Electoral Fraud and Biometric Identification Machine Failure in a Competitive Democracy *

Miriam Golden *, Eric Kramon †, and George Ofosu *

*University of California, Los Angeles  
†George Washington University

December 17, 2014  
Version 2.5

Word count: 8,425  
Key words: elections, electoral fraud, biometric identification, Ghana

Abstract

We study election fraud in a competitive but not fully consolidated two-party democracy. Using a randomized experimental design in the field, we investigate patterns of biometric identification machine breakdowns in Ghana’s December 2012 national elections. We identify a non-random pattern to machine breakdowns. In polling stations with a randomly assigned election observer, machines were about 50 percent less likely to experience breakdown as they were in polling stations without observers. We also find that electoral competition in the parliamentary race is strongly associated with machine breakdown. Machine malfunction in turn facilitated election fraud, including overvoting and ballot stuffing, especially where election observers were not present. Our results substantiate that partisan competition may promote election fraud in contexts of newly-established competitive democracy. They also show that technological solutions are valuable but insufficient to solving political problems when political interests have the incentive and ability to manipulate the technology.

* Corresponding author: Miriam Golden, Department of Political Science, University of California at Los Angeles, CA 90095; email: golden@ucla.edu. An earlier version of this paper was presented at the 2014 annual meetings of the American Political Science Association, August 28–31, Washington, D.C. We gratefully acknowledge the collaboration of our research partner in Ghana, the Centre for Democratic Development, as well as Ghana’s Coalition of Domestic Election Observers. We also thank our 300 field assistants for data collection. Joseph Asunka and Sarah Brierley collaborated on the design and implementation of the project. Bronwyn Lewis and Luke Sonnet provided research assistance. Funding came from the U.K.’s Ghana office of the Department for International Development, a National Science Foundation Grant for Rapid Response Research (RAPID) SES–1265247, and the UCLA Academic Senate, none of which bears responsibility for the results reported here. This research was approved by the University of California at Los Angeles IRB #00004642 on October 15, 2012.
1 Introduction to the Problem

Most countries in the world use elections to select their political leaders but in new, fragile, or unconsolidated democracies, the electoral process may be compromised by strategic manipulation on the part of various actors. Election fraud is common in these settings. How fraud occurs, which types of preventive efforts are effective, and who perpetuates fraud are still poorly understood.

At least two classes of responses have been mounted in the contemporary world to the problem of election fraud. The first involves use of election observers, especially teams that are deployed by international bodies whose missions involve election integrity. Research shows that election observers operate as anticipated and successfully reduce election fraud, particularly fraud that occurs during the process of voting itself (Enikolopov et al., 2013; Hyde, 2007, 2010, 2011; Ichino and Schündeln, 2012; Kelley, 2012; Sjoberg, 2012). The second involves the introduction of new technologies aimed at uncovering — and thereby reducing — election fraud. These technological solutions, such as electronic voting machines, polling station webcams, and biometric identification equipment, offer the promise of rapid, accurate, and ostensibly tamper-proof innovations that are expected to reduce fraud in the processes of registration, voting, or vote count aggregation. Little is known, however, about the effectiveness of these technologies in reducing fraud, and it seems likely that this will vary according to the political context (Bader, 2013). Although we can be relatively certain that election observation reduces (but does not eliminate) election fraud, we do not know when new technologies operate as intended.

Biometric identification machines authenticate the identity of the individual using biometric markers, such as fingerprints, that are almost impossible to counterfeit (Jain, Hong and Pankanti, 2000). Biometric identification is particularly useful in settings where governments have not previously established reliable or complete paper-based identification systems for their populations (Gelb and Decker, 2012). Thanks to their supposed in-built capacity to prevent or substan-
tially reduce fraud in the distribution of government allocations or services, biometric identification systems are already in widespread use for voter registration. As of early 2013, 34 of the world’s low and middle income countries had adopted biometric technology as part of their voter identification system (Gelb and Clark, 2013).

The replacement of paper-based voter registration with biometric identification machines entails start-up costs ranging from the tens to the hundreds of millions of U.S. dollars, funded primarily by major international donors. The central objective of these investments is the reduction of electoral fraud (Gelb and Clark, 2013). Because these technologies can only be expected to become more widely adopted, assessing their impact is important for both theoretical and practical reasons.

Despite the obvious difficulties in counterfeiting biometric markers, studies of biometric authentication systems have questioned whether they are tamper-proof in the real world. In India, a country in the process of distributing national identity biometric smartcards for the delivery of numerous government goods and services, including pensions and poverty relief, concern has been raised about the potential of local vested interests to strategically manipulate the process in ways that subvert the accurate delivery of government goods to intended recipients (Muralidharan, Niehaus and Sukhtankar, 2014). This concern overlaps with work claiming that polling place webcams reduce ballot stuffing but do not reduce electoral fraud overall; instead of ballot stuffing, incumbents switch to other methods of fraud that are out of sight of the camera (Sjoberg, 2014). New forms of monitoring may only induce new forms of evasion.

In this paper, we report results of a study that uses a randomized experimental design to study the impact of election observers on the malfunction of biometric identification machines. Our study is set in Ghana during the 2012 national elections, when biometric identification machines were introduced into every polling station in the country as a way to reduce the very high levels of fraud known in particular to affect voter registration. We randomly select a large sample of electoral constituencies and polling places in four of ten Ghanaian regions, home to half the country’s
population, and study whether election observers systematically reduce machine malfunction.

Our main results include a non-random pattern in machine breakdowns: machines were much more likely to break down in electorally competitive areas and in polling stations without an election observer present. We also find that two types of election fraud — overvoting and ballot stuffing — more commonly occurred in polling stations affected by the breakdown of the biometric identification machines, especially when an election observer was not present. We interpret these results as evidence that individuals interfered with the operation of biometric identification machines and also took advantage of machine breakdowns to commit electoral fraud.

As far as we are aware, ours is the first study to find evidence of widespread and potentially consequential tampering with biometric identification equipment used at scale in a real-world setting. The extent of the problems that we identify in the operation of the verification equipment may be a transitory artifact of the initial roll-out of the hardware. Nonetheless, one implication of our study is that technological solutions are valuable but insufficient to solving political problems when political interests have the incentive and the ability to manipulate the actual operation of the technology. In the context of this investigation, our results highlight the importance of independent and non-partisan election observation by trained personnel who are professionally committed to clean elections.

This study uses data collected in a randomized control trial about the effects of election observers on fraud, violence and intimidation. A pre-analysis plan was filed prior to conducting the analysis that is reported in this paper (Authors, 2014). The pre-analysis plan contains no mention of any possible impact of election observers on biometric machine breakdown. Our findings in this regard were completely unexpected. But they are important theoretically and empirically. Moreover, the effect of election observers on machine breakdown is extremely large — much larger than the effects on election fraud. Neither “fishing” nor data mining was required to uncover these relationships (Humphreys, Sanchez de la Sierra and van der Windt, 2013). To reassure readers of this point, we keep the data analysis simple and straightforward. We also explicitly note where
the analysis is design-based and where we present results from analyses that go beyond the initial
research design.

The contribution of this paper is twofold. First, this is one of only a few studies that
investigates the causal dynamics of election fraud in a competitive democracy (others include Cox
and Kousser (1981); Ichino and Schündeln (2012); Lehoucq (2002).) Drawing on substantive
insights from these earlier studies, we gather data using an experimental research design and test
whether partisan competition and party organization capacity encourage fraud. Second, to the
best of our knowledge, this is the first systematic empirical investigation of how well biometric
identification machines operate in an electoral context.

The paper is organized as follows. We first discuss the reasons that electoral fraud occurs,
who commits it, and why they do so. From this, we draw out some hypotheses. We then provide
information on the setting we study. A fourth section presents our research design. A fifth section
studies the patterns of breakdown of the biometric identification machines and a sixth investigates
whether machine breakdown is associated with higher rates of electoral fraud. A final section
concludes.

2 Theory and Hypotheses

Election fraud is widespread globally. Eighty percent of elections around the world are
observed by monitors in efforts to reduce fraud (Kelley, 2012). Fraud is of sufficient magnitude
that it reportedly affects the outcome for the executive branch of government in about a fifth of the
world’s elections (Keefer, 2002). Most elections that experience any significant level of fraud are
in poor or middle income countries or in countries with incomplete, new or unstable democratic
institutions. Because detecting fraud is difficult, progress in understanding why it occurs and who
perpetuates it is challenging. We distinguish two sets of theories of the causes and perpetrators
of election fraud: incumbent-centered and party-centered theories. The first is relevant mainly to
authoritarian or semi-authoritarian settings and the second to democratic settings.
An incumbent-centered theory of election fraud derives from studies set in non-democratic countries, defined as countries in which election outcomes do not exhibit uncertainty (Przeworski, 2008). Thanks to their control over the election administration, authoritarian incumbents are particularly well placed to commit election fraud. The incumbent-centered theory has been supported by experimental results of studies in contemporary countries that document that election observers reduce vote shares of incumbents in authoritarian or semi-authoritarian regimes (Callen and Long, Forthcoming; Hyde, 2007; Enikolopov et al., 2013). These results imply that election fraud is centrally orchestrated to benefit a sitting president (or other executive branch office holder) and that it is perpetuated with the involvement of officials who are part of the body responsible for the administration of the election. Incumbent-centered theory resonates with historical research documenting widespread election fraud during the extended process of democratization in Europe (Mares and Zhu, 2011; Ziblatt, 2009) and in Latin America (Baland and Robinson, 2008), when economic and political elites utilized fraud to resist democratization.

