability and integrity of the voting process, and have increasingly called for the use of modern technology such as laptops and tablets to improve convenience.[14] Technological innovation, however, has proven elusive in this industry. As a first step in assessing why this is so, this section will describe the industry, providing some historical background, a depiction of the vendors and consumers that populate the election technology market, and a brief overview the regulatory environment that mediates transactions between them. The content here sets the stage for analyzing the industry structure in the second part of the report.

13 *The American Voting Experience*, p. 11.

14 "Around the U.S., Voting Technology Is All Over the Place," *NPR*, February 14, 2015, http://www.npr.org/sections/itsallpolitics/2015/02/14/386191861/around-the-u-s-voting-technology-is-all-over-the-place. See also "WANTED: New Voting Machines and Money to Pay for Them," *Council of State Governments*, June 7, 2016, http://knowledgecenter.csg.org/kc/content/wanted-new-voting-machines-and-money-pay-them.

Before proceeding with our description and analysis of the industry, though, a few points about the data used in the report must be raised. Our data on the election technology industry was generously provided by the Verified Voting Foundation (updated last in September 2016), with tremendous assistance from Communications Director Warren Stewart.[15] There are two reasons we used this dataset rather than other sources. One reason is its scope. While some states do provide overviews of the types of machines used in different jurisdictions within their states, Verified Voting's dataset is the most complete, comprehensive account of the voting technology currently used in jurisdictions across the country. The second reason is continuity. The election technology report published by the Brennan Center for Justice, which strongly informs this industry study, also references data provided by Verified Voting.

We employed two methodologies to infer information from the data. One, "registrant reach" or "voter reach," is used as proxy for vendor market share. Specifically, we assume the revenue generated by a vendor in a particular market is proportional to the number of voter registrants in a jurisdiction served by a particular vendor. More direct measures, such as number of machines, capital cost or annual expenditure by vendor, are not readily available. Our voter reach calculation does not account for differences in prices (either across vendors or over time). However, the methodology is consistent with the approach used by the CalTech/MIT Voting Technology Project[16] when computing election technology costs by jurisdiction, and we believe it is adequate for the broader inferences made in this study. Additionally, jurisdictions may have machines from multiple vendors, and potentially multiple models from any particular vendor. In these jurisdictions, we assume that voters are equally distributed among the vendors with machines in that jurisdiction (e.g., if both vendor A and vendor B have presence in a jurisdiction, regardless of their *actual* proportional number of machines and 'voter reaches' within that jurisdiction, vendor A and vendor B split the voters evenly for the purposes of our calculations).

In addition to registrant reach, we also use the Verified Voting data to calculate market concentrations on a state and national level, with standard economic measures used for competitive analysis.[17] While these metrics are commonly used for antitrust analysis, our use of them is for purely descriptive purposes and is not meant to imply anything about oligopolistic behavior or the inappropriate exercise of market power. Indeed, much of the concentration in the market, as we discuss in the report, is a matter of circumstance. For instance, many states and county coalitions purchase election technology in aggregate to reduce costs, which directly contributes to concentration in vendor shares.[18]

15 VerifiedVoting.org conducts a survey of each precinct on a semi-regular basis by contacting local election officials to determine which machines are in use. We then match those machines to the company that currently provides them (because of considerable consolidation, machines that were sold by since acquired companies are counted for the acquiring entity). From the provided data, we have information on the vendors present in each precinct as well as the number of registered voters in each precinct. Jurisdictions are demarcated by FIPS codes. These are the Federal Information Processing Standard county codes that uniquely identify counties and county equivalents in the United States.

16 MIT and CalTech researchers provide estimates for technology costs on a per voter basis, therefore using voters as an approximation for the number of machines/cost of machines and scope of maintenance costs incurred by a jurisdiction. See *Voting--What Is, What Could Be*, p. 23.

17 We specifically use the Herfindahl-Hirschman index, which measures the extent to which an industry is concentrated (relatively few competitors and/or large market shares). Other alternative measures (such as the CR4 or 4-firmconcentration index) are not meaningful in an industry with a small number of participants.

18 Costs/benefits of coalition formation are discussed later in this report.

Some caveat is necessary regarding the accuracy of the data. First, Verified Voting has said that while they attempt to maintain this dataset to ensure its accuracy, at particularly granular levels of analysis, and even at more intermediate levels of analysis, it has real potential for error. Also, it is worth noting that some of the data provided by Verified Voting contradicts information provided by another key data source, the National Council of State Legislatures (NCSL). In particular, the NCSL reports that a number of states use the same vendor and type of voting equipment in polling places statewide, and that—in contradiction to the Verified Voting data—Connecticut, New Hampshire, Delaware, Maine, and Vermont are among these states.[19] In light of these caveats, throughout this report, we attempt to look at the 'big picture' of the industry and focus on general trends, for which, as noted earlier, the dataset is more than adequate despite its limitations.

Beyond the Verified Voting data, we also occasionally reference in this report a survey we distributed to election officials. The survey, administered via Qualtrics, asked questions regarding recent acquisitions of voting equipment, procurement procedures and priorities, technology service and support procedures, sources and scope of funding, deployment challenges, best practices, voter feedback, and expectations for future acquisitions. This survey was distributed in March 2016 to the Election Administration listserv members of the National Association of County Recorders, Election Officials, and Clerks, consisting of 117 election officials. Thirty-three officials responded. Due to the sample size, response rate, and non-random distribution of this survey, *it is not meant to provide statistically significant inferences* or demonstrate generally representative responses. Rather, this survey simply provides a window into the experiences of at least some election officials. Their perspectives have informed our thinking and, we believe, enriched our analysis.

HAVA Funding

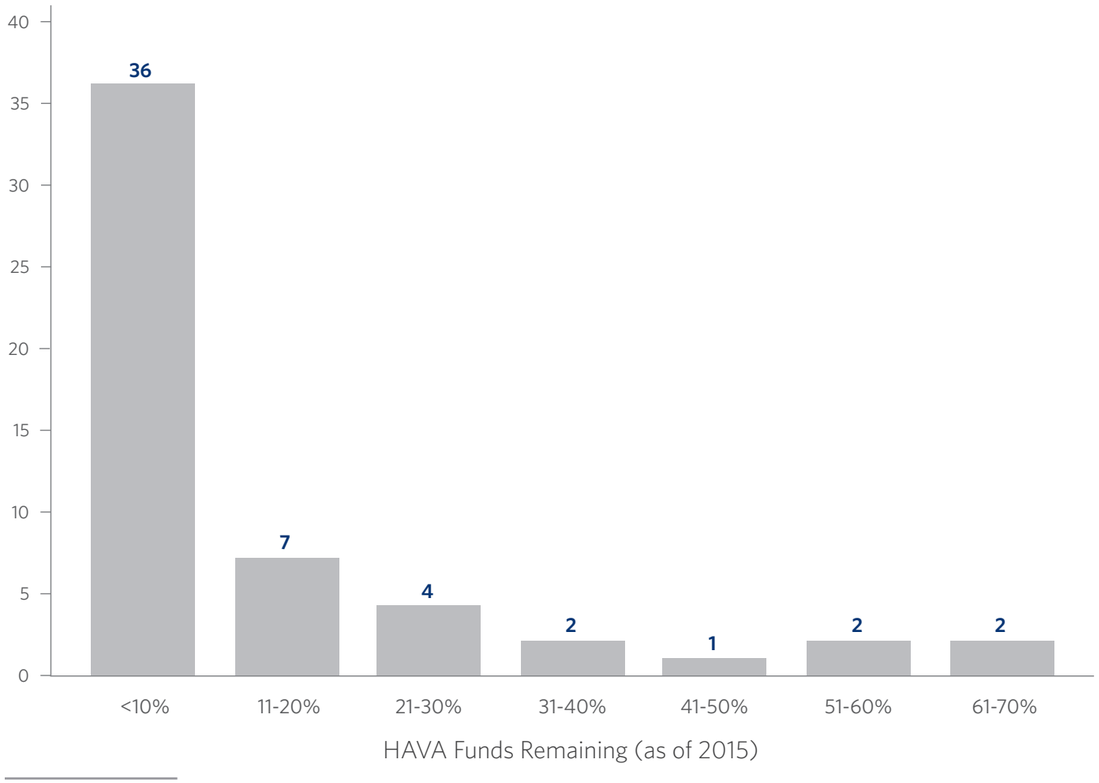
In order to assess the present state of the industry, it is important to understand how it has changed since 2002, when Congress passed the Help America Vote Act (HAVA), authorizing the allocation of $3 billion to states (based on voter populations), to fund the purchase of new voting technology. The legislation was borne out of the 2000 Presidential election controversy, which revealed the grave limitations of punch card voting and the need for investment in more modern and reliable voting systems. HAVA also created the Election Assistance Commission (EAC),[20] a federal body tasked with providing guidance on voting technology standards and administering the HAVA funds.

19 "Election Costs: What States Pay," *National Council of State Legislatures*, June 16, 2016, http://www.ncsl.org/research/elections-and-campaigns/election-costs.aspx.

20 The EAC is charged with certifying voting systems and allocating HAVA funds. However, it serves a largely advisory role, as ultimate authority for the procurement and administration of elections still resides with local elections officials. See our discussion of the regulatory environment.

This round of funding delivered a sudden stimulus to the industry, creating a wave of investment that significantly increased technology expenditure and led to the deployment of new technologies for electronic voting machines. However, as of 2016, most of the HAVA funds that were distributed to states for the purpose of refreshing their voting technology have been exhausted. As depicted in Figure 1, 36 of 55[21] (65%) states and territories in the US have less than 10% of their originally allocated HAVA funds left (including interest), another 14 states and territories (25%) have less than half of their funding left.[22]

Figure 1:
Number of States by Percentage of HAVA Funding Remaining (as of 2015)[23]



21 The Northern Mariana Islands were not included in the HAVA legislation. See Sec. 901 of HAVA for definition of "State," https://www.eac.gov/assets/1/workflow_staging/Page/41.PDF.

22 Based on an analysis of data provided in: United States Election Assistance Commission, *EAC Report to Congress on State Expenditures of HAVA Funds – 2015* (March 2016), https://www.eac.gov/assets/1/Documents/Final%20FY%202015%20Grants%20Report.pdf.

23 Id., p. 7. Figure is based on an analysis of data from the EAC Report. In the report, the EAC uses 2014 funding levels for states and territories that had not yet submitted 2015 financial reports.

The depletion of the HAVA funds has significant implications today, as the systems deployed as a result of HAVA are nearing the end of their useful life and need to be replaced. The service life of new voting hardware and software purchased and installed immediately after the passing of HAVA is 10-15 years, and states that now lack HAVA funds have to go to extraordinary lengths to keep their aging systems operational.[24] As noted by the Brennan Center, "[n]early every state is using some machines that are no longer manufactured and many election officials struggle to find replacement parts."[25] In many cases, election administrators do not have the funds to purchase new machines, but rather take it upon themselves to replace the malfunctioning parts—storage devices, printer ribbons, modems, etc. In some instances, those component parts are only available in other machines of the same make. Election administrators have gone so far as to stockpile obsolete hardware to keep their current machines running for the next election cycle. Several indicated that they also have used eBay to find these parts.[26] Despite how essential this machinery is to the democratic process, industry participants do not believe that there is sufficient political appetite for federal legislators to pass a bill similar to HAVA in the near future to support the purchase of new systems. While a bill like HAVA is not a preferred solution or even a "solution" at all in some experts' minds, the absence of any plan for a federal initiative creates uncertainty as to how to fund the replacement of existing systems, most of which will have to be retired in the next five years.[27]

Despite the funding constraints faced by state and local election officials, voters have been demanding the development of new and even more complex technology, most notably Internet voting, based on their personal experiences with the profusion of Web-based applications deployed in other industries. By July 2015, at least 13 states were considering legislation to start moving towards online voting, but so far only one such bill (Maine SB 552) has been enacted.[28] Although Internet voting may appeal instinctively to voters, a recent report by the U.S. Vote Foundation affirms that "computer scientists, cryptographers, and cybersecurity experts warn that no current Internet voting system is sufficiently secure and reliable for use in public elections." To meet the highest standards of election integrity, these experts maintain that any Internet voting system must have "end-to-end verifiability (E2E-V)"—meaning that it must allow voters to check that it recorded their vote accurately and included the vote in the final tally, as well as enable them to count the recorded votes and confirm the election

24 *America's Voting Machines at Risk*, p. 8.

25 Id., p. 4.

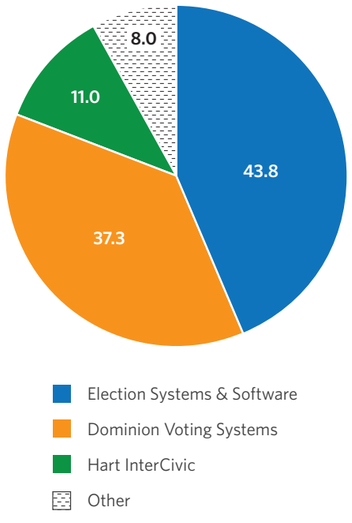
26 Id., p. 14.

27 Id., p. 17.

28 National Council of State Legislatures, "Internet Voting: Creeping Our Way?" *The Canvass: States and Election Reform*, Issue 60 (July 2015), http://www.ncsl.org/Documents/Elections/The_Canvass_July_2015_60.pdf. In this July 2015 report, the National Conference of State Legislators highlights six security concerns regarding online voting. (1) Malware can interfere with a user's ability to vote, as demonstrated by a team from the University of Michigan, which successfully compromised a Washington, DC attempt at online voting, changing user votes without detection. (2) Botnets could be used to cause a distributed-denial-of-service (DDOS) attack on an online voting portal, not affecting the actual votes themselves but potentially denying voters the opportunity to cast their ballots. (3) Authentication problems become compounded when voters cannot be physically identified; online voting would only make it harder to ensure that the person casting the vote is who they say they are. (4) Verifiability also becomes more difficult with online voting, as it leaves no paper trail by which to audit an election. (5) Online voting is subject to file vulnerability, as PDFs and other files can be intercepted in transit, potentially allowing the votes to be manipulated before being tallied. (6) Coercion opportunities: online voting allows users to vote from anywhere, which opens voters to coercion by others, and also enables pay-for-vote schemes to flourish.

outcome. (It bears noting that E2E-V is an attribute that current electronic voting systems do not offer.) Internet voting also would need to be usable and accessible to all voters, including those with disabilities, and "designed, constructed, verified, certified, operated, and supported according to the most rigorous engineering requirements of mission-and safety-critical systems." It is doubtful, however, that a cost-effective Internet voting system meeting all of these recommended standards can be deployed anytime soon.[29] As such, it is nearly certain that online voting will not play a significant role in shaping the industry structure in the near term. In fact, several post-HAVA innovations in election technology that are far less complicated than Internet voting, such as touchscreen voting, have experienced unexpected problems, further undermining the public's confidence in the ability of the industry to provide new technology that is as secure and reliable as it is easy-to-use.[30]

Figure 2a:
Vendor Marketplace Coverage by Percentage of Eligible Voters



Vendors

Over the past decade, while there has been limited progress in terms of technological innovation, there have been significant changes in the landscape of vendors that develop, supply, and service the nation's voting machines. The seller side of the election technology industry has come to be characterized by a consolidated, highly concentrated market dominated by a few major vendors, where industry growth and competition are constrained.[31]

Industry Participants. The firms in the election technology industry sell integrated voting solutions, typically including a package of hardware, software, services and support. The industry has a two-tier structure with the three top-tier vendors, Election Systems and Software ("ES&S"), Hart Intercivic ("Hart") and Dominion Voting Systems

29 U.S. Vote Foundation, *The Future of Voting: End-to End Verifiable Internet Voting – Specification and Feasibility Assessment Study* (July 2015). Quote taken from the Executive Summary, available at https://www.usvotefoundation.org/sites/default/files/E2EVIV_executive_summary.pdf. See also "End-to-End Verifiability," http://research.microsoft.com/en-us/um/people/benaloh/papers/e2e-primer.pdf.

