Biometric Elections in Poor Countries: Wasteful or a Worthwhile Investment?

Alan Gelb and Anna Diofasi

Abstract

Elections have emerged as a leading area for the application of biometric technology in developing countries, despite its high costs and uncertainty over its effectiveness. One-off voter registrations, as practiced in many countries and supported by donors, also often leave nothing behind in terms of permanent, sustainable, identification assets. Why then do donors support such programs? The paper considers the costs and benefits of technology, where the latter involves its potential to reduce the probability of seriously disputed elections that escalate into violence. Based on the limited data available, it finds that a reduction in the probability of post-election violence by only a few percentage points could offset the cost of the technology. However, this is possible only in particular situations where political parties value the legitimacy conferred by elections that are sufficiently credible to provide an acceptable basis for governing, but where democracy is not yet well-institutionalized. One priority is therefore to screen potential cases carefully. Another step towards using technology more effectively would be to build on the powerful momentum created by voter registration drives to strengthen permanent identity assets such as civil registration and national ID programs, so that they can provide a more sustainable foundation for subsequent voter rolls. This is possible with careful planning but may require some reconsideration of institutional mandates.

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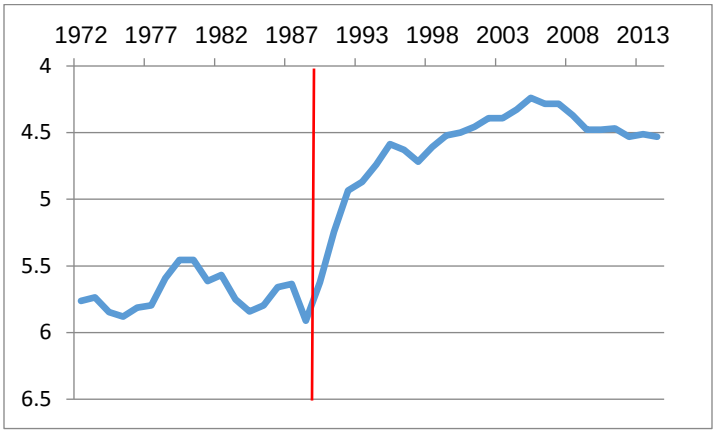
1. Introduction

Over the last quarter century, many developing countries have turned towards electoral politics. Democracy indicators for Sub-Saharan Africa made substantial gains after 1990 at the end of the Cold War. At the same time, political rights and civil liberties—as measured by Freedom House—have mostly remained stuck around the middle of the scale (Figure 1). Even if they have implemented multi-party elections, many countries have not transitioned fully towards liberal democracies. Elections have often been far from free and fair and their results have frequently been disputed, sometimes violently and at heavy cost to lives and the economy.

Figure 1
The Evolution of Political Rights in Sub-Saharan Africa[1]



Source: Freedom House

One response has been to turn to technology to register voters and sometimes to authenticate them at the polls in a bid to improve the integrity of the election. As of 2014, 38 low- and middle-income countries had used biometrics to register voters and the number has continued to rise (IDEA 2014). Biometrics, most commonly fingerprints, can be deployed at registration to help ensure a clean voter roll as well as on Election Day to verify a voter's identity. Biometric technology can eliminate multiple registrations and individuals can be prevented from voting more than once or from voting outside their correct constituency. Biometric verification at the polls is less common; in the majority of cases Election Day checks are limited to a comparison of the voter against the picture on his or her voting card. To date, only three African countries have used (or attempted to use) biometric voter identification at the polls: Ghana in 2012, Kenya in 2013, and Nigeria in 2015.

Biometric elections have been generously supported by donors despite two serious reservations. The first concern—as demonstrated by many cases—is that using sophisticated technology does not necessarily increase the credibility or the fairness of elections and can even undermine it. Technologies "are not the solution on their own, and typically they are not the problem alone" (EC-UNDP 2012). Biometrics can only address certain types of

[1] Average score across all SSA countries for which data is available. The Freedom House scale is from 1 (more political rights) to 7 (least political rights).

electoral fraud so that their potential contribution to cleaner elections depends on whether the most egregious threats to electoral integrity coincide with these categories. The use of advanced biometric technology may also not be the most cost-effective solution.