When there is no uncertainty over who will win the election — as in non-democracies — election fraud is not conducted in order to win the election. This raises the question of why it occurs. One reason that incumbents commit fraud is to increase their vote shares to levels that allow them to retain constitutional veto power (Magaloni, 2006). In these cases, election fraud is aimed at retaining a supermajority. Other reasons that authoritarian leaders commit fraud is to signal to voters that potential opponents comprise small numbers, that opposition is likely to be fruitless, and that the current rulers are invincible. In this case, election fraud is aimed at discouraging anti-regime protest or the formation of an organized opposition. The second set of reasons that incumbents commit fraud even when they know they will retain power is thus informational (Simpser, 2013).

Democratic settings, which are marked by robust party competition and genuine uncertainty over whether the sitting executive will retain office, naturally give rise to an alternative theory of election fraud. In democracies, political competition is organized by political parties.
These are therefore the relevant actors with interests in committing election fraud. Election fraud occurs when political parties use localized control over the administrative apparatus to rig the vote or when they engage in intimidation or patronage-based threats over voters in order to gain votes or reduce turnout. The heart of the theory of election fraud that we utilize is that it is committed by political party agents in order to win competitive elections. The localized and incomplete control over the election machinery exerted by any single party — even the governing party — results in lower aggregate levels of election fraud in democracies than in authoritarian regimes, all else equal.

In the democratic context, we expect that election fraud will occur where political parties have the incentive, the capacity, and the opportunity to carry it out. That is, the extent of election fraud should vary systematically with markers of party incentives, capacity, and opportunity. With respect to incentives, parties will seek to commit fraud in order to increase their vote shares in the settings where electoral competition is most intense (Lehoucq, 2002; Molina and Lehoucq, 1999). This will vary in systematic ways with the nature of the electoral system (Birch, 2007) as well as locally with the specific balance of partisan forces. Regarding capacity, electoral fraud of any magnitude requires complex and coordinated action across localities. Parties will be most adept at activities related to fraud where they are organizationally strongest. Opportunities to commit fraud, finally, are reduced where other independent actors, including other political parties as well as the courts and a free press, are able to monitor and report on it. The deployment of trained and neutral election observers is among the most common strategies used by international and domestic actors to reduce electoral fraud (Hyde, 2011; Kelley, 2012). The effectiveness of these observers lies in part in the domestic political context, and whether the government self-commits to attempting to implement and observe the rule of law.

Aspects of the arguments just discussed are not easily studied within a single national context. Opportunities for political parties to commit election fraud, in particular, are shaped by complex factors, such as the strength of the rule of law, that either do not vary subnationally or
are difficult to measure at subnational levels. Nonetheless, the theory of election fraud in democratic settings that we have outlined generates in a natural and straightforward way the following hypotheses that are testable across localities within a single country:

**H1:** Fraud should be more prevalent with greater partisan competition;

**H2:** Fraud should be more prevalent where party organization is stronger;

**H3:** Fraud should be less prevalent where election observation is present.

Theories of election fraud do not offer any particular guidance regarding the possible impact of biometric verification machines, except for the obvious expectation that this technology reduces fraud. Because in Ghana the machines were introduced to every polling station in the country in the 2012 election, we have no way to assess how effective this introduction was or the size of the impact of the machines on the overall incidence of fraud. This would require that machines have been delivered to a random sample of polling stations, which was not the case. As an alternative, we can make inferences based on what happens when a machine fails to operate. This is not identical to a situation where no biometric verification machine is present in the polling station, but it gives rise to a similar idea: namely, an operational biometric verification machine reduces opportunities for interested parties to commit election fraud. If biometric verification machines reduce election fraud, then we can expect:

**H4:** Fraud should be more prevalent where machines break down.

In what follows, we report results of tests of these four hypotheses.

3 **The Setting**

Ghana is one of sub-Saharan Africa’s democratic success stories. Home to a population of 25 million, the country has a competitive, stable two-party system and alternation of the political party holding the presidency has twice occurred (2000 and 2008) since adoption of the 1992
constitution and establishment of the country’s Fourth Republic. The two major parties — the New Patriotic Party (NPP) and the National Democratic Congress (NDC) — enjoy support from roughly equal numbers of voters, together claiming more than 95 percent of the vote. In the 2008 presidential elections, the NDC won the executive with a margin of 40,000 out of an electorate of 14 million, illustrating the highly competitive nature of national politics. Electoral violence is relatively rare, voter turnout is high, and the two major parties exhibit modest but genuine programmatic differences as well as partially distinct social bases of support.

The president is elected by majority vote in a single, nationwide district. The country’s unicameral parliament comprises 275 representatives elected from single-member constituencies, which constitute the main levels of party organization. Elections are held simultaneously for parliament and presidency. Partisan competition is not evenly distributed across the country nor its ten regions; each party has stronghold areas. The NPP is especially concentrated in the Ashanti region, whereas the NDC receives a particularly concentrated vote share in Volta [Fridy 2007; Morrison and Hong 2006]. These two regions are commonly thought of as party strongholds, whereas the other eight regions exhibit greater partisan competition. We include constituencies from both stronghold regions in our sample as well as from two regions that are highly competitive.

Elections in Ghana have been systematically observed by a Coalition of Domestic Election Observers (CODEO) since 2000, building on experience observing the 1996 election. The organization recruits and trains professionals — typically school teachers and college students — in neutral, non-partisan observation of the electoral process. Due to their professions, observers benefit from high status in their communities; for this reason, CODEO assigns observers to polling stations in their home areas, where observers are likely to be personally known and to enjoy local trust. CODEO itself is nationally respected, with a strong public reputation for its work in improving electoral integrity. Its observers are recognized and accredited by the Electoral Commission of Ghana (EC) and have the legal right to enter and observe polling station proceedings. Each CODEO observer is assigned a single polling station to observe for the whole of the election day,
including the public counting of votes that occurs at the end of the process. Polling places selected
for observation are not known publicly in advance of the election itself, meaning that officials and
voters at every polling station may realistically anticipate an observer. Observers are distinguish-
able by identifying paraphernalia (tee-shirts, hats, etc) and carry official accreditation materials
with them.

The training of election observers includes instructions to observe the EC mandate and not
interfere in election proceedings. The official CODEO training manual opens with explicit instruc-
tions not to help any aspect of the voting processes. The manual’s first two rules and regulations
are that “An Observer shall not offer advice or give direction to or in any way interfere with an
election official in the performance of his or her duties” and “An Observer shall not touch any
election material or equipment without the express consent of the Presiding Officer at the polling
station or the Returning officer at the constituency center. Observers may not involve themselves in
the conduct of the election” (Coalition of Domestic Election Observers 2012 p. 6). Observers are
trained to contact constituency-level CODEO supervisors if election materials, such as ballots, are
needed, and observers also record administrative or other irregularities on incident forms. During
the voting process, the observer usually places himself at a distance from other individuals allowed
into the polling place. These include the presiding officer, a security officer, and a representative
designated by each of the major political parties, as well as those persons in the process of voting.
No one else is legally permitted to enter the polling station which, although usually outdoors, are
clearly demarcated.

Despite two decades of election observation, fraud was known to have occurred regularly
in elections in Ghana. Perhaps thanks to the very effectiveness of election observation during the
voting process, fraud appears to have been especially marked in the pre-election phase, which is
also observed by CODEO but less extensively. Implausibly large numbers of names appeared on
the voter rolls in the aughts (Oduro 2012). Earlier experimental research in Ghana confirmed
this, and also identified spillover effects of CODEO observers on fraudulent registrations (Ichino
Spillovers were interpreted to mean that political party operatives were relocating fraudulent voter registration efforts to nearby polling stations when a CODEO observer was present during the registration process. This suggests that party operatives are experienced in reacting strategically to monitoring intended to reduce fraud in the electoral process.

Biometric voter registration and polling place biometric identification processes were introduced by the Electoral Commission for the concurrent parliamentary and presidential elections of 2012 in a deliberate attempt to eliminate the irregularities and delays that had occurred in previous elections. The entire electorate was reregistered using biometric markers (ten fingerprints) in a six-week period in spring 2012. New voter identification cards were issued which featured head shots as well. Reregistration was effective in identifying 8,000 double registrations, of which 6,000 were judged intentional (Darkwa, 2013). Verification machines were delivered to all 26,000 polling stations in the country prior to December’s election. Because the equipment is battery-operated, spare batteries accompanied each machine. Legal stipulations meant that only persons whose identities could be verified biometrically would be permitted to vote on December 7.