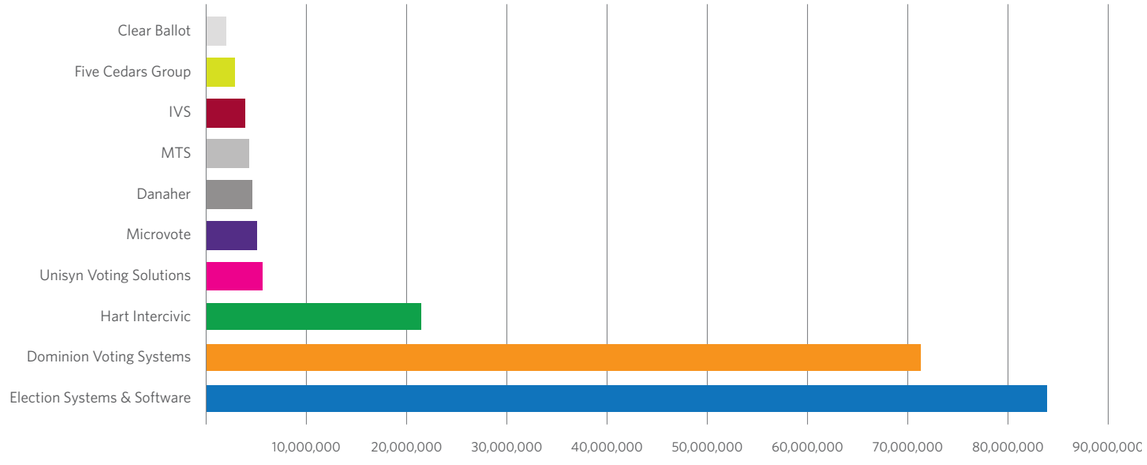
30 Mark Clayton, "Voting-Machine Glitches: How Bad Was It on Election Day around the Country?" *Christian Science Monitor,* November 7, 2012, http://www.csmonitor.com/USA/Elections/2012/1107/Voting-machine-glitches-How-bad-was-it-on-Election-Day-around-the-country; Dave Ress, "Touchscreen Problems Worry Virginia Election Officials," *Daily Press*, April 2, 2015.

31 Although innovation often is conducive to industry growth in general, the domestic voting technology market is limited intrinsically by the number of voters and voting districts in the United States. While expansion into international markets is possible, there are number of regulatory, financial, and technological challenges to such an endeavor that are not discussed here. See footnote 9 for more information on current vendors' reach into international markets.

("Dominion") covering approximately 92% of the total eligible voter population.[32] About a half dozen other firms fill out the second tier, often providing exclusively specialized technology (for instance, IVS, a small firm based in Kentucky, focuses on Vote-by-Phone products), or serving only a specific geographic market, or acting as a supplier to a larger firm that sells machines to end consumers. (See below for section on *Vendor Customer Segmentation* for more discussion on this topic.)

Figure 2a depicts the percentage of eligible[33] voters covered by each vendor. Figure 2b illustrates the number of voters each vendor reaches in absolute terms. A table showing the voter reach statistics for vendors with more than 0.1% market share appears at the back of the report in Appendix A.

Figure 2b: Vendor Marketplace Coverage by Number of Eligible Voters



Note: Only vendors that reach more than 500,000 registrants are included.

The big three firms solidified their market position over the past decade. While the influx of HAVA funding into the industry in 2002 incited a flurry of investment in new electronic voting technology, as this funding dried up, the industry began to consolidate, with Hart Intercivic, Dominion Voting and ES&S rapidly acquiring their smaller competitors. This enabled these larger firms to establish customer relationships in counties to which they previously did not have access.

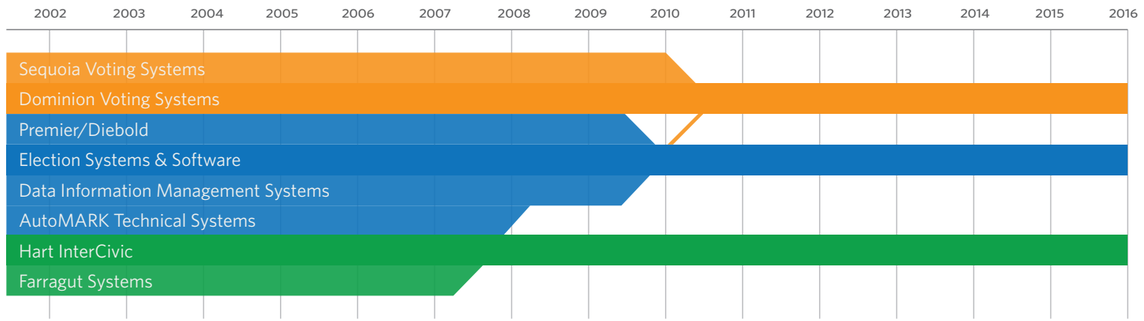
32 It is difficult to get revenue-based market share estimates due to the mix of initial acquisition, services and support revenues and because, none of the major vendors (nor most of the smaller ones) have public financial reports. We can, however, tabulate the number of voters reached by each vendors as an alternative metric of market share. These data were obtained from the Verified Voting Foundation

33 "Eligible" here, and throughout this report, refers to individuals who are registered to vote and have access to electronic voting machines. The data, sourced directly from Verified Voting, does not include jurisdictions that use paper ballots exclusively.

Figure 3a shows some highlights of the consolidation activity of the three largest vendors in the market since 2003, while Figure 3b specifically visualizes the consolidation under the name of one firm, Dominion, using 2016 machine data.

It is worth noting that while we refer to ES&S, Hart, and Dominion as the "large" or "major" vendors, they are only big relative to the other vendors in the market. The largest vendor, ES&S, only has about 460 employees.[34] Election technology is an IT subindustry that the IT giants generally have avoided. "Apple, Dell, IBM, and HP have all steered clear of the sector," affirms a recent article in *Bloomberg Businessweek*.[35] Josh Benaloh, Senior Cryptographer at Microsoft Research, likewise commented that Microsoft "has very little interest in election technologies," at least as far as developing software or hardware for voting machines is concerned; "it's not the kind of mass market that Microsoft generally targets with its products."[36] Rather than investing directly in creating and selling proprietary voting systems, the company focuses instead on partnering with smaller firms to provide voting and election management solutions built on the Microsoft platform.[37]

Figure 3a: **Vendor Consolidation**



Note: The thin diagonal orange line represents the divestment by ES&S of the assets acquired by its purchase of Premier Election Solutions in September 2009, and the purchase of those assets by Dominion in May 2010.

Vendor Customer Segmentation. As noted above, certain vendors seem to cater to specific segments of the market—they only serve jurisdictions of a certain size, or provide particular types of election technology, or do business in certain geographic areas—while others cover the market more broadly.

34 Number of employees as of January 30, 2014. Data obtained from a Public Information Act request to the Maryland State Board of Elections.

35 Michael Riley, Jordan Robertson, and David Kocieniewski, "The Computer Voting Revolution Is Already Crappy, Buggy, and Obsolete," *Bloomberg Businessweek,* September 29, 2016, https://www.bloomberg.com/features/2016-voting-technology/.

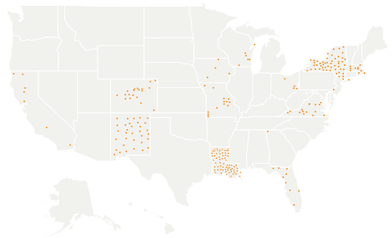
36 Email from Josh Benaloh to Matthew Caulfield, March 30, 2016.

37 See, for instance, http://democracylive.com/about-us/ and https://www.scytl.com/en/partner/microsoft/.

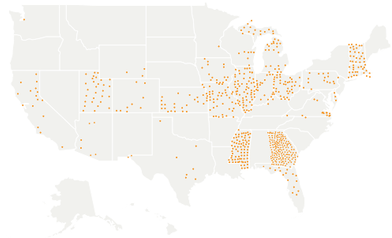
Figure 3b: **Vendor Consolidation Example: Dominion Voting Systems**

In 2010, Canadian election technology firm Dominion Voting Systems conducted a number of acquisitions, consolidating its position in the election technology market in the United States. Dominion acquired Sequoia Voting Systems as well as Premier Election Solutions (formerly part of Diebold, which sold Premier to ES&S in 2009, until antitrust issues forced ES&S to sell Premier, which then was acquired by Dominion). This map illustrates 2016 voting machine data—meaning, these data do not reflect geographic aggregation at the time of acquisition, but rather the machines that retain the Sequoia or Premier/Diebold brand that now fall under Dominion's market share.

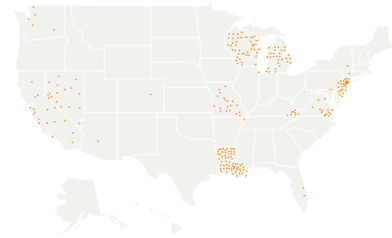
Dominion, *Pre-Merger*



Premier Election Solutions/Diebold



Sequoia Voting Systems



Dominion Voting Systems, *Post-Merger*

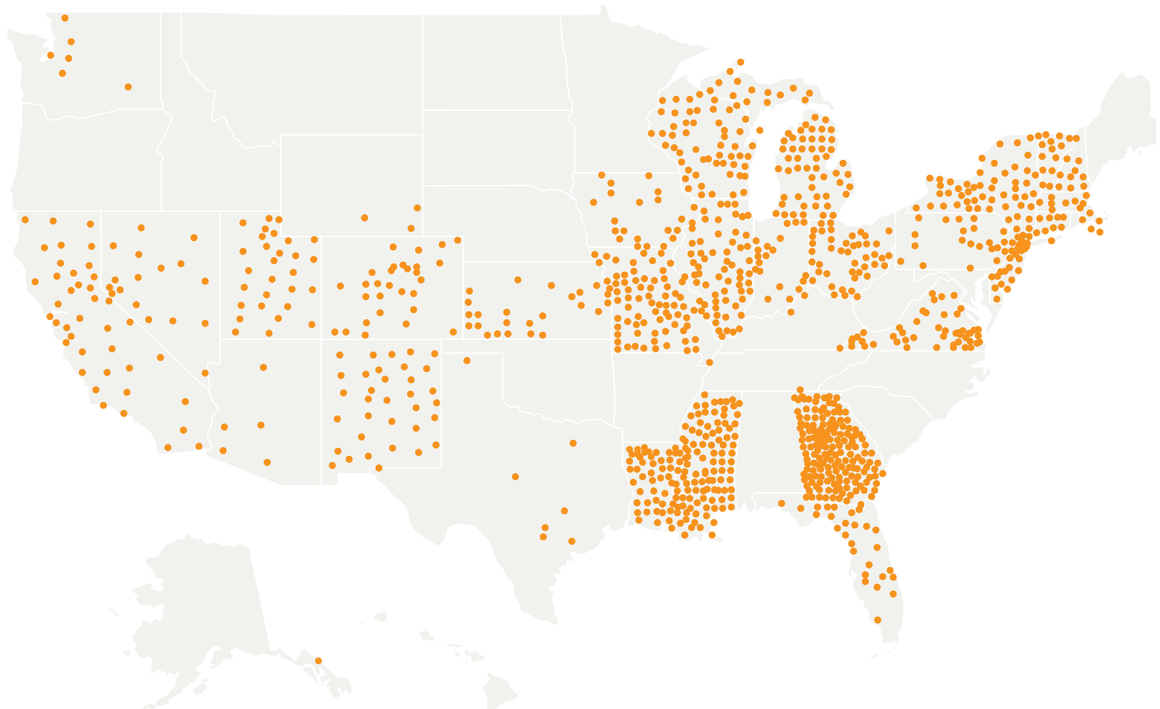


Figure 4 looks at those vendors that individually reach at least 35 jurisdictions, showing the number of registrants and jurisdictions they cover, and calculating a "Registrants per Jurisdiction" average for each. The range is substantial. IVS, the provider of a telephone-based voting system that produces a paper record, is present in a large number of small counties and municipalities with about 3,200 voters per jurisdiction, in contrast with other larger vendors such as Hart, which while present in a similar amount of jurisdictions, has about 50,200 voters per jurisdiction. (The aggregate voter/jurisdiction ratio among the top three vendors is 39,700 voters per jurisdiction.)

Figure 4: Registrants, Jurisdictions, and Registrants per Jurisdiction by Vendor

Vendor	Registrants Reached	Jurisdictions	Registrants/ Jurisdiction (Average)
Election Systems & Software	83,380,867	2,360	35,331
Dominion Voting Systems	71,006,665	1,635	43,429
Hart InterCivic	20,983,037	418	50,199
Unisyn Voting Solutions	3,430,900	120	28,591
MicroVote	3,291,260	93	35,390
IVS	1,336,070	415	3,219
Five Cedars Group	972,475	35	27,785

Note: Only vendors who reach more than 500,000 registrants are included.

In the data provided by Verified Voting, jurisdictions are demarcated by FIPS codes. These are the Federal Information Processing Standard county codes that uniquely identify counties and county equivalents in the United States. Data from the state of Wisconsin are excluded from these numbers, due to an outlier jurisdictional count. Wisconsin data would significantly skew the registrants/ jurisdiction count due the sheer number of its jurisdictions as defined by FIPS codes. Only those vendors reaching more than 35 jurisdictions (outside of Wisconsin) are listed.

Similar variation can be seen in the range of technologies offered by different vendors. As for the technologies themselves, the offerings for voting hardware and software have not advanced much in the past 10 years, especially relative to other contemporary technologies. Among the voting system products most widely used in the US currently, there are 6 common technical approaches for casting and counting ballots:

- Hand marked pre-printed paper ballots counted by optical scan devices.
- Machine marked pre-printed ballots, created by a ballot marking device, counted by optical scan devices.
- Hand marked ballots of several kinds (e.g., emergency ballots, Federal Write-In Absentee Ballots) that are either hand counted, or hand transcribed to pre-printed paper ballots counted by optical scan devices.
- Machine-prepared ballots of several kinds (e.g., Oregon Alternate Format Ballots, or ballots from military voter online ballot marking systems) that are either hand counted, or hand transcribed to pre-printed paper ballots counted by optical scan devices, or are machine transcribed by devices that scan a barcode and generate a ballot counted by optical scan.
- Paperless direct-record election (DRE) devices
- DREs with a paper trail that can be used for ballot audits.

