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Were the 2014 United States Senatorial and Gubernatorial Elections Manipulated?

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Abstract

Were the 2014 U.S. election results manipulated? Most Americans do not want to entertain the possibility that electronic vote-count manipulation determines who controls the reigns of government. However, the probability that the disparities between predicted and reported state vote margins were caused by random sampling error is virtually zero. A new method for measuring necessity levels, extending fuzzy set qualitative comparative analysis (FsQCA) methods, reveals non-auditable voting systems or lack of post-election audits to be a necessary condition for the occurrence of high levels of disparity between statewide polls and election results. A multi-method approach reveals some states' discrepancy between polls and election results cannot be explained solely by partisan poll response bias. The Maryland 2014 gubernatorial contest is identified as the one most consistent with sufficient vote mistabulation to have altered its outcome. This leads to a case study of Maryland's partisan voter registration, turnout, and vote data by ballot type that statistically confirms vote miscount as a consistent explanation for its unexpected gubernatorial outcome.

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1 Introduction

This paper examines three possible causes of the large, one-sided discrepancies between 2014 pre-election opinion polls and election results: random sampling error, partisan poll response bias, and vote fraud or miscount. It does not examine voter fraud, the possibility that ineligible voters cast ballots.[1] If votes are not accurately cast and tallied as voters intend, then vote fraud or vote miscount exists. Following identification of state election results that cannot be explained by sampling error or partisan poll response bias, section 4 is a case study of detailed Maryland election data confirming Maryland governor's contest data is consistent with vote miscasting or mistabulation having altered its outcome.

When, after an election but before certification, the accuracy of reported election outcomes is effectively checked by manually counting a sufficient quantity of verified records of voter intent then the voting system has high audit quality. The requirements for high audit quality is briefly discussed in section 1.2. If votes are accurately cast and tallied by voting equipment, then there will not be a significant relationship between voting system audit quality and the size and direction of discrepancy between predicted and reported election margins. Similarly, if votes are accurately cast and tallied significant differences between vote margins cast on voting systems having different levels of auditability is not expected.

1.1 Are the 2014 Election Discrepancies Due to Random Error?

Could the discrepancies between poll and election results margins in the 2014 elections be caused by random sampling error? If these discrepancies, which for brevity, I shall refer to as Poll Election Discrepancies (PED) were caused by random sampling error in pre-election opinion polls, then two things would occur: First, approximately five percent (5%) of opinion polls would exhibit PED greater than their margin of error. In the case of the seventy (70) 2014 senate and governor elections in our data, five percent, or four (4) contests would exhibit discrepancy of more than the poll margins of error (MOE); and, second, PED in negative and positive directions would occur in roughly equal amounts.

Instead, 40%, or 14 of 35 U.S. governor contests and 62.9%, or 22 of 35 senate contests, exhibited PED outside the 95% confidence intervals defined by their average poll MOEs. The probability of 22 or more state Senate polls out of 35 all having PED outside their 95% confidence

[1] Studies have shown that voter fraud is virtually nonexistent.

interval due to random sampling error can be computed using a binomial distribution, $n = 35, x = 22, p = 0.05$ as shown in appendix A, formula A.1a. The probability that the 2014 senate PED were due to random chance is at most 1.86e-20 for errors occurring in both directions; and half that, at most, for all 22 states' discrepancies occurring in the same direction, all favoring Democrats in opinion polls and Republicans in the election results. Thus, the probability is 9.31e-21, virtually nil or less than one chance in a quintillion.[2]

Similarly, the probability that 14 or more out of 35 state U.S. governor election PED are outside their 95% confidence intervals, since the discrepancies all occurred in the same direction, is 2.60e-10, i.e., less than one in a billion. Clearly, there is no dispute that the 2014 election PED were not caused by random sampling error.

1.2 United States Voting Systems

What does election history reveal about the interplay of illicit vote manipulation, election administration, and attempts to deter election manipulation by altering voting equipment? An excellent history of United States voting technology to current times is *Broken Ballots — Will Your Vote Count?*. It is written by computer scientists Douglas Jones and Barbara Simons, both of whom were appointed to positions connected to the United States Election Assistance Commission and have a long list of credentials related to computer science and voting system technology (Jones and Simons, 2012).

Table 1: Hidden Vote Manipulation in Aggregated Reporting

Ballot type	# Voters	# Votes	Fraud Type
Mail in	10	13	Stuffing for candidate A
Election Day	10	7	Under-counting for candidate B
Aggregated	20	20	Looks good

The topic of vote manipulation is, inherently, a more complex technical topic than voter poll access issues; and, is not often addressed by political scientists. Yet, there are dozens of ways to manipulate vote tallies, including ballot box stuffing, failure to record votes or voters, ballot tampering to cause over-votes, mis-recording votes, or losing ballots. Manipulation can be hidden from view via aggregation of ballot types that hide vote padding in one type for one candidate and undervotes or vote subtraction in another ballot type for an opposing candidate

[2] A quintillion is defined as 1,000,000,000,000,000,000.

(See table 1). "Regardless of the extent of fraud or its nature, what is clear from the historical record is that most of the innovations in voting technology made during the 19th century were motivated by the perception of fraud. ... As the 19th century progressed we can identify several rounds in the battle between technology and election fraud. In each round, the introduction of a new voting technology moved the battle lines, setting the stage for the next round" (Jones and Simons, 2012). " The fundamental problems faced by election officials over the past 150 years have not changed. As each new voting technology is adopted, there is an initial period of enthusiasm before flaws begin to emerge. When the public discovers that corrupt voters or politicians have found new and creative ways to commit fraud, the search begins for new technology. Election fraud is hardly a new invention" (Jones and Simons, 2012).

Voting Rights & Election Law

The U.S. lacks an explicit federal legal right for all citizens to vote and provides no right for the public to access records necessary to judge the accuracy and currency of electoral outcomes.[3] Citations: Congress (1787); Gerken (2009); Congress (1993, 1965, 2002); Emerson et al. (2011); Thompson (2002); Gerken (2012)

The *Inter-American Democratic Charter of 2001*, which the United States is a signatory to, says that "the peoples of the Americas have a right to democracy ... and periodic, free and fair elections based on secret balloting and universal suffrage". From this, one can conclude that signatories should not use electronic voting systems, such as digital recording electronic (DRE) voting machines, that do not offer a secret ballot" (Jones and Simons, 2012, p.156).

Do Post-Election Audits Verify Election Outcome Integrity?

What qualities of post-election audits are necessary for effective detection and correction of vote miscount? The Center for Election Integrity, Minnesota, has created a concise, categorical list of features it tracks in its database on state election audit laws. All the following features influence the effectiveness of post-election audits. I define effectiveness, roughly, as the ability to detect

[3]The Voting Rights Act of 1965 as amended guarantee the voting rights of the protected classes and The National Voter Registration Act of 1993 guarantees public access to records pertaining to the accuracy and currency of voter registration records. Thus, if it can be determined that voter registration practices discriminate against any legally eligible voters or election administration practices discriminate against a protected class, legal actions may be taken to remedy the situation. Members of a particular political party are not a protected class, and most states employ no routine method to detect many types of vote manipulation favoring a particular political party prior to certifying their election results.

and correct any outcome-altering errors in official vote tallies prior to certifying election results.

- **Transparency:** "Any requirement for the honesty and accuracy of counting and reporting votes leads naturally to a requirement for transparency, since there is no way to determine the honesty of a count conducted in secret." (Jones and Simons, 2012, p.156). Are the post-election audits conducted publicly? Are audit results and data made public? Are observers allowed to verify ballot marks? [and I add] Are the unofficial tallies of audit units reported publicly prior to the audit so the tallies cannot be manipulated afterwards to match the audit tallies?
- **Auditability of Voting System Output:** Does the system use auditable voter–marked paper ballots and ballot marking devices? Are DREs used? If DREs with voter-verfiable paper audit trails (VVPAT)s are used, are records kept of all reports of alleged screen miscallibration where voters were forced to select candidates more than once before their verification screen correctly displayed their choices?
- **Binding:** Are the audit results binding on the official results?
- **Expansion:** Are audit samples risk-limiting or expanded in response to discrepancies?
- **Comprehensiveness:** Are all ballot types audited?
- **Targeted Samples:** Are candidates or officials permitted to choose additional targeted samples?
- **Contests and Issues Audited:** Are all election contests and ballot issues audited?
- **Audit Units:** Are the selected audit units precincts/districts, ballots, machines, or other?
- **Counting Method:** Hand counting, machine counting, or chosen by election official?
- **Oversight and Conduct of Audit:** Who conducts the audit? Who selects the random samples? Who has oversight?
- **Timeline for Audit:** Is the audit conducted before or after certification of election results?
- **Verifiable Ballot Security:** To CEIM's list, I would add the question: Is there publicly verifiable secure transportation and storage of all ballots between the time ballots are cast in the polls and audited?

All of the above impact the capacity of post-election audits to detect and correct levels of vote miscount sufficient to alter election outcomes. Subsection 3.1 and tables 5 and 6 list a few of these key features for states having high PED in the 2014 elections.

Are U.S. Voting Systems Auditable?

In order to check the accuracy of reported vote tallies, a voting system must be auditable independent of its software.[4] No one deposits money anonymously into a bank that never manually audits the accuracy of its banking records. Yet, voters often deposit their votes unseen and anonymously into inauditable voting systems. The accuracy of a voting system must be "software independent," defined as a voting system capable of detecting any error in election results caused by an error or fault in its software. If it is also possible to correct any such errors, the system is "strongly software independent".(Jones and Simons, 2012, pp.153-4) Because the ballot cast by the software on a DRE is invisible and never seen by the voter, DRE voting machines are considered to be inauditable. Even though some DREs have VVPATs, studies show that fewer than 10% of voters accurately verify their ballots. Experiments show few voters attempt to verify VVPATs and of those who do, few notice any deliberately introduced errors. Further, if the roughly 9% of voters who accurately check VVPATs were to notice and correct an error, they may think the error is due to screen miscalibration and not to vote manipulation.

To facilitate efficient and effective auditing, a voting system must be able to print an audit report of detailed election results by ballot type and by precinct. Unfortunately, most U.S. voting systems are not designed to easily produce such a report. For instance, the Diebold central tabular sums a running total, but does not record the vote tallies of individual precincts (Dopp, 2010). When RFP's were put out to voting machine manufacturers by election officials following the Help America Vote Act of 2002 (HAVA), no requirements were made for voting systems to produce an auditable report of precinct tallies.

How Are Voting System Standards Set?

This section relies on *Broken Ballots* (Jones and Simons, 2012). However, this author was among those persons who were invited to join the IEEE standards committee, who were not added to the discussion lists by the voting machine vendor representatives who, by then, had control over

[4]Since software is compiled into machine language that is not humanly readable, this is true even for all types of software, including open source software and commercial off-the-shelf software.

the process. Thus, I can attest to some of the facts in this section.

With elections, it is difficult to create a system of checks and balances for independent testing and certification of voting systems. Each individual state legislature or chief election official sets its own requirements. Types of equipment and procedures vary by county. By 1997, the Election Center, owned by the Academy for State and Local Government since 1986, was deeply involved in voting system certification. In 1989, the Election Center launched the National Association of State Election Directors (NASED). The Election Center provides training and certification of election officials, but there are serious questions about how much of the training it offers is covert marketing and lobbying support for its vendor members. The potential for conflict of interest is significant (Jones and Simons, 2012). In 1990, the Federal Election Commission released voluntary standards for voting systems.

The technical complexity of voting systems has moved well beyond the level that typical election officials are capable of handling. In 1994, NASED created a testing process for voting systems where vendors pay independent testing authorities (ITAs) for testing and certification. "Election directors depend on vendors for the maintenance of complex voting systems, and public officials have a strong vested interest in discouraging public disclosure or discussion of flaws in systems acquired under their leadership. ... In the elections domain, there is nothing analogous to insurers acting on behalf of policy holders to investigate failures" and provide incentive to manufacturers to avoid costly lawsuits. (Jones and Simons, 2012)

Attempts to set standards for voting systems have been made by Congress, NASED, NIST, IEEE, and the EAC's Technical Guidelines Development Committee. In late 2001, a standards committee was formed by the IEEE to develop new standards for voting systems. In 2003, voting system vendors worked to shut out others from the IEEE voting system standards effort and the standards process broke down over a dispute about whether or not providing a reasonable level of security and auditability would be too costly. "At the crux of the breakdown was the issue of voter-verified paper trails. ... primarily vendor representatives and their allies, wanted to write rules that discouraged the use of paper–based technologies."