Approximately 19 percent of polling stations experienced a breakdowns of the verification machine at some point, according to CODEO’s reports (Coalition of Domestic Election Observers, 2013). Breakdowns appear associated with battery overheating; when battery replacement was attempted, the machines froze up. Breakdowns delayed voting while the biometric equipment was restored to operation. By noon, Ghana’s President, John Dramani Mahama, had appealed the Electoral Commission to allow individuals with valid voter ID cards to vote at polling stations where biometric verification machines were not functioning. This would have reopened significant opportunities for election fraud, and the Electoral Commission rejected the proposal, instructing their local officials to permit voting to continue into a second day where necessary. This occurred at a

---

1In our sample, we find machine breakdowns in 25 percent of polling stations but in 17 percent of polling stations with a CODEO observer. The CODEO figure reflects information collected only from the latter, so our sample result is approximately the same as the national figure for observed polling stations.

small number of polling stations. More frequently, breakdowns caused delays in voting that did not require extension of the electoral process.

4 Research Design, Sample Selection, and Measures

In collaboration with CODEO, we randomly assigned election observers to 1,292 of Ghana’s 26,000 polling stations in the 2012 general elections. We collect data from these 1,292 stations and from an additional randomly selected 1,000 control stations. We collect identical information from polling stations with and without observers. (Details appear in Appendix A.)

4.1 Sampling and Treatment Assignment

We implement the project in four of Ghana’s ten regions. Almost half of the Ghanaian population (46.5 percent) resides in our sampled regions. More relevant for the external validity of our study is the fact that the party system is similar in the six regions not covered to those included. Although the four regions that we sample from were not selected to be statistically representative of the entire country, we have no reason to believe results would differ significantly had our sample been national.

We randomly sample 60 (out of 122) political constituencies from the four regions. We construct the sample as follows. First, each region is assigned a target number of sample constituencies based on its proportion of the total 122 constituencies. Since each region’s number of electoral constituencies is determined by the Electoral Commission on the basis of population, this means the number of constituencies included in the sample from each region makes the sample proportional to population.

To select constituencies within regions, we block on electoral competitiveness and urbanization. We construct a sample with roughly equal numbers of constituencies that vary on these

---

3For logistical reasons, we sample only in the south of the country. We exclude the Greater Accra region, the location of Ghana’s capital, because we anticipated that international election observers might focus on the easy-to-reach polling stations there and that their presence could contaminate the treatment.

4Sample size was determined on the basis of power calculations and logistical constraints.

5For example, the largest region we study is Ashanti, which has 47 constituencies, or about 38 percent of the 122 total. We sample 23 constituencies in Ashanti: 23 is approximately 38 percent of the total sample size of 60.
characteristics. We block on electoral competitiveness because we hypothesized that election fraud would vary with competitiveness. To generate our indicator of constituency-level electoral competition, we use data from the prior (2008) presidential elections. We define a constituency as competitive if the vote margin between the top two presidential candidates was less than 10 percent and as uncompetitive otherwise. Constituencies that experienced alternations in the party winning a majority in the 2008 presidential elections had a 2004 average margin of victory of 12 percent. Therefore, a 10 percent margin is, in the context in which we operate, easily reversible. Blocking on urbanization is a way to capture the hypothesis that stronger party organizations are capable of more election fraud. Direct measures of the capacity of party organizations are not available. Ghana is a heavily rural country, with half the population living in small villages that are often isolated and difficult to reach due to poor road networks. Party organization there, as elsewhere in Africa, is less developed and less capable than in urban settings (Bratton 2008). Political parties are able to reach more voters with the same amount of resources in urban than rural areas. Therefore, parties generally enjoy greater organizational capacity in urban areas. We code urban and rural constituencies using a measure of polling station density. We define as urban those constituencies with a higher-than-the-median number of polling stations per square kilometer (where the median in our sample is 0.14 polling stations per square kilometer) and rural as those with lower-than-the-median.

Constituency sampling was performed as follows. Within each region, constituencies are coded as competitive/stronghold and as urban/rural. We select a random sample of constituencies from each of these four possible combinations (competitive-urban, competitive-rural, stronghold-urban, stronghold-rural) such that the total number of constituencies sampled from each region equals its target number. To the extent feasible, we sample equal numbers of constituencies within regions from each of the four conditions.\footnote{In some regions, equal numbers of competitive and stronghold constituencies do not exist, narrowing our choices.} Our units of analysis are individual polling stations, which are nested within the 60 con-
constituencies in our sample. We randomly sample 30 percent of the polling stations in each constituency. We then randomly assign each polling station to either treatment (observer) or control (no observer). Appendix B further details the experimental design. In Appendix C, we provide evidence that treated and control polling station areas are comparable across socio-economic, development, and political characteristics.

In our analyses, we report intent-to-treat effects of election observers. Our underlying research design allows us to account for spillover effects when estimating the causal effect of observers. Spillovers occur when parties shift fraud to control polling stations in response to an election observer (Ichino and Schündeln, 2012). In this paper, we do not study spillover effects but (in Appendix B) we report intent-to-treat estimates that incorporate spillover effects. These do not differ from the direct effects that we report in the body of the paper.

4.2 Measuring Machine Breakdown

We gathered data at treated and control polling stations on election day. Enumerators gathered polling station level election results and completed a questionnaire that CODEO observers use to report activities at their assigned polling stations. It included the question “Did biometric verification machine fail to function properly at any point in time?” Possible responses were “Yes”/“No.” We use this information to measure breakdowns of biometric verification machines. The structure of the question allows us to code every polling station in our sample (treated and control) for whether breakdown of biometric equipment occurred. We do not know if machines broke down repeatedly in the same polling place, how long breakdowns lasted, why they occurred, or what was done about them.

---

7To study spillover, we implement a randomized saturation design (Baird et al., 2014), which assigns varying proportions of polling stations to treatment in different constituencies. We saturate the constituencies at three rates: in the low condition, 30 percent of the polling stations in the constituency sample is assigned to treatment; in the medium condition, 50 percent; and in the high condition, 80 percent. Differences in saturation are used to study spillovers effects. For details on the randomized saturation design used and the spillover impact of observers on fraud, see Authors (2014b); Baird et al. (2014). We detail the design in Appendix B.

8The questionnaire also asked whether a biometric verification machine was present at the polling station. Eleven polling stations in our sample did not have machines, and we drop these from the analysis.
In the design phase of this project, we did not expect observers to have an impact on machine operation. For this reason, and due to logistical constraints, enumerators gathered information on machine malfunction in treatment and control areas as follows. At treated stations, all information we use was gathered by CODEO observers as part of their official assigned activities. At control stations, we use data collected by enumerators who interviewed multiple people — party agents of each of the two major political parties and presiding officers — after the polls closed. To avoid “observing” control stations, our research design could not send enumerators to control stations during the election process. They were provided identical training as CODEO observers but their data collection occurred after the end of voting.

This variation in the data collection processes raises concerns that reporting differences may drive the causal relation (reported below) between election observers and machine malfunction. Although we cannot completely rule this out, any bias is likely to be minimal for three reasons. First, reporting differences are likely to bias results against finding that rates of machine malfunction are lower at treated than control stations. CODEO observers are trained to diligently document all events at their assigned stations, where they remain for the entire day. Relative to party agents and presiding officers, official observers seem inherently more likely to over-report events such as machine malfunction. Second, reporting differences cannot explain the result (presented below) that the extent of parliamentary electoral competition is associated with machine breakdown. Observers are randomly assigned within constituencies, so data they gather should not be correlated with constituency-level variables. Results on the relationship between electoral competition and machine breakdown are also almost identical when we subset the sample into treated and control stations: thus, any differences in data collection methods between treated and control stations do not affect this finding. Finally, Appendix A reports results of robustness tests with further evidence that results are not driven by reporting bias.

If breakdowns were a result of mechanical defects, they should be randomly distributed across treatment and control polling stations. Election observers should have no effect on the oper-
ation of the biometric equipment; their training, as detailed above, includes specific and prominent instructions not to interfere with the conduct of the election. If breakdowns are not randomly distributed, it suggests that equipment malfunction may be the result of deliberate actions — if not sabotage of the machines themselves then perhaps pilfering of spare batteries in order to induce breakdown when existing batteries became exhausted.

During the course of the election, observer missions reported that they “found no reason to suspect that the breakdown of the biometric identification mechanism was deliberate” (Economic Community of West African States, 2012, p. 6). Such reports were necessarily drawn from polling stations where observers were sent. Our study collects data from unobserved polling stations in addition to those under observation, and our data are therefore more reliable than reports that rely on information only from observed stations.

4.3 Measures of Election Fraud

We construct indicators of election fraud that rely on objective information gathered from sample polling places on election day. By law, ballots must be counted in public at each polling station after the polls close. This makes it possible to collect polling station level information before it is aggregated (and potentially tampered with) at higher levels.

We construct two measures of fraud. Our first, overvoting, identifies whether more voters cast presidential votes than were officially registered to do so. Each voter is legally allowed to vote only at the polling station where registered. Overvoting is a marker of potential fraud since it suggests that unregistered voters cast ballots, that double voting occurred, or that vote counts were artificially inflated in some other way. To measure overvoting, we used data collected at our sample polling stations on the numbers of valid votes cast in relation to official figures from the Electoral Commission on the number of registered voters at each polling station. The latter figures were released prior to election day. The number of valid votes cast in each polling station is reported on an official form that is filled out at the close of day; we collected these figures in sample polling stations. Overvoting is a dichotomous variable that takes a value of 1 if a polling place had more
people vote than the number of voters who had been registered by the EC.