The second concern is that costly one-off electoral registrations leave little or nothing behind in terms of permanent identification assets. Instead, they may even divert attention and funding away from supporting civil registration and financially sustainable national identification systems that, among other functions, should provide the basis for voter rolls. Despite their shortcomings as identification credentials, voter cards can also reduce the incentive to enroll in these programs. Impelled by political parties' urge to register supporters, well-funded voter registration drives often enroll far more people than civil registration or civil identification programs, but without the due diligence and infrastructure needed to provide a fully acceptable ID.

Why, then, are such wasteful exercises supported despite uncertainty over their effectiveness? And how can the momentum created by voter registration be harnessed to support a more sustainable system of registration and identification?

This paper explores the first question by looking at the social and economic costs of disputed elections and comparing them with the cost of electoral biometric technology. We find that the use of technology only needs to decrease the likelihood of serious post-election violence by a few percentage points to make it a worthwhile investment. The high risk of failure can be mitigated by recognizing that technology can only be helpful in some circumstances and by screening potential cases before committing to support them. On the second question, we argue that support for voter registration should include plans to harness its momentum to strengthen core identity management systems and derive lessons from some recent initiatives. We recognize that this may require some re-thinking of institutional mandates, both within the countries and among donors.

While we draw on a variety of country experiences, we focus our analysis and cost comparison on Sub-Saharan Africa (SSA) which is home to the largest number of countries with official UNDP electoral assistance programs.[2] Despite the positive trend over the last two decades, many political systems remain fragile and the risk of electoral violence remains high. As of 2012, 23 countries in the region had used or were currently implementing biometric-based voter registration and/or identification programs (UNDP 2012). At the same time, many of the challenges and policy recommendations described in this paper are likely to apply to countries and electoral processes beyond Africa.

Section II reviews the relationship between "free and fair" elections and the contestation of results with risk of violence. It also considers the positive outcomes associated with successful elections that head off the possibility of violent protests.

[2] UNDP electoral assistance is under the overall lead of the UN's Electoral Focal Point, the Under-Secretary-General for Political Affairs. UNDP assistance is provided once two conditions have been met: 1) there needs to be a request for assistance from the national authorities; and 2) the Focal Point has carried out an assessment of needs to set the parameters for UN assistance.

Section III offers estimates of the cost of elections in twelve countries and, within this, of technology. The costs per voter are often high when compared with estimates for civil registration and national identification, partly because of the equipment and logistics needed to register all eligible voters in a short window of time. It compares the benefits of biometric technology in terms of a reduced probability of post-election violence from successful elections with the costs of technology. The calculations show that under reasonable parameters it is only necessary to reduce the probability of serious post-election violence by a few percentage points for the technology to be a good investment. This points to the very high value of effective identity management—especially under certain conditions—in emerging democracies.

Section IV addresses the use of biometric technology in elections and the circumstances in which it is most likely to be effective. It argues that these are typically in countries at an intermediate stage—neither autocracies nor liberal democracies—where both incumbents and challengers recognize the value of coming to power through a clean election.

Nevertheless, even if these conditions are satisfied high-technology one-off voter registration drives are extremely wasteful. Section V offers additional suggestions to help ensure that electoral assistance builds into a sustainable identification system that breaks the cycle. Section VI concludes.

Before proceeding, we emphasize two points. First, the paper does not advocate for the indiscriminate use of technology in elections. We argue that it is unlikely to be cost-effective at the two ends of the democracy spectrum—either when political regimes are far from free or respectful of democratic processes, or when the country has a well-established track record of upholding political rights and supporting democratic institutions. In the first case, the regime cannot be credible even with a "well-managed" election. In the second, the probability of a disruptive challenge is so small that additional measures to mitigate it cannot be cost-effective. A checklist can be used to delineate the middle ground, to screen cases and focus assistance on the best prospects for success.