In addition, in 2003, "R. Doug Lewis, executive director of The Election Center and administrator for the [National Association of State Election Directors] NASED voting system certification program had helped organize a conference call in August between representatives of the major voting system vendors and the Information Technology Association of america, a major lobbying group. The goal of the call was to establish a public relations campaign to

counter questions about voting systems being raised by security researchers and opponents of electronic voting, a reference to the Hopkins-Rice Report that had just come out" (Jones and Simons, 2012, p. 151).

In 2004 the U.S. Election Assistance Commission (EAC) convened the Technical Guidelines Development Committee (TGDC) and in December, 2005 adopted new voluntary guidelines that largely carried forward the structure of the 2002 and 1990 standards and went into effect in December 2007. It allows several serious exemptions and loopholes in voting systems. In August, 2007 the TGDC released a completely reorganized set of standards that was never approved because of opposition to its requirement for weak software independence.

In 2007 and 2008, the National Association of Counties (NACo) joined with R. Doug Lewis, Executive Director of The Election Center and the American Association of People with Disabilities (AAPD) to kill a House bill that would have required election officials to replace paperless DREs with optical scan systems along with ballot marking devices for people with disabilities, requiring all voting systems to have durable, accessible, and privacy-protecting paper ballots. There was never a vote on the bill.

Are Timely Detailed Election Data Publicly Reported?

Many states use inauditable voting systems or fail to conduct effective post-election audits. Thus, statistical analysis of election data is, often, the only tool available for detecting suspicious patterns of election results caused by partisan vote manipulation. Yet, many states do not publicly report the data in a timely fashion that can be used for statistical analysis. Maryland and New Mexico provide excellent examples of states that publicly report election data in a timely fashion with enough detail to detect suspicious patterns consistent with vote fraud. Maryland, for instance, publicly posts partisan turnout, registration, and votes broken out by early, Election Day, and absentee or provisional ballot types. Thus, given partisan turnout rates and vote shares in each ballot type, it may be statistically noticeable when there are potentially outcome-altering discrepancies between different ballot types.

2 Theory and Methods

To familiarize readers with how to measure necessity, section 2.3 reviews beginning classical logic and the data patterns and set relationships produced when one condition is necessary but

not sufficient for the occurrence of another. Section 2.3 explains how to use this new measure of necessity to calculate the extent to which low quality voting systems vis-a-vis audits are necessary for the occurrence of high PED in the 2014 election. Similarly, appendix B shows how to conceptualize data patterns occurring when a condition is sufficient but not necessary for another.

Section 3 presents an of analyses of the 2014 election results at the state level. Section 3.1 presents summary aggregate statistics. Appendix D compares fundamental differences between standard OLS (symmetrical) statistical methods designed to detect conditions that are both necessary and sufficient to asymmetric measures designed to detect condition that are one or the other or both necessary and sufficient. Section 3.2 presents necessity analyses of several conditions hypothesized to be necessary for high discrepancy between pre-election opinion polls and officially reported election results. Section 3.2 shows the results of applying a soon-to-be published method for estimaing levels of poll bias and vote miscount most consistent with the PED pattern.

In section 3.3, we learn Maryland's high PED cannot be explained by partisan poll response bias. No direct way exists to check the accuracy of Maryland's paperless DRE election results other than statistical analysis. Section 4 is a case study of Maryland's turnout and vote tally data broken out by early voting, election day voting, and absentee and provisional ballots. An examination of partisan vote and turnout margins by ballot type casts additional doubt on the accuracy of the 2014 Maryland governor's outcome. In section 4.5, we learn that the differences in partisan vote share margins in Election Day polling, early voting, and absentee/provisional voting cannot be explained by differences in partisan voter turnout rates and are consistent with an explanation of outcome-altering vote miscount.

2.1 What is Poll vs. Election Results Discrepancy (PED)?

What causes the discrepancy between poll and election results margins (PED)? First, we examine the observable and unobservable conditions that could cause PED.

$$
\begin{aligned}
v_d, v_r &= \text{reported Democrat and Republican vote shares} \\
p_d, p_r &= \text{Democrat and Republican precinct poll shares} \\
d, r &= \text{unseen actual Democrat and Republican vote shares} \\
D, R &= \text{unseen Democrat and Republican poll response rates} \\
s_d, s_r &= \text{unseen vote switch rates to Democrat or to Republican candidate}
\end{aligned}
$$

the observable vote and observable poll margins, out of the total Democrat and Republican shares are, respectively, $\frac{v_d - v_r}{v_d + v_r}$ and $\frac{p_d - p_r}{p_d + p_r}$ and the observable discrepancy between them is:

$$
PED = \frac{v_d - v_r}{(v_d + v_r)} - \frac{p_d - p_r}{p_d + p_r} \text{ in terms of seen variables} \tag{1}
$$

$$
= \frac{(d - s_r d + s_d r) - (r + s_r d - s_d r)}{(d + r)} - \left(\frac{dD - rR}{dD + rR} + e_s \right) \text{ in terms of unseen variables} \tag{2}
$$

Thus, PED can be caused by random sampling error, e_s, vote miscount favoring Democrats or Republicans, s_d or s_r, or different partisan poll response rates, D or R.

2.2 Theory: Pre-Election Polls, Election Results, & Voting Systems

If election results are accurately counted, then discrepancies between polls and election results should be unrelated to voting system and post-election audit quality. Similarly, if the polls are biased in favor of Democrats, i.e. Democratic voters were sampled in disproportionate amounts as compared to Republican voters, then the pattern of discrepancies should be consistent with a pattern produced by poll response bias but should be unrelated to voting system and post-election audit quality. If you believe these inferential relationships are true, and I do, then the contrapositives are also true. In other words, if the discrepancies are related to voting system and post-election audit quality, then the election results were not accurately counted. If the pattern of discrepancies is not fully consistent with partisan poll response bias, then the

discrepancies cannot be fully explained by partisan poll response bias. Thus, if we find that low quality, inauditable voting systems, or lack of post-election audits is necessary for the occurrence of high discrepancy between election results and pre-election opinion polls, then we are led by logic to believe that the discrepancy is consistent with having been caused by vote miscount rather than partisan poll response bias.

2.3 Formal Logic, Causal Inference, & Measuring Necessity

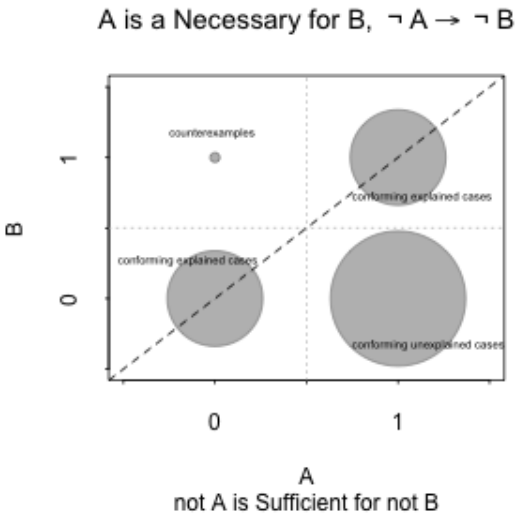
Most social scientists agree correlation alone is not sufficient to establish causation. A causal mechanism must be shown to exist, rather than, simply, a spurious correlation However, relying on standard statistical methods, implicitly and incorrectly assumes correlation is a necessary condition for causation to occur. This section attempts to provide understanding of the fact that causation may occur without correlation whenever there are multiple independent causes for the same outcome. In other words, significant correlation often does not occur between an irrefutable cause and its outcome when the set of outcomes due to that particular cause is a, relatively, small subset of the total set of outcomes. Thus, methods exist that are mathematically better–designed than OLS regression to detect causes that are necessary but not sufficient or are, vice-versa, sufficient but not necessary for an outcome.

This section presents ways to visualize and measure the degree to which the presence of one condition is necessary but not sufficient for another condition to occur. The statement condition A is necessary for condition B is equivalent to stating "Not A implies not B." In other words, if A is not present, then B cannot occur because the presence of condition A is necessary for condition B to occur. Table 2 lists the truth values for all possible combinations of simple dichotomous variables A and B, where 0 denotes the absence, and 1 denotes the presence of condition A or B.

Figure 1a shows a plot of two dichotomous conditions A and B where the occurrence of A is necessary, but not sufficient for B to occur. Thus, we see that sometimes A occurs without B, but any instances of B without the presence of A are counterexamples to the claim that A is necessary for B. In figure 1a, the diameter of the circle is proportional to the number of cases having each pair of values for (A, B). If there are counter-examples in cell, $(A, B) = (0, 1)$ it means that the claim A is necessary for B is probabilistic not deterministic. Figure 1b shows a set-theoretic view of the phrase condition A is necessary for condition B. In set theoretic terms, the set of cases exhibiting condition B is a subset of the set of cases exhibiting condition A.

Figure 1: Visualization of A is Necessary for B.

(a) Dichotomous Variables



(b) Euler Diagram

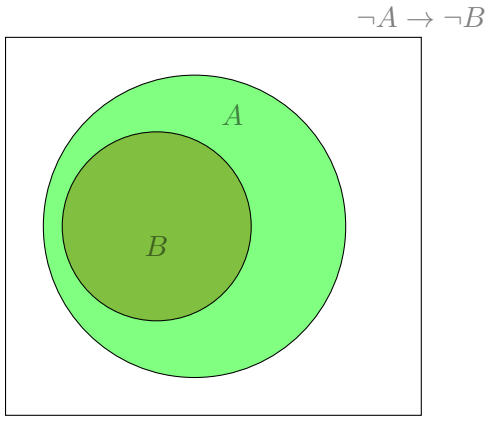


Table 2: Truth Table for Inference $\neg A \rightarrow \neg B$ or $(A \vee \neg B)$

A	B	$\neg A \rightarrow \neg B$
0	0	T
0	1	F
1	0	T
1	1	T

$$\text{Necessity}_{X\,for\,Y:} \frac{\sum_i^n min(x_i, y_i)}{\sum y_i} \tag{3a}$$

$$\text{Necessity}_{f(X)\,for\,Y:} \frac{\sum_i^n min(f(x_i), y_i)}{\sum y_i} \tag{3b}$$

Expression 3a is the qualitative comparative analysis (QCA) fuzzy set method for measuring the extent to which condition X is necessary for condition Y to occur. It measures the extent to which points fall below the line $y = x$. If points fall above the line where $x_i < y_i$, x_i is the minimum and since we divide by the sum of y_i, we add more to the denominator than to the numerator. If points fall below the line $y = x$, then we $y_i < x_i$ and we add the same amount to both numerator and denominator. Thus, the more points fall above the line $y = x$ and the farther above they fall, the smaller measure 3a becomes; and, the more points fall on or under

the line $y = x$, the closer measure 3a is to one (1). It is accepted practice in QCA to require at least 75% necessity level to claim one condition is necessary for another.

Expression 3b is a similar formula. However, I extend QCA measures for necessity to measure necessity by any functional shape whereby one relationship may constrain another.

In other words, expression 3b generalizes QCA's measure for determining the levels that one condition is necessary for another to any shaped function, where y_i are the observed values of the outcome condition and x_i are whatever combination of independent variables make up the precedent condition, and $f(x_i)$ is a function of any shape representing the real-life relationship between conditions that constrains the values of the outcome. This formula for expanding necessity measurement to any shaped function measures the extent to which condition $f(X)$ is necessary for outcome condition Y. It is simply the sum of the minimums of the observed outcome values, y_i, and the functional values $f(x_i)$ divided by the sum of the observed outcome values, y_i.

A similar presentation of ways to visualize and measure the degree to which the presence of one condition is sufficient but not necessary for another condition to occur is found in appendix B.

2.4 Data, Methods, and Variables

The following independent conditions have been suggested as possible causes for high PED discrepancy due to vote miscount or voter disenfranchisement: Low quality voting systems susceptible to vote miscount, close predicted poll margins between leading candidates, interaction of voting system quality and poll margins, partisanship of state election administration, and the presence of strict voter ID laws[5]. I measure the necessity levels of these five independent conditions for high standardized discrepancy between poll and election results margins.

Standardizing Discrepancies: To make the discrepancies comparable between states, I standardize each state's PED measure by using the absolute value of its average PED for all its polls divided by the average poll margin of error divided by number of polls: $\frac{|Polls-Election|*\sqrt{(NumPolls)}}{PollMOE}$. This is a standardized measure of the unlikelihood of the discrepancy between the pre-election opinion polls and the election results, allowing an apples-to-apples comparison of state discrepancies. In testing for necessary conditions, this is the outcome or dependent variable I examine.