Our second fraud measure captures whether the presidential ballot box appears to have been stuffed. This ballot stuffing measure takes a value of 1 if more ballots were discovered in the ballot box than the number of voters known to have cast ballots and 0 otherwise. The data were collected using the questionnaire; enumerators responded “Yes”/“No” to the question “Were more ballot papers found in the presidential ballot box than voters who cast ballots?” Because votes are counted at each polling station in public at the end of the day, enumerators had direct access to this information.

We analyze these indicators separately because they capture different types of irregularities but represent a similar underlying pattern of electoral malfeasance: attempts to alter the electoral outcome through election day vote rigging. The two types of irregularities are not correlated in our sample of polling stations ($r = 0.02$). Overvoting and ballot stuffing almost never occurred in the same polling stations, appearing instead as substitute types of fraud. One possible explanation for this is that the two types of irregularities may have been committed by different types of individuals and in different ways. Overvoting may have occurred with the complicity of the presiding officer, when individual registered voters were permitted (or encouraged) to vote more than once, perhaps as party activists escorted them back into line after they had voted. Ballot stuffing, by contrast, may have occurred when the presiding officer was inattentive (either deliberately or when distracted), allowing others on the scene to add more ballots to the box. The data reported below show roughly equivalent rates of overvoting and ballot stuffing in our sample.

9 Since overvoting is a binary measure of whether turnout is more than 100 percent, we also experimented with using continuous turnout figures in addition to overvoting. The advantage of using turnout is that continuous variables are generally more informative than binary measures. However, there is no clear threshold (other than 100 percent) at which turnout becomes an unequivocal marker of fraud, making theoretical interpretation of turnout problematic. Only what we have defined as overvoting constitutes an unequivocally valid measure of election fraud. Below, we also provide information on how machine breakdown affected turnout.

10 These two types of irregularities were grouped together by the NPP when the party petitioned Ghana’s Supreme Court to nullify the election results in a lengthy post-election court case. The NPP labeled both “overvoting.” While the petition was ultimately rejected, four of the nine Supreme Court justices ruled that the NPP’s petition was valid, suggesting our measures of fraud are broadly in line with what legal authorities in Ghana believe true.
The measures of election fraud on which we have data are, strictly speaking, relevant exclusively to the presidential election. Our data collection did not include information that allows us to construct measures of fraud specific to the parliamentary races that were also underway. Our theory of election fraud posits that the extent of competitiveness — which in Ghana varies across constituencies for the parliamentary but not for the presidential races — affects the likelihood that political parties engage in fraud. We use the two measures of fraud in the presidential election just described to proxy generally for the extent of election fraud at the polling station. We assume that where political parties committed more election fraud in the parliamentary election, they also committed more fraud in the presidential race.

4.4 Measuring Electoral Competition in the Parliamentary Elections

Our first hypothesis posits that electoral fraud will be concentrated in electorally competitive areas. Since Ghana’s president is elected in a single nationwide district, there are incentives for parties to win votes everywhere in the presidential contest. We cannot test whether election competition affects election fraud at the level of the presidential race. We therefore test this hypothesis with data on electoral competition in constituency-level parliamentary elections. The rationale for this is as follows. Political parties in Ghana, as elsewhere, seek to maximize seats in the legislature, as well as to win the presidency. If electoral competition creates incentives for fraud, we are likely to observe more fraud in electorally competitive parliamentary constituencies. Political parties in Ghana are organized hierarchically, with relatively independent constituency-level organizations guiding campaign operations (Osei, 2012). These constituency-level organizations are in the first instance creatures of the member of parliament. The degree of electoral competition in the parliamentary elections is therefore likely to shape the incentives of constituency-level party organizations to commit fraud.

We create a continuous measure of the parliamentary vote margin to capture the degree of

\footnote{The blocking variable for electoral competition is derived from the prior presidential race, and is therefore an invalid indicator of the incentives parties face to commit election fraud.}
electoral competition in each constituency. To clearly distinguish this variable from the measure of competition in the prior presidential race that we block on, we refer to the parliamentary variable as the election margin. We use results from the prior (2008) parliamentary elections in Ghana and calculate the measure as the difference in the vote shares of the first- and second-place candidates in each constituency. Small values on the margin variable indicate higher levels of electoral competition, while high values on the margin variable indicate low levels of competition. Figure 1 displays the distribution of the parliamentary vote margin variable in our sample of 60 constituencies. The average vote margin in the sample constituencies is 0.31 and the median is 0.23. The constituencies in our sample display a large range of values on this variable, verifying that parliamentary competitiveness is highly variable. There are also a noticeable number of constituencies in our sample with extremely tight parliamentary races, where the margin in 2008 was close to 0.

Figure 1: Distribution of Parliamentary Vote Margin Across 60 Sample Constituencies

Notes: Parliamentary vote margin calculated the difference in vote share won by the first and second place 2008 parliamentary candidates.
5 Results

Table 1 presents descriptive information about direct rates of machine breakdown and the two measures of electoral fraud in our experimental and blocking conditions. We report means and standard deviations. As the data presented in the first row documents, a quarter of the polling stations in our sample experienced machine breakdowns. Columns 2 and 3 provide preliminary evidence about the effects of election observers. Machine breakdown occurred at 17 percent of polling stations with a CODEO observer present but at 38 percent of those without an observer. This is a very large fraction of polling stations and implies an increase in the rate of breakdown of more than 100 percent when an election observer was not present. The remaining columns present rates of machine breakdown in blocking environments: competitive and uncompetitive as well as urban and rural constituencies. We find that machines break down more frequently in electorally competitive constituencies: 28 percent of polling stations in competitive areas experience machine breakdown compared with 23 percent in uncompetitive constituencies. (To repeat, here competitiveness is a dichotomous blocking variable drawn from 2008 presidential not parliamentary election data; see above.) Rates of breakdown are also 2 percentage points higher in urban than in rural areas. These data exhibit patterns consistent with our hypotheses, if we interpret machine breakdown as a proxy for election fraud. The data describe an election in which biometric verification machines broke down more often when an election observer was not present, in competitive constituencies rather than party strongholds, and in urban rather than rural areas.

Rows 2 and 3 present the same information for the two indicators of fraud that we analyze. Fraud occurred at about 4.5 percent of polling stations and was more likely to occur in the absence of an election observer. There were relatively low rates of polling stations affected by overvoting and ballot stuffing, especially compared with the rates of machine breakdown. Overvoting and ballot stuffing were each more likely to occur in competitive than in stronghold constituencies. The data on fraud thus exhibit patterns consistent with our hypotheses that fraud increases with election
Table 1: Descriptive Statistics of Machine Breakdown and Measures of Fraud in Sampled Polling Stations

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full Sample</td>
<td>Observed</td>
<td>Unobserved</td>
<td>Competitive</td>
<td>Stronghold</td>
<td>Urban</td>
<td>Rural</td>
</tr>
<tr>
<td>Machine Breakdown</td>
<td>0.253</td>
<td>0.172</td>
<td>0.387</td>
<td>0.284</td>
<td>0.231</td>
<td>0.266</td>
<td>0.239</td>
</tr>
<tr>
<td></td>
<td>(0.435)</td>
<td>(0.378)</td>
<td>(0.487)</td>
<td>(0.451)</td>
<td>(0.422)</td>
<td>(0.442)</td>
<td>(0.426)</td>
</tr>
<tr>
<td>Overvoting</td>
<td>0.042</td>
<td>0.025</td>
<td>0.072</td>
<td>0.050</td>
<td>0.037</td>
<td>0.040</td>
<td>0.045</td>
</tr>
<tr>
<td></td>
<td>(0.201)</td>
<td>(0.157)</td>
<td>(0.259)</td>
<td>(0.218)</td>
<td>(0.188)</td>
<td>(0.195)</td>
<td>(0.208)</td>
</tr>
<tr>
<td>Ballot Stuffing</td>
<td>0.046</td>
<td>0.032</td>
<td>0.070</td>
<td>0.058</td>
<td>0.037</td>
<td>0.048</td>
<td>0.043</td>
</tr>
<tr>
<td></td>
<td>(0.209)</td>
<td>(0.175)</td>
<td>(0.256)</td>
<td>(0.233)</td>
<td>(0.189)</td>
<td>(0.215)</td>
<td>(0.203)</td>
</tr>
<tr>
<td>Observations</td>
<td>2036</td>
<td>1271</td>
<td>765</td>
<td>859</td>
<td>1177</td>
<td>1073</td>
<td>963</td>
</tr>
</tbody>
</table>

Notes: Standard deviations in parentheses. Eleven polling stations without biometric verification machines removed from sample. Competitive/stronghold and urban/rural were used as blocking variables.

competition and with greater (urban) party organization, as well as when election observers are not present.