Second, cost and benefit estimates are only indicative. Different sources sometimes give varying estimates for the cost of holding elections. The share of technology in the total is also often not clear. Even if data is available for the costs of hardware there will be other costs such as training and logistics, but some of these would have been needed even in the absence of technology. Neither are there precise estimates for the cost of disputed elections that can extend beyond the immediate impact to include the effects of longer-run political and economic uncertainty. The paper is only a first effort to assemble a picture.

2. Why Credible Elections Are a Risk Worth Taking: The Cost of Violent Disputes

It is sometimes argued that successful elections are part of a learning process in a wider process of democratization and development (Lindberg 2006). According to this view, "elections create democracy": once an African country has managed to hold three credible elections the probability of a serious reversal away from democratic governance is reduced due to the internalization of democratic norms.[3] On the downside**,** developing countries with weak institutions and low administrative capacity are considered to be particularly vulnerable to political violence following elections (Collier 2009; Flores and Nooruddin 2012). Without the legitimizing power of free and fair elections, results are more likely to be disputed by the losing party or candidate (Daxecker 2012; Kuntz and Thompson 2009). Straus and Taylor (2012) find that while electoral violence is more common in the pre-election period, post-election violence is usually more intense and more likely to involve both the incumbent(s) and the opposition.

In principle, election results could be disputed for a variety of reasons, including the simple refusal of some parties to abide by the results of a free and fair process. However, in practice there appears to be a strong relationship between elections that are assessed as un-free and unfair and subsequent electoral disputes. Lindberg (2009a) assembles an extensive data set on the timing and sequencing of 256 African elections between 1989 and 2007. He also documents whether they were considered free and fair by international and local election observers and whether their results were disputed by the losing party. When these dimensions are cross-tabulated we see a strong relationship between them (Table 1). Close to 98 percent of presidential and parliamentary elections were disputed when the elections were not considered free and fair. In contrast, only 1 out of 12 entirely free and fair elections was challenged by the losing side.[4]

These are important metrics if we think of disputes in terms of their potential for violence. Even elections that are accepted eventually may be followed by widespread violence in the interim. Given the limitations of the data, only when results are fully accepted (column 1) can we be reasonably sure that no post-election violence will occur. As Table 1 also shows, the likelihood of immediate acceptance rises rapidly as elections progress from having some irregularities to ones that are considered fully free and fair. If technology can help to facilitate this 'jump', it could have an important role in reducing the likelihood of disputes following elections.

[3] This thesis of cumulative experience as building democracy is not uncontested. For a variety of views see Lindberg (2009b).

[4] Logistic regression shows that an election that was largely free and fair (including elections categorized as 'free and fair' and 'free and fair with some irregularities') was 10 times as likely to be eventually accepted by the opposition as one that was not largely free and fair. An election that was largely free and fair was also 49 times as likely to be fully accepted (not disputed at any point) by the opposition than one that was not largely free and fair.

Table 1[5]
Incidence of Disputed Elections in Africa by Prevalence of Electoral Fraud (1989-2007)

		Acceptance of Results			
		Results accepted, election not disputed	Somewhat disputed; acceptance later or none by some players	Results disputed	Total
Quality of elections	Free and fair	11 91.7%	1 8.3%	0 0%	12 100%
	Free and fair with some irregularities	69 47.3%	58 38.7%	19 13%	146 100%
	Irregularities affected the results	2 2.3%	37 42.5%	48 55.2%	87 100%
	Not at all free and fair	0 0%	1 9.1%	10 90.9%	11 100%
	Total	82 32%	97 37.9%	77 30.1%	256 100%

Disputed elections can quickly evolve into violence, with a high human as well as economic cost. Data from Hyde and Marinov's National Elections across Democracy and Autocracy (NELDA) database indicate that 23 percent of all elections in low income and lower-middle income countries[6] over the period 1990-2006 were followed by riots or protests. Close to 80 percent of these post-election protests and riots involved allegations of electoral fraud.

The latest round of Afrobarometer data collected from 34 African countries provides further information. Table 2 shows the relationship between citizen perceptions of the fairness of recent elections and fears of post-electoral violence. In countries where citizens perceive elections as not free and fair or as free and fair with major problems, over 27 percent of the population expresses 'a lot' of fear of violence and political intimidation during elections. In contrast, less than 14 percent express the same high level of fear when elections are perceived as completely free and fair or free and fair with minor problems.[7]

[5] Based on data from Lindberg (2009). For a detailed description of the construction of these variables, see Lindberg (2006), particularly Annex IV.