[5]The source for voter ID information is The Brennan Center for Justice web site http://www.brennancenter.org/new-voting-restrictions-2010-election

The data includes almost all U.S. 2014 senatorial and gubernatorial election contest data except for Connecticut's which I excluded because poll margin of errors were not reported by my data source, Real Clear Politics.[6] Polls include poll averages of likely voter polls conducted within a month prior to the November 4th election date, as well as a list of the individual poll results, sample sizes, and margin of errors. The data included average likely voter predicted poll and election results margins and poll margins of error. I obtained the partisanship of state election administration from Ballot Pedia.[7]

The rankings of post-election audits, information on state audits and types of voting systems were obtained from on-line searchable data-bases from Verified Voting Foundation[8], and Citizens for Election Integrity, Minnesota[9] (Dan Pederson, Program Coordinator, 2014). The Citizens for Election Integrity, Minnesota State site links to state audit statutes. It includes information on voting systems used, statutory audit transparency including whether the audits are publicly observable, whether or not the audit results affect official results or are expanded to a full recount when discrepancies are found, which types of ballots are audited, whether targeted samples are included, which election contests are subjected to auditing, type of audit units, and the audit counting method. The audit rating system I adopted from Verified Voting's rankings could possibly be improved by further inclusion of the detailed information found at the CEIMN site.

Fuzzy Set Membership Values of Voting System Quality: I employ well-accepted methods for composing voting system quality ratings from Verified Voting's audit rankings and voting system types (Ragin, 2008; Kosko, 1992; Goertz, 2006). This combined set theoretic membership measure of voting system verifiability using Verified Voting's rankings takes on values in the interval $[0, 1]$ and is the minimum of the numerical ratings based on Verified Voting's audit rankings and the audibility level of state voting systems, as shown in tables 3 and 4.

[6] http://www.realclearpolitics.com/epolls/2014/senate/2014_elections_senate_map.html

[7] http://ballotpedia.org

[8] https://www.verifiedvoting.org/resources/post-election-audits/ and http://www.verifiedvoting.org/verifier2014/

[9] http://www.ceimn.org/searchable_databases/state_audit_laws

Table 3: Ratings from Verified Voting's Audit Quality Rankings

Verified Voting Audit Rank	Rating
Excellent	1.000
Good	0.875
Generally Good	0.625
Needs Improvement	0.375
Inadequate	0.125

Source of ranking is (Verified Voting Foundation, 2012)

Table 4: Voting System Ratings

Voting System Type	Auditability Rating
Paper Ballots	1.00
All Mail Paper Ballots	0.75
Mixed DRE/Paper Ballot	0.50
DRE with VPAT	0.25
Paperless DRE	0.00

Necessary Condition Measurement

To measure the level of necessity of the five independent conditions on the outcome, standardized PED, I use formula 3b with $f(x)$ defined in equation 4c.

$$b = max(Y_i) \tag{4a}$$

$$m = -max(Y_i)/max(X_i) \tag{4b}$$

$$f(x) = b + mx \tag{4c}$$

where Y_i are the standardized state discrepancies between pre-election polls and reported election results; X_i are the values of the independent condition. The slope of the line is m and b is its y intercept for pairs $(x_i, f(x_i)$. Using this function has the same effect as calibrating the two variable conditions into fuzzy set membership values between zero and one, in this application, reversing the order of the X values. Thus, this method is simpler, takes less effort, and avoids any need for a researcher to set arbitrary discretionary values such as a maximum point of set

membership, or ambiguity, full membership, or full nonmembership values. In other words, using this simple technique eliminates the need for messy conversions/calibrations of X_i and Y_i into set membership values in $[0, 1]$.

3 2014 U.S. Senate & Governor Elections

This section analyzes state-level election data in three ways: (1) An examination of state post-election audit statutes and voting systems for states having higher than average PED[10], (2) measurement of level of necessity of five conditions for the occurrence of high PED, and (3) maximum likelihood estimation of overall levels of partisan poll response bias and vote miscount consistent with state PED levels.

3.1 Summary Statistics & Voting System Analyses

Two questions can be answered with simple summary statistics. Was PED of sufficient magnitude and direction to indicate vote miscount may have altered any election outcomes from a predicted winner of one political party to another? Do states exhibiting higher than average PED conduct effective post-election audits to publicly verify the integrity of their election outcomes?

Were Discrepancies Sufficient to Alter Election Outcomes?

In 2014 governor elections, the magnitude and direction of PED was sufficient, if due to vote miscount, to alter election outcomes in Maryland, Kansas, Illinois, and Florida. In all four states, the Democrat candidates outpaced Republicans in the opinion polls, but Republican won in the election. The discrepancy in margins, in descending order, were, respectively 14.8%, 5.9%, 5.6%, and 1.5% in Maryland, Kansas, Illinois, and Florida. Table 5 shows the actual and standardized discrepancies for all states having outcome-altering magnitude of discrepancy or having above the mean absolute value of discrepancy for all governor elections.

In 2014 senate elections, discrepancies were of sufficient magnitude and direction to alter outcomes in Kansas and North Carolina having, respectively, discrepancies of 12% and 2%. Table 6 shows actual and standardized discrepancies for all states having outcome-altering magnitude

[10]PED is standardized (Poll - Election results) Discrepancies

of discrepancy or having above the mean absolute value of discrepancy for all 2014 senate elections.

Also of interest, large discrepancies in two states, Vermont and Virginia, were within 1% of over-turning their election outcomes, with, respectively 9% and 14% discrepancy between pre-election polls and reported results.

Table 5: 2014 U.S. Governor Elections with High Discrepancy between Polls and Results

	Winning Margin	Actual Discrepancy	#Standard Discrepancies	Voting System Rating	Audits?
AR	-0.14	-0.06	4.30	0.20	no audits & PL DREs
FL	-0.01	-0.01	0.80	0.40	no effective & PL DREs
IL	-0.05	-0.06	3.80	0.40	DREs
KS	-0.04	-0.06	3.60	0.20	no audits & DREs
MD	-0.05	-0.15	10.80	0.00	no audits & PL DREs
NV	-0.47	-0.22	9.50	0.25	¬all ballot types & DREs
NY	0.13	-0.10	6.20	0.60	¬all ballot types
OH	-0.31	-0.10	5.70	0.40	optional
SD	-0.45	-0.15	7.50	0.20	no audits
TN	-0.47	-0.21	6.60	0.20	machine recounts & PL DREs
VT	0.01	-0.14	4.70	0.40	optional
WY	-0.34	-0.11	2.00	0.20	no audits & DREs

This table includes states where the partisan outcome is different than predicted or where the absolute value of actual discrepancy is above its mean value. Shaded rows denote states with sufficient discrepancies to have altered, or were very close to altering election outcomes. Notes: (1) What Maryland calls an audit, is actually a reconciliation of voters with ballots and DRE vote tally summation. (2) Florida audits only *after certification* and only one randomly-selected election contest, selected separately in each county. No contest with boundaries greater than a county-wide contest can be effectively audited.

Table 6: 2014 U.S. Senate Elections with High Discrepancy between Polls and Results

	Winning Margin	Actual Discrepancy	#Standard Discrepancies	Vot.System Rating	Audits?
AR	-0.17	-0.10	6.20	0.20	no audits & PL DREs
DE	0.14	-0.06	1.50	0.00	no audits & PL DREs
IA	-0.09	-0.06	4.60	0.20	no audits
ID	-0.31	-0.06	2.10	0.20	no audits
KS	-0.11	-0.12	7.00	0.20	no audits & PL DREs
KY	-0.15	-0.08	5.20	0.25	¬all ballot types & PL DREs
MA	0.24	0.06	-3.10	0.20	no audits
ME	-0.37	-0.08	3.90	0.20	no audits
MS	-0.23	-0.07	2.30	0.20	no audits & DREs
NC	-0.02	-0.02	1.30	0.50	optional & DREs
NE	-0.34	-0.11	3.40	0.20	no audits
OK1	-0.40	-0.06	2.30	0.20	no audits
OK2	-0.39	-0.08	3.20	0.20	no audits
SD	-0.21	-0.09	4.40	0.20	no audits
TN	-0.30	-0.12	3.60	0.20	no audits
TX	-0.27	-0.06	3.20	0.40	¬all ballot types & PL DREs
VA	0.01	-0.09	4.20	0.20	no audits & PL DREs
WV	-0.28	-0.11	4.10	0.50	¬all ballot types & DREs
WY	-0.55	-0.17	3.10	0.20	no audits & DREs

Paperless digital recording electronic voting systems are denoted by "PL DREs". This table includes states where the partisan outcome is different than predicted or where the absolute value of actual discrepancy is above its mean value. Shaded rows denote states with sufficient discrepancies to have altered, or were very close to altering election outcomes. Notes: (1) What Delaware calls an audit, is actually a reconciliation of voters with ballots. (2) North Carolina's audit law requires that only one election contest per election be audited.

Do High Discrepancy States Conduct Effective Post-Election Audits

The relationship between the magnitude of PED and the quality of state voting systems vis-a-vis auditability is measurable. All four states exhibting sufficient PED to alter gubernatorial outcomes, Maryland, Illinois, Kansas, and Florida are rated by Verified Voting as having inadequate audits or audits needing improvement. This section briefly discusses flaws in voting systems utilized by states having higher than average PED.

In high discrepancy gubernatorial contests:

- With the highest PED, Maryland's paperless digital recording device (DRE) voting systems are inauditable, relaying solely on the 100% integrity and infallibility of all the people who maintain, program, and update its trade secret software and ballot definition files. Thus, no post-election manual audits capable of verifying the accuracy of the software are possible;
- Kansas uses a mix of paper ballots and DREs, and conducts no post-election audits;
- Florida, also, uses a mixed voting system including inauditable DREs without paper trails, and conducts its post-election audits only *after* it certifies its election results. "not binding on official results, does not lead to a full recount, and audits only one randomly-selected election contest, selected separately in each county. No contest with boundaries greater than a county-wide contest can be effectively audited. ... No statutory guidance allowing observers to verify ballot marks ... The random selection is conducted at the local level." All ballot types are included in the audits;
- Illinois uses a mix of DRE and paper ballot voting systems. Its audits are not publicly observable and are prohibited from influencing any reported election results when errors are found in the audits (yikes): ""The results of the examination and count shall not be certified, used to amend or change the abstracts of the votes previously completed, used to deny the successful candidate for the same office his certificate of nomination or election, nor used to change the previously declared result of the vote on a question of public policy. Such count shall not be binding in an election contest brought about under the provisions of the Election Code, shall not be a prerequisite to bringing such an election contest, shall not prevent the bringing of such an election contest, nor shall it affect the results of the canvass previously proclaimed." See 5/22-9.1; and
- In New York all the early, absentee, ballots counted by hand on Election Day, and provisional ballots are not audited. The public has no right to observe the audits and there is

no statutory requirement to allow observers to verify ballot marks.

In high discrepancy senate elections:

- Nevada uses DREs with VVPATs that are essentially inauditable. The audit law mentions only VVPATs from the polling place, and does not include absentee or provisional ballots. Nevada has no statutory requirement that audit results and data be made public and no statutory guidance allowing observers to verify ballot marks. The counting method is chosen by election official
- In Tennesee the audit is by machine not manual; and "Full implementation of the Tennessee Voter Confidence Act, passed in 2008 and containing the state's audit provisions, has yet to occur" (Dan Pederson, Program Coordinator, 2014). Mixed paper ballot and inauditable DREs without VVPAT. Do not audit the Senate contest.

In sum, there are, most often, virtually no checks and balances of competing interests involved in casting and counting ballots in the states having the highest discrepancies between polls and election results.

3.2 Necessary Conditions for High Discrepancy

In qualitative comparative analysis (QCA) a 75% and above level of measurable necessity is considered significant. I adopt the same convention for my extended asymmetric measure of necessity in formula 3b. Table 7 summarizes the findings of an asymmetric necessity analysis of independent conditions that have been hypothesized as possibly necessary for the occurrence of high ($poll - electionresults$) discrepancy (PED). As shown in table 7 only conditions having to do with voting system quality showed significant necessity for the occurrence of high PED in both gubernatorial and senatorial elections. However, predicted close margin elections were a necessary condition to the 87.8% level in senatorial election contests.