To test the hypotheses that fraud is concentrated in electorally competitive constituencies and in areas where party organization is stronger, we run logistic regressions in which the dependent variable is the dichotomous indicator of biometric machine malfunction and the independent variables proxy electoral competitiveness and party organization. Results appear in Table 2. In the first column, we report results of a regression that examines the association between the constituency-level parliamentary margin in the 2008 elections and machine malfunction. The results show that machines are significantly more likely to break down in polling stations that are located in constituencies with closer parliamentary races. This is indicated by the negative and statistically significant coefficient on the margin variable. In column 2, we examine the connection between our two blocking variables (competitive/stronghold and urban/rural) and machine malfunction. Consistent with our expectations, machines malfunction more often in urban and in competitive constituencies, although neither association is statistically significant. In column 3, we introduce the presence of an election observer at the polling station. The coefficient on the observer indicator is negative and significant, meaning that election observers reduce machine malfunction.
Table 2: Logistic Regression Results of the Impact of Marginality, Election Observation, Electoral Competition, and Urbanization on Machine Breakdown

<table>
<thead>
<tr>
<th></th>
<th>(1) Malfunction</th>
<th>(2) Malfunction</th>
<th>(3) Malfunction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parliamentary Electoral Margin (Constituency)</td>
<td>-0.860*** (0.333)</td>
<td>-0.757** (0.337)</td>
<td></td>
</tr>
<tr>
<td>Competitive</td>
<td>0.288 (0.198)</td>
<td>0.040 (0.222)</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>0.171 (0.192)</td>
<td>0.108 (0.188)</td>
<td></td>
</tr>
<tr>
<td>Election Observer</td>
<td>-1.096*** (0.175)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.826*** (0.154)</td>
<td>-1.299*** (0.139)</td>
<td>-0.321 (0.216)</td>
</tr>
</tbody>
</table>

Observations 2,013 2,013 2,013

Notes: *** indicates significance at \( p < 0.01 \), ** indicates significance at \( p < 0.05 \), * indicates significance at \( p < 0.10 \). Robust standard errors clustered by constituency in parantheses. Eleven polling stations without biometric verification machines removed from sample of machine breakdown. Urban and competitive were used as blocking variables.

The significant association between electoral competition in the parliamentary elections and biometric machine malfunction is robust to the inclusion of other variables. The magnitude of the effect is substantial. Moving from the 75th percentile on the margin variable (less competitive) to the 25th percentile (more competitive) is associated with an 8 percentage point increase in the probability of machine malfunction, a 40 percent increase. These results provide evidence that machine malfunction was systematic and not random. The patterns of breakdown we observe are consistent with the expectations of a theory of electoral fraud in democratic contexts, in which political parties have greater incentives to commit fraud where partisan competition is more intense, have more capacity to do so with greater organization, and have more ability to do so where they are not under observation by other organizations, such as CODEO.

In Table 3, we report results when we examine the effect of electoral observers on machine malfunction, results that draw directly on the experimental design of the study. We present the main intent-to-treat results. We use regression analysis in order to incorporate our blocking variables as
Table 3: Intent-to-Treat Effects of Election Observers on Machine Breakdown

<table>
<thead>
<tr>
<th></th>
<th>(1) Malfunction</th>
<th>(2) Malfunction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Election Observer</td>
<td>-0.215***</td>
<td>-0.215***</td>
</tr>
<tr>
<td></td>
<td>(0.033)</td>
<td>(0.034)</td>
</tr>
<tr>
<td>Competitive</td>
<td>0.059</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.037)</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>0.022</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.033)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.387***</td>
<td>0.350***</td>
</tr>
<tr>
<td></td>
<td>(0.030)</td>
<td>(0.035)</td>
</tr>
<tr>
<td>Observations</td>
<td>2,013</td>
<td>2,013</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.057</td>
<td>0.062</td>
</tr>
</tbody>
</table>

Notes: *** indicates significance at $p < 0.01$, ** indicates significance at $p < 0.05$, * indicates significance at $p < 0.10$. Robust standard errors clustered by constituency parentheses. Eleven polling stations without biometric verification machines removed from sample.

covariates. (For details on the design and for parallel results that also incorporate spillover, see Appendix B.)

Results in both columns show that election observers have a negative and statistically significant impact on machine breakdown. The size of the effect is unaltered when we incorporate blocking variables into the model, as shown in Column 2. Rates of machine breakdown are consistently less where an election observer is present. The estimated average treatment effect is very large, with observers reducing rates of machine breakdown by 20 percentage points (and by 15 percentage points when spillover is taken into consideration; see Appendix B). The estimated treatment effect on machine malfunction is much larger than the estimated effect on the two measures of fraud that we study.

There is no administrative or technical reason that election observers should have any significant impact on the operation of biometric verification machines. CODEO observers were not instructed in the use of the machines nor were they expected to ensure their operation; indeed, as
we have already indicated, they were instructed not to touch or tamper with equipment in polling stations. The results thus imply that some substantial fraction of machine breakdown — apparently about half — was deliberately orchestrated when an election observer was not present. This raises the question of whether machine breakdown was used strategically as an opportunity to commit election fraud — by encouraging voters to double vote, for instance. To explore this, we next turn to the effect of machine breakdown on overvoting and ballot stuffing.

6 Effects of Machine Malfunction on Election Fraud

In this section, we study whether machine breakdown is a significant predictor of election fraud. This part of the analysis goes beyond the research design to explore important but unanticipated results. Our research was designed to study the impact of election observers on electoral integrity. Election observation was randomized, whereas machine breakdown was not. We cannot know with certainty whether associations that we observe between machine breakdown and other variables, such as proxies for election fraud, are genuinely causal. Nonetheless, our data provide the opportunity to explore and understand further the unanticipated finding that breakdowns of the biometric verification machines were systematically related to observer absence.

In Table 4, we report results of logistic regressions that study the impact of election observers and machine malfunctions on our two measures of voter fraud. (These results do not take spillover into account but they do include potentially important control variables.) In Column 1, we report results for these two theoretically-relevant variables and for their interaction on overvoting. In Column 3, we do the same for ballot stuffing.

Consistent with prior research on election observation, we find that election observers reduce the likelihood of electoral fraud. Treatment reduces overvoting by about 4.5 percentage

---

\[ \text{If the breakdown rate with no observer present is about 35 percent, as indicated by the value of the constant reported in columns 1 and 2 in Table 3, and the breakdown rate with an observer present is about 16 percent, then the absence of electoral observation more than doubles the rate of breakdown. If we assume that all incidents of breakdown when observers were present were accidental, then the non-accidental frequency of breakdown is twice the random rate.} \]
Table 4: Logistic Regression Results of the Impact of Biometric Machine Breakdown and Election Observation on Overvoting and Ballot Stuffing

<table>
<thead>
<tr>
<th></th>
<th>(1) Overvoting</th>
<th>(2) Overvoting</th>
<th>(3) Ballot Stuffing</th>
<th>(4) Ballot Stuffing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Election Observer</td>
<td>-0.892***</td>
<td>-0.909***</td>
<td>-0.555</td>
<td>-0.551</td>
</tr>
<tr>
<td></td>
<td>(0.281)</td>
<td>(0.275)</td>
<td>(0.393)</td>
<td>(0.416)</td>
</tr>
<tr>
<td>Machine Breakdown</td>
<td>0.680**</td>
<td>0.658**</td>
<td>0.925***</td>
<td>0.920***</td>
</tr>
<tr>
<td></td>
<td>(0.316)</td>
<td>(0.319)</td>
<td>(0.334)</td>
<td>(0.313)</td>
</tr>
<tr>
<td>Observer x Machine Breakdown</td>
<td>-0.419</td>
<td>-0.422</td>
<td>-0.256</td>
<td>-0.314</td>
</tr>
<tr>
<td></td>
<td>(0.459)</td>
<td>(0.470)</td>
<td>(0.469)</td>
<td>(0.450)</td>
</tr>
<tr>
<td>Competitive</td>
<td></td>
<td></td>
<td>0.299</td>
<td>0.432</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.267)</td>
<td>(0.380)</td>
</tr>
<tr>
<td>Urban</td>
<td>-0.153</td>
<td>0.103</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.267)</td>
<td>(0.392)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-2.861***</td>
<td>-2.902***</td>
<td>-3.024***</td>
<td>-3.278***</td>
</tr>
<tr>
<td></td>
<td>(0.225)</td>
<td>(0.283)</td>
<td>(0.296)</td>
<td>(0.365)</td>
</tr>
<tr>
<td>Observations</td>
<td>1,898</td>
<td>1,898</td>
<td>1,981</td>
<td>1,981</td>
</tr>
</tbody>
</table>

Notes: *** indicates significance at \( p < 0.01 \), ** indicates significance at \( p < 0.05 \), * indicates significance at \( p < 0.10 \). Robust standard errors clustered by constituency in parentheses.

points, and the impact is statistically significant[13] Observers’ effects on ballot stuffing are also negative, though they are smaller and are not statistically significant. In column 1, the positive and statistically significant coefficient on machine malfunction shows that machine breakdown increases overvoting. Identical findings are reported in Column 3 for ballot stuffing. Both overvoting and ballot stuffing are significantly increased by machine breakdown.

We also report results for the interaction effects of observers and machine malfunction. In neither case is the coefficient on the interaction variable statistically significant. However, the direction of the coefficient supports the notion that the relation of biometric machine breakdown to electoral fraud is conditioned by the presence of an observer: the effect of machine breakdown on fraud is substantially lower when an observer is present.