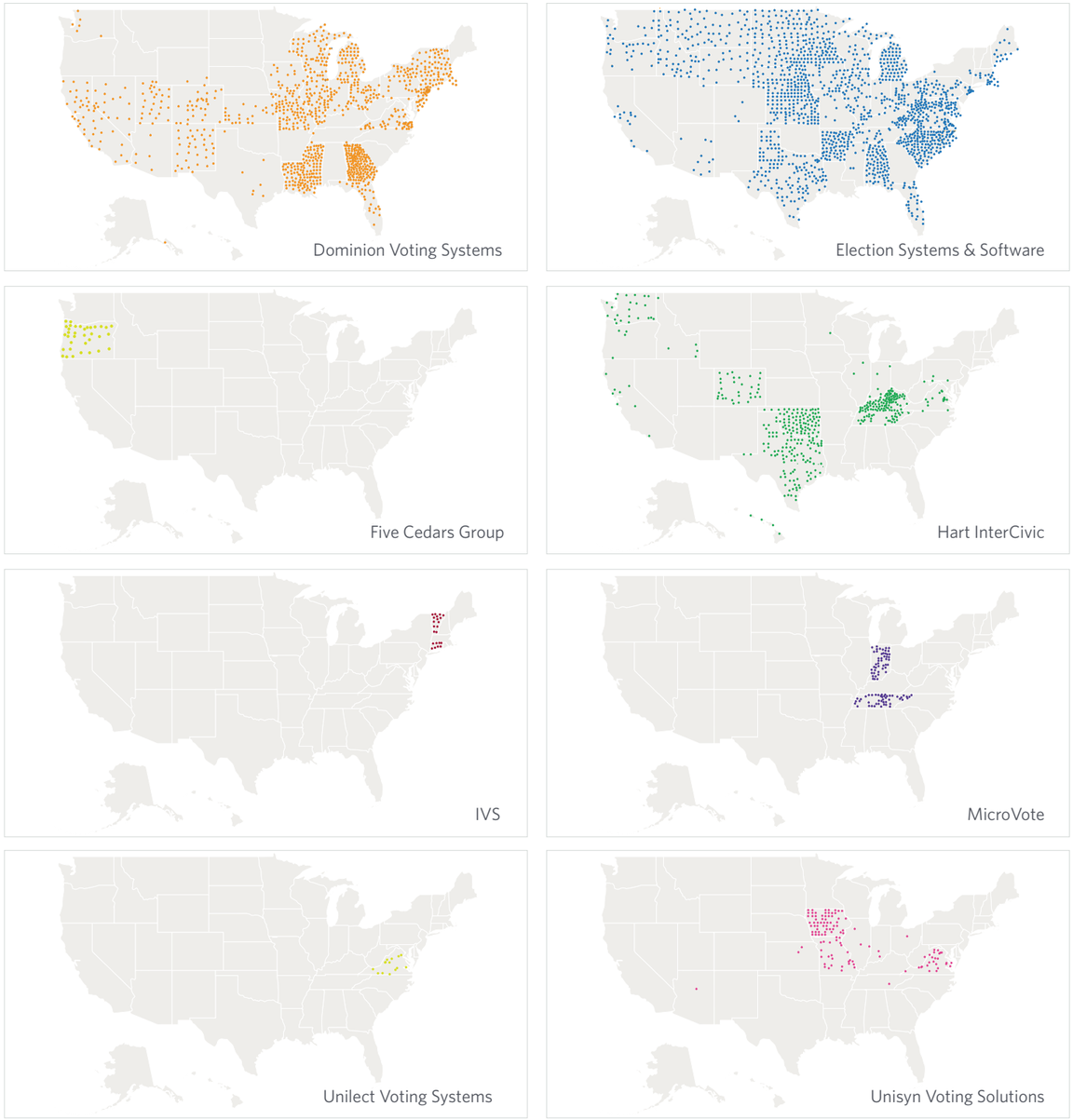
Ballot marking devices involve technology that directly indicates voter preferences on paper ballots, which are tabulated by hand or machine. Direct recording electronic systems involve an electronic interface (telephone, touchscreen, or push button) that captures an electronic record, which is then consolidated and tabulated electronically. Optical scan technologies begin with the voter marking preferences on a ballot and then submitting these ballots to a local or central scanner to complete the vote. [38]

Appendix B illustrates the deployment of these different types of voting systems by vendor. The larger vendors provide or have provided all of the major technologies, although the number of installations for each technology varies. Smaller vendors, however, generally have had less diversified offerings. For example, Unisyn Voting Solutions has not offered any DRE systems, focusing solely on ballot marking devices and optical scan systems. Many other smaller vendors likewise specialize in a particular technology, rather than offer a wider range of products.

Figure 5 illustrates the geographic breakdown of vendor voting machines. While the larger vendors have a wide geographic breadth, smaller vendors typically develop business in particular, localized markets. For example, the Five Cedars Group supplies only the Pacific Northwest. The figure includes only those vendors reaching more than 15 jurisdictions total.

38 For historical and political background on the evolution of voting rights and voting technology, see Douglas W. Jones and Barbara Simons, *Broken Ballots: Will Your Vote Count?* (Center for the Study of Language and Information, 2012); Alexander Keyssar, *The Right to Vote: The Contested History of Democracy in the United States.* (Basic Books, 2009); R. Michael Alvarez and Thad E. Hall, *Electronic Elections: The Perils and Promises of Digital Democracy* (Princeton University Press, 2008); R. Michael Alvarez and Thad E. Hall, *Point, Click and Vote: The Future of Internet Voting* (Brookings Institution Press, 2004); Tracy Campbell, *Deliver the Vote: A History of Election Fraud, an American Political Tradition-1742-2004* (Basic Books, 2006).

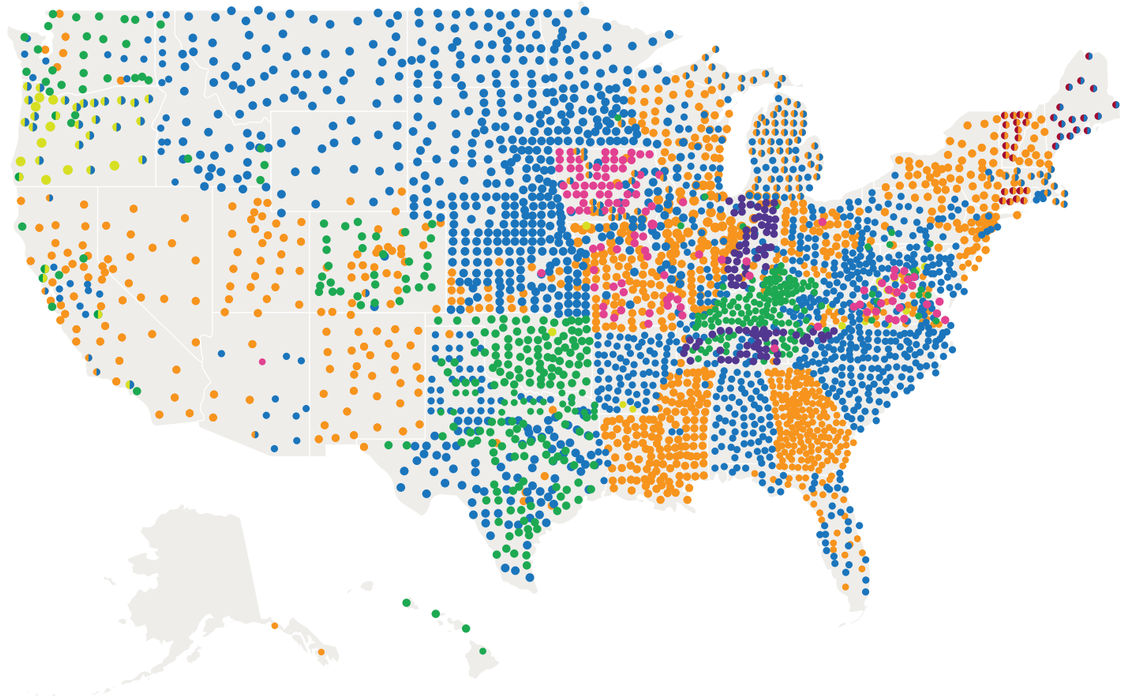
Figure 5: Geographic Breakdown of Voting Machine Use by Vendor



(As noted on Figure 4, jurisdictions are demarcated by FIPS codes in the data provided by Verified Voting; unlike Figure 4, though, the visualization in Figure 5 includes the data from Wisconsin.)

Across the United States, there is significant variation from state to state in the diversity of vendors present within each state. Figure 6 shows aggregated jurisdictional distribution of voting machines by vendor. Some states (such as Georgia, Utah and South Carolina) rely on a single vendor while others, such as California, deploy systems offered by a variety of vendors. When looking at individual presence by vendor, among the top three vendors it is clear that Dominion and ES&S have a more national presence than Hart.

Figure 6: Aggregated Jurisdictional Distribution of Voting Machines by Vendor



Note: If more than one vendor is present in a district, a multi-color pie chart indicates the vendors.

Concentration. Earlier, we traced how the industry has experienced remarkable consolidation over the past decade. Here, we consider the current state of market *concentration* in the industry. An industry is concentrated if the market as a whole, or subsets of the market, are served by a limited number of vendors. Since revenue data for voting technology vendors is limited, we use the "voter reach" market share metric as a proxy. For example, if a firm reaches 50% of voters in a given state, in our calculations it has a 50% market share of that state. Calculations of nationwide market share per vendor are provided in Appendix A.

From a regulatory standpoint, concentrated markets are of interest because they raise the possibility of imperfect competition and attendant problems associated with market power, such as unusually high prices or limited incentives for innovation. When formally measuring market concentration, the Department of Justice (DOJ) and Federal Trade Commission (FTC)[39] typically use the Herfindahl-Hirschman Index (HHI),[40] which is computed as the sum of the squares of the market shares of each participant. The index ranges from 0 (completely un-concentrated, with a large number of very small firms) to 10,000 (a monopoly, with a single firm controlling 100% of the market). The DOJ and FTC consider markets in which the HHI is between 1,500 and 2,500 points to be "moderately concentrated," while markets in which the HHI is in excess of 2,500 points are deemed to be "highly concentrated."

It should be noted that the measurement of concentration for understanding industry structure and supplier behavior is perhaps more meaningful at a national level than a state level. Many states create a state-imposed "monopoly" of voting equipment by establishing common purchasing procedures where a single vendor is selected and serves the state as a whole. According to the National Council of State Legislatures, states that currently have the same vendor and type of voting equipment in polling places statewide include: Alabama, Alaska, Connecticut, Delaware, Georgia, Hawaii, Louisiana, Maine, Maryland, Nevada, New Hampshire, New Mexico, North Dakota, Oklahoma, Rhode Island, South Carolina, Utah, and Vermont.[41] Other states, such as Arkansas and Colorado, are moving toward uniformity as well.[42] As a result, market concentrations in many states are entirely due to buyer behavior and are not necessarily indicative of market power. Regardless, the HHI for *every single* US state is above the 2500 DOJ/FTC threshold for being highly concentrated. (The smallest is Tennessee, at 2,550.) Nationally, even when considering potential variation across states, the market is highly concentrated, with an overall HHI index of 3,435.

Revenue. There are two major revenue streams for election technology vendors. First, there are periodic, large purchases of new equipment. Systems are typically replaced with new purchases when they reach the end of their useful life or when funding

39 United States Department of Justice and the Federal Trade Commission, *Horizontal Merger Guidelines*, August 19, 2010, https://www.ftc.gov/sites/default/files/attachments/merger-review/100819hmg.pdf, p. 19.

40 "Herfindahl–Hirschman Index," *United States Department of Justice*, updated July 29, 2015, https://www.justice.gov/atr/herfindahl-hirschman-index.

41 "Election Costs: What States Pay," *National Council of State Legislatures*, June 16, 2016, http://www.ncsl.org/research/elections-and-campaigns/election-costs.aspx.

42 Id.

becomes available. New purchases may account for about a third of industry revenue.[43] The second revenue stream relates to ongoing maintenance, support, and services, which constitute the remaining two-thirds of industry revenue. Previous research has shown that enterprise software systems typically entail support costs equal to around 20% of the software licensing costs.[44] Procurement contracts reviewed for this study suggest that these costs are similar in the election technology market, on the order of 20-25% of the initial purchase price annually, although the financial intelligence firm PrivCo reports that "[l]ong-term service contracts can sometimes be worth half as much as new equipment."[45] This revenue stream, however, is not smooth year-to-year, primarily because of the "lumpiness" of new equipment procurement. In particular, the influx of HAVA funds for machine replacement precipitated a mass purchasing of voting machines in the early 2000's, clustering replacement cycles disproportionally on certain years (e.g., the many states that purchased machines in 2002 would have to replace them around 2012, and again around 2022).

An exact figure for annual industry revenue is not known with certainty. A report put out by the Caltech/MIT Voting Project sizes the industry at about $300 million, in the same range of prior publicly available market size estimates.[46] The Brennan Center estimates that replacing all the voting machines in the United States would entail costs that "fall somewhere between $580 million and $3.5 billion," and forecasts the actual figure at "well over $1 billion."[47] Including support costs, this again would translate into about a $300 million annual industry ($1 billion amortized over a 10-year useful life, plus an estimated 20% of acquisition annual cost of support). Data available online from PrivCo seem to corroborate this revenue picture, and indicate that the revenues of the top three firms (ES&S, Dominion, and Hart, which together comprise over 90% of the market) totaled approximately $351 million in 2015 (see Figure 7).[48] The OSET Institute, however, believes the replacement costs will be toward the high end of the range cited by the Brennan Center, coming in slightly over $3 billion. They base their calculation on the premise that 2.45 million machines will need to be purchased to serve the 10,079 jurisdictions throughout the U.S., with the replacement cost of those machines estimated at $1,250 "per seat." Those figures would imply that annual revenue going forward would reach $800 to $900 million (with the range depending on whether machines have a 10- or 15-year useful life). However, in the best case, it likely would take several years to reach this level due to the timing of the procurement cycle, even if funding became immediately available.

43 To illustrate how this revenue relates to the lifecycle cost of a voting machine, consider the purchase of a new voting machine installation for $100,000 which has a useful life of 10 years. This contributes about $10,000 per year. If annual maintenance revenues are 20% of new purchase price per year, then this machine will also be associated with $20,000 of services revenue per year. Thus, capital costs comprise about a third of annual expenditure over a long time period under these assumptions.

44 Lorin M. Hitt, D.J. Wu, and Xiaoge Zhou, "Investment in Enterprise Resource Planning: Business Impact and Productivity Measures," *Journal of Management Information Systems*, 19:1 (Summer 2002), https://www.scheller.gatech.edu/directory/faculty/wu/pubs/Hitt_Wu_Zhou_JMIS_2002.pdf.

45 PrivCo report on Dominion Voting Systems, Inc. Accessed at www.privco.com, January 2017.

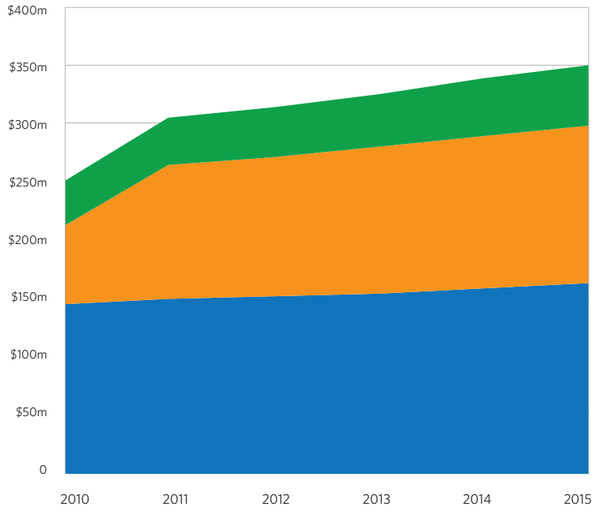
46 Caltech/MIT Voting Technology Project, *Voting: What Has Changed, What Hasn't, and What Needs Improvement* (2013), http://vote.caltech.edu/reports/6, p. 22. An earlier report from the MIT/Caltech Voting Project estimated total costs over a 15-year lifetime of $32.75 per voter for direct-recording electronic (DRE) voting systems and $29.50 per voter for optical scanning systems. Using a figure of 142.2 million registered voters from the US Census data on the November 2014 election, this yields annual costs of $280 million to $310 million.

47 *America's Voting Machines at Risk,* p. 17.