[6] As defined by the World Bank's 2015 income classification.

[7] A chi-square test and logistic regression support a statistically significant relationship between the free and fairness of the last election and citizens' fear of violence. For these tests, categories were condensed into dummy variables.

Table 2
Afrobarometer: Election Quality and Electoral Violence

Rating of last national election	Fear of becoming a victim of political intimidation or violence during election campaigns				
	A lot	Somewhat	A little	Not at all	Total
Not free and fair	1,870	987	1,130	2,063	6,050
	30.9%	*16.3%*	*18.7%*	*34.1%*	*100%*
Free and fair, with major problems	1,565	1,022	1,496	2,564	6,647
	23.5%	*15.4%*	*22.5%*	*38.6%*	*100%*
Free and fair, but with minor problems	1,583	1,493	2,928	5,698	11,702
	13.5%	*12.8%*	*25.0%*	*48.7%*	*100%*
Completely free and fair	2,891	1,947	3,522	12,934	21,294
	13.6%	*9.1%*	*16.5%*	*60.7%*	*100%*
Total	7,909	5,449	9,076	23,259	45,693
	17.3%	*11.9%*	*19.9%*	*50.9%*	*100%*

Estimating the costs of post-election violence is complicated by the fact that the scale of violence may reflect pre-election conditions rather than the elections themselves—for example, when an election is part of an effort to end a civil war. In these conditions it is misleading to attribute the full cost of post-election violence to the elections themselves. With this strong caveat, there is no doubt that the economic cost of conflict is extremely high. Collier and Hoeffler (2004) estimate that one year of conflict reduces a country's growth rate by 2.2 percent. The negative consequences of both short-term and long-term conflict are wide ranging. Production and livelihoods are lost as factories and farms are destroyed, workers are displaced, and infrastructure is damaged; foreign investment declines for years due to higher perceived risks. Based on Collier and Hoeffler's calculations, should post-election conflict escalate into a civil war, the cumulative economic cost would rise to 105 percent of the country's pre-conflict annual GDP. The hidden costs of violence are also high[8]: children miss out on future opportunities as their education is disrupted; lower incomes and food consumption endanger the health of current and future generations.[9] In an inverse of Lindberg's argument, continuing low levels of trust between different groups in society also make future hostilities more likely.

[8] The economic cost of harm to human health is estimated to be USD 500 million for each year of civil war.

[9] Collier et al. (2008) find that more democratic post-conflict countries (with a Polity IV index score of -4 or above on a scale from -10 to 10) have a 70 percent chance of falling back into conflict, significantly higher than more autocratic nations. They also observe that the year after the election the risk of conflict reversion is significantly higher than the year before.

Elections as the catalyst for violence: Kenya 2007-2008. There are only a few carefully-researched estimates of the economic cost of post-election violence for countries that did not embark on the election from a conflict situation. Kenya's experience after the disputed December 2007 elections has been extensively studied and provides an illustrative example of the potential losses. Irregularities were rampant in the run-up to the presidential election. Opinion polls and early vote counts showed Raila Odinga as the frontrunner. When Mwai Kibaki was announced as the surprise winner, Odinga and the opposition declared the elections fraudulent. The widespread violence that ensued claimed over 1,200 lives and had displaced an estimated 500,000 people by the time a power-sharing agreement between the two political factions was signed on February 28, 2008.

The economic impact was substantial. Kenya's tourist industry, the country's second largest source of foreign exchange, registered a 54 percent decline in revenues in the first quarter of 2008 (Dercon and Gutierrez-Romero 2010). Flower exports, the country's third-largest foreign currency earner, fell by 38 percent in regions affected by the violence (Ksoll et al.

2009). Guibert and Perez-Quiros (2012) create a synthetic control to estimate the overall cost of the post-election disturbances. They find that per capita GDP was reduced by an average of US$70 per year for the 2007-2011 period, about 5 percent of the 2007 baseline level. With Kenya's total GDP at $42 billion in 2007, this would represent a loss of US$ 2 billion per year or over $8 billion for a four-year period.