[13] When we incorporate spillover into the analysis, the estimates of observers’ impact of observers are reduced but are still statistically significant and relatively large. For details, see Authors (2014b).
In Columns 2 and 4, we report the same logistic regressions also controlling for the two blocking variables used in the study (whether the constituency is competitive or a stronghold and whether it is urban or rural). Neither of the blocking variables significantly affects overvoting or ballot stuffing in these estimates. The coefficients on machine breakdowns and election observers remain stable. Results all suggest that election observers and the malfunction of biometric identification machines operate in different directions. The first is associated with a reduction in election fraud while the second is associated with an increase in it.

To further explore possible scenarios, Figures 2 and 3 show the predicted probabilities of overvoting and ballot stuffing with each of the four combinations of variables: with and without an observer present and with and without machine malfunction. The predicted probabilities are produced from the models reported in Columns 2 and 4 of Table 4. We find the lowest average expected probability of overvoting and ballot stuffing when an election observer is present and the biometric verification equipment operates without breakdown. In this setting, the predicted probability of overvoting or of ballot stuffing is about 2.5 percent. This represents a relatively small probability. We observe the highest expected probability of overvoting or ballot stuffing when an observer is absent and the biometric verification machine malfunctions. In this scenario, the expected probability of overvoting or of ballot stuffing increases fourfold, to 10 percent. This represents a relatively high probability of election fraud in a competitive democracy. The expected probability of overvoting is similar when an observer is present regardless of whether the biometric identification machine malfunctions or not. The predicted probability of overvoting ranges from 2 to 3 percent in either scenario. The expected outcome is similar for ballot stuffing in the presence of an observer, but the expected probability of ballot stuffing increases much more if the biometric identification machine fails, suggesting that observers are more effective in preventing overvoting than ballot stuffing.

These results highlight that breakdowns of the biometric identification machines were associated with higher rates of election fraud. They also show that the presence of an observer
Figure 2: Marginal Probabilities from Logistic Regressions of the Impact of Machine Breakdowns and Election Observers on Overvoting

Probability of Overvoting

No Malfunction  Malfunction

Machine Breakdown

No Observer  Observer

Figure 3: Marginal Probabilities from Logistic Regressions of the Impact of Machine Breakdowns and Election Observers on Ballot Stuffing

Probability of Ballot Stuffing

No Malfunction  Malfunction

Machine Breakdown

No Observer  Observer
attenuates the negative impact of machine malfunction. The worst outcome obtains when the machine breaks down and no election observer is present. The expected probability of overvoting in that setting is three times what it is if the machine breaks down and an election observer is present at the polling station. Election observers have independent effects in reducing overvoting even with a fully functional biometric identification machine. There is almost no effect on the probability of overvoting if a biometric identification machine breaks down and an election observer is standing by. If there is no observer present, however, not only are machines more likely to break down but overvoting is twice as likely to occur than if the machines operates uninterruptedly. Likewise, the expected probability of ballot stuffing if the biometric verification machine breaks down and no election observer is present is twice that if an election observer is present.

A final auxiliary question that we study is whether the breakdown of the biometric verification machines affects turnout, or the proportion of registered voters who cast votes. If machine breakdowns prevent registered voters from casting ballots due to the inevitable delays that breakdowns generate, then breakdowns should be associated with lower turnout. If, conversely, machine breakdowns are used as opportunities to perpetuate election fraud, perhaps by permitting double or illegal voting, they should be associated with higher turnout. Table 5 reports results of regression analysis studying the relationship between machine malfunction, election observers, and turnout.

The results reported in Column 1 show that turnout (which averages 84 percent across the polling stations in our sample) is approximately 4.5 percent higher with machine breakdown and the effect is statistically significant. One interpretation of this result is that machine malfunction permits double or illegal voting. This interpretation is consistent with the results reported above showing that machine malfunction is associated with markers of election fraud.

Column 2 presents results on the relation between election observers and turnout. If observers promote election integrity and prevent some double voting, we expect that their presence will actually reduce turnout. The results reported are consistent with this; average turnout is 83 percent with an observer present and 88 percent without one (significant at the 0.01 level). These
Table 5: Regression Results for the Impact of Biometric Machine Breakdown and Election Observation on Turnout

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnout</td>
<td>Turnout</td>
<td></td>
</tr>
<tr>
<td>Machine Breakdown</td>
<td>0.046***</td>
<td>0.046***</td>
</tr>
<tr>
<td></td>
<td>(0.016)</td>
<td>(0.016)</td>
</tr>
<tr>
<td>Election Observer</td>
<td>-0.053***</td>
<td>-0.053***</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.014)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.835***</td>
<td>0.880***</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.011)</td>
</tr>
<tr>
<td>Observations</td>
<td>1,898</td>
<td>1,919</td>
</tr>
</tbody>
</table>

Notes: *** indicates significance at $p < 0.01$, ** indicates significance at $p < 0.05$, * indicates significance at $p < 0.10$. Robust standard errors clustered by constituency in parentheses. Dependent variable is the polling station turnout rate.

results imply that as much as five percent of votes that were cast in the presidential election may have been fraudulent.

Our experimental design allows us to state with confidence that the absence of election observers is causally related to machine breakdowns. Our results also show that machine breakdowns permitted twice the rate of election fraud to occur when an observer was not present as when one was present. These results underscore that machine breakdown is likely to have been deliberately induced, especially when no election observer was posted to the polling station, and also that persons on the scene took advantage of breakdowns to commit fraud, especially when an observer was not present. These results are consistent with our finding that turnout is higher when an election observer is not present, and that machine breakdowns are also associated with higher turnout.

7 Conclusion

This paper investigates the malfunction of biometric identification machines during Ghana’s 2012 presidential and parliamentary elections. We document non-random patterns to breakdown. Consistent with a theory of fraud in the context of democratic political competition, we find that machines were significantly more likely to break down in constituencies that were more electorally
competitive for the parliamentary seat (H1). This corroborates that fraud increases with competitive pressures on political parties. We also find that biometric identification machines broke down significantly more often and at very high rates when an election observer was not present (H3). These results suggest that the operation of biometric verification machines was in many instances deliberately induced. Our results also show that fraud was more prevalent where biometric identification machines failed to operate (H4). Machine breakdowns were used strategically to increase overvoting and also to increase ballot stuffing, although the latter effects are less precisely estimated. Finally, our results are consistent with our theory that better organized political parties are more capable of perpetuating election fraud (H2). However, perhaps because we have only a rough proxy for party organization, these results are not statistically significant.

We can only speculate about how machine breakdowns occurred and how this permitted election fraud to occur. There was a “natural” rate of breakdown, which appears to have been under 20 percent. This was the rate of breakdown when an election observer was present, and probably was chiefly because of battery exhaustion. The additional breakdowns that took place when election observers were not present may have been deliberately induced by pilfering spare batteries, by exposing the machine to excessive heat or sunlight, or by rending any available backup machine non-operational. The occasional machine may have been stolen outright. Only a quarter of the country’s polling stations were provided backup machines due to an absence of sufficient equipment, leading to delays in many places when a machine broke down and no back up was immediately available. Breakdowns may also have been induced when presiding officers exhibited (perhaps strategically) unfamiliarity with the machines, despite the fact that temporary technical staff from the EC was supposed to be on site to keep the machines operating. Machine breakdowns could have led to confusion in the polling station, permitting ballot stuffing to occur as

---


15Ghana has approximately 26,000 polling stations, and the EC reported that it had funds to purchase 33,500 biometric identification machines. Thus, there were only 7,500 backup machines available. As a result, a backup machine often had to be brought from a neighboring polling station if the original machine failed.
presiding officials were distracted trying to restore equipment. Aware of some of the problems that occurred in 2012, Ghana’s Election Commission subsequently upgraded the biometric machines. The subsequent (2014) upgrade included programming the machines to warn when the batteries were running out. The extent of electoral fraud that our research shows was associated with biometric machine failure in 2012 is unlikely to be repeated in the future.

Because biometric identification was used in every polling station in the December 2012 elections, we are unable to assess whether its introduction reduced electoral fraud. However, this is likely to be the case. The fact that twice as many biometric identification machines did not operate uninterruptedly during the election in polling stations without observers suggests that malfunction was deliberately induced. Why would this occur if not to commit election fraud? The utility of functioning biometric identification machines in fraud prevention provides the incentive for individuals to sabotage their operation when no election observer is present. If biometric identification machines did not reduce fraud, we would not observe a non-random pattern of breakdown or a significant association of machine breakdown and election fraud. However, this inference goes beyond what our research was designed to investigate.

Our study cautions that biometric technology is susceptible to manipulation, especially in an initial large scale rollout and even in a genuinely competitive democracy. In this context, breakdown may be deliberately induced when machines are not monitored by neutral, trained election observers. The overall legal and political environment is sufficiently relaxed that political party operatives apparently feel free to take advantage of unmonitored voting to tamper with new and still imperfectly designed equipment. These results carry implications for the use of biometric identification technology. If our results are general, then introduction of such equipment reduces fraud, even if we cannot estimate how much fraud is prevented. However, it remains important to use the technology under the watchful eyes of independent, non-partisan and neutral observers.

who have no interest in perpetuating fraud and who are professionally committed to the practices of good governance. There is no technical fix to election fraud.
References


32


Appendices

Appendix A: Robustness Checks

In this section, we describe features of the data collection and analysis that led us to undertake specific robustness checks.