48 Data downloaded from www.privco.com in January 2017.

Profitability. The profitability of the industry as a whole is unknown. While PrivCo provides revenue numbers for the major players, their cost structures can only be estimated. We do have some cost data, though, for Unisyn Voting Solutions, the industry's fourth-largest vendor, which has struggled financially since its inception. Unisyn reported a positive operating income in the election years 2008 and 2012, but had negative operating income in the three intervening years. During part of that period (2008-2010), Unisyn was investing in the development of a new digital optical scan election system, which necessarily affected its financial position. But even after Unisyn stopped spending on R&D, the company still had weak profit numbers. Despite revenues of over $5 million in 2012 and $3 million in 2013, the company barely earned a positive operating income—just $280,000 in 2012 and $50,000 in 2013.[49]

Figure 7:
Revenue of Top Three Vendors over Time



It is unlikely, though, that the larger vendors have generated similarly disappointing figures. The top three firms all have had much higher revenue figures as well as significantly greater voter reach within the market. Moreover, two of them, ES&S and Hart, are at least partially owned either by private equity investment firms or financial holding companies. This category of investors typically has aggressive return rate targets for their investments. It is unclear, however, whether they believe those targets can be met with the industry as it exists today, or if they made their investments in anticipation of a significant, HAVA-like influx of new funding to modernize the voting systems currently in use (or in anticipation of some other unascertained market event).

Competitive Dynamics. Absent a major change in either technology or funding, growth in the industry is constrained by the growth in the base of registered voters. In addition, since voting systems can last for 10 or more years and are not interoperable, competition is focused around the limited number of events where systems are being replaced, which is typically done by some variation of an open bidding process, whereby vendors compete aggressively for new business. For vendors, the process entails substantial investments in direct marketing to election administrators, engagement in lobbying and other political activity, and even the initiation of litigation proceedings over unsuccessful bids. An analysis of the industry's largest vendor, ES&S, describes its sales practices in this way: "Management has aggressively increased its market share by regularly offering the lowest bids to local governments and outbidding competitors with better terms to cash-strapped governments. Such pricing power and strong sales tactics help the company drive competitors out of large markets." In one documented instance, ES&S negotiated a contract in 2010 with Nassau County in New York for a new integrated voting system and service agreement costing over $14 million, in which the company offered to buy back, "at a higher price than the original purchase price," all 450 of the county's current ImageCast voting machines (manufactured by competitor Dominion), thus effectively granting the county a rebate of over $4.5 million. To make the deal sweeter, ES&S agreed to re-market and sell the discarded Dominion machines "as is," and to split the resulting proceeds 50/50 with Nassau County, which the county would then use as an additional credit "for their future purchase of products and services from ES&S." ES&S was even willing to "guarantee a minimum of $500,000 in sale proceeds" and to make those funds "immediately available to the County Board of Elections" in Nassau County for making the proposed purchases from ES&S.[50]

Although vendors compete aggressively for business, the limited size of the industry and the existence of certain common interests also provide motivation and opportunity for cooperation between vendors in areas such as regulation, certification, standards-setting, and the identification and encouragement of new funding sources. That is, there are at least a few areas where vendors have common interests, and as such, are not pitted against each other aggressively. For instance, voting technology companies are invited to send representatives to events such as "Manufacturers' Meetings," where they have incentives to work together in providing technical advice and information to representatives from standard setters to prevent the establishment of standards or time frames for the delivery of new systems that are impossible to meet or are generally unfavorable for them.

Existing vendors also face little threat of external entry from technology firms not currently working in the election technology realm. Vendors have voiced concerns that the process of certifying new voting technology creates enormous development costs and implementation delays, which are difficult to recover and therefore create disincentives for innovation. (Such barriers to innovation will be discussed in more detail in the second part of this report.) As a result, both vendors and their customers feel that they are 'locked in' to older technologies that are difficult to support over the full 10- to 15-year product lifecycle. Idiosyncratic customer preferences—each jurisdiction has its own budget constraints and voting format preferences (e.g., DRE vs. paper ballots), as well as required or preferred customizations (e.g., for multilingual voting, or disability access)—also have limited the ability of vendors to offer standardized services, while at the same time requiring significant sales, marketing and support infrastructure to handle the number and variety of customers. These challenges collectively create a substantial barrier to entry and limit interest in this industry among outside IT vendors.

49 PrivCo report on Unisyn Voting Solutions. Accessed at www.privco.com, January 2017.

50 PrivCo report on Election Systems & Software. Accessed at www.privco.com, January 2017. PrivCo report includes documentation on the agreement with Nassau County.

Customers

Whereas vendors are few in number, and offer a limited range of election systems within a constrained, concentrated market environment, their thousands of consumers have particular, idiosyncratic needs, as well as limited budgets with which to procure them.

Election Administrators. In the US, decisions about elections are typically managed at the county level, although some states provide purchasing support or other central services to facilitate the procurement of election technology (typically coordinated through the office of the Secretary of State). This creates more than 10,000 potential customers, all of whom can vary in their budgets, technological resources, preferences, requirements, and knowledge about voting technology. Turnover among election officials creates further variability.[51]

There is, however, some natural segmentation of customers. It has been estimated that less than 6% of local election officials serve more than two-thirds of the voters nationally.[52] The jurisdictions with high concentrations of voters command significant vendor interest and have the scale, in some cases, to request specific features or customizations for the voting systems they receive.[53] Some of these jurisdictions have election officials who are especially invested in innovation and are willing to expend the time and effort to encourage vendors to develop systems that fit their specific needs. They may also have full-time, professional information technology staff to support and monitor their procurement and operations. Regardless, most jurisdictions select one particular technology, or at most two, as well as a particular vendor, and retain these systems through their useful life (and often beyond).[54]

Procurement Process. All buyers of voting machines in states without centralized procurement processes operate under the constraints of their local and state procurement regulations. While these regulations were created in hopes of improving the purchasing process—offering a largely objective means for selecting vendors and ensuring proper attention to requirements and specifications, while yielding higher quality at a lower cost through competitive bidding—they often have unintended consequences that can be costly.

Procurement typically involves a cumbersome, time consuming, multi-stage process of soliciting vendor interest, performing vendor pre-qualification, preparing requests for proposals (RFPs), collecting responses to the RFPs, clarifying responses, selecting vendors, publicizing the selection, and then finally engaging in the contracting process.

51 Telephone Interview with Warren Stewart from Verified Voting, April 15, 2016. When collecting county official contact information, he notes "incredible turnover."

52 David C. Kimball and Brady Baybeck, "Are All Jurisdictions Equal? Size Disparity in Election Administration," *Election Law Journal* 12: 2 (2013), p. 130-131.

53 See below for a case study on Miami-Dade County, FL exploring this trend.

54 See generally *America's Voting Machines at Risk*.

Los Angeles Registrar-Recorder/County Clerk Conny B. McCormack recalled that "it required six months of preparation and multi-departmental coordination to write [the county's] comprehensive 150+ page RFP" when it sought to replace its voting machines after the 2000 election.[55] Even after the RFP was submitted, reaching an agreement with a vendor proved difficult, owing to differences in expectations about the timeline for delivery, schedule of payments, legal dispute resolution system, and use of the equipment (i.e., whether it could be used for other purposes outside of elections). Indeed, stringent procurement criteria and complex processes reduce the possible vendors to a short list of well-established players who have the resources and internal expertise to research and prepare successful RFP submissions. At the same time, many election officials—who may never have been involved in IT procurement—simply lack the technical expertise or do not have a specific interest in the technological side of voting to participate effectively in the RFP process and contracting of IT services. By contrast, vendors tend to be significantly more seasoned in voting machine and technical services contract negotiations. This mismatch in skills can result in sub-optimally negotiated contracts for jurisdictions.[56]

The complexities of the RFP process entail both direct costs and opportunity costs, and they raise switching costs for customers and development costs (that may ultimately be passed on to the customers) for vendors. As noted earlier, the infrequent nature and large volume of system procurements create strong incentives for vendors to compete for these contracts, and unsuccessful bidders may also contest the decision through lobbying and litigation, which further increases costs and introduces delays and uncertainty into the process.

The illustrations on the following pages describe a couple of notable examples of how convoluted this RFP process can become for vendors and customers alike.

55 Memo from Conny B. McCormack, Registrar-Recorder/County Clerk, "The Challenge: Voting System Replacement," October 1, 2001, http://rrcc.lacounty.gov/general/ARCHIVES/vs-replacement.htm.

56 Seeing an opportunity in the skills mismatch, at least one firm, InfoSentry Services, went so far as to develop and offer courses "on purchasing procedures and contract negotiation strategies for election technology," geared toward election officials. "The courses covered contract negotiation strategies and skills, as well as common mistakes government organizations make when dealing with vendors' experienced contract negotiators." See http://www.infosentry.com/IS_Purchasing-Contract-Negotiations-Certification_20041013.htm.

A Closer Look:

San Francisco

With the city's contract with Dominion set to expire at the end of 2016, the San Francisco Department of Elections submitted a Request for Information (RFI) in August 2015 highlighting criteria for a new voting system, including requirements regarding functionality, usability/transparency, results reporting, and adaptability that were so particular as to be beyond the abilities of many vendors.

The Department enumerated 24 criteria related to functionality alone. The Department sought to implement a new voting system specifically with open-source software that provides information in open data formats, and invited information from companies with solutions that are "fully accessible to all voters, are based on voters marking paper ballots, and conduct ranked-choice elections." The city also wanted a system that would accommodate "the formatting of multiple-language ballots" and "integrate additional languages with minimal preparation of and modification to the overall system"; be "designed with minimal moving parts to reduce maintenance and associated costs"; as well as have "a small footprint inside delivery vehicles" so as to enable the Department to "transport equipment using minimal resources." At the same time, though, the Department of Elections made it clear that "the City will not award a contract based on this RFI," and would use responses only to "inform the City's scoping process when preparing the expected RFP in 2016."[57] In the end, San Francisco cancelled its plans to issue an RFP to solicit new machines from traditional vendors after the city's Elections Commission unanimously approved a resolution in November 2015 to pursue, instead, the development of an open source voting system based on non-proprietary software code. (A discussion of open source technology for voting can be found later in this report.)

San Francisco hopes to launch this open source voting system by November 2019, and in the interim has focused on extending its existing contract with Dominion Voting Systems.[58]

57 City and County of San Francisco, Department of Elections, "Request for Information (RFI): City and County of San Francisco's Voting System, RFI# REG2015-01," https://www.eac.gov/assets/1/Documents/SF_RFI_VotingSystem.pdf. Quotes taken from p. 1-2, 4-5.

58 "San Francisco Sets Sights on Open Source Voting by November 2019," *San Francisco Examiner,* November 26, 2015, http://www.sfexaminer.com/san-francisco-sets-sights-on-open-source-voting-by-november-2019/; "San Francisco Prepares to Open Source Its Voting System Software," *The Register,* February 10, 2016, http://www.theregister.co.uk/2016/02/10/san_francisco_to_open_source_voting_systems/.

A Closer Look:

Arkansas

An RFP issued in April 2015 announced that the Arkansas Secretary of State "[was] considering replacing the voting equipment in 75 Arkansas Counties," and wanted to do so by the following March, in anticipation of the 2016 election cycle.

"If the project proceeds"—the RFP offered no clear commitment on that—Arkansas sought a vendor to take responsibility for the complete replacement of the state's existing machines, and the installation, training, testing, and maintenance for a new sole-source voting system that would integrate polling place equipment and voter registration systems. Although the Arkansas legislature made an appropriation of $30 million to pay for a 5-year contract with a vendor, the RFP emphasized that annual funding was not guaranteed, and that the Secretary of State therefore reserved the right terminate any agreement "effective upon delivery of written notice to the Vendor."

Vendors that wanted to submit a proposal needed to present five years of audited financial reports, show a history of three successful statewide voting system implementations, document their employee base and company size, identify the original manufacturers of any equipment acquired from outside vendors, and demonstrate proof of nationwide presence. This last requirement alone would disqualify most potential bidders

Indeed, the Arkansas Secretary of State received just three replies to the RFP, and selected a new system provided by the industry's largest player, ES&S. Despite the $30 million appropriation, however, no funding was set aside to pay for rolling out the new voting system statewide. The Office of the Secretary of State ultimately pulled over $2 million from its own reserves to pay for a limited rollout. Only 4 of the 75 counties had upgraded voting systems in place by the March 2016 target date; as of early 2017, that number had risen to just 11.[59]

59 Arkansas Secretary of State, "Request for Proposal for Statewide Integrated Voting System," https://www.eac.gov/assets/1/Documents/State%20of%20Arkansas%20RFP-RFQ%20Elections%20Integrated%20Voting%20System.pdf; "Funding Elections Technology," National Council of State Legislatures, February 2, 2017, http://www.ncsl.org/research/elections-and-campaigns/funding-election-technology.aspx; "New Voting Machines Worked as Planned; Record Turnout for Republican Primary," HarrisonDaily.com, March 4, 2016, http://harrisondaily.com/news/new-voting-machines-worked-as-planned-record-turnout-for-republican/article_829f1efc-e190-11e5-8698-a735d7082691.html; "County Clerks Push to Replace Aging Voting Machines," ArkansasMatters.com, February 2, 2017, http://www.arkansasmatters.com/news/local-news/county-clerks-push-to-replace-aging-voting-machines/648986711.

The Regulatory Environment

Transactions between customers and vendors are shaped by federal and state guidelines; understanding the voting technology regulatory environment is critical to understanding potential mechanisms for reform in this industry. While state laws are subject to certain federal constitutional[60] and statutory[61] constraints, states and lower-level jurisdictions have wide latitude in making decisions central to the integrity of elections, including purchasing voting machines, establishing training procedures, implementing testing procedures, and setting certification standards. There are two federal agencies commonly associated with elections—the Federal Election Commission (FEC) and the Election Assistance Commission (EAC). The FEC's domain falls mainly in the financing of federal elections, and though it has had some role in developing standards historically, it holds little sway over the election technology industry as we present it here.[62] The EAC, which may soon be eliminated, is notably not named the 'Election Regulation Commission';[63] it offers assistance and significant resources to states and other stakeholders, but holds no direct regulatory authority over them.[64] Some of its functions include developing the Voluntary Voting System Guidelines (VVSG) with standard-setting entities,[65] certifying Voting System Test Laboratories (VSTLs),[66] and acting as an information hub for election officials needing guidance.

Despite its lack of fiat, thirty-seven states in addition to the District of Columbia use some aspect of the federal testing and certification program: nine states and D.C. require testing to federal standards, sixteen require testing by a federally accredited laboratory, and twelve require full federal certification (see Figure 8).[67] Otherwise, states develop their own standards and put

60 For example, the Fifteenth and Nineteenth Amendments forbid racial and gender discrimination respectively, the Twenty-fourth Amendment prohibits poll taxes, and the Twenty-sixth Amendment sets the maximum voting eligibility age at 18 years. See generally http://constitutioncenter.org/interactive-constitution/amendments/amendment-xv.

61 Most notably, the Voting Rights Act of 1965.

62 For an early history, see United States Federal Election Commission, "History of the Voting System Standards Program," http://www.fec.gov/pages/vsshst.htm.

63 We thank Greg Miller from the OSET Institute for raising this point.

64 It is worth noting a previous attempt to eliminate the EAC, under charges of redundancy. See "Election Commission May Be Closing," *Roll Call*, April 13, 2011, http://www.rollcall.com/issues/56_111/Election-Assistance-Commission-May-Be-Closing-204942-1.html.