Elections as failure to end civil war: Ivory Coast 2010/2011. The costs of a failed election can be greater if it fails to prevent continuing civil conflict. The 1992 elections in Angola and the 2010 elections in Ivory Coast offer examples where elections that were intended to put an end to civil war failed to do so, resulting in a return to conflict. Ivory Coast's GDP fell by over 4 percent in 2011 as the fighting between the two main political factions reached its peak; this was almost 10 percentage points below average growth for Sub-Saharan Africa in the same year and 6.5 percentage points below Ivory Coast's five-year average growth in the preceding years. Taking its 2010 GDP as the baseline—and with the important caveat that the roots of the conflict preceded the election itself[10]—post-election conflict is likely to have cost the country at least $1.6 billion, counting losses in just one year.

[10] Ivory Coast offers an example where biometric voter registration was used, but the probability that its use would have decreased the odds of violence was likely extremely low since problems included violent voter intimidation before and during elections as well as unwillingness to accept adverse outcomes. See Section 4 for more details on why the use of biometrics in these cases is likely not a worthwhile investment.

3. Can the Potential Benefits of Biometric Technology Justify its Cost?

Elections have become costly in many developing countries relative to their levels of income although it is not easy to find consistent data. Information on a number of cases suggests a typical cost range spanning $5—$20 per head (Table 3), but this probably does not include a range of other expenses not covered by donors. Spending on this scale is unsustainable for poor countries in the absence of donor support.

Table 3
Estimated Election Costs (in USD)[11]

Country	Year	Registered voters	Election cost	Biometric technology cost	Per voter election cost	Per voter biometric cost
Benin	2011	4,483,000	51,704,000[12]	12,950,000	14.1	2.7
Burkina Faso	2012	4,365,000	58,000,000	23,000,000	13.3	5.3
Cameroon	2013	5,481,226	39,000,000	15,000,000	7.1	2.7
Cote d'Ivoire	2010	5,780,000	330,000,000	266,000,000[13]	57.1	46.0
DRC	2011	32,000,000	360,000,000	58,000,000	11.3	1.8
Ghana	2012	14,031,793	124,000,000	70,000,000[14]	8.8	5.4
Kenya	2013	14,350,000	325,000,000	106,200,000	22.6	7.4
Mali	2013	6,800,000	50,000,000	14,300,000	7.4	2.1
Nigeria	2015	70,000,000	627,000,000	Not available	8.6	-----
Sierra Leone	2012	2,700,000	25,000,000	10,000,000[15]	9.3	3.7
Tanzania	2015	23,161,440	120,000,000	72,000,0000	5.2	3.1
Zambia	2011	5,167,000	67,600,000	14,700,000[16]	13.1	2.8

It is also difficult to separate out the costs of biometric systems (hardware, software, testing and training) from costs that would have been incurred in their absence. Cases suggest that technology costs average around one third of the total, though it is not clear whether this is all related to the biometric systems themselves. Table 3 shows that reported per person technology costs range from close to $46 in Ivory Coast (a noteworthy outlier) to under $2 in the DRC. In a few cases we have good information. The Auditor General's report on Kenya's 2013 election put the cost at $325 million or over $22 per voter, with one third of this representing the cost of the 15,000 biometric voter kits used in the elections (Box 1).

[11] Table 3 draws on a range of studies and reports. For a full list of sources, see Annex.

[12] Voter registration cost; no data on total election costs

[13] Estimates for the biometric technology cost, defined as the amount paid by the Government of Cote d'Ivoire to SAGEM, the provider of biometric kits, vary from $266 million (Piccolino 2015a) to $100 million (Mieu and Airault 2009). See Annex for more details.

[14] Reflects the total cost of biometric voter registration. The cost of biometric equipment alone would be lower.

[15] $10 million is cited by the EC/UNDP Joint Task Force on Electoral Assistance (2013); other sources indicate the cost to be higher, at $18.6 million. See Annex for full sources.