Data was collected on election day from sampled polling stations by enumerators using a checklist. In treated areas, enumerators acted as election observers for the whole of the day. These observer/enumerators remained in a single randomly selected polling station through the vote count. They recorded the information reported and analyzed here by observing events at the polling station as well as the vote count. Due to logistical challenges and because we wanted to avoid inadvertently treating control stations by sending enumerators to observe activities throughout the course of election day, other enumerators were assigned to visit three to four control polling stations after the polls had closed at 17:00 and, using identical checklists, to collect the same information. They were instructed to collect information from two persons, ideally the two official representatives of the major political parties in each polling place. These representatives typically gather similar information to report to central party offices. If enumerators could not speak with a party representative, they were instructed to collect the information from the presiding officer. Members of both groups of enumerators received identical training, were officially designated CODEO election observers, and received appropriate identification materials that permitted them entry into polling stations.

The analysis reported in this paper relies on four pieces of information collected by enumerators: (1) the number of rejected ballots; (2) the number of valid votes; (3) whether more ballot papers were found in the presidential ballot box than had been cast; and (4) whether at any point during the data the biometric verification machine malfunctioned. In addition, we use data supplied by the Election Commission on the number of registered voters at each polling station.

The analysis reported in the main body of the paper uses the maximum amount of data
available, including observations where only one party official provided information. It omits observations where two party officials provided different answers. In the robustness tests presented below, we drop observations that fail to meet one of two criteria: the enumerator collected the information through direct observation, or the enumerator collected identical information from two separate respondents.

In Table A.1 through Table A.4 and Figures A.1 and A.2, we report the same information as reported in the body of the paper using this smaller dataset. All results remain stable.

Appendix B: Experimental Design

We implement a “randomized saturation” experimental design (Baird et al., 2014). The advantage of the randomized saturation design is that it allows us to estimate the causal effect of election observers while including in the estimates their potential “spillover” effects. Spillover effects occur when the treatment status of one unit impacts outcomes at other units (Gerber and Green, 2012): in our case, when the deployment of an observer to one polling station influences election integrity at other polling stations (because the observer “pushes” election fraud to unobserved polling stations).

The design involves a two-stage randomization process: in our case, first at the constituency level and then at the polling station level. In the first stage, we assign constituencies to an observer “saturation” treatment. Saturation is defined as the proportion of polling stations within a constituency that is monitored by observers. In the second stage, we randomly assign observers to polling stations within the sample of constituencies.

In the first stage, we randomly assign each constituency to one of three saturations: low, medium, and high. In the low condition, observers are deployed to 30 percent of sample polling stations in the constituency. In the medium condition, we treat 50 percent of sample polling stations. In the high condition, we treat 80 percent of sample polling stations. In the second stage
of our randomization process, we randomly assign individual polling stations to treated (observed) or control (unobserved) status. The proportion of polling stations randomly assigned to treatment within a constituency is determined by the randomly assigned saturation level in the first stage. The approach yields a $3 \times 2$ experimental design. In total, we send observers to 1,292 polling stations across 60 constituencies in the sample.

In our experimental framework, potential outcomes are determined by the polling station’s treatment status and the treatment condition of each station’s constituency. Potential outcomes can be written as follows:

$$Y_{ij}(T_{ij}, S_j)$$

where $Y_{ij}$ is one of the indices of election integrity (such as ballot stuffing or overvoting) at polling station $i$ in constituency $j$. $T_{ij}$ indicates treatment status at polling station $i$ in constituency $j$ ($T_{ij} = 1$ if an observer is present, and 0 otherwise). The constituency level treatment status is indicated by $S_j$, where $S_j = s$ and $s \in \{\text{low, medium, high}\}$.

To account for spillover in our estimation of causal effects, we compare outcomes in treated polling stations to outcomes in control polling stations in the low saturation constituencies. Since the saturation of treatment in the low condition constituencies is relatively low, the control polling stations in the low condition constituencies are less likely to be affected by spillover effects. Comparing outcomes in treated polling stations only to these low condition control stations should therefore generate less biased estimates of observers’ causal effects. To estimate the average higher saturation constituencies, we assign the constituency treatments with a probability of 20 percent for the low condition and 40 percent for the medium and high conditions. This increases the statistical power to detect spillover effects. Such spillovers are not the focus of the present study.

Ideally, we would have implemented the study with “pure” control polling stations. Pure control units are untreated units that are not susceptible to spillover effects because there are no treated units in the same constituency (or local area). In our study, no control units were assigned to this pure control status. This decision was driven solely by practical considerations. Given CODEO’s mission, which is to deter electoral malfeasance and enhance the quality of elections across the country, we were unable to create constituencies in which no observers were present. It is an important part of CODEO’s mission to be present in all regions and constituencies of the country, in part so that the organization maintains credibility as an impartial observer. Therefore, we use control stations in low saturation conditions.
intent-to-treat effect of election observers, we therefore define a dummy variable, $W_{ij}$, which takes a value of 1 if the unit is a control polling station located in one of the medium and high saturation constituencies (following Baird et al., 2014). To estimate the average treatment effect, we estimate the following regression model:

$$Y_{ij} = \beta_0 + \beta_1 T_{ij} + \beta_2 W_{ij} + \epsilon_{ij} \quad (2)$$

Here, $\beta_1$ provides the estimate of the average treatment effect. It compares outcomes in all treated polling stations to outcomes in control stations in the low saturation constituencies. We cluster standard errors by constituency to account for the fact that the cluster-level treatments are assigned at that level.

In Table 3, we reported intent-to-treat effects. In Table B.1 we report results of the same regressions but including spillover effects.

**Appendix C: Covariate Balance Tests**

In this section, we present data showing balance on various dimensions for treated and control polling stations. We use data from a household survey we conducted in the communities near observed and unobserved polling places during the two days following the elections. As part of the survey, we gathered data on voting behavior in the prior 2008 election as well as measures of socio-economic conditions.

Table C.1 presents means in control and observed communities on a number of pre-election covariates. It also presents the difference in these means and the p-value of a two-tailed difference-of-means test. The first section of the table shows that the partisan voting histories of residents near observed and unobserved polling are comparable. In both sets of communities, about 35 percent of the constituency as our main comparison set.

---

19 We surveyed over 6,000 Ghanaians. Ideally, we would have randomly sampled individuals from the official voter register. As this was not available, we instead employed the random sampling techniques used across Africa by the Afrobarometer public opinion survey. Our enumerators visited each sampled polling place and then selected four households using a random walk technique.
report voting for the NPP in the 2008 presidential election, while about 43 percent report voting for the NDC, whose candidate was the winner of that election. The remaining sections of the table examine measures of education, poverty and well-being. Observed and control polling stations are also similar along these dimensions. The data presented in the table shows that the communities surrounding our observed and control polling stations are comparable across a range of political and socio-economic characteristics that may be thought to affect the level of fraud.
Table A.1: Descriptive Statistics of Machine Breakdown and Measures of Fraud, Robustness Check

<table>
<thead>
<tr>
<th></th>
<th>(1) Full Sample</th>
<th>(2) Observed</th>
<th>(3) Unobserved</th>
<th>(4) Competitive</th>
<th>(5) Stronghold</th>
<th>(6) Urban</th>
<th>(7) Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Breakdown</td>
<td>0.225 (0.418)</td>
<td>0.172 (0.378)</td>
<td>0.340 (0.474)</td>
<td>0.267 (0.443)</td>
<td>0.194 (0.395)</td>
<td>0.242 (0.429)</td>
<td>0.206 (0.405)</td>
</tr>
<tr>
<td>Overvoting</td>
<td>0.038 (0.192)</td>
<td>0.025 (0.157)</td>
<td>0.067 (0.250)</td>
<td>0.046 (0.209)</td>
<td>0.033 (0.180)</td>
<td>0.036 (0.187)</td>
<td>0.041 (0.199)</td>
</tr>
<tr>
<td>Ballot Stuffing</td>
<td>0.041 (0.199)</td>
<td>0.032 (0.175)</td>
<td>0.061 (0.239)</td>
<td>0.054 (0.226)</td>
<td>0.032 (0.177)</td>
<td>0.043 (0.203)</td>
<td>0.040 (0.196)</td>
</tr>
<tr>
<td>Observations</td>
<td>1974</td>
<td>1271</td>
<td>703</td>
<td>828</td>
<td>1146</td>
<td>1044</td>
<td>930</td>
</tr>
</tbody>
</table>

Notes: Standard deviations in parentheses. Eleven polling stations without biometric verification machines removed from sample. Includes observations only where two sources of information available or where enumerator directly observed the polling station.
Table A.2: Electoral Competition, Urbanization, and Incidences of Machine Breakdown, Robustness Check