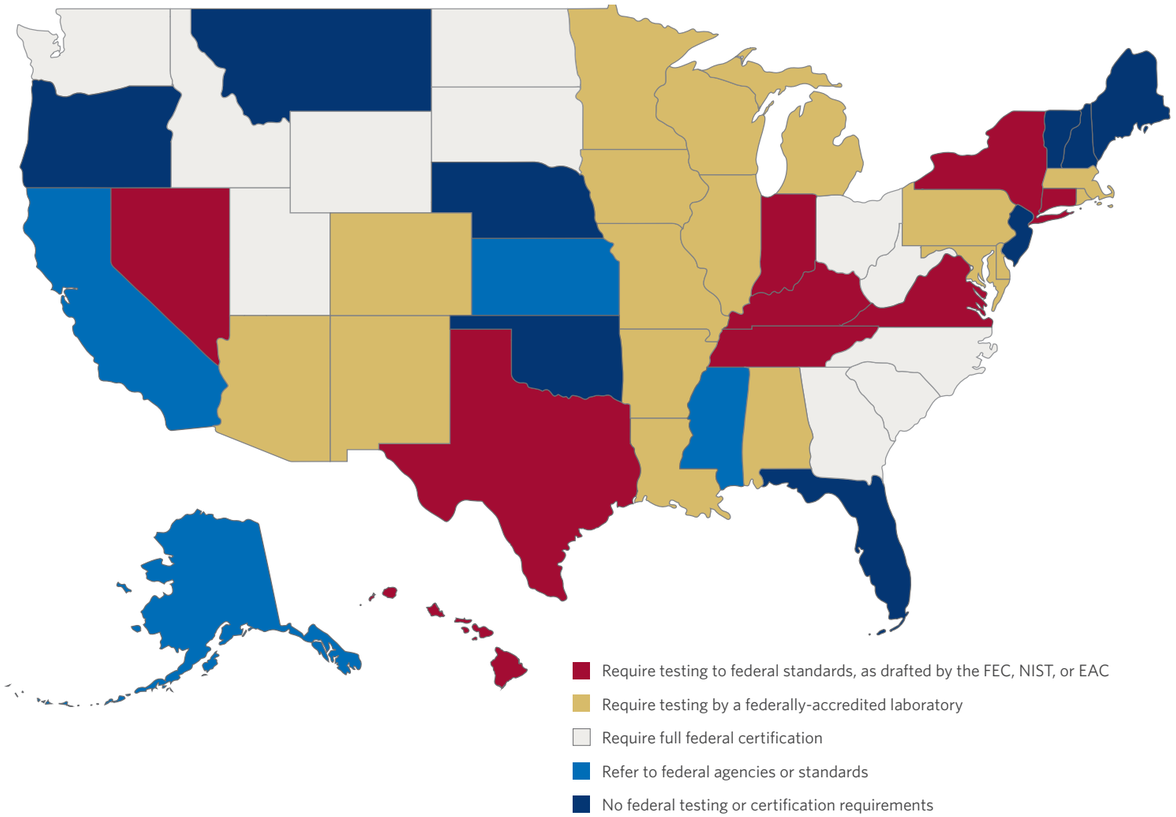
65 The purpose of the VVSG is to enumerate a baseline set of specifications and requirements against which to test voting systems, to determine if they meet expected standards of integrity with respect to functionality, accessibility and security capabilities. The National Institute of Standards and Technology (NIST) and the Technical Guidelines Development Committee (TGDC) are heavily involved in this process.

66 One concern that has been voiced about the current certification system is that manufacturers are allowed to pay VSTLs directly, giving rise to conflicts of interest. While the EAC has expressed desire to collect money from all vendors and pay the costs of testing itself, they do not have the legal authority to collect money directly from manufacturers by statute. (See Election Administration Commission, "Frequently Asked Questions," http://www.eac.gov/testing_and_certification/frequently_asked_questions.aspx.) Experts have expressed concern that this leaves the country with "few checks and balances…if [testing labs] fail to serve the public interest." (See *Written Testimony of David Wagner, Ph.D., Computer Science Division, University of California, Berkeley, Before the Committee on Oversight and Government Reform, Subcommittee on Information Policy, Census, and National Archives, U.S. House of Representatives, May 7, 2007,* https://people.eecs.berkeley.edu/~daw/papers/testimony-oversight07.pdf. At least one VSTL has previously been suspended for failing to perform tests with sound methods, qualified personnel, or proper documentation. (See "Lab That Tests and Certifies Voting Machines Suspended," *Wired*, October 29, 2008, https://www.wired.com/2008/10/lab-that-tests/.)

67 Data provided by the National Council of State Legislatures, "Voting System Standards, Testing and Certification," December 14, 2015, http://www.ncsl.org/research/elections-and-campaigns/voting-system-standards-testing-and-certification.aspx. The NCSL notes that four additional states refer to federal agencies or statutes, but this is only more tangentially.

in place their own testing procedures, drawing on guidance from other voting technology experts. For example, states such as Connecticut and Georgia have cultivated partnerships with universities for advice and assistance.[68]

Figure 8: Voting System Testing and Certification



68 Id. The NCSL states: "The Connecticut secretary of state partners with the University of Connecticut's Center for Voting Technology Research to perform these functions. In Georgia, Kennesaw State University's Center for Election Systems serves as the designated certification agent (Ga Comp. R. & Regs. 590-8-1-.01) and Ball State University's Voting System Technical Oversight Program (VSTOP) advises the secretary of state on the certification of voting systems in Indiana (Ind. Code §3-11-16-4)." See also: electionline.org, *Case Study: Election Partnerships* (June 2007), https://voter.engr.uconn.edu/voter/wp-content/uploads/UCONN%20partnership%20report.pdf.

While the EAC certainly had sway over a plurality of states, the fact is that the federal government does not have the authority to institute changes in a "top-down" fashion when it comes to election technology. Even if change were easier at the federal level, some states clearly worry about federal overreach and infringement on state-level affairs. When the Department of Homeland Security in August of 2016 offered to help states across the country ensure the integrity of their technology given the technology's relevance to national security concerns, Georgia's Secretary of State, Brian Kemp, reacted with alarm. As he put it: "The question remains whether the federal government will subvert the Constitution to achieve the goal of federalizing elections under the guise of security."[69] The regulatory environment, which embodies American principles of federalism, seems to limit the promotion of any sort of national standards for all election systems.

Industry Structure and Innovation

Whereas the first section of the report characterized the election technology industry, we now turn to analyzing the industry structure.

The election technology industry exhibits low- to moderate- levels of competition.[70] There is no meaningful competitive pressure from the suppliers to the vendors. Most are technology component providers that either make generic commodities that are primarily consumed by players in other industries (e.g., touchscreens, disk drives), or operate under contract as manufacturers or assemblers. Similarly, there is little threat from existing substitute technologies, given the unique requirements for voting technology. That is to say, America needs voting machines and no other product can fulfill their function or satisfy that specific need.[71] The highly fragmented customer base with widely varying levels of technological and purchasing expertise, along with high switching costs and a costly procurement process, create limited buyer power for all but the largest customers. Moreover, any new technologies have to go through a costly certification process, further deterring entry into the market. Finally, the high degree of concentration of the incumbent firms limits the rivalry among them.

69 "Elections Security: Federal Help or a Power Grab?" *Politico*, August 28, 2016, http://www.politico.com/story/2016/08/election-cyber-security-georgia-227475.

70 The classic "Porter's Five Forces" framework, as a common analytical approach in strategic management for understanding the factors that drive the structure and profitability of an industry, is instructive here. The five forces are: supplier power, buyer power, rivalry among firms, entry barriers, and threat of substitutes. See Michael E. Porter, "The Five Competitive Forces That Shape Strategy," *Harvard Business Review* 86:1 (2008), https://hbr.org/2008/01/the-five-competitive-forces-that-shape-strategy.

71 The classic example of a substitute relationship is neckties as substitutes for power tools—both are very popular purchases around Father's Day.

Government regulators typically view a low level of competition as a sign of potential collusion among firms. We have no evidence that suggests the existence of active, collusive behavior or the inappropriate exercise of market power by firms, which can occur in other imperfectly competitive industries. We can say, however, that the low level of competition is attributable at least in part to certain deliberate structural characteristics of the voting technology industry—in particular, the fact that many states and county coalitions purchase *en bloc* from a single vendor. Moreover, what we observe is that the consequences of such structural characteristics are directly tied to a key concern articulated by many industry stakeholders: limited incentives for technological innovation. There are several ways in which the structure of the industry can stifle innovation, and in the remainder of this section we discuss these structural characteristics and their implications in more detail.

Barriers to Innovation: Lack of a Consistent Funding Stream

It is difficult if not impossible to spur technological innovation without steady funding, but that is exactly what the election technology industry lacks. It appears that most jurisdictions provide a minimum baseline level of funding to maintain existing systems and tend to keep new investment to a minimum. As a result, it typically requires a substantial infusion of external funds to cause purchasing to significantly increase (at least temporarily), such as when the federal government made HAVA funds available nationally.[72]

Aside from such an infusion, specifically in states with non-centralized voting technology acquisition, most resources are obtained through local funding. In our survey of 33 election officials in counties that had made recent purchases, around two-fifths purchased equipment with HAVA funds,[73] one-fifth purchased equipment with appropriations from local municipalities, and a few others did so with appropriations from state funds. Other sources of capital included county and town appropriations. Going forward, as HAVA funding is further exhausted, more funding will need to be sourced from non-federal budgets whenever voting technology needs to be upgraded. When asked about funding future purchases, only about one-fifth of our survey respondents expected to use unspent HAVA funds; the rest expected to obtain funding from local municipalities, state funds, county funds, and other local appropriations. Raising funds on a consistent basis from any one of these sources is challenging. Our discussions with county officials revealed that many state-level bureaucrats do not believe that voting technology is a priority budget item. As pointed out by Matthew Dunlap, Secretary of State of Maine, a central aim of state legislatures is to 'stay off the front page of the newspaper,' which can impact how they think about appropriations.[74] It is difficult to justify new investment in voting technology when the returns from it are unclear, especially since funds may have to be diverted away from other seemingly more pressing and more visible expenditures, such as those on roads and schools.

72 Survey respondents noted that an infusion of HAVA funds prompted many of their districts to buy new technology.

73 One respondent, when asked what the three priorities that drove their funding acquisition, responded merely: "HAVA, HAVA, HAVA."

74 Matthew Dunlap, Secretary of State for the State of Maine, Presentation at the 2016 Election Verification Network Conference, March 10, 2016, Washington D.C.

Barriers to Innovation: Buyer Switching Costs

In addition to the paucity of available and adequate funding, buyer switching costs are high, which tends to further limit competition and reduce incentives for innovation. Voting systems are durable goods with a life cycle of at least 10 years. The infrequency of purchase, combined with the noted staffing turnover among county officials, means there is little accrual of useful experience among counties for acquisition, especially when new or different technologies are introduced. Given that funding for new purchases may be difficult to obtain, jurisdictions are especially committed to getting the full useful life out of the systems they have already purchased, limiting their ability to adopt new technology, accommodate changes in voter preferences, or simply correct past procurement mistakes. Systems are typically not interoperable, and as such, would necessitate replacement as a whole, making the task all the more daunting. As a result, election administrators feel 'locked in' to their existing technology.

Difficulties with the implementation and management of new systems create additional switching costs. Almost every surveyed election official listed training as the main challenge accompanying the adoption of any new technology. Depending on the nature of the transition, election officials, poll managers, poll workers, system maintenance specialists, election programmers, and voters all need to be trained under a new system.[75] Vendors too have pointed to training issues as a source of chaos on election days.[76]

At the same time, there is an understanding that greater efforts are warranted to ensure improved voting accuracy and election integrity, including requiring pre-Election Day testing and post-election audits.[77] This could be facilitated by aggressive "schedule management" for new installations and effective coordination with the vendor.[78] But given the risks involved, as well as the concerns of election officials that they do not have adequate processes in place to evaluate the effectiveness and efficiency of voting machines on their own, these officials have become dependent upon the vendors to support, maintain and even operate their systems. In the enterprise software industry broadly, some of this support burden could be picked up by consultants and third-party support vendors. Here, however, third-party support, where an outside firm supports or maintains a system provided by a different vendor, is unusual and rarely permitted under contracting terms, particularly since auxiliary services constitute such a large part of industry revenue. A company analysis of one major election systems vendor

75 United States Election Assistance Commission, *Ten Things to Know About Selecting a Voting System* (Managing Election Technology Series #1), http://www.eac.gov/assets/1/Documents/Managing%20Election%20Technology%20Series%201%20Ten%20Things%20FINAL.6.24.15.pdf, p. 3.

76 Lida Rodriguez-Taseff, "Florida's Post 2000 Voting Systems Overhaul: The Road to Perdition," *The John Marshall Journal of Information Technology & Privacy Law* 23:3 (2005) p. 500-501.

77 National Council of State Legislatures, "Voting Technology: Current and Future Choices," *The Canvass: States and Election Reform*, Issue 31 (June 2012), http://www.ncsl.org/documents/legismgt/elect/Canvass_June_2012_No_31.pdf.

78 For instance, the Director of Elections in Multnomah County, Oregon shared: "Timing is everything—make sure that you time your acquisition so that your first election with the new system is a small one. Test, test, test and then test some more—I can't tell you how valuable it was for us to hold a full scale test election of the system before final acceptance and payment. Dedicated project management staff on both the vendor side and the jurisdiction side to move the project forward all the way from developing the procurement documents to final acceptance testing."

noted the strong incentive for the vendor to offer a closed system and to engage in practices that limit the market for third party services.[79] The dependence on vendors for technological support is especially common for smaller jurisdictions that do not have dedicated information technology staff and lack the resources to manage their voting hardware. Larger jurisdictions nonetheless have had this issue too. In the aftermath of the rocky 2002 midterm elections in Miami-Dade County, Florida, its Office of the Inspector General issued a biting report, which addressed in part the dependence that vendor agreement structures created. "[T]he relationship between ES&S and the County can be summed up in one word: dependence," the report asserted. "ES&S' intention is to sell the County extended Hardware Maintenance Agreements, and not to assist the County to become self-sufficient."[80] Such contractual relationships limit the interest of vendors in making substantial changes to their products that would affect the customer over the lifetime of a contract.

There is also an inherent economic risk in any investment in new technology. Election officials know that putting in place new technology does not guarantee improvement—and that failed implementations that have to be abandoned or modified entail high real costs and opportunity costs. In the survey responses we received from election officials, there seemed to be wide variation in experiences across counties with respect to the benefits of new technology. For example, the Elections Administrator in Bexar County, Texas indicated that voters "loved" the new direct recording electronic (DRE) voting system they acquired after the enactment of HAVA. By contrast, the Bourbon County Clerk in Kentucky recalled acquiring new machines to address disability accessibility concerns with the county's previous machines, only to find that voters overwhelmingly preferred the older machines because (ironically) they seemed easier to use. People get accustomed to voting in certain ways—for instance, in person versus by mail—and to using specific types of voting systems, and the accumulation of those past experiences can affect how accepting they are of new voting infrastructure. In other cases, new technologies lack capabilities of the older technology, such as an archival paper ballot. Election officials have noted that many voters do not trust DREs for that reason. In California, that distrust prompted lawmakers to impose a costly modification to the state's electronic voting systems. In 2004, the California legislature enacted a paper trail law requiring printed records of all ballots cast on electronic voting machines, to ensure their reliability. While printers already were part of the contracts that some California counties had with their election system vendors, many others found themselves having to pay extra for them. "Orange County estimates it will cost $9 million to make the changes," the *Los Angeles Times* reported. "Riverside County estimates its cost at between $3.4 million and $4.7 million, and Alameda County may have to pay between $5 million and $8 million."[81]

79 In their analysis of ES&S, PrivCo noted that the company was "economically incentivized to offer closed-system solutions to lock-in clients for future services" as part of its business model. "ES&S doesn't share, provide and sell its software to other parties to perform services such as printing ballots and testing," but rather seeks "to dominate the majority of the auxiliary services related to its products" and to sell those services at "higher price points than those available in the retail market." See PrivCo report on Election Systems & Software LLC, accessed at privco.com in January 2017.

80 Miami-Dade County Office of the Investigator General, "Miami Dade County Voting Systems" (2003), http://www.miamidadeig.org/Reports/votingfinalreport.pdf, p 39.