By Voting System Auditability & Audits

Figure 2 displays the senate and governor election PED margin of errors plotted by state voting system quality for the gubernatorial contests. Figure 3 displays the PED margin of errors plotted by state voting system quality for the senatorial contests. In both pairs of plots, the triangular shape of the data, is visually consistent with small values of the data plotted on the

Table 7: Variables & Methods for Analyzing State Data

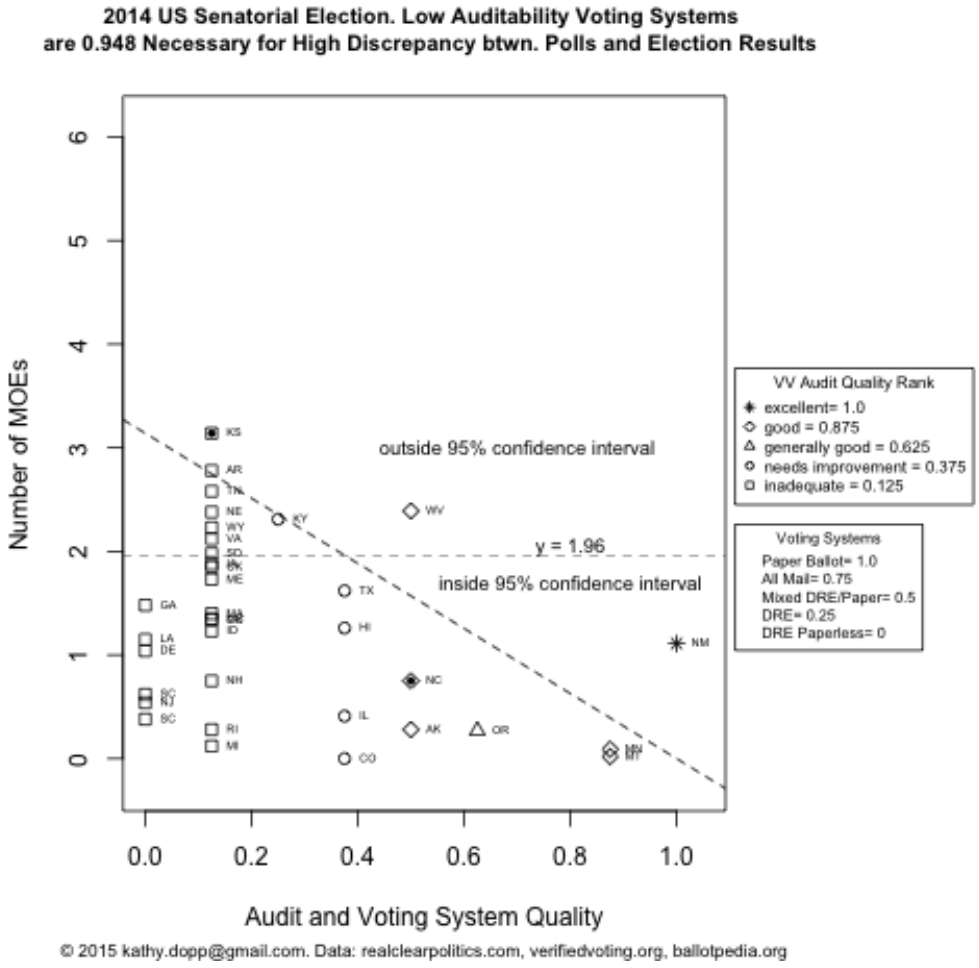
Method	Dependent variable	Independent variable(s)	Significant result?	2014	
				Gov.	Sen.
Necessity measure	Absolute PED (Dem-Rep) margin	VS quality	Yes	94.7%	95.3%
		VS quality & poll margin	Yes	89%	94.1%
		Poll margin	No	66.3%	87.8%
		Partisanship adminis.	No		
		Strict voter ID laws	No		
Pattern analysis	PED by vote share	Vote shift & response bias	Yes		

horizontal axis (poor quality voting systems) being necessary for large values of the data plotted on the vertical axis (high levels of PED). The necessity level measurements of low quality voting systems for the occurrence of high PED, measured according to formulas 3b and 4c are provided in table 7. Low voting system auditability or lack of audits exhibit a very high 94.7% and 95.3% level of necessity for high magnitude PED to occur in United States gubernatorial and senatorial election contests.

Figure 4 shows the PED by voting system quality for the 2012 midterm elections.

These analyses are consistent with poor quality or unaudited voting systems allowing for high levels of discrepancy as would result from undetected vote manipulation overwhelmingly in a direction favoring Republican party candidates. Wyoming makes no pretense of auditing; Tennessee counties overwhelmingly use inauditable paperless DREs that cannot be audited independently of its trade secret software; and, Nevada's audits may be counted either manually or by machine and, thus, may not independent. Although Nevada's DRE machines have paper roll records of votes attached, studies have shown that fewer than 9% of voters accurately verify their ballots, and other studies have shown that under such circumstances, the trade secret software may be programmed to modify votes without detection. If a rare voter detects an error on the DRE screen prior to checking his vote, the voter may imagine that the problem was caused by screen mis-calibration and the software can then correct that one voter's vote and proceed to switch the votes of less observant voters. In addition, Nevada does not require any audits of its early, absentee or provisional ballots; and does not require expanding the audit if discrepancies are found. However, all three states, Tennessee, Wyoming, and Nevada, had

Figure 2: 2014 Senate Elections: Discrepancy by Quality of Voting System & Audits



even higher winning margins than the amount of discrepancies in 2014, so that their enormous discrepancies were unlikely to be outcome-altering.

Kansas, Arkansas, Kentucky, Iowa, and Georgia had very high discrepancy and all have inauditable or low quality voting systems and inadequate post-election audits. Republicans won in Kentucky, Seats switched control from Democrat held seats to Republican held seats in Arkansas, Colorado, Iowa, Montana, North Carolina, South Dakota, and West Virginia. Of these, Arkansas, Colorado, Iowa, and South Dakota are considered to have low quality voting systems or inadequate post-election audits. In Kansas and North Carolina the Democrat was predicted to win by the likely voter polls.

Figure 3: 2014 Governor Elections: Discrepancy by Quality of Voting System & Audits

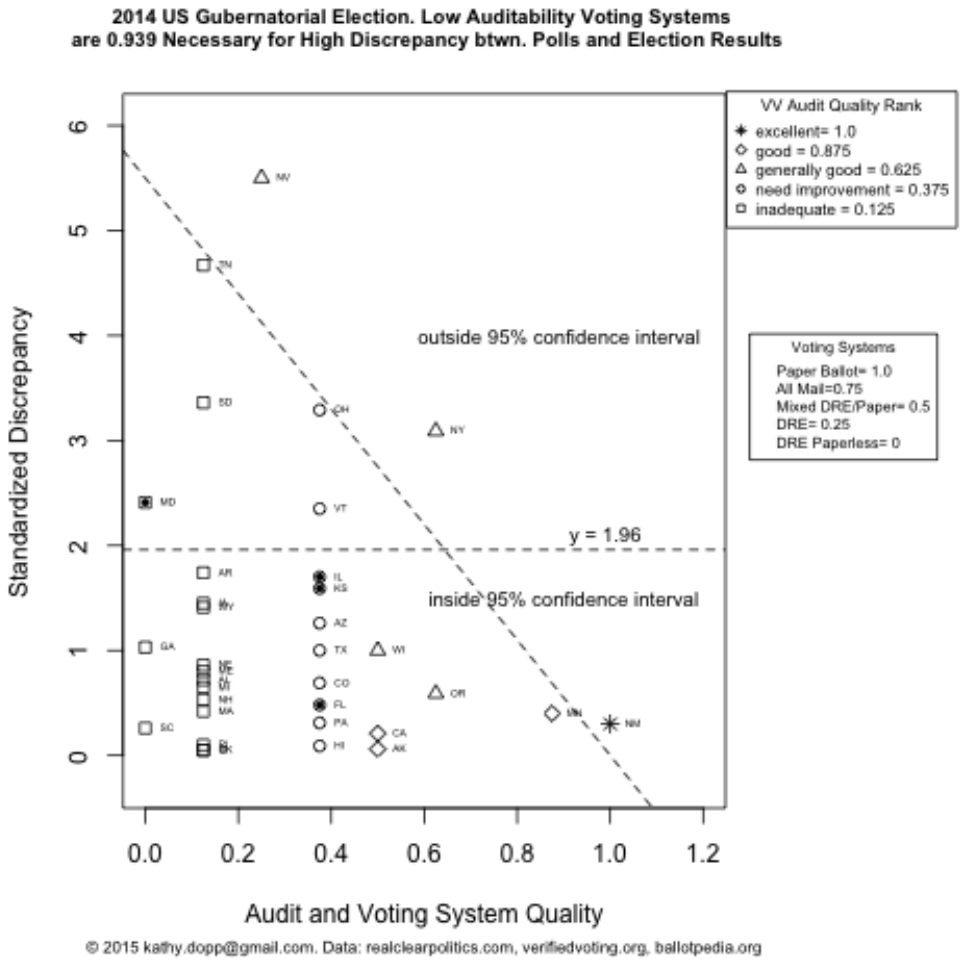
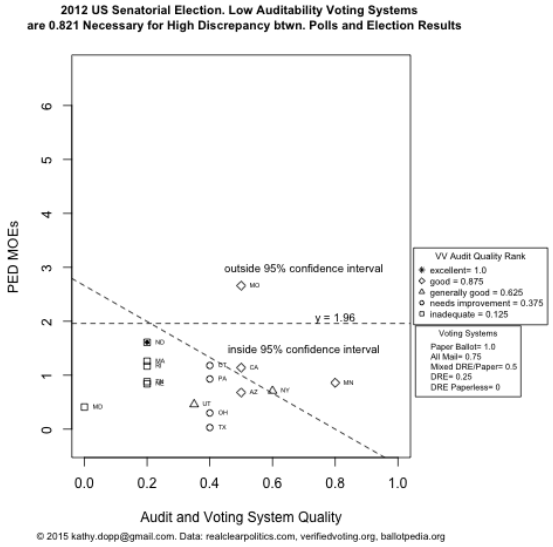
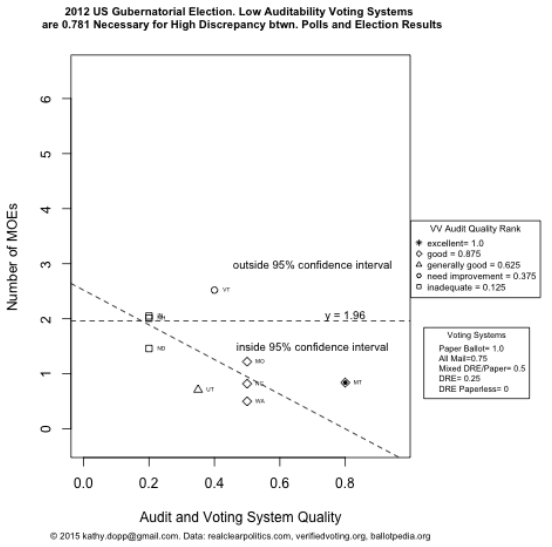


Figure 4: 2012 Elections: Discrepancy by Quality of Voting System & Audits

(a) Senate Contest PED MOEs (VS 82% Necessary)



(b) Governor Contest PED MOEs (VS 78% Necessary)



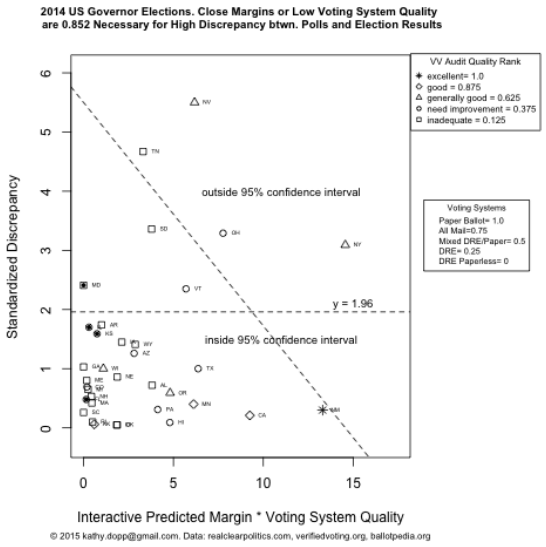
By Interaction of Voting System Quality and Predicted Margins

Figures 5a and 5b display the standardized state PED in the governor and senate elections plotted by the interaction of predicted closeness of election and state voting system quality. In both pairs of plots, the triangular shape of the data, is visually consistent with small values of the data plotted on the horizontal axis (close margin elections and poor quality voting systems) being necessary for the occurrence of large values of the data plotted on the vertical axis (high levels of PED).