<table>
<thead>
<tr>
<th></th>
<th>(1) Malfunction</th>
<th>(2) Malfunction</th>
<th>(3) Malfunction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parliamentary Electoral Margin (Constituency)</td>
<td>-1.085*** (0.348)</td>
<td>-0.842** (0.354)</td>
<td></td>
</tr>
<tr>
<td>Competitive</td>
<td>0.432** (0.212)</td>
<td>0.136 (0.243)</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>0.233 (0.215)</td>
<td>0.166 (0.214)</td>
<td></td>
</tr>
<tr>
<td>Election Observer</td>
<td></td>
<td>-0.890*** (0.210)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.922*** (0.169)</td>
<td>-1.559*** (0.150)</td>
<td>-0.583** (0.241)</td>
</tr>
</tbody>
</table>

Observations 1,826 1,826 1,826

Notes: ** indicates significance at $p < 0.05$, * indicates significance at $p < 0.10$. Robust standard errors clustered by constituency in parentheses. Eleven polling stations without biometric verification machines removed from sample of machine breakdown. Includes observations only where two sources of information available or where enumerator directly observed the polling station.
Table A.3: Average Treatment Effects of the Incidence of Machine Breakdown and Fraud, Robustness Check

<table>
<thead>
<tr>
<th></th>
<th>(1) Malfunction</th>
<th>(2) Malfunction</th>
<th>(3) Malfunction with Spillover</th>
<th>(4) Malfunction with Spillover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Election Observer</td>
<td>-0.168***</td>
<td>-0.168***</td>
<td>-0.104**</td>
<td>-0.099**</td>
</tr>
<tr>
<td></td>
<td>(0.040)</td>
<td>(0.041)</td>
<td>(0.043)</td>
<td>(0.048)</td>
</tr>
<tr>
<td>Competitive</td>
<td>0.078**</td>
<td></td>
<td>0.078**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.039)</td>
<td></td>
<td>(0.037)</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>0.031</td>
<td></td>
<td>0.035</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.035)</td>
<td></td>
<td>(0.034)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.340***</td>
<td>0.290***</td>
<td>0.276***</td>
<td>0.220***</td>
</tr>
<tr>
<td></td>
<td>(0.037)</td>
<td>(0.041)</td>
<td>(0.039)</td>
<td>(0.049)</td>
</tr>
<tr>
<td>Observations</td>
<td>1,826</td>
<td>1,826</td>
<td>1,826</td>
<td>1,826</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.035</td>
<td>0.045</td>
<td>0.038</td>
<td>0.048</td>
</tr>
</tbody>
</table>

Notes: ** indicates significance at $p < 0.05$, * indicates significance at $p < 0.10$. Robust standard errors clustered by constituency in parentheses. Eleven polling stations without biometric verification machines removed from sample of machine breakdown. Includes observations only where two sources of information available or where enumerator directly observed the polling station.
Table A.4: Results of Logistic Regressions on the Impact of Biometric Machine Breakdown on Overvoting and Ballot Stuffing: Robustness Check

<table>
<thead>
<tr>
<th></th>
<th>(1) Overvoting</th>
<th>(2) Overvoting</th>
<th>(3) Ballot Stuffing</th>
<th>(4) Ballot Stuffing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Election Observer</td>
<td>-0.952***</td>
<td>-0.969***</td>
<td>-0.344</td>
<td>-0.365</td>
</tr>
<tr>
<td></td>
<td>(0.278)</td>
<td>(0.268)</td>
<td>(0.524)</td>
<td>(0.564)</td>
</tr>
<tr>
<td>Machine Breakdown</td>
<td>0.391</td>
<td>0.353</td>
<td>1.313***</td>
<td>1.271***</td>
</tr>
<tr>
<td></td>
<td>(0.377)</td>
<td>(0.379)</td>
<td>(0.372)</td>
<td>(0.336)</td>
</tr>
<tr>
<td>Observer x Machine Breakdown</td>
<td>-0.129</td>
<td>-0.130</td>
<td>-0.645</td>
<td>-0.660</td>
</tr>
<tr>
<td></td>
<td>(0.482)</td>
<td>(0.499)</td>
<td>(0.500)</td>
<td>(0.459)</td>
</tr>
<tr>
<td>Competitive</td>
<td>0.330</td>
<td>0.519</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.303)</td>
<td>(0.399)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>-0.074</td>
<td>-0.028</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.300)</td>
<td>(0.426)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-2.802***</td>
<td>-2.893***</td>
<td>-3.234***</td>
<td>-3.444***</td>
</tr>
<tr>
<td></td>
<td>(0.253)</td>
<td>(0.308)</td>
<td>(0.432)</td>
<td>(0.504)</td>
</tr>
<tr>
<td>Observations</td>
<td>1,674</td>
<td>1,674</td>
<td>1,767</td>
<td>1,767</td>
</tr>
</tbody>
</table>

Notes: *** indicates significance at $p < 0.01$, ** indicates significance at $p < 0.05$, * indicates significance at $p < 0.10$. Robust standard errors clustered by constituency in parentheses. Includes observations only where two sources of information available or where enumerator directly observed the polling station.
**Figure A.1: Marginal Probabilities from Logistic Regressions of Impact of Machine Breakdowns and Election Observers on Overvoting, Robustness Check**

![Graph showing marginal probabilities]

**Notes:** Includes observations only where two sources of information available or where enumerator directly observed the polling station.
Figure A.2: Marginal Probabilities from Logistic Regressions of Impact of Machine Breakdowns and Election Observers on Ballot Stuffing, Robustness Check

Notes: Includes observations only where two sources of information available or where enumerator directly observed the polling station.
Table B.1: Intent-to-Treat Effects of Election Observers on Machine Breakdown Including Spillover

<table>
<thead>
<tr>
<th></th>
<th>(1) Malfunction with Spillover</th>
<th>(2) Malfunction with Spillover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Election Observer</td>
<td>-0.156*** (0.044)</td>
<td>-0.155*** (0.046)</td>
</tr>
<tr>
<td>Competitive</td>
<td></td>
<td>0.059 (0.036)</td>
</tr>
<tr>
<td>Urban</td>
<td>0.026 (0.032)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.328*** (0.039)</td>
<td>0.289*** (0.048)</td>
</tr>
<tr>
<td>Observations</td>
<td>2,013</td>
<td>2,013</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.060</td>
<td>0.065</td>
</tr>
</tbody>
</table>

Notes: *** indicates significance at $p < 0.01$, ** indicates significance at $p < 0.05$, * indicates significance at $p < 0.10$. Robust standard errors clustered by constituency in parentheses. Eleven polling stations without biometric verification machines removed from sample.
Table C.1: Polling Station (Unit) Level Covariate Balance

<table>
<thead>
<tr>
<th></th>
<th>Mean Control</th>
<th>Mean Observed</th>
<th>Difference</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPP Presidential Vote 2008</td>
<td>.357</td>
<td>.355</td>
<td>.002</td>
<td>.864</td>
</tr>
<tr>
<td>NDC Presidential Vote 2008</td>
<td>.436</td>
<td>.433</td>
<td>.002</td>
<td>.881</td>
</tr>
<tr>
<td>NPP Parliamentary Vote 2008</td>
<td>.383</td>
<td>.358</td>
<td>.025</td>
<td>.087</td>
</tr>
<tr>
<td>NDC Parliamentary Vote 2008</td>
<td>.408</td>
<td>.414</td>
<td>-.006</td>
<td>.694</td>
</tr>
<tr>
<td>Poverty index</td>
<td>.984</td>
<td>.963</td>
<td>.02</td>
<td>.23</td>
</tr>
<tr>
<td>Electricity</td>
<td>1.154</td>
<td>1.129</td>
<td>.025</td>
<td>.286</td>
</tr>
<tr>
<td>Medicine</td>
<td>.891</td>
<td>.905</td>
<td>-.014</td>
<td>.514</td>
</tr>
<tr>
<td>Sufficient Food</td>
<td>.881</td>
<td>.842</td>
<td>.038</td>
<td>.1</td>
</tr>
<tr>
<td>Cash Income</td>
<td>1.008</td>
<td>.976</td>
<td>.032</td>
<td>.126</td>
</tr>
<tr>
<td>No Formal Schooling</td>
<td>.147</td>
<td>.15</td>
<td>-.003</td>
<td>.793</td>
</tr>
<tr>
<td>Completed Primary Schooling</td>
<td>.685</td>
<td>.708</td>
<td>-.022</td>
<td>.11</td>
</tr>
<tr>
<td>Post Primary Schooling</td>
<td>.511</td>
<td>.537</td>
<td>-.026</td>
<td>.088</td>
</tr>
<tr>
<td>Formal House</td>
<td>.172</td>
<td>.178</td>
<td>-.006</td>
<td>.626</td>
</tr>
<tr>
<td>Concrete Permanent House</td>
<td>.41</td>
<td>.422</td>
<td>-.012</td>
<td>.427</td>
</tr>
<tr>
<td>Concrete and Mud House</td>
<td>.224</td>
<td>.215</td>
<td>.008</td>
<td>.504</td>
</tr>
<tr>
<td>Mud House</td>
<td>.187</td>
<td>.179</td>
<td>.008</td>
<td>.494</td>
</tr>
</tbody>
</table>

Notes: Data are from a post-election survey conducted in the communities around each polling station in the sample (N=6,000). P-values calculated from two-tailed difference-of-means tests.