81 "Adding E-Voting Printers Could Cost $23 Million, Counties Say," *Los Angeles Times*, February 7, 2005, http://articles.latimes.com/2005/feb/07/local/me-machines7. See also "California Could Be First in Nation to Implement E-Voting Paper Trail," *Government Technology*, May 4, 2006, http://www.govtech.com/security/California-Could-be-First-in-Nation.html.

Customer satisfaction with the process as a whole is poor. Fewer than one in five of our election official respondents would choose the same equipment and implementation practices if they had to re-do the procurement process, with the majority looking to new vendors or alternative voting solutions. But customers are limited by the complications and costs involved in implementing a new system, which causes counties to avoid or postpone purchases, as well as by the few vendor options available that can meet all system requirements.

Returning to Paper Ballots

States that have gone through the costs and effort to procure modern voting equipment are not always satisfied with their performance in elections. Maryland put in place touchscreen electronic voting machines by Diebold[82] for their 2004 elections, spending a total of $65 million.[83] Diminishing budgets for election technology prevented upgrades from 2004 to 2014, but a $28 million lease was approved in 2014. Voters seemed to approve of the system, but in 2016, Maryland decided to return to paper ballots after a vote by the General Assembly.[84] Pamela Wood from *The Baltimore Sun* reported, "The change was made after elections officials said they realized that many primary contests will feature long lists of candidates that can't fit on one screen, and some candidates threatened legal action for being stuck on a second or third screen."[85] Following problems with touchscreen and computer ballots, voters in Albemarle County and Charlottesville, Virginia also returned to paper ballots in 2015 after a law passed in 2007, prohibiting localities from making any more purchases of election technology. State Delegate Timothy D. Hugo expressed voter concerns with miscounts and the unavailability of a back-up system.[86] Although there were concerns that paper ballots would take longer to fill out and cause long lines to form at the polls, voting officials found this to not be the case.[87] These instances of states reverting to "less advanced" voting systems after testing and deployment can serve as a deterrent for states considering adopting new technology, as well as for vendors considering the costly investment in the development and certification of new machines.

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82 Diebold has a complex history. At the time of the Maryland transaction, they were independent and operating under the name Diebold Election Systems, Incorporated (DESI). They later changed their name to Premier Voting Systems ("Premier") in 2007. Premier was acquired by ES&S in 2009, but the Premier assets were sold to Dominion in 2010 to settle an antitrust issue. They remain part of Dominion today. See "Canadian Company Buys Allen-based Diebold/Premier Election Solutions," *Democratic Blog News,* June 2, 2010, http://www.demblognews.com/2009/09/diebold-sells-allen-based-premier.html.

83 "Voters to Return to Paper Ballots in 2016," *Cecil Whig,* November 15, 2015, http://www.cecildaily.com/news/local_news/article_d9bb87ce-12a4-5b49-8854-3b8a4d9ae0b5.html.

84 Conny B. McCormack, *Democracy Rebooted: The Future of Technology in Elections* (Atlantic Council, 2016), http://publications.atlanticcouncil.org/election-tech/assets/report.pdf, p. 14.

85 "Maryland Ditches Touch Screen Machines for Early Voting," *The Baltimore Sun*, February 4, 2016, http://www.baltimoresun.com/news/maryland/politics/bs-md-paper-ballots-20160204-story.html.

86 "Md., Virginia Will Return to Paper Ballots," *The Daily Progress*, October 30, 2008, http://www.dailyprogress.com/news/md-virginia-will-return-to-paper-ballots/article_1e7fd450-b3a0-5e8f-90b8-5d58f7fd9841.html.

87 Return to Paper Ballots Successful in Abermarle County," *Newsplex*, November 3, 2015, http://www.newsplex.com/home/headlines/Return-to-Paper-Ballots-Successful-in-Albemarle-Co-340007602.html.

Barriers to Innovation: Certification

The standards set by counties and states make investments in new election systems riskier. Most states look to the EAC for guidelines (i.e., the Voluntary Voting System Guidelines, or "VVSG"), and will only purchase voting system hardware that has been tested against these specifications. The vendors have little choice but to ensure their products meet these standards. As discussed earlier, states can use federal guidelines and testing procedures in a variety of ways. They may use the guidelines and/or the EAC-accredited Voting System Test Laboratories for certification and testing purposes, or they may specifically require EAC certification. In the latter case, the test laboratory provides a recommendation to the EAC, and the Commission's executive director makes the determination on whether to issue a certification.

The process of preparing, administering, and reporting the testing can take up to two years or more, given the many steps involved. After the initial certification test and before a system is deployed, there are often additional testing steps by the end customer, including acceptance testing, logic/accuracy testing for each device, audits and special purpose tests (which may be required by the state), and pilot projects or other field tests prior to full deployment. Most of the process is delegated to election administrators within their jurisdictions, creating the possibility that the same or a very similar system may yield different results in different locations. Industry information aggregated by PrivCo indicates that "EAC certification can easily run to more than $1 million" per voting system, and that figure does not even include costs for certification by the state or jurisdiction, which can be substantial. "ES&S spent about $4 million to become certified in one state alone," PrivCo reports. Given the costs and the time investment it entails, the certification process "substantially raises the barriers of entry for competitors and strongly favors incumbent firms," which then have an interest in sticking with existing technologies and avoiding changes that would require re-entering the certification process.[88]

In addition to the direct costs of the process, this approach of certifying only entire systems in full is increasingly incompatible with modern technology that relies on interoperable, but commoditized hardware (e.g., standard PCs or tablets). Regardless of the technology, there is also a significant barrier to both entry and innovation because there is no guarantee the technology will be deemed secure or viable by the certifying authorities, in which case it would necessitate a new round of modification and re-testing. Though different in scope and many other important respects, this risk is similar in character to the research and development risks faced by pharmaceutical companies, where the risk of failure in attaining FDA approval is significant and central to decision-making. In the election technology industry, it is a risk few vendors seem willing to take. Lida Rodriguez-Taseff, a partner at Duane Morris LLP who advises on election legal issues on a pro bono basis, remarked that market leaders consequently seek wide profit margins to compensate for the high risk of entry. But as noted earlier in this report, it is not clear that such profit margins exist. According to Rodriguez-Taseff, those that do enter look to secure the desired profit margins by using the lowest level software possible and by selling products and services at prices that are not competitive with other technology subindustries.[89]

88 PrivCo report on Election Systems & Software LLC, accessed at privco.com, January 2017.

89 Telephone interview with Lida Rodriguez-Taseff, Esq., April 26, 2016.

Strategies for Adaptation

While the current structure of the election technology industry imposes substantial barriers to innovation, this section of the report highlights several strategies that some election officials are pursuing that potentially could alter the industry dynamics and spur the development of new election systems. The ultimate hope is that these strategies might better serve both the needs of voters and the cost constraints of jurisdictions.

Coalition Formation

A consistent theme that emerged from our interviews is that election officials, especially in smaller districts, have found it difficult to persuade vendors to customize their products for idiosyncratic local requirements. This may simply be due to a lack of bargaining power, or the fact that such customizations (given the development, certification, and support costs) cannot be offered by vendors profitably. Election officials also have found it difficult to drive prices down when they are buying relatively few machines at a county or jurisdictional level. One possible strategy to remedy this situation is for customers to form coalitions, so as to facilitate bargaining for customized extensions of existing commercial offerings at better prices and allow vendors the economies of scale that would make such modifications profitable.

The benefits of coalition formation are three-fold. First, coalitions can minimize transaction costs. Rather than having a number of purchasers expending time, money, and other resources on researching election technology, consulting with authorities, and meeting with vendors, multiple entities can each contribute a fraction of the resources to completing a transaction. This pooling of resources benefits all involved.

The second benefit is the relative effect that coalition formation has on aggregate "buyer power." In general, buyer power can be amplified by consolidation, and increased buyer power enables buyers to capture more value.[90] Buyer power concentrates

90 Porter, "The Five Competitive Forces That Shape Strategy," p. 83-84.

more business or revenue into a single transaction,[91] enhancing the transactional importance of the coalition's members. This transactional importance creates leverage for the coalition to demand customizations and/or lower prices on products, which members of the coalition otherwise could not have acquired independently.

The third benefit flows from economies of scale rather than the creation of leverage. Making larger volume purchases can make orders less costly per unit to produce and transport, and thus render customizations that otherwise would be refused more economical for a vendor to accommodate. This is especially true given the relatively large per transaction fixed costs of contracting and the natural economies of scale that exist in software development. (It costs the same amount to implement and certify new functionality regardless of the number of users.) Many vendors already have tiered volume prices built into their offerings, whether explicitly (where price tiers are stated clearly in deal materials) or implicitly (where vendors will tend to offer better prices to those looking buy more volume).[92] A coalition would be more capable of taking advantage of volume pricing while still obtaining needed product customizations.

One avenue for coalition formation is to involve states in the acquisition processes. This can take the form of a direct appropriation of funds for an entire state, as New Mexico did in 2014 in purchasing voting machines statewide. It may also involve a state-level lease with costs split between state and county. Maryland, for example, leased new equipment with such a cost structure in 2015. It also could entail a grant structure, such as that used by Missouri when its Secretary of State allocated $2 million for counties to purchase new machines.[93] In theory, generally, the greater extent to which purchasing is consolidated, the more benefits will flow from the coalition.[94]

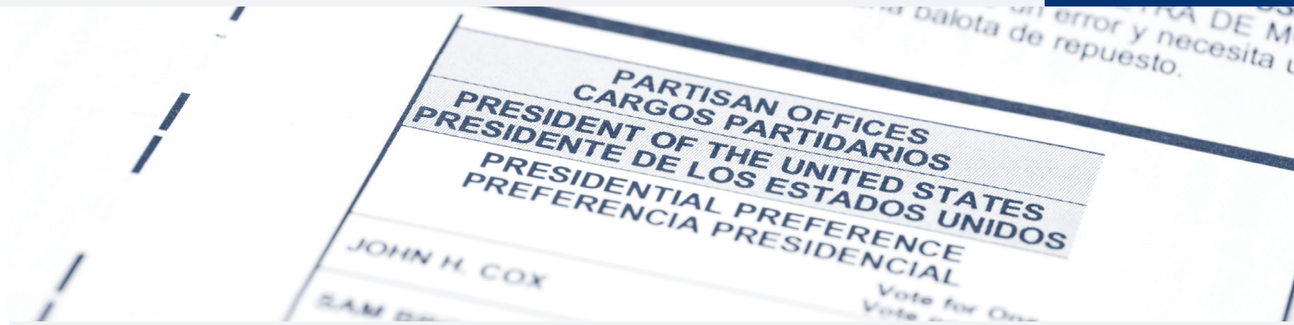
An alternative format for jurisdictions in states that lack the ability or interest to manage these types of state-supported buying programs is to pursue formal or informal coalitions among themselves. A good example of this type of cooperation is the effort by Miami-Dade, Broward, and Palm Beach counties in Florida to pool their resources and efforts to request the development of multilingual voting systems for their particular jurisdictions. Consequently, as described in greater detail on the following page, they were able to encourage their systems vendor, ES&S, to allocate the necessary research, development and implementation resources to deliver a system that met their requirements.

91 In the general case, multiple transactions at different times can be implicated in an agreement. When we refer to a transaction, we make reference to a unified "deal" or contract.

92 For a description of how vendors incorporate these volume discounts either explicitly or implicitly, see Brennan Center for Justice at NYU School of Law, *The Machinery of Democracy: Voting System Security, Usability, and Cost* (2006), https://www.brennancenter.org/sites/default/files/publications/Machinery_Democracy.pdf, p. 135.

93 All of this information was helpfully provided by the National Council of State Legislatures See "Funding Elections Technology," September 26, 2016, http://www.ncsl.org/research/elections-and-campaigns/funding-election-technology.aspx.

94 *America's Voting Machines at Risk,* p. 38. The benefits of such consolidation do have their limits, though. At some point, increased consolidation may reach a trade-off with the efficiency benefits offered by competitive markets. In the most extreme case, for example, it is not clear whether a full 55-state and territory coalition that could grant a company a national monopoly would be more efficient than a system where there is less consolidation and more competition.



Multilingual Voting in South Florida

Miami-Dade County and Broward County in Florida vote in three languages (English, Spanish, and Haitian Creole), while Palm Beach uses two (English and Spanish). After the voting crisis in 2000, the counties quickly moved to purchase new electronic equipment. Concerned about language access, they bought the only technology on the market that could make such accommodations—touchscreen technology. This was one of the first large-scale usages of touchscreen technology. The 2002 midterm elections turned out to be an "unmitigated disaster," plagued by issues with voting machine operation.[95] The Investigator General report on the incident blamed ES&S, the elections system vendor, for using the counties as essentially a "live beta test site,"[96] while ES&S blamed the county for making cost and feature demands that made machine operations more complicated, and for failing to properly train poll workers on the new electronic system.

In response to this incident, the county clerks of these three multilingual counties banded together to seek the development of specialized, multilingual optical scanners. The three of them together were able to negotiate service contracts with the vendor that made it profitable to take on this venture. According to Lida Rodriguez-Taseff, former chair of the Miami-Dade Election Reform Coalition (MDERC) and an activist at the time, it was only when the counties demonstrated their willingness to switch vendors that ES&S became agreeable to this new system development: "ES&S realized that Miami-Dade could bring more counties than just them."[97]

There are several other examples of this type of coordination. For example, another twelve counties in Florida banded together in 2015 to negotiate the purchase of new equipment from ES&S.[98] Their collaboration involved not only negotiations with ES&S, but with the state as well, in order to obtain HAVA funding for the purchase. A representative of Franklin County who was involved in this deal pointed out that these collective negotiations "save[d] the taxpayers a considerable amount of money."[99] Another collaborative RFP was issued in 2015 by a group of four counties in Kansas.[100]

95 Telephone Interview with Lida Rodriguez-Taseff, Esq., April 26, 2016.

96 Miami-Dade County OIG Final Report: Miami-Dade County Voting Systems, Contract No. 326, May 20, 2003, http://www.miamidadeig.org/Reports/votingfinalreport.pdf#search="final report 2003", p. 42.

97 Telephone Interview with Lida Rodriguez-Taseff, Esq., April 26, 2016.

98 "Partnership Paves Way for New Voting System," *The Apalachicola & Carrabelle Times,* August 20, 2015, http://www.apalachtimes.com/article/20150820/NEWS/150829949.

99 Id.

100 Sedgwick County, Kansas, Division of Finance, Purchasing Department, Request for Proposal #15-0078 Voting System, http://www.eac.gov/assets/1/Documents/Kansas.RFP%2015-0078%20Voting%20System.pdf.

Open Source Systems Development in Large Counties

As the coalitions described above illustrate, size matters. Larger buyers are better able to negotiate customizations with vendors, and in general, buyers in large districts seem more willing to try to surmount the existing barriers to innovation in voting strategies and technology. A study conducted by David C. Kimball and Brady Baybeck found that support for new voting methods and innovations was higher among administrators of districts serving more than 50,000 voters.[101] The tasks that go into administering an election, such as maintaining accurate voter registration lists and managing poll workers, are much more challenging for larger jurisdictions; they therefore tend to be more receptive to the benefits that derive from innovations in technology.[102] Given the high cost of election systems and the limited options available in the marketplace, some election officials in larger jurisdictions have turned to developing their own customized technologies. Two counties that stand out for having spearheaded such efforts are Travis County, TX and Los Angeles County, CA.