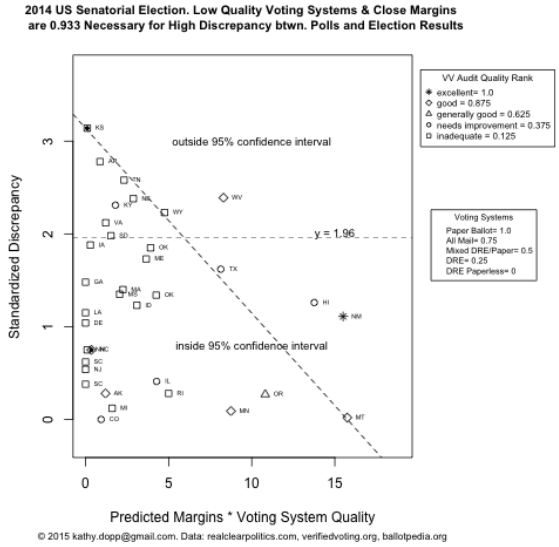
The necessity level measurements of the interaction of margin closeness and low quality voting systems for the occurrence of high PED, measured according to formulas 3b and 4c are provided in table 7. The confluence of close margins and low voting systems exhibit a respectively significant 89% and 94.1% level of necessity for high magnitude PED to occur in United States gubernatorial and senatorial election contests.

Figure 5: Standard Discrepancies by by Voting System Quality and Predicted Margin

(a) 2014 Governor Elections (89% Necessary)



(b) 2014 Senate Elections (94.1% Necessary)



Although, low predicted margin is not, overall, a necessary condition for high discrepancy in the 2014 governor contests, three of the four states with sufficient magnitude PED to alter gubernatorial outcomes, Florida, Kansas, and Illinois, had predictions of close margins. Maryland's outcome is the most unexpected, with a difference of almost 15% between predicted and reported margins.

3.3 Pattern Analyses: Poll Response Bias or Vote Miscount?

Even though random sampling is inconsistent with the PED, some may claim partisan poll response bias could explain the discrepancies between Do Democrats have a higher response rate to pre-election opinion polls than Republicans? Demographic weighting by census data should avoid this possibility to a large extent. A possible explanation for the large discrepancies between polls and election results in the 2014 elections is partisan response bias, or Democrats responding to polls more than Republicans. However, we show by two methods, that partisan response bias does not fully explain the discrepancy patterns. Thus, the discrepancies between opinion polls and 2014 election results cannot be explained by random sampling errors. Further, if these discrepancies were caused by survey sampling error, the pattern would be random and, thus, unrelated to the quality of election audits and audit procedures, as will be shown in subsequent sections.

This section asks the question, "Were the non-random nature of the PED possibly due to over-sampling of Democratic voters relative to election turnout or due to miscounted votes?" tables 9 and 10.

Table 8: 2014 Governor Election - Overall Pattern of Response Bias & Vote Shift

Parameters	Estimates	95% Confidence Interval
Switch to Dem	0.0013	(0 , 0.007)
Switch to Rep	0.0094	(0 , 0.039)
Dem:Rep Resp.ratio	1.0809	(1.009 , 1.153)

Even assuming a partisan response bias where Democrats are assumed to have a greater response rate to the polls (in the poll pattern section), the probability that 13 (senate) and 8 (governor) discrepancies were outside the 90% confidence interval is: 1.8 e-05 and 0.02 respectively. However, because all the discrepancies went only in the negative direction favoring Republicans in the election results more than in the polls, the probabilities would be half that or 8.8e-06 and 0.01 respectively.

Table 9: 2014 U.S. Governor Elections with PED outside Model 90% Confidence Interval

	Winning Margin	Model PED	#Standard PED	Vot.System Rating	Audits?	Auditable Vot.Sys.?
MD	-0.05	-0.15	10.80	0.00	no audits	PL DREs
NV	-0.47	-0.22	9.50	0.25	¬all ballot types	DREs
NY	0.13	-0.10	6.20	0.60	¬all ballot types	
OH	-0.31	-0.10	5.70	0.40	optional	DREs
SD	-0.45	-0.15	7.50	0.20	no audits	
TN	-0.47	-0.21	6.60	0.20	machine counts	PL DREs
VT	0.01	-0.14	4.70	0.40	optional	
WY	-0.34	-0.11	2.00	0.20	no audits	DREs

Model estimates overall Dem:Rep response bias of 1.35, and vote margin shift favoring Republicans of 0.056. Note: (1) While Maryland uses the term "audit", its voting system is 100% paperless DREs (inauditable) and it only does a post-election reconciliation of the number of voters with the number of votes and checks that the DREs tallies are correctly summed. (2) Ohio's audits are conducted after certification of the results. "After Election Day, the Secretary of State will randomly select at least one other statewide contest to be included in the post-election audit in addition to the top of the ticket contest (e.g., President)." (3) Vermont's audits are conducted at the discretion of the secretary of state, may not cover all ballots, use machine counting, be done after certification and not be binding on results.

Table 10: 2014 U.S. Senate Elections with PED outside Model 90% Confidence Interval

	Winning Margin	Model Discrepancy	#Standard Discrepancies	Vot.System Rating	Audits?	Auditable Vot.Systems?
AR	-0.17	-0.10	6.20	0.20	no audits	PL DREs
KS	-0.11	-0.12	7.00	0.20	no audits	PL DREs
KY	-0.15	-0.08	5.20	0.25	¬all ballot types	PL DREs
ME	-0.37	-0.08	3.90	0.20	no audits	
MS	-0.23	-0.07	2.30	0.20	no audits	DREs
NE	-0.34	-0.11	3.40	0.20	no audits	PL DREs
OK1	-0.40	-0.06	2.30	0.20	no audits	
OK2	-0.39	-0.08	3.20	0.20	no audits	
SD	-0.21	-0.09	4.40	0.20	no audits	
TN	-0.30	-0.12	3.60	0.20	no audits	PL DREs
TX	-0.27	-0.05	3.20	0.40	¬all ballot types	PL DREs
VA	0.01	-0.09	4.20	0.20	no audits	PL DREs
WV	-0.28	-0.11	4.10	0.50	¬all ballot types	DREs
WY	-0.55	-0.17	3.10	0.20	no audits	DREs

Model estimates overall Dem:Rep response bias of 1.215, and vote margin shift favoring Republicans of 0.039. Note: VA only audits wide-margin election results where the margin is more than 10% *after* certification and it is discretionary for the county and the state to do the audit.

4 Case Study: Maryland Governor's Contest

"Republican Larry Hogan's victory in Maryland's governor's race was a stunning political upset.. . . [the Democratic candidate, African American Anthony Brown] lost and lost badly, despite calling on President Barack Obama, First Lady Michelle Obama and Bill and Hillary Clinton to turn out the base, and despite hundreds of thousands of dollars in attack ads [against his opponent]. . . . Baltimore County's East Side [predominantly African American], which went for Mr. Hogan in a rout." — Baltimore Sun, November 5, 2014.

Pundits find political explanations for all unexpected election outcomes. As one story goes, the Democratic candidate Brown was a lackluster candidate who failed to articulate a clear, cohesive vision. Though he looked good on paper – young, handsome African American Harvard Law graduate who served active duty in Iraq as a highly decorated Army pilot – he didn't connect with voters. The primary election was nasty, bruising and personal. Brown portrayed his "main" primary opponent, the sitting Attorney General, as reckless and lawless. Brown was portrayed as weak and incompetent, presiding over MD's failed roll-out of its healthcare exchange. The negativity of the primary campaigns may have contributed to alienating voters from both candidates and Brown did not effectively counter the impression he was a weak manager. Brown was ushered quickly in and out of campaign events by his handlers, not stopping to listen to voters. He offered no real vision, took very few questions, and was gone. During the general election campaign voters rarely saw Brown, and when Hogan began gaining on him in the polls, voters received occasional robocalls from Bill Clinton or Michelle Obama or a union. It was a poorly run campaign. By contrast, the Republican candidate, Hogan, ran a very energetic statewide campaign where he connected with voters and energized his base to turn out. A *Washington Post* article claims, "Thirty-seven percent of white Democrats and Democratic-leaning independents voted for Hogan [although] . . . Only 11 percent of this group supported Ehrlich [the Republican candidate] for governor in a 2010 pre-election poll."[11] However, both academic and media pollsters adjust and weight their samples to match reported election results, assuming election results are accurate. Anyone skeptical of a naive unquestioned assumption that Maryland's officially reported election results, tallied on DREs since 2002, are accurate will, likewise, be skeptical of opinion and exit polls that are progressively adjusted over time to match prior results.

[11] http://www.washingtonpost.com/local/md-politics/hogans-victory-political-future-hinge-on-disaffected-democrats-2015/02/17/13943e9e-b6b6-11e4-aa05-1ce812b3fdd2_story.html

Even if all but four of Maryland's most recent pre-election opinion polls are dropped from our calculations, the standardized discrepancy of Maryland's pre-election opinion polls is 4.8 MOE's, keeping Maryland among those states having the highest discrepancies. Thus, this section examines Maryland's voter registration, turnout and vote data.

4.1 Maryland's Voting System: The Story of Diebold

> "I need some answers! Our department is being audited by the County. I have been waiting for someone to give me an explanation as to why Precinct 216 [Florida] gave Al Gore a minus 16,022 when it was uploaded. Will someone please explain this so that I have the information to give the auditor instead of standing her 'looking dumb'." — Source: A large archive of Diebold [voting system] internal emails dating from January 1999 to March 2003, provided by a hacker to Wired News. Source: (Jones and Simons, 2012, p.159)

Maryland uses paperless DRE voting systems manufactured by Diebold Election Systems, Inc.[12] Voting system information, germane to many states' voting systems, is available on the "Voting System Studies" page, on Save Our Votes[13], as well as on *Broken Ballots – Will Your Vote Count?*.

Avi Rubin, professor of computer science at Johns Hopkins University and technical director of the JHU Information Security Institute, together with computer scientists Kohno, Subblefield, and Wallach conducted one of the first scientific analyses of the source code of the Diebold touch-screen voting system, which had been found on an unsecured Internet site by Bev Harris of Black Box Voting (Kohno et al., 2003).[14] "Our analysis shows that this voting system is far below even the most minimal security standards applicable in other contexts, and, We conclude that this voting system is unsuitable for use in a general election. Any paperless electronic voting system might suffer similar flaws, despite any "certification" it could have otherwise received."(Kohno et al., 2003)

In August 2003, computer scientist Doug Jones presented a paper entitled, The Diebold

[12]In August 2007 Diebold, Inc. spun off Diebold Election Systems, Inc. as a wholly owned subsidiary renamed Premier Election Solutions and began seeking a buyer for it. In 2009, it was sold to competitor Election Systems and Software (ES&S), the largest voting system manufacturer in the US. The US Department of Justice began an antitrust investigation of the transaction and required ES&S to unwind part of the acquisition. In 2010, Dominion Voting Systems purchased the primary assets of Premier from ES&S.

[13]source http://saveourvotes.org/reports/index.htm. This information was organized by Robert Ferraro.

[14]Analysis of an Electronic Voting System (July 2003) http://avirubin.com/vote.pdf

AccuVote TS Should be Decertified and What This Tells Us about the Certification Process" at the USENEX Security Symposium. It revealed that Dr. Jones had warned Diebold (then Global Election Systems) of some of the major security flaws identified by the Rubin study way back in 1997 and showed that the entire certification process was broken. In *Broken Ballots*Jones said, "I want to emphasize that this story represents more than just a black eye for Diebold. As I said in my 1997 letter, it represents a black eye for the entire system of Voting System Standards promulgated by the Federal Election Commission and the National Association of State Election Directors. Not only did the I-Mark/Global/Diebold touch screen system pass all of the tests imposed by this standards process, but it passed them many times, and the source code auditors even gave it exceptionally high marks. Given this, should we trust the security of any of the other direct recording electronic voting systems on the market?"

In early August 2003, the state of Maryland hired a third-party consulting firm (SAIC) to perform an analysis of Diebold's AccuVote-TS voting system. On Sept. 24, 2003, Maryland made public a redacted version (40 pages) of SAIC's *Risk Assessment Report (September 2003)* which found, [t]he system, as implemented in policy, procedure, and technology, is at high risk of compromise. In November of 2006, the complete unredacted version of the report (197 pages) was leaked to the media.