[16] Represents the total amount committed by the Government of Zambia to Continuous Voter Registration in 2010, which uses electronic and biometric technologies to create a permanent register of voters.

Box 1
Procurement of Biometric Voter Registration (BVR) Kits in Kenya's 2013 Elections

Kenya's 2013 election highlights some of the pitfalls of the procurement process and the unsustainable costs of repeated large-scale voter registration exercises. The Independent Electoral and Boundary Commission's (IEBC) total election-related expenditure was about $325 million or over $22 per voter—an amount considerably above the African average (Office of the Auditor General 2014). The procurement process for the BVR kits was opaque and lacked a clear framework for decision-making. Bidding was opened on March 26, 2012 and 29 companies submitted proposals. The proposals were assessed by four different committees: the first Tender Committee, the Evaluation Committee, the Special Evaluation Committee, and the second Tender Committee. The committees arrived at three different conclusions with regards to the proposed winner. The tender process was eventually terminated on July 30, 2012 by the CEO of the IEBC, with no winner selected. After the termination, the Government of Canada (GoC) was chosen, without an open or competitive selection process, to finance and supply the BVR kits. The GoC selected Safran Morpho—a French company which had participated in the previous tender—to supply the kits without any competitive bidding. The IEBC signed a contract with the Canadian Commercial Corporation for $75 million to purchase 15,000 BVR kits from Safran Morpho. Due to the delays in the procurement process that further compressed the enrollment period, this was 5,250 kits more than originally envisioned. The purchase was financed through a commercial loan, which increased the total costs by $31.2million (including loan insurance and interest), to over $106 million for voter registration equipment alone. Other costs of voter registration were $43.7 million, adding up to a total of $149.7 million. This represents an equipment cost of $7.4 per voter and a total voter registration cost of $10.4. In 2016 the election commissioners came under investigation by the Public Affairs Commission for questionable procurement.

From these estimates, the cost of biometric technology for an election can easily run into tens of millions of dollars. The high expense can be explained by a number of factors. Financial support from donors tends to be offered in the run-up to important elections rather than on a continuing basis, leaving countries to start registration only a few months before elections (Gelb and Clark 2013). Huge numbers of registration kits are required to cover the country in a short time, far more than needed for a continuous registration process.[17] Last-minute procurement along with less-informed decisions and, in some cases questionable procurement have led to the acquisition of high-cost packages that inflate the contracts (Box 1). In many countries voter registration remains a one off or periodic affair,

[17] Eight thousand biometric voter kits were procured for Tanzania's 2015 election which registered 23.2 million voters in four months. This translates into an average of around 30 voters per kit per day and only a total of 2,800 voters per kit.

separate from any other program[18] and without follow-up plans to harness its momentum to strengthen permanent registries.

3.1 The Cost of Biometrics vs. the Cost of Disputed Elections

Donors and political actors have often argued that biometric technology can contribute to a cleaner, more meddle-proof electoral process. We assess how sensible it is to invest in biometrics by contrasting the cost of biometric technology to the cost of post-election violence—a risk associated with disputed elections (see Section II).

For the purposes of this analysis, we define the expected cost of an election as the expected probability of violence multiplied by the cost of violence. We could consider an investment in biometric technology worthwhile if the difference between expected costs of the elections *without* the use of technology (expected probability of violence$_{noTech}$ X cost of violence) and expected costs *with* the use of technology (expected probability of violence$_{Tech}$ X cost of violence) would be greater than the cost of biometric technology itself. Because of the limited data points available and the different conditions in each country, we approach this cost comparison through illustrative scenarios using a probabilistic framework.

Drawing on the example of Kenya,[19] we can consider three scenarios for the cost of post-election violence: a loss (possibly over several years) equivalent to 1 percent, 5 percent, or 10 percent of one year's GDP. We could also consider a "worst-case" extreme where the disputed election provokes (or fails to prevent) a descent into civil conflict with a loss of the magnitude scenario (105 percent) suggested by the Collier-Hoeffler study although, as noted above, it is not reasonable to load this full loss onto the conduct of the election itself. The four columns (1 percent, 5 percent, 10 percent, 105 percent) to the right of the dotted line in Table 4 represent these four cost scenarios.