Both LA County and Travis County are basing their voting system development initiatives on an open source platform. In the existing market, it is largely the case that the underlying code that powers a voting system is proprietary to the vendor. Customers and other industry participants have limited or no ability to inspect, modify or reuse that code. By contrast, in an open source model, the code is public, enabling technical professionals to review and analyze the code, to suggest modifications or make changes, and, under some types of licensing approaches, to incorporate the code into a new system in whole or in part.[103]

The motivations for moving to open source are well illustrated by the experiences of LA County. As chronicled in public documents, the principal appeal of open source for LA County was the belief that the proprietary voting system products available through the existing market did not meet local requirements.[104] Housing over 4 million registered voters with native fluency in a multiplicity of languages, Los Angeles is "the largest and most complex county election jurisdiction in the nation," according to one voting systems assessment memo. "It is very likely that no pre-existing system will satisfy the County's needs." Indeed, as LA County confirmed through survey research, its diverse constituents also prefer different voting methods. "The focus group data compiled included Vote by Mail, Early Voting, Paper Ballots and Electronically-marked ballots as the variety of options that might be available

101 Kimball and Baybeck, "Are All Jurisdictions Equal?" p. 139-140.

102 Id., p. 131.

103 Beyond being a "licensing model" for software that requires software source code be available for public review, it also can be a popular "development model."

104 There are several other perceived benefits to the application of open source to election technology that, while not as primary in the minds of election officials, appeal to many technology experts, voting reform advocates, government officials, and other stakeholders. Open source involves an "open process" that can be more transparent to citizen oversight and more receptive to citizen input, thus fostering greater public trust in the administration of elections. There are also related "transparency benefits" that come into play downstream, such as enabling public scrutiny of the following: software quality and reliability, device verification (to demonstrate and ensure that the voting devices in use are exactly the ones that have been tested and certified), correctness of vote identification and ballot tabulation, and adequacy of record-keeping for ballot audits. (It should be noted that while open source, non-proprietary software, by definition, has these technology transparency benefits, proprietary software can provide them as well, while remaining subject to vendor licensing agreements. So-called "disclosed source" products are relatively rare and ill-suited to the certification requirements of election technology.) And while open source code, when compared to closed source, is not necessarily more secure, or resistant to malicious attack, or transparent with respect to identifying software defects, proponents point out that it is no less so.

to ensure voters have options." The lack of a ready-made system that could satisfy such requirements became, for LA County, a unique opportunity to forge "a more creative market solution," one that "might provide a model for other jurisdictions or states."[105]

An open source development strategy offered LA County a transparent process for creating the customized solution it desired, allowing for review, input and oversight from citizens. Just as important, it held the promise of cost savings. Many proponents of open source believe that by getting around expensive licensing fees and contracts with established vendors, and by marrying open source software with off-the-shelf hardware, it is possible to build an election system at a reduced cost, compared to traditional procurement methods. "This project will break the mold of the traditional voting system acquisition model," the Registrar-Recorder/County Clerk of Los Angeles, Dean Logan, said of the county's open source technology initiative, called the Voting Systems Assessment Project (VSAP). As explained in one news account, "Traditionally, counties sign end-to-end agreements with private vendors, wherein one company provides the software, hardware, and support for a voting system, offering little flexibility in pricing, use, and design. By managing its own software, LA becomes independent from the single-vendor schema, and it has relative control over the types of hardware it invests in and the amount of money it spends." Logan put it this way: "So if there's somebody who can provide us the video monitors at the best price, then we'll buy the video monitors from them, and we'll integrate that with other components."[106] With this flexibility and independence from traditional vendors, Logan believes the county's design approach "should result in lower-cost voting systems and market expansion" and "has the ability to move the regulatory environment and the market to a more competitive landscape that could allow jurisdictions to replace systems at a lower cost than in the past."[107]

Time will tell if the expected cost reduction actually materializes. LA County's new system (which will have voters indicate their choices on a touchscreen-operated tablet, after which a machine at the voting booth will print, process, and tally their paper ballots) is not scheduled to launch until 2020. As of March 2016, the VSAP system was just entering the later stages of certification and manufacturing.

There are reasons to be skeptical, though, about the potential cost savings. While it is true that a deployed voting system, consisting entirely of open source software, would not include the software licensing costs that are typical of commercial products, those licensing fees are only one factor among many that constitute the total cost of ownership (TCO). It is not necessarily the case that one voting system without licensing fees would have a lower TCO than another voting system that is subject to such fees. First, and perhaps obviously, the total cost of ownership is ultimately system-dependent. Software costs constitute only one part of the equation; hardware matters too. For example, consider two hypothetical systems—one with

105 County of Los Angeles, Office of the Registrar-Recorder/County Clerk, *Los Angeles County Voting Systems Assessment Project Concept Paper,* August 22, 2009, https://www.lavote.net/Documents/vsap/press_room/_08222009_concept_paper.pdf, p. 6; County of Los Angeles, Office of the Registrar-Recorder/County Clerk, *Voting Systems Assessment Project Report*, July 9, 2010, https://www.lavote.net/Documents/vsap/vsap_project_report_070910.pdf, p. 8.

106 "Los Angeles County Voting to Shift from Inkblots to Open Source," *Ars Technica,* June 13, 2015, http://arstechnica.com/tech-policy/2015/06/los-angeles-county-moves-to-open-source-voting-technology/.

107 *America's Voting Machines at Risk*, p. 23.

licensing fees and one without—where the one without fees includes substantially larger and heavier hardware components with lower physical and environmental tolerances. The additional, ongoing operational costs of secure temperature controlled storage and transportation might be even greater than the ongoing software license fees of the other commercial system. But this possibility is not unique to open source systems. A second concern that does pertain specifically to open source is that the cost structure over the life cycle of an open source system is dominated by support costs, and these support costs need not be less—and could in fact be more—than the costs that would be incurred in a non-open source model.

A closer look at another county-based initiative—Travis County STAR Vote™—echoes Los Angeles County's hopes to create new and better market alternatives, but also highlights the limitations and pitfalls of customers taking a larger role in technology project management, especially the challenge of preventing such efforts from becoming prohibitively costly.

In 2009, Travis County, TX organized a citizen "Elections Study Group" to determine what the community was looking for in its voting machines, as the county's existing system, which had been introduced in 2001, was approaching the end of its useful life.[108] After numerous discussions and demonstrations of various voting systems, the group determined that a paper ballot system with electronic counting was preferred. However, nothing on the market satisfied their criteria, so Travis County Clerk Dana DeBeauvoir was tasked with securing a system that would. This led to the creation of STAR Vote: a voting system meant to be Secure, Transparent, Auditable, and Reliable. The STAR Vote system will integrate electronic balloting, commercial off the shelf hardware, and ballot boxes with optical scanning capabilities.

DeBeauvoir issued a Request for Information (RFI) in 2015 that was directed to the elections marketplace, to help Travis County finalize the specifications for its new voting infrastructure with 1,700 direct-recording machines and 350 accessible machines for 650,000 registered voters.[109] One goal of the RFI was to test the willingness of traditional vendors to reconsider their technology and processes. The County Clerk was also very receptive to collaborating with software firms that had never ventured into election territory as well as companies with election expertise that could offer advising or other forms of support.[110] Buy using off-the-shelf hardware and a combination of off-the-shelf commercial, open source and custom software development, the goal is to create a system that can be owned and operated by the county with vendor support. In addition to leveraging open source technology, the STAR Vote system, which will provide voters with a paper ballot summary and an encrypted receipt upon casting their vote, also achieves the elusive standard of end-to-end verifiability.

108 "Texas: Travis County to Update Aging Voting Technology with New Tablet-Based System," *The Voting News*, September 17, 2015, http://thevotingnews.com/travis-county-to-update-aging-voting-technology-with-new-tablet-based-system-kut.

109 "Travis County, Texas, Building New Voting System," *Pew Charitable Trusts*, July 9, 2015, http://www.pewtrusts.org/en/research-and-analysis/analysis/2015/07/09/travis-county-texas-building-new-voting-system.

110 "Travis County, TX Forges New Territory in Voting Machines," Govtech, July 9, 2014, http://www.govtech.com/local/Travis-County-TX-Forges-New-Territory-in-Voting-Machines.html.

Responses to the RFI were used in finalizing the Request for Proposals (RFP), which was issued in late 2016, and which will close in January 2017. Once those proposals are reviewed, the County Clerk expects to advance the procurement process into the contracting and development stage, likely by late 2017.

One of the potential advantages of this open source development approach is that it could provide future flexibility that is not currently available from existing "black box" technology provided by vendors. In particular, County Clerk DeBeauvoir "believe[s] that it will redefine the polling place by using current technology that can evolve over time as laws, voter needs, and computer systems change." DeBeauvoir continued:

> *We want a system that is not obsolete from the moment it is purchased. Rather, we aspire to have a system that can evolve when improved operating systems, software, and hardware enter the marketplace. We want a system that is flexible and economically adaptive to changes in laws and voter demands. We seek to redefine voting systems so that they are more modular, to help reduce the time and cost of certification and to give vendors more freedom and creativity to enhance all processes involved in conducting elections. And importantly, we want a system that is affordable for all counties to purchase, maintain, and upgrade.*[111]

Although it is touted as potentially revolutionary, STAR Vote (like the VSAP initiative in LA County) is not without its challenges. Few (if any) election administrators have a full range of specialized knowledge in voting systems development, intellectual property, information technology management and commercial product development needed to oversee the creation, deployment, and operation of an independent voting system based on open source technology. In considering those complexities, DeBeauvoir recently conceded: "STAR Vote needs a home. It needs infrastructure to organize financing, software management" and provide "answers to questions about managing open source systems." It requires "a team of reviewers to look at bug fixes and upgrades" and even "a non-profit organization, a private company, or a traditional vendor to take on this support role."[112] In order to address this concern, the Travis County Clerk's Office has issued, as part of the RFP, a Statement of Intent regarding a likely governance structure for STAR Vote. Moreover, given the scope of the project—current cost estimates sit at $9-10 million[113]—one potential avenue for cost recovery would be to distribute the system to other jurisdictions. The business structure proposed in the Statement of Intent describes the cost recovery structure. However, the business model that would underlie such an initiative is untested. Of central concern to Travis County are the intellectual property issues involved in structuring "the business side" of STAR Vote.[114] DeBeauvoir explained:

111 Travis County Purchasing Office, *Request for Information, STAR-Vote A New Voting System, RFI # 1505-003-LC, June 2, 2015*, http://traviscountyclerk.org/eclerk/content/images/pdf_STARVote_2015.06.03_RFI.pdf, p. 8.

112 "STAR-Vote: Keynote Speech by Dana DeBeauvoir, Elections Verification Network March 2016," http://traviscountyclerk.org/eclerk/content/images/presentations_articles/pdf_tc_elections_keynote2016.pdf, p. 1.

113 Id., p. 2.

114 Id., p. 1.

> *We know STAR Vote needs a home, yet mixing current proprietary software with open source software may not be workable....In such a mixed system, how will we decide what to charge for maintenance costs and licensing? In a somewhat different circumstance, asking a current vendor to take over the project raises similar questions about [identifying] a reasonable revenue stream.*[115]

The issue of cost recovery can become particularly important since it is quite common for information technology projects to wind up costing considerably more than originally anticipated.[116] For instance, Travis County initially expected STAR Vote to cost around $5 million, not including certification or hardware, but later revised its estimates to almost double that figure. As DeBeauvoir notes, the actual expenses belie the cost-saving benefits that Travis County hoped to reap, and bring cost estimates closer to market prices for existing systems. Additionally, there is no guarantee that the costs will not increase going forward. Travis County, which likely will have to begin replacing its systems within the next two years, now struggles with the issue of whether it should foot the bill for the development of such a voting system. There is particular concern that the county will have to allocate more funds in the near term to buy replacement systems from the existing market before STAR Vote is tested and ready for deployment.[117]

Finally, the effects of such independent initiatives (if successful) on the structure of the industry are still unclear. On the one hand, additional competition could influence the incentives to innovate and could possibly lead to lower prices. On the other hand, introducing competitors with fundamentally different incentives and underlying cost structures—taxpayer-funded initiatives like VSAP and STAR Vote are not as concerned with making a profit, and thus could keep their prices artificially low—may worsen the perception of the profitability of the industry, which in turn could further deter new entry.

Open source, paradigmatically, means non-proprietary. If these counties do, in the end, make their software entirely open and free to use, as opposed to pursuing a proprietary/open-source hybrid of the kind DeBeauvoir contemplated above, the market could also undergo extreme change in which the availability of open source infrastructure would catalyze the development of competitive markets in voting systems solutions that integrate complementary products and services built around this technology, and encourage the development of the core technology directly. As explained by Gunnar Hellekson, Director of Product Management at Red Hat, Inc.,[118] by commoditizing the digital infrastructure for elections and making it freely available, open source "can lower the barrier of entry for new participants who can then build additional products and services on top of that infrastructure," thus "continuing the innovation process" and pushing it in new directions. The expectation is that "once

115 Id., p. 1.

116 For instance, a well-known industry survey suggests the majority of information technology projects tend to be late, over-budget or both, and a significant fraction of IT projects never produce a working system at all. (See The Standish Group, *CHAOS Report, 2014*, https://www.projectsmart.co.uk/white-papers/chaos-report.pdf.)

117 "STAR-Vote: Keynote Speech by Dana DeBeauvoir," p. 1.

118 Hellekson is also a member of the board of the Open Source Election Technology Institute.

the open source technology is readily available, commercial ventures [will] emerge" and make it their business "to enhance, support, and sustain that technology." In that way, open source becomes the catalyst for "a new business model" focused not on the intellectual property of software, but rather on rolling out "value-added services to extend that software, layer new software on top of it, and to provide the systems integration services." This would include making needed modifications to the open source software to meet customer demands, combining hardware with the software to create complete voting systems, and overseeing delivery, deployment and maintenance. The revenue in this model is "generated not from proprietary software licensing" or "selling proprietary integrated systems and services with high switching costs," but from "producing, enhancing, servicing, and supporting finished systems."[119]

Proponents like Hellekson predict these fresh revenue streams will keep current vendors in the market, but induce them to shift their investments and operations toward new and different business opportunities. While open source projects may initially be driven by funding from philanthropists, foundations, and individual contributors, Hellekson points out that federal research dollars are more forthcoming now, as is corporate support from entities such as Amazon Web Services. New firms that rely on open source—for instance, Five Cedars Group (creator of the Alternate Ballot Format used by voters with disabilities in Oregon) and Free & Fair (provider and customizer of open source software specifically for election tools)—have emerged recently, and Hellekson expects larger and more established commercial corporations to begin investing in open source projects as they observe growing market demand for the technology.[120]

At the moment, however, this is all a matter of potentiality. There is no historical evidence yet to show how open source will alter the election technology industry, as the major undertakings thus far—including VSAP and STAR Vote—are still under development. While it is commonplace today for commercial IT firms to invest in open source projects, it is unclear if the same will be true in this subindustry of government IT, where the consumer base is limited in size and consumer demand is constrained by tight budgets. Consequently, it is possible that the main drivers of innovation will be found not in the private sector, but in municipalities like Los Angeles County and Travis County that invest. If this is true, open source could end up creating an almost entirely publicly-funded model for innovation in voting technology, which would be a major paradigm shift in its own right.

Modularity and Use of Commercial Off-The-Shelf Technologies

There also is potential for positive change on the regulatory side. A core component of the current regulation scheme is that a voting system must be presented in its entirety before it can be tested for certification. This conservative approach often is used for "mission critical" information systems, but is not congruent with modern information technology system designs,

119 Questionnaire responses from Gunnar Hellekson, contained in email from Gregory Miller to Andrew Coopersmith, January 17, 2017.

120 Id.

which rely on interoperability standards to allow different combinations of components to be integrated into an overall design. Such structural flexibility is broadly referred to as modular design or simply "modularity." The open source solutions under development in LA County and Travis County are examples of modularity, as they envision marrying open source software with hardware components that can be switched out as needed.