Additional technical examinations of Diebold's DRE voting machines were afterwards conducted by the California and Ohio Secretary of State offices, corroborating previously discovered flaws that were still present despite the manufacturers' claims that they had been fixed and uncovering additional serious security flaws in Diebold and in all other manufacturer's examined voting systems.

Motivation and opportunity clearly exist for undetectable outcome-altering vote manipulation and miscount. Finding: Insufficient publicly verifiable evidence exists – to support the assumption underlying academic and media opinion and exit polling and political and voting behavior research – that publicly reported election results are accurate.

4.2 Methods, Data and Variables

The data source is source is Maryland's official State Board of Elections web site for election results and turnout data,[15] for partisan voter registration statistics[16] including voter registration

[15] http://elections.state.md.us/elections/2014/index.html
[16] http://elections.state.md.us/voter_registration/stats.html

numbers as of June 7, 2014.[17]

Thus far, aggregate and asymmetric statistics, and discrepancy pattern analysis are consistent with vote miscount having altered the outcome of Maryland governor's contest. Next, I examine Maryland's partisan registration and turnout; then partisan vote margin by type of vote: Election Day, early voting, and absentee/provisional; and, finally, I compare partisan vote and turnout margins for each type of ballot. All of these analyses are consistent with a manipulated election outcome in the Maryland's governor contest.

4.3 Partisan Voter Registration

Partisan voter registration records for Maryland provide another method to check whether or not we should expect, a fair and honest count of votes to have elected a Democrat or the Republican gubernatorial candidate.

Simple arithmetic shows registered Democrats are 60.5% of Maryland's registered voters, as compared to 28.1% registered Republicans, a margin of 28% advantaging Democrats. Even if all voters registered as Libertarian, other parties, and unaffiliated voters are added to the numbers of registered Republicans; and only registered Green party voters are added to the number of Democrat voters, the relative shares of Democrat-leaning voters would be 60.6% as compared to 39.3% of remaining voters, a margin of 21.4% favoring Democrats.

Thus, the amount of discrepancy between partisan voter registration and Maryland's gubernatorial election results is, between, at the least, 32.4% to as high as 43.5%. Consistent with the previous analyses, it seems highly improbable that a Republican candidate would win the Maryland governor's office.

Do Voter Registration Records Accurately Reflect Partisanship?

Recent federal laws require the purging of voter registration records for inactive voters. Inactivity is defined as not voting in two sequential federal elections, or for 4 years.

> Under the NVRA, states must send forwardable address confirmation notices to voters believed to have moved with a postage prepaid and pre-addressed response card to either confirm a continuing address or update the state with a new address. If the card is not returned, the state cannot remove the voter unless the voter not

[17] http://elections.state.md.us/press_room/2014_stats/PrecinctRegisterCounts_ByCounty.pdf

only does not return the card confirming her address, but also does not vote in at least one of the two general federal elections following the notices mailing. — (Perez, 2008)

I spoke to Maryland's State Board of Elections on February 11, 2015 and was informed that Maryland requires its local boards to purge inactive voters from its voter registration rolls in December following each federal election every two years. Thus, Maryland's "2014 Gubernatorial Primary Voter Registration Counts as of Close of Registration" provides an aggregate estimation of the differential partisanship of active voters. Of course more detailed research could be conducted to verify partisan turnout rates in states like Maryland, which does have partisan voter registration and should maintain records of which voters voted in accordance with the National Voter Registration Act of 1993. More painstaking research into possible partisan differential voter turnout effects specific to the 2014 election could be conducted.

Partisan Turnout

A specious argument may be made that Republican turnout rates were, 58.7%, as opposed to the Democrat turnout rate of only 46.8%, to claim that is why the Republican governor candidate won. However, the Republicans are registered in much smaller numbers of voters overall. It is the margin of actual Dem and Repubs voters who turn out that matters. Table 11 shows the turnout rates and actual turnout numbers of Democrats and Republicans in 2014. In terms of number of voters, Democrat turnout was 1.7 time higher than Republican turnout and the turnout margin was 26% higher for Democrats as compared to total turnout of Democratic and Republican voters.

Table 11: 2014 Maryland Voter Republican & Democrat Turnout

Party	Voter Turnout	Registered Voters	Turnout rate out of partisans	Turnout rate out of all voters
Republican Voters	557,490	949,564	58.7%	31.9%
Democrat Voters	952,740	2,036,281	46.8%	54.5%
Ratio Dem:Repub	1.71	2.14	Margin 22.6% favoring Dems.	

4.4 Partisan Vote Margins by Ballot Type

A comparison of Democrat minus Republican vote margin by ballot type, as shown in table 12, reveals that the 2014 Maryland Democratic candidate for governor won in the absentee/provisional and early voting, but lost in the Election Day voting.[18]

This pattern seems consistent with 7% to 9.5% vote switch, half of the unexplained observed margin change, from Democrat to Republican in Election Day DRE votes in both the attorney general and governor's contests. The discrepancy between Election Day results and absentee/provisional results are clear. However, if these discrepancies are due to DRE vote manipulation, why would the early voting results (also produced by DREs) still go to the Democratic candidate? We can never know for certain. However, there is no reason to assume that fraudulent vote switching must occur in the same rate in early and Election Day voting. It is conceivable that a perpetrator, lacking control over absentee and provisional ballots, might want to show a trend from early to Election Day voting or may want to begin by rigging a smaller amount during early voting and, after checking partisan voter turnout rates, up the vote switch rate on Election Day if the outcome looks iffy or too close.

However, before making any conclusions about the causes of this discrepancy, we should consider partisan turnout rates by ballot type because it is feasible that more Democrats voted by absentee and provisional ballots than voted early and on Election Day. Thankfully, voter turnout and vote tallies by ballot type are available on Maryland State Board of Election's web site. Thus, the next section compares the discrepant partisan vote margins with the reported partisan turnout margins by ballot type.

Table 12: 2014 Maryland Election Votes by Vote Type

(Dem - Repub) Margins	Election Day (ED)	Early	Absentee/Provisional
Governor	-7.8%	9.1%	11.4%
Difference from ED		+16.9% Dem	+19% Dem
Attorney General	12.2%	27.7%	26.3%
Difference from ED		+15.5% Dem	+ 14% Dem

[18] Note: Voters are required to cast a provisional ballot usually when there is an unresolved question about their voter registration. This tends to affect people who move frequently and don't update their voter registration. Provisional voters can be either early or Election Day voters. All provisional ballots are counted at the same time regardless of when they were cast, so they are lumped together as one category. For the purposes of this analysis, provisional ballots are best grouped in the same category as other non-DRE auditable paper ballots that are tallied by the same mechanism, optical scanning devices.

4.5 Partisan Vote and Turnout Margins by Ballot Type

Relative partisan turnout rates by ballot type must be taken into account before coming to any conclusions. The discrepancies between vote and turnout margins by ballot type are the key quantities of interest.

As shown in row 14 of table 13, even taking partisan turnout rate margins into account, remains a 5.3% greater spread between the vote and turnout margins in the early voting than in the absentee/provisional voting and an 8.4% greater spread between vote and turnout margins in the Election Day voting than in the absentee/provisional voting. Thus, these 5.3% and 8.4% discrepancies in the vote share by ballot type are unexplained by partisan turnout differences, and are consistent with vote manipulation. There does not appear to be another explanation consistent with the data for why Democrats who voted via DREs early or on Election Day would vote, respectively 5.3% and 8.4%less for the Democratic candidate, than Democrats who voted on absentee and provisional ballots.

Turnout margins all favored Democrats more than reported vote margins. The difference in turnout margins minus the vote margins (Democrat - Republican) were a positive 19% in combined absentee/provisional, 24.2% in early voting, and a high of 27.3% in Election Day voting (see row 9 in table 13). In other words, Democratic turnout margins were much higher than Democratic vote margins. Thus, there are still significant (in terms of potentially outcome altering) differences between the Election Day and other voting types ranging from 3.4% greater ($Democrat - Republican$) margin in early voting and 8.7% greater ($Democrat - Republican$) margin in the absentee/provisional than in the Election Day voting.

Assuming that the absentee/provisional votes gives us the most valid estimate of voter intentions, I subtract the 18.95% margin difference from the other differences. This is analogous to assuming, consistent with absentee/provisional voting, that a bad campaign by the Democratic gubernatorial candidate or attitudes against the Democratic candidate likely cost him 9.47% of normally Democratic vote share to the Republican candidate overall.

Thus, adjusting to the partisan voter turnout differences by ballot type, gives us a, still outcome-altering, 8.4% higher margin the Democratic Governor candidate should have received in Election Day votes and a 5.3% higher margin he should have received in early voting(see row 14 in table 13). Thus, unless there is a convincing story for why there would be (adjusted for turnout) an 8.4% lower Democratic vote margin in Election Day voting than in absentee/provisional voting and a 3.1% lower Democratic vote margin in Election Day voting than

Table 13: 2014 Maryland Governor Election: Differential Vote Margins by Vote Type

		Total	Election Day Poll	Early	Absentee & Provisional
1	Total Votes Cast Governor	1,733,177	1,342,837	305,594	84,746
2	Democrat Brown	818,890	608,476	164,219	46,195
3	Republican Hogan	884,400	710,854	136,781	36,765
4	Total Turnout	1,748,309	1,350,930	307,665	89,714
5	Democratic Turnout	952,740	711,724	189,188	51,828
6	Republican Turnout	557,490	445,609	87,039	24,842
7	(Dem-Rep)Margin: **Vote**	**-0.038**	**-0.076**	**0.090**	**0.111**
8	(Dem-Rep)Margin: **Turnout**	0.226	0.197	0.332	0.301
9	(Turnout - Vote) Marg. diff. (row(8) - row(9))	**0.264**	**0.273**	**0.242**	**0.190**
10	Diff. from ED: row(9) (EV - ED) & (ABS - ED)			**0.031**	**0.084**
11	Turnout Margin Diff row(8): (EV - ED) & (ABS - ED)			-0.135	-0.104
12	Vote Margin Diff row(7): (EV - ED) & (ABS - ED)			-0.166	-0.188
13	Difference: row(11) - row(12)			**0.031**	**0.084**
14	Unexplained Margin Switch (row(9)-0.190)		**-0.084**	**-0.053**	
15	Margins adjusted to ABS: (row(7) - row(14))		0.008	0.143	0.111
16	Adjusted vote margin: sum(Votes)/TotVotes & (row(15)*row(1))	**0.0363**	10,017	43,543	9,430

Notes: GOV= governor, EV = early voting, ED= Election Day voting, ABS = absentee/provisional voting. Total turnout is for all voters, unaffiliated and of any political party.

in early voting (see row 10 and 13 in table 13)[19], the argument that the Maryland's governor's outcome was caused by vote manipulation is difficult to refute. In fact, there is no irrefutable evidence either way, but the statistical evidence all points to out-come-altering vote manipulation on the inauditable paperless DREs.

In other words, even adjusting for differential turnout rates for different ballot types there is plenty suspicious margin difference to cast suspicion on the Governor's contest outcome. Calculations show if the absentee/provisional ballots are a better reflection of the true Maryland vote, the Democratic candidate Brown won the governor's election by a 3.63% margin.

Suffice it to say, even adjusting for turnout rates, the pattern of much lower Democratic vote share in Election Day votes as compared to absentee/provisional and early voting, is enough to have altered the election outcome, if, as it seems, the explanation of the suspicious pattern in DRE Election Day tallies is vote manipulation. And, after all, why wouldn't the correct explanation be illicit vote manipulation when there is no direct way, other than statistics, to detect or correct vote miscount and even less chance to detect a perpetrator? Given the long history of vote fraud in the United States, it would be very naive to imagine that no one would perpetrate vote fraud given the ample opportunity provided by paperless (or even papered) DREs or, even, paper ballots without an effective post-election audit.

Thus, even taking into account actual partisan turnout and some Democratic cross-over voting for the Republican candidate, the outcome of Maryland's governor's election is explained by outcome-altering vote miscount in its paperless DREs. Let me add that it would not be necessary for even one of Maryland's election officials to participate in illicit vote fraud since election officials rely on private voting vendors to program, maintain, and upgrade the voting system software.

5 It May be Worse or Better than it Seems

Poll weightings for "likely voters" may be causing polls to shift right with red-shifted partisan miscount over multiple election cycles. Such red shifting of both polls and election results would mask increasing levels of partisan vote manipulation.

[19] I did the calculations two ways to check my work.