Using the four scenarios and the reported biometric technology costs from Table 3, we calculate how large the 'impact' of biometric technology would have to be in terms of a reduction in the expected probability of post-election violence to justify its costs. We do not know (and do not attempt to estimate) the true probability of electoral violence for the twelve countries for which have biometric cost estimates. However, we can calculate what share of the expected losses from violence the cost of biometrics would equal to. For

[18] This is sometimes justified by the Electoral Commission on the grounds that the national ID or civil registry, usually operated by the Ministry of Interior or Home Affairs, is liable to manipulation by the government. However, like other public agencies, the Electoral Commission can have other interests for wanting its own systems and database, including to benefit from large technology procurements. Kenya's experience is especially egregious because the national ID was required to register to vote. The large expenditures cannot be justified by the need for a de-duplicated roll (the national ID is itself de-duplicated) nor by the argument that voter rolls will otherwise be manipulated by selective refusal to issue national IDs.

[19] While Kenya provides a reasonable benchmark, the economic cost of post-election violence could depend on many factors. For example, Kenya's economy is based on industries like horticulture and tourism that are vulnerable to disruptive shocks and thus it may be more sensitive than an economy dominated by natural resources, as in Nigeria. At the same time, the GDP-based measure probably understates the full economic and human cost of violence.

example, 5 percent of Kenya's 2013 (election year) GDP is about $2.7 billion—this represents the country's potential losses from post-election violence under the '5 percent' cost scenario. Kenya's electoral biometric technology cost was $106 million in the same year, or about 3.85 percent of these potential losses. Thus, biometric technology would need to reduce the expected probability of violence by 3.85 percentage points for it to be a "break-even" investment. [20] The 'break-even' reduction would be smaller if we expected violence to cause greater damage and cost more in terms of GDP (e.g. 10 percent of GDP) and larger if we expected violence to have less damaging consequences and cost less in terms of GDP (1 percent of GDP).

Table 4 shows the 'break-even' reduction in the probability of violence for twelve Sub-Saharan African countries at which the benefits from technology would equal its cost. It includes a speculative calculation for Nigeria, on the basis of technology costs at one third of total election costs as suggested by other cases. With a violence cost of 5 percent of GDP, the break-even probability would be less than one percentage point. These relatively small 'break-even' reductions suggest that technology does not need to be seen as an infallible panacea to be a worthwhile bet. It is usually sufficient to have reason to believe that it has a modest chance of making a contribution to credibility and reducing the likelihood of violence.

[20] If our expected probability of violence was reduced from 20 percent to 16 percent, for instance, the 'benefits' of the technology—in terms of the reduction in the total expected cost of post-election conflict—would be greater than its costs.

Table 4
Break-even Reduction in Probability Violence, by Expected Cost of Post-Election Violence

		Break-even reduction in probability of post-election violence (percentage points)			
Country	**Cost of biometric technology**	By the cost of post-election violence (as a share of GDP)			
		1%	5%	10%	105%
Benin	$12,950,000	17.76	3.55	1.78	0.17
Burkina Faso	$23,000,000	21.44	4.29	2.14	0.20
Cameroon	$15,000,000	5.07	1.01	0.51	0.05
Cote d'Ivoire	$266,000,000	No break-even	21.38	10.69	1.02
DRC	$58,000,000	22.45	4.49	2.24	0.21
Ghana	$70,000,000	16.77	3.35	1.68	0.16
Kenya	$106,200,000	19.23	3.85	1.92	0.18
Mali	$14,300,000	13.07	2.61	1.31	0.12
Nigeria	$200,000,000[21]	3.52	0.70	0.35	0.03
Tanzania	$72,000,000	14.98	3.00	1.5	0.14
Sierra Leone	$18,600,000	52.69	10.54	5.27	0.50
Zambia	$14,700,000	6.20	1.24	0.62	0.06

These conclusions do not, of course, suggest that biometric elections are the most cost-effective way to support a credible voting process. Our calculations simply serve to illustrate that if biometrics are seen as a tool for delivering more credible elections—as both donors and local political actors claim it to be—an expectation of large potential losses from post-election conflict would appear to justify the investment even if the expected impact of biometrics on electoral disputes were relatively small. , how effectively biometric technology can reduce the probability of violence depends on a number of factors, including the type of election fraud that is expected to take place and political actors' level of commitment to a free and fair process. The next section provides an overview of the conditions under which the use of technology is more likely to be a worthwhile investment and when it will likely be a waste of resources.