Modularity can be present in both hardware and software. Modular hardware architecture (prevalent in personal computing) allows the same system to be built with different hardware components, to varying specifications (e.g., capacity), by different vendors. Modular software takes advantage of modern programming techniques, such as object-oriented programming or component-based designs, that separate the function of a part of a software system from how it is implemented. This allows larger platforms to be constructed from smaller components without having to redesign code within the component to make a system change.

Modularity provides a number of advantages, such as reduced development costs through reuse, as well as economies of scale, especially though the use of mass market hardware. To conceptualize these cost-savings, take the hardware example: personal computers and servers are largely assembled today with common standards and components, and are designed specifically to allow for upgrades with newer, lower cost technology for any component. For instance, it typically is very easy to replace a monitor or display, and relatively easy to shift from electromechanical storage devices (e.g., hard drives) to more reliable solid state storage devices without modifying any other aspect of the system.

As such, most systems in use or under development today are modular in design. For instance, Google deploys a combination of custom and open source code on large server farms that rely almost entirely on off-the-shelf, industry standard hardware to power their search features and other online services. This not only keeps the initial costs low, but it enables new hardware to be deployed as technology changes (e.g., upgrading processors with lower power equivalents), and allows software to be updated to add new services without a major redesign of the system. Through open standards, consumers can access online content on a variety of devices, from smartphones to desktop PCs. Modular design has allowed service providers to operate with a common set of capabilities, requiring only limited customization for presentation on different devices, and it has the ability to adapt to new devices as they emerge.

Voting systems are comprised of a number of different technology components that serve different functions, making them amenable to a modular design approach. Several organizations already have published detailed architectures for modular voting systems.[121] These architectures detail separate interoperating components, including multiple software components

121 The OSET Institute has proposed a "democracy operating system" called ElectOS. (See *Introducing the Election Technology Frramework—Critical Infrastructure to Increase Trust and Preserve Democracy,* http://www.dubberly.com/wp-content/uploads/2014/09/TTV_Framework_Book.pdf.) Travis County's Star-Vote (discussed infra) pursues a modular architecture. (For details, see the County's RFI, available at http://traviscountyclerk.org/eclerk/content/images/pdf_STARVote_2015.06.03_RFI.pdf.) Free & Fair Inc. has developed a supervised voting system based on Star-Vote: http://freeandfair.us/products/supervised-voting-system/. Los Angeles County's VSAP (discussed infra) also has a modular structure: https://lavote.net/vsap/research.

for election administration (election management, ballot design, device configuration, ballot audit, and reporting) and various hardware/software components for marking ballots, casting and counting ballots, taking central count of ballots, and consolidating tally data from counting devices.[122] And an added benefit of these systems is the general familiarity with component-based systems. Prior reports have noted that commercial off-the-shelf (COTS) technologies are better understood by election officials and are considerably cheaper than current voting system hardware.[123]

The National Institute of Standards and Technology (NIST) and EAC have public working groups on election data interoperability that are producing the standardized common data formats (CDFs) needed for interoperability of these components.[124] Voting system product vendors, state and local election officials (including those considering open source development of voting systems), and other election technologists from a variety of NGOs are currently participating in these working groups. The EAC also was working toward a new set of voting system guidelines[125] that may support the testing and certification of individual components, including conformance testing for CDF usage. The eventual completion of new CDFs and voting system guidelines may enable election officials to acquire components that have all been independently designed, implemented, and tested, allowing them to be integrated with other components into a complete voting system component set.

Modularity and standards-based interoperability can create conditions for a larger set of more competitive players in the election technology market, with an expanded set of roles. In addition to the existing roles of integrated voting system production and system-based technical services and support, new roles might include: software-as-a-service for software-based election administration components; hardware/software integration and test services for one or more hardware/software components; voting system assembly (from components) and test services; and ongoing component-based technical service and field support. The result of such a market expansion may enable the election technology industry to benefit from the scale of operation, breadth of IT services, and competitive landscape that is now typical of the global IT services industry.

Increasing competition in what already has been characterized as a "profits-thin" industry might seem, on the surface, to further hurt vendor interests. Increased competition may, however, occur without adverse effects on election technology vendors because they would benefit from lower component costs. They also may face reduced support costs by not having to service obsolete hardware or maintain a large hardware field service organization to support peak demand from election officials, which is heavily concentrated on just a few days in a year. Despite these possibilities, it is hard to say what is likely to occur since a movement to modularity would be, essentially, a paradigm shift.

122 See generally NIST's Smart Grid Collaboration Wiki for Smart Grid Interoperability Standards: http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/WebHome.

123 *America's Voting Machines* at Risk, p. 38-39.

124 "NIST-EAC Public Working Groups," https://www.nist.gov/itl/voting/nist-eac-public-working-groups.

125 "Commissioner Masterson: EAC Wants YOU to Help Develop New Voting System Guidelines!" The Official Blog of the United States Election Assistance Commission, December 21, 2015, https://www.eac.gov/blogs/blog.aspx?PostId=325.

Modular systems that use commercial off-the-shelf technologies are not without potential problems. A poll book system or other election equipment designed to run on a tablet, for instance, could be rendered useless if the operating system changes and becomes incompatible. Resolving such changes could also require putting the updated system through another lengthy and costly certification process. Nevertheless, there appears to be general agreement among election officials and election technology industry observers that despite such risks, moving to modularity is critical for getting the dynamics of the industry to change.

Modular systems would require some substantial changes within the existing industry. Perhaps the most important is a change in the regulatory and testing scheme to certify architectures instead of systems. The boundaries between changes that require system recertification and those that are simply matters of system maintenance, and thus require no recertification or only a reduced or expedited review process, would have to be established. The number of possible testing scenarios and test cases also would likely need to expand, to accommodate a broader range of device designs. Similarly, while many system components would be items in general usage (such as personal computers with network connections), some component technologies would be more specialized (such as ballot marking devices), requiring that unique specifications for the operation and interoperability of these components (such as interface designs and communications protocols) be developed and adopted. Similarly, in an EAC report about the use of off-the-shelf technologies[126] for building voting systems, researchers noted that modular systems would require defining reliability standards for component devices. For instance, consumer technology may have substantially higher error or failure rates than those found in the voting systems currently used. It is not acceptable for a voting machine to crash as often, for example, as your laptop or home computer might. In addition to this concern, a framework for which components could be substituted for existing components of election systems would also have to be created.

126 United States Election Assistance Commission, *Considerations for Implementing Voting Systems with COTS Products* (Managing Election Technology Series #3), http://www.eac.gov/assets/1/Documents/Considerations%20for%20Implementing%20Voting%20Systems%20with%20COTS%20Products%20FINAL%20for%20Web%20Posting%2002.03.16.pdf, p. 3-5.

It is worth noting that new types of certification are already under discussion. EAC public meetings have started to address: (a) recertification of a single component—as opposed to the entire voting system—following a software modification; and (b) recertification of component software that can be integrated into a different hardware set.[127] This will be especially important as hardware evolves, so as to avoid the current efforts of election officials to keep obsolete and broken-down hardware on life support.

Fundamentally, a switch to modularity would constitute a real culture shift as well. It therefore carries with it the challenge of uprooting familiar ways of thinking about election technology. As one election administration expert put it: "the current election systems are not designed or written in a modular fashion."[128] Moving in that direction would mean doing away with a large installed base of existing hardware and software that are not interoperable, as well as leaving behind the associated industry expertise for developing those systems in the traditional way. The switch to a more modular design for new systems, or the conversion of existing code to a new architecture, would require considerable investment and would be subject to all the problems, risks, and uncertainties that have limited innovation in this industry in the past. The same challenges that currently apply to vendors also would apply to jurisdictions engaged in developing their own modular systems. For these reasons, a wholesale changeover to modular systems would be drastic and likely unwise. Incremental progress seems more plausible and prudent, especially in such a publicly sensitive and high-stakes area as voting.

127 Agenda for EAC Roundtable Discussion on "Reforming the Testing and Certification Process," June 12, 2014, available at https://www.eac.gov/assets/1/Documents/June%2012_Roundtable_DRAFT%20Agenda%20and%20Sample%20Discussion%20Questions-Final.pdf.

128 Email from Merle King to Maggie Diehl, October 20, 2016.

Conclusion

This report presents a first investigation into the dynamics of the election technology industry. To date, no major consulting firm has studied this market, and few equity research services have any up-to-date or complete information on its vendors.[129]

The lack of interest likely stems from the fact that the election technology industry, as it exists today, has all the aspects of an industry that new investors would want to avoid—a costly regulatory environment, constrained market size, cost-conscious customers, and concentrated and entrenched vendors.[130] Nevertheless, it is an industry that demands our attention. The security of our democratic processes relies on the integrity of our election technology, and the type, cost, and quality of this election technology depends, in turn, on the market that produces it.

Our objective in this report has been primarily descriptive, to articulate a consistent set of facts about how the industry is currently structured and how activities by market participants both created and perpetuate this structure. After evaluating the industry from the perspective of both vendors and buyers, and defining the regulatory environment that shapes their behavior, we profiled some strategies that illustrated how one could make the industry more attractive for innovative investment and entry, and thereby increase the "competitiveness" of the election technology industry.

Contrary to what some commentators have asserted, however, merely increasing competitiveness is not a panacea. Competitiveness is a double-edged sword, in that it presents a tradeoff between cost from the customer's point of view and profitability from the vendor's perspective. While competition makes products less costly for the buyer, downward pressure on margins from increased competition makes entry even less attractive for vendors and innovation even less tenable. The existing election technology firms already seem to struggle to generate profits. What would the industry look like if profitability were further eroded?

129 Many of the resources that industry researchers would typically rely on (e.g., Hoover's, IBISWorld, LexisNexis Corporate Affiliations) have no, little, or out of date information on election technology vendors.

130 The fact that vendors are entrenched may make the industry more attractive for investors who seek to take stakes in the existing dominant firms, but for most investors it is a deterrent.

This is not to say that vendors' interests are primary. Markets are (at least) two-sided, and function best when both sides derive value. Thus the best strategies going forward entail finding the middle ground where vendors have profit incentives to engage in the creation of products that meet buyers' needs. Many of the changes that yield such parallel benefits would involve a paradigm shift, such as a movement towards modular systems that rely on commercial off-the-shelf technology or the use of open-source technology. This kind of change, however, opens up new uncertainties in the vendor landscape. Will today's vendors be able to remain competitive in a modular technology market, or will they be pushed out by the entry of large component makers that dominate other component markets? If we begin to use more commodity-like, off-the-shelf technology, will today's election technology vendors be able to adapt?

It is not possible to answer such questions currently. What this report helps illuminate, however, is that many of the ills in the election technology industry that have been profiled in previous studies actually originate in the industry structure itself. While the lack of funding for new election technology procurement remains a major problem, policymakers need to do much more than throw money at the issue. If the industry's challenges ever are to be addressed, policymakers, buyers, and vendors need to take actions that will trigger changes in the industry structure.

Appendix A: Percentage Market Share by Vendor

Vendor	Registrants Reached	% Market Share
Election Systems & Software	83,380,867	43.8%
Dominion Voting Systems	71,006,665	37.3%
Hart InterCivic	20,983,037	11.0%
Unisyn Voting Solutions	3,430,900	1.8%
MicroVote	3,291,260	1.7%
Danaher	2,685,409	1.4%
MTS	2,435,360	1.3%
IVS	1,336,070	0.7%
Five Cedars Group	972,475	0.5%
Clear Ballot	623,083	0.3%

Only vendors with more than 0.1% of Market Share (i.e., those that reach more than approximately 200,000 voters) are listed.

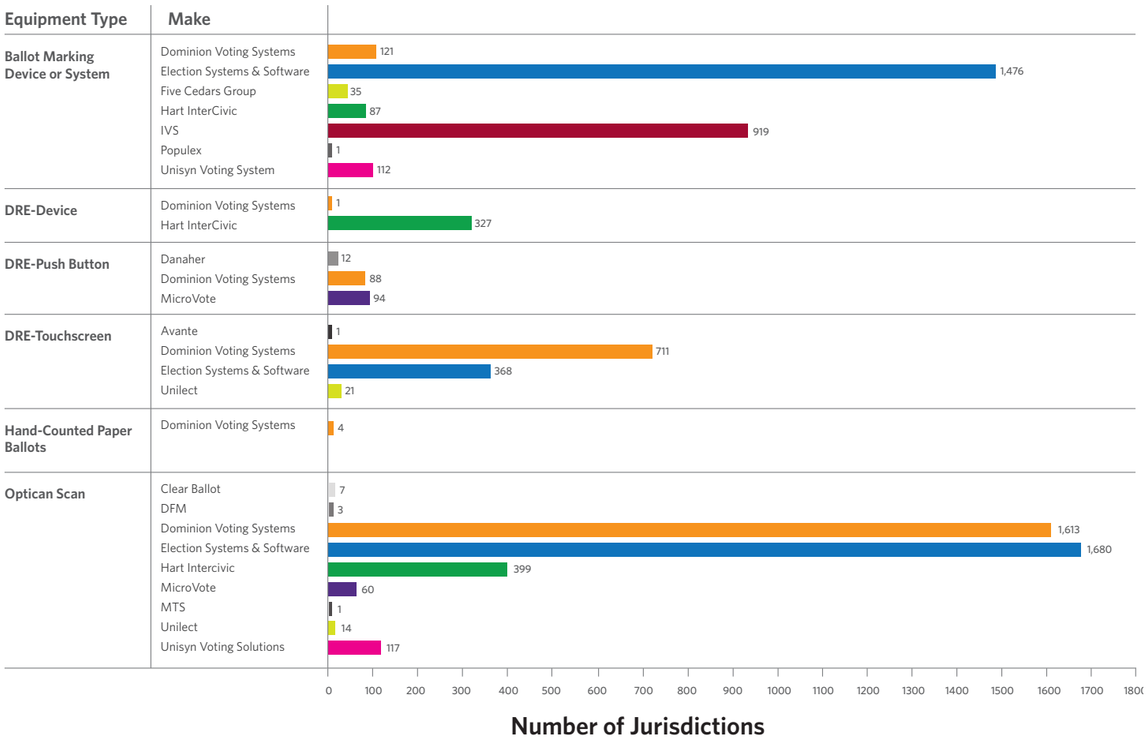
See page 10 of this report for a detailed definition of "Registrant Reach."

Appendix B: Relative Deployment of Different Voting Systems by Vendor

Type of Machine	Registrants
Optical Scan	**180,929,792**
Election Systems & Software	77,651,429
Dominion Voting Systems	72,649,822
Hart InterCivic	20,523,084
Unisyn Voting Solutions	3,430,900
MicroVote	2,485,033
MTS	2,435,360
Clear Ballot	1,246,166
DFM	330,555
Unilect	177,443
DRE - Touchscreen	**69,750,056**
Dominion Voting Systems	46,527,935
Election Systems & Software	22,938,607
Unilect	211,998
Avante	71,516
DRE - Push Button	**15,418,753**
Dominion Voting Systems	9,059,678
Microvote	3,347,622
Danaher	3,011,453
DRE - Dial	**17,689,791**
Hart InterCivic	17,689,791
Ballot Marking Device or System	**89,555,565**
Election Systems & Software	67,763,884
Dominion Voting Systems	10,448,666
Unisyn Voting Solutions	3,430,900
Hart InterCivic	3,355,081
IVS	2,605,178
Five Cedars Group	1,944,949
Vote-PAD	5,127
Populex	1,780

Note: Registrants here are aggregated by machine type and not by vendor. Consequently, individuals in jurisdictions served by multiple machine types are counted an equivalent number of times in this table.

Appendix C: Relative Deployment of Different Voting Systems by Vendor



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The OSET Institute was established in November 2006 by a couple of concerned technologists in the Silicon Valley as a California non-profit corporation dedicated to the public benefit. The mission of OSET is to increase confidence in elections and their outcomes in order to preserve the operational continuity of democracy worldwide, and because everyone deserves a better voting experience.

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