Weighting Polls to Match Prior Election Results

Opinion poll samples are weighted in a variety of ways including by self-reports, complex demographic adjustments, or previous election results. For example, a Washington Post-University of Maryland telephone poll conducted February 5-8, 2015 says, "Interviewers called landlines and asked to interview the youngest male or youngest female who is at home at the time, with the male requested 75 percent of the time".[20] Although males may respond to polls somewhat less than females, because males tend to vote Republican more so than females, this method might tend to better match election results and outcomes produced by 8% partisan miscount favoring Republican candidates.

So the disparities could be attributed to inaccuracies introduced by bad-guess poll weightings and/or by partisan vote miscount. However, the analysis in section 3.3 above reveals that even assuming generous amounts of poll response bias or bad-guess weighting, a 3.9% to 5.6% of vote miscount favoring Republican candidates is still necessary to explain the discrepancy patterns in 22 2014 state senate or governor election contests.

According to election integrity advocate, Jonathan Simon, "Likely voter polls have been adjusted to match previous election results, which have also been suspect. To my knowledge, likely voter polls have not been calibrated using the tedious research of investigating voter records via obtaining and investigating voter registration databases, but were, instead calibrated to the officially reported election results, which showed highly unlikely discrepancies with pre-election and exit polls favoring the Republican direction."

There are implications to using likely voter polls to predict unaudited election results. Likely voter cutoff models include screening questions to disproportionately eliminate young, minority, poor, and transient, i.e. mostly Democratic, voters from the sample. Some respondents who actually do vote are assigned a 0% chance of voting, effectively shifting the sample to the right. This could naturally result in red shifting of election results and polls over several election cycles.

Returning Voter Question – A Smoking Gun?

A recent presidential election exit poll question about returning voters claims more voters who voted for the Republican candidate in the prior elections are returning to vote than are alive.

[20] The Washington Post - University of Maryland poll and its methodological description is available on-line at http://www.washingtonpost.com/page/2010-2019/WashingtonPost/2015/02/17/National-Politics/Polling/release_389.xml.

In other words, according to exit polls that are adjusted to match current presidential election results, the number of voters who say they voted for the Republican candidate in the previous election are more than 100% of Republican voters in the prior election who would still be alive. That is, unless Republican presidential voters do not die at the same rate as Democratic voters. These exit poll samples were adjusted to match current election results by removing sufficient voters who voted for Democrats in prior elections, so much so, that the proportion of returning voters for the Republican candidate is over 100%. According to Richard Charnin, a mathematician and election integrity advocate:

> This [returning voter] question has proven to be devastating for those who still believe there is no such thing as election fraud. The exit pollsters freely admit that they adjust the polls to match the recorded vote. The rationale is that the exit polls are always off (by 8% on average), therefore they must be adjusted to match the pristine, fraud-free recorded vote. ... review the basic method used to match the vote: changing the mix of returning voters. We will look at the 2004-2008 presidential elections and the 2010-2014 Wisconsin and Florida governor elections ... adjustments made to the number of exit poll respondents and returning voters to match the official recorded vote counts.

These facts mean that the amount of partisan discrepancy favoring Republican candidates in the election and Democrats in the polls, could be greater than that revealed by current data.

6 Findings

Voter ID: I found no significant relationship of the occurrence of strict voter ID laws being necessary or sufficient for the occurrence of high discrepancy between pre-election polls and election results. This does not necessarily mean that voter ID laws did not affect election outcomes, but it does mean that polls were unlikely to take into account voters who were more likely to be turned away at the polls such as students, poor, or the elderly who do not have the required IDs.

Inauditable voting systems in Gubernatorial races: In the 2014 US Gubernatorial elections, overall, low quality inauditable voting systems are a 95.3% necessary condition for producing high discrepancy between pre-election opinion polls and official election results (PED). In Maryland, Illinois, Florida, and Kansas governor elections there was sufficient magnitude and

direction of discrepancy between polls and election results to alter the election outcomes if the cause was vote miscount. In Vermont, the magnitude and direction of discrepancy was within one percent of altering its gubernatorial election outcome. All of these states use inauditable voting systems or conduct no post-election, pre-certification manual audits.[21] The amount of PED discrepancy in Nevada, and Tennessee was, also, unusually high but was less than the winning margin. PED discrepancy amounts in NV, TN, MD, SD, and VT could not be explained solely by partisan response bias of Democrats responding to polls even 35% more than Republicans, and were consistent with 5.6% or more vote miscount margin. A case study of Maryland's vote and turnout data affirms the likelihood that Maryland's official gubernatorial outcome was a result of vote miscount rather than Maryland voters' intent.

Inauditable voting systems in Senate races: In the 2014 US Senate contests, overall, low quality inauditable voting systems are a 95% necessary condition for producing high discrepancy between pre-election opinion polls and official election results (PED). Close margin elections are an 87.9% necessary condition for producing high levels of discrepancy between polls and election results in 2014 United States Senate elections. In Kansas and North Carolina senate elections there was sufficient magnitude and direction of discrepancy between polls and election results to alter the election outcomes if the cause was vote miscount. In Virginia, the magnitude and direction of discrepancy was within one percent of altering its senatorial election outcome. All three of these states use inauditable voting systems or conduct no post-election, pre-certification manual audits.[22] The amount of PED discrepancy in Wyoming, Tennessee, Nebraska, and Kansas was unusually high but was less than the winning margin. PED discrepancy amounts in WY, TN, KS, WV, NE, and AR could not be explained solely by partisan response bias of Democrats responding to polls 20% more than Republicans, and were consistent with 3.9% or more vote margin miscount. A case study of Maryland's vote and turnout data reaffirms the likelihood that Maryland's official gubernatorial outcome was the result of vote miscount rather than due to Maryland voters' intended votes.

The most significant discrepancies: Three states in particular stand out in terms of concerning discrepancy: Maryland, Vermont, and Virginia. Maryland's results cannot be explainable by

[21] Florida conducts a post-certification manual audit and uses inauditable, paperless DRE voting systems in many counties.

[22] North Carolina's audits are optional and some counties' use DREs.

random sampling error or partisan poll response bias. It is naive not to consider the possibility that the discrepancy in Maryland's outcome could have been caused by partisan vote manipulation. The enormous discrepancies in both the Vermont governor election and Virginia's senate contest are consistent with having come perilously close to being overturned by vote manipulation (within 1%). Just another 1% of discrepancy, and the official winners would have been the Republican candidates, a result that would be unexplainable by either random error or partisan poll response bias.

The lack of public verifiability of current United States voting systems and the lack of a Federal right for public to access electoral records necessary to evaluate the accuracy and currency of election results fail to provide citizens with the ability to know with certainty whether United States election outcomes represent voters' will.

The available statistical evidence mentioned in this paper is consistent with a hypothesis of corruption, but it is not proof. Without tangible forensic evidence, it remains an untestable hypothesis. Proof of vote manipulation or its lack could, possibly, be obtained via risk-limiting post-election audits of auditable voter-marked paper ballot voting systems. Only effective risk-limiting audits of a sufficiently large random sample of reported vote tallies of voter-marked paper ballots can establish with certainty whether U.S. elections have been corrupted. Given the history of election fraud, the inauditable and unaccountable designs of at least 1/3rd of U.S. voting systems, and a lack of effective, comprehensive, post-election auditing, it is naive to assume that all United States election outcomes are accurately decided by voters rather than by vote fraud. For example, in the case of Maryland's 2014 gubernatorial election outcome, there is, as yet, only an explanation of vote manipulation consistent with the statistical evidence of discrepancy patterns between pre-election polls, and voter turnout and vote data by ballot type.

After all, why wouldn't a perpetrator conduct illicit vote manipulation when there is no direct way, other than statistics, to detect miscount, and no possible method to correct any miscount or to detect a perpetrator? Given a long history of election manipulation in the United States, it is naive to imagine no one would manipulate votes given the opportunity provided by inauditable voting systems and lack of effective manual post-election audits.

More work needs to be done to analyze additional election data and improvements are needed to United States voting systems, election data reporting, and post-election audit statutes, regulations, and procedures.

7 Acknowledgments

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Appendices

A Computing the Probability of Discrepancy Due to Random Chance

In formula A.1a, the probability calculation requires summing the number of ways to choose exactly 22 states having MOE outside their 95% confidence interval times the probability of such occurrence happening 22 times with the same calculation for 23 states, 24 states, up to all 35 states having observed discrepancies having only 5% probability.

$$\text{Probability}_{22^{+}\text{of }35} = \sum_{i=22}^{35} \binom{35}{i} (.05)^{i} (.95)^{35-i} \tag{A.1a}$$

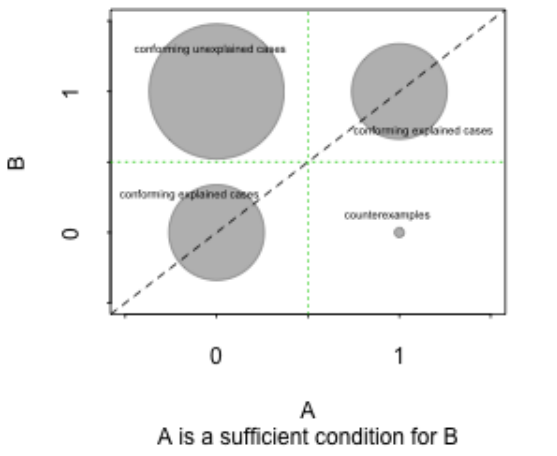
where the number of ways to choose k out of 35 items is, $\binom{n}{k} = \frac{n!}{k!(n-k)!}$ (A.1b)

B Visualizing and Measuring Sufficiency

This appendix presents three ways to visualize when the presence of condition A is sufficient but not necessary for condition B to occur.

Figure 6: Visualization of A is Sufficient for B.

(a) Dichotomous Variables



(b) Euler Diagram

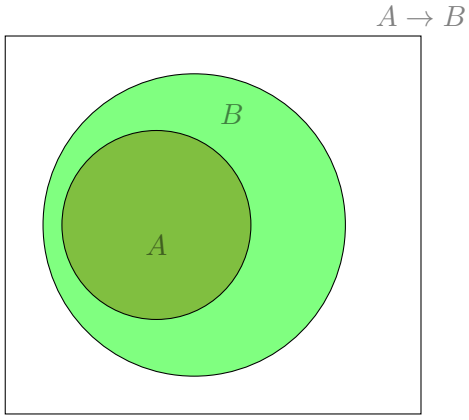


Table 14: Truth Table for Inference $A \rightarrow B$ or $(B \vee \neg A)$

A	B	$A \rightarrow B$
0	0	T
0	1	T
1	0	F
1	1	T

Expression B.1a is QCA's measure of the extent to which condition X is sufficient for condition Y to occur. Expression B.1b extends the reach of QCA's formula to measure the extent to which any functional constraint $f(X)$ is a sufficient condition for outcome Y to occur. In other words, expression B.1b measures the extent to which $f(X)$ is a sufficient condition for outcome Y to occur:

$$\text{Sufficiency}_{(X for Y)} \frac{\sum_i^n min(x_i, y_i)}{\sum_i^n x_i} \tag{B.1a}$$

$$\text{Sufficiency}_{(f(X) for Y)} = \frac{\sum_i^n min(f(x_i), y_i)}{\sum_i^n f(x_i)} \tag{B.1b}$$

It measures the sufficiency of any functional condition for another conditions, regardless of their complexity. Expression B.1b is simply the sum of the minimums of the observed outcome values, y_i, and the functional values $f(x_i)$ divided by the sum of the functional values, $f(x_i)$. A similar formula is available for measuring the degree of coincidence of any functional condition for another condition, regardless of their complexities.

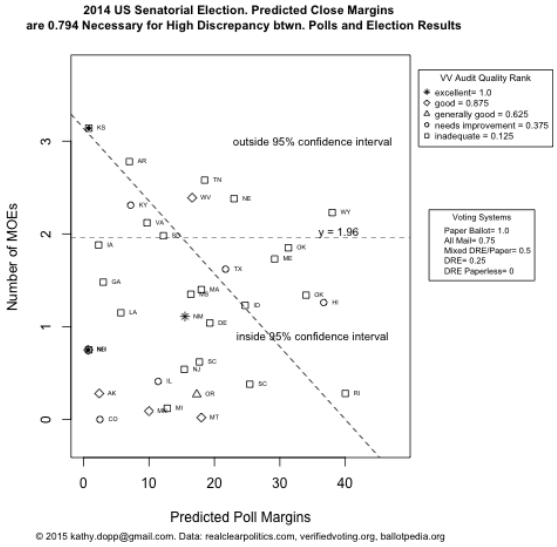
C Are Predicted Margins a Necessary Condition?