[21] Estimate; we found no reliable data on the actual cost of biometric technology used in the 2015 Nigerian elections. The estimate is based on the relationship observed between the cost of technology and the cost of the election overall in other SSA elections, where technology tends to make up about one-third of the total election cost.

4. When Can Biometric Technology Make a Difference in Elections?

Biometric elections have produced positive outcomes in a number of countries. Bolivia's biometric registration effort helped allay concerns regarding the quality of the electoral roll and expanded the number of registrants from 3 million to 5 million through enrolling previously undocumented citizens largely from indigenous communities, even though constraints on connectivity hampered efforts to fully de-duplicate the electoral roll (Gelb and Clark 2013; The Carter Center 2009). Pakistan effected a massive cleaning and updating of its voter roll in 2012 using its biometrically-based ID system: almost half the entries in the existing roll were struck off and replaced by a similar number of new enrollees (Malik 2014). In Benin and the DRC biometric voter cards were often applicants' first official identity documents and were used for other purposes after the elections (Gelb and Clark 2013).

Technology can also reinforce voters' trust in the electoral process with perceived reductions in electoral fraud. Following Ghana's 2012 voter registration, over three-quarters of registered Ghanaian voters agreed that biometric registration represented an improvement over the old system; 87 percent believed it to be a useful tool for promoting credible and peaceful elections (Piccolino 2015b). Similarly, a 2014 Gallup poll in Pakistan found that 52 percent of Pakistanis believed that the introduction of electronic voting machines and a biometric system was the most effective reform for free and fair elections—more than twice as many as those who picked any other alternative (Gallup 2014). Public perceptions are supported by some empirical evidence: in a recent study of Ghana's elections Golden et al. (2014) found that polls with working biometric voter authentication machines were less likely to experience multiple voting and out-of-district voting as well as ballot stuffing.

Before Nigeria's polarized 2015 election there was widespread concern that disputes could turn violent, leading to serious conflict and possibly even to a breakup of the Federation. Nwangwu (2015) notes the gloomy predictions of the International Crisis Group, the CLEEN Foundation and the National Human Rights Commission. News reports were similarly dire, prompting prominent officials to assure the public that the nation would not disintegrate.[22] Instead, the election resulted in a peaceful transition of power. Biometric permanent voter cards and card readers were widely credited with curbing multiple voting and ballot stuffing despite reports of technical difficulties in authenticating voters at the polls (Nwangwu 2015; Wallis 2015).[23] The avoidance of disputed results and post-election

[22] An example of coverage from Reuters: "As Nigeria approaches its most divisive and closely fought election since the end of military rule in 1999, its leaders are having to reassure voters that Africa's most populous nation will remain in one piece. […] there are signs the elections could trigger violence that may not be as easy to quell as in 2011, when Buhari's loss to Jonathan triggered three days of riots in the north that killed 800 and displaced 65,000." From: http://www.reuters.com/article/us-nigeria-election-analysis-idUSKBN0KU1HG20150121

[23] Kayode Fayemi, the policy chief of opposition candidate and winner of the presidential elections Muhammadu Buhari, was quoted by the Financial Times: "The card readers and PVCs [permanent voter cards] won us the elections." From: http://www.ft.com/intl/cms/s/0/182a947e-d7a6-11e4-849b-00144feab7de.html#axzz4AZ7mxKM7 Another Financial Times report quotes Nasir

violence has been taken by some to suggest a turning point for the country and possibly for the use of biometric technology in African elections.

Despite such cases, the track record of technological solutions is mixed. Failures can be technological (failure to read fingerprints) or due to poor implementation and logistics (kits distributed without power or time for a charge). They may be unintended or result from deliberate actions. Golden et al. (2014) show that breakdown rates