Figure 7a and figure 7b

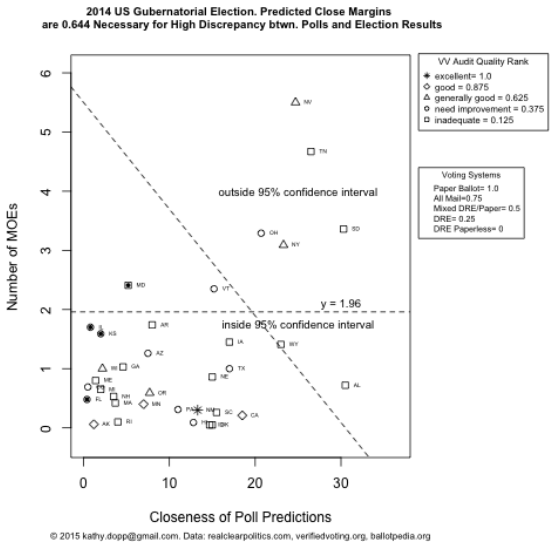
In US Senate contest in KS, the polls favored the Democrat and the results the Republican by 11.6%. In US Gubernatorial contest in NC, the polls favored the Democrat and the results the Republican by 2.4%.

Figure 7: 2014 Election: Average Discrepancy by Predicted Poll Margins

(a) Senate (79.6% necessary)



(b) Governor (87.8% necessary)



D Comparison of Symmetric & Asymmetric Statistics

Table 15: Theoretical Comparison of Symmetric and Asymmetric Statistics

METHOD	OLS Statistics	Asymmetrical QCA Measures	Asymmetrical Statistics (New)
Designed to detect conditions that are:	only sufficient and necessary, i.e. correlated	only sufficient, only necessary, or both	only sufficient, only necessary, or both
Designed to detect data relationships:	Symmetric to any function	Asymmetric or symmetric to $y = x$	Asymmetric or symmetric to any function
Recognize and deconstruct data generation process:	Single causal process	Multiple causal processes, i.e. Missing variables are okay.	Multiple causal processes, i.e. Missing variables are okay.
Metric for fit	Squared distance from observed Y to $f(X)$	Distance from $f(X) = X$ to observed Y	Distance from function $f(X)$ to observed Y
Model shape	Equidistant to any function	Constrained above or below by, or equidistant to $y = x$	Constrained above or below by, or equidistant to, any function
Input data format	Any number	Set membership values in the interval [0,1]	Any number (with valid functional form or set-membership relationship)
Case selection approaches for hypothesis-testing	Deviant and conforming cases	Deviant, conforming, and "irrelevant" cases	Deviant, conforming, and "irrelevant" cases
Output	Estimated parameters & uncertainty levels for asymmetric relationship to a functional model	1- uncertainty measure for sufficient and/or necessary (asymmetric) relationship for set values in $[0, 1]$	1- uncertainty measure for asymmetric relationship to a given functional model
Dimensionality of solution set	N–1 dimensional surface	N dimensional region	N dimensional region
Results stability for a dataset	Model Dependent	Calibration Dependent	Seems Stable

In table 15, when a method may be considered more informative or more flexible than another method, it is hi-lighted in a darker gray. Squared vertical distance may be considered less desirable due to over emphasizing outliers. Given a data set, asymmetrical statistical methods may be used to estimate coefficients for a given functional shape, given a fixed level of necessity or sufficiency, or, alternatively, can be used to measure the level of necessity or sufficiency, given a fixed functional model. More research is needed on asymmetric statistical methods.

E 2014 Election DATA

Table 16: 2014 Senate Election DATA

ST	C	Cont.	Candidates	DPAv	RPAv	DemV	RepV	SmplS	Aud.	VSys	AvMOE
AK	R	Senate	BegichDvSullivanR	43.8	46.2	45.3	49	4453	0.8	0.5	4.6
AR	R	Senate	PryorDvCottonR	41.2	48.2	39.5	56.5	4815	0.2	0.5	3.6
CO	R	Senate	UdallDvGardner	44	46.5	46	48.5	5310	0.4	0.75	3.5
DE	D	Senate	CoonsDvWadeR	51	31.7	55.8	42.2	1980	0.2	0	5.5
GA	R	Senate	Nunn D v.Perdue	44.8	47.8	45.1	53	5132	0.2	0	3.3
HI	D	Senate	SchaltzDvCavassoR	61.7	25	69.8	27.7	2973	0.4	0.5	4.3
IA	R	Senate	BraleyDvErnstR	45.7	48	43.7	52.2	5292	0.2	1	3.3
ID	R	Senate	MitchellDvRisch R	30.3	55	34.7	65.3	1847	0.2	1	4.8
IL	D	Senate	DurbinDvOberweis R	49.8	38.4	53.1	43.1	6897	0.4	0.5	3.4
KS	R	Senate	OrmanIvRoberts R	43.4	42.6	42.5	53.3	4387	0.2	0.5	3.7
KY	D	Senate	GrimesDvMcConnell	41.8	49	40.7	56.2	5158	0.4	0.25	3.6
LA	R	Senate	LandrieuDvCassidy R	40.2	34.5	43.1	41.9	4729	0.2	0	3.9
MA	D	Senate	MarkeyDvHerrR	53	35	62	38	4454	0.2	1	4.3
ME	D	Senate	BellowsDvCollins R	32.2	61.4	31.6	68.4	3638	0.2	1	4.4
MI	R	Senate	PetersDvLand	50.4	37.6	54.6	41.4	4338	0.2	1	3.4
MN	D	Senate	FrakenDvMcFaddenR	50	40	53.2	42.9	3826	0.8	1	3.5
MS	R	Senate	ChildersDvCochranR	29.3	45.7	37.4	60.4	2095	0.2	0.5	4.9
MT	D	Senate	CurtisDvDainesR	34.7	52.7	40	57.9	1657	0.8	1	5
NC	D	Senate	HaganDvTillisR	44.1	43.4	47.3	49	7197	0.8	0.5	3.2
NE	R	Senate	DominaDvSasseR	32	55	31.1	64.8	1431	0.2	1	4.5
NH	D	Senate	ShaheenDvBrownR	48.8	48	51.6	48.4	6151	0.2	1	3.2
NJ	R	Senate	BookerDvBellR	53.8	38.4	55.8	42.4	5007	0.2	0	3.7
NM	R	Senate	UdallDvWehR	52.7	36.6	55.4	44.6	7338	1	1	4.1
OK	R	Senate	SilversteinDvInhofe R	27.3	61.3	28.5	68	2694	0.2	1	4.1
OK	R	Senate	JohnsonDvLankfordR	28.7	60	29	67.9	2694	0.2	1	4.1
OR	D	Senate	MerkleyDvWehbyR	51	33.7	55.8	37.3	2376	0.6	0.75	4.4
RI	D	Senate	ReedDvZaccariaR	63	23	70.7	29.3	1616	0.2	1	5
SC	R	Senate	HuttoDvGrahamR	28.3	46	38.9	54.5	3565	0.2	0	3.4
SC	R	Senate	DickersonDvScottR	30.3	55.7	37.1	61.2	3565	0.2	0	3.4
SD	R	Senate	WeilandDvRoundsR	30	42.2	29.5	50.4	3576	0.2	1	4.4
TN	R	Senate	BallDvAlexanderR	32.5	51	31.8	61.9	1724	0.2	0.5	4.5
TX	R	Senate	AlameelDvCornynR	31.3	53	34.4	61.6	6359	0.4	0.5	3.4
VA	D	Senate	WarnerDvGillespieR	48.5	38.8	49.2	48.4	3421	0.2	0.5	4.2
WV	D	Senate	TennantDvCapitoR	36.7	53.3	34.5	62.1	2028	0.8	0.5	4.6
WY	R	Senate	HardyDvEnziR	27	65	17.6	72.3	958	0.2	0.5	7.5

Table 17: 2014 Governor Election DATA

ST	C	Cont.	Candidates	DPAv	RPAv	DemV	RepV	SmplS	Aud.	VSys	AvMOE
AK	R	Governor	WalkerIvParnellR	44.6	43.4	48	46.6	3910	0.8	0.5	3.6
AL	R	Governor	GriffithDvBentleyR	28.5	59	36.4	63.6	1411	0.2	1	4.6
AR	R	Governor	RossDvHutchinson	41	49	41.5	55.4	6890	0.2	0.5	3.4
AZ	R	Governor	DuValDvDuceyR	41	48.5	41.6	53.5	3677	0.4	0.5	3.5
CA	D	Governor	BrownvKashkariR	54.3	35.8	58.9	41.1	10542	0.8	0.5	3.3
CO	R	Governor	HicknlprDvBeauprz	45.3	44.8	49.1	46.2	5310	0.4	0.75	3.5
CT		Governor	MalloyDvFoleyR	42.3	41	50.7	48.2	1857	0.4	1	NA
FL	R	Governor	CristDvScottR	40.7	40.3	47.1	48.2	2865	0.4	0.5	3.1
GA	R	Governor	CarterDvDealR	43.4	48	44.8	52.8	5132	0.2	0	3.3
HI	D	Governor	IgeDvAionaR	45.3	32.5	49.5	37.1	2479	0.4	0.5	4.3
IA	R	Governor	HatchDvBranstadR	36.7	53.7	37.3	59.1	6886	0.2	1	3.3
ID	R	Governor	BalukoffDvOtterR	50.7	36	53.5	38.6	2326	0.2	0.5	4.4
IL	D	Governor	QuinnDvRaunerR	45.6	44.8	45.9	50.7	7206	0.4	0.5	3.3
KS	R	Governor	DavisDvBrwnbckR	44.6	42.6	46.1	50	4387	0.2	0.5	3.7
MA	D	Governor	CoakleyDvBakerR	42	45.7	46.6	48.5	3635	0.2	1	4.3
MD	D	Governor	BrownDvHoganR	48.9	38.8	46.9	51.6	9060	0.2	0	4.1
ME	D	Governor	MichaudDvLePageR	39.8	41.2	43.3	48.2	4540	0.2	1	4.4
MI	R	Governor	SchauerDvSnyderR	44.3	46.3	46.8	51	6818	0.2	1	3.4
MN	D	Governor	DaytonDvJohnsonR	47.3	40.3	50.1	44.5	3826	0.8	1	3.5
NE	R	Governor	HassebrkDvRickttsR	37	52	38.9	57.6	3994	0.2	1	4.3
NH	D	Governor	HassanDvHavenstnR	49.2	45.7	52.6	47.4	6151	0.2	1	3.2
NM	R	Governor	KingDvMartinexR	37.7	51	42.7	57.3	2406	1	1	4.3
NV	D	Governor	GoodmnDvSandvlR	30	54.7	23.9	70.6	2666	0.6	0.25	4
NY	D	Governor	CuomoDvAstorinoR	55.3	32	54	40.6	6910	0.6 1	3.2	
OH	R	Governor	FitzGerldDvKaschR	35	55.7	32.9	63.8	4540	0.4	0.5	3.1
OK	R	Governor	DormanDvFallinR	34.3	49.3	41	55.8	2444	0.2	1	4.1
OR	D	Governor	KitzhbrDvRchrdsnR	47.7	40	49.8	44.7	2376	0.6	0.75	4.4
PA	R	Governor	WolfDvCorbettR	51.2	40.2	54.9	45.1	5959	0.4	0.5	3.9
RI	D	Governor	RaimondoDvFungR	40	36	40.8	36.3	1871	0.2	1	5
SC	R	Governor	SheheenDvHaleyR	33.5	49	41.4	56	4315	0.2	0	3.4
SD	R	Governor	WismerDvDaugrdR	29	59.3	25.4	70.5	2668	0.2	1	4.4
TN	R	Governor	BrownDvHaslamR	30	56.5	22.8	70.3	1724	0.2	0.5	4.5
TX	R	Governor	DavisDvAbbottR	35.7	52.7	38.9	59.3	5634	0.4	0.5	3.4
VT	D	Governor	ShumlinDvMilneR	47.6	32.4	46.4	45.3	2299	0.4	1	6
WI	D	Governor	BurkeDvWalkerR	45.3	47.5	46.6	52.3	4156	0.6	0.5	3.5
WY	R	Governor	GosarDvMeadR	33.5	56.5	28.9	62.5	958	0.2	0.5	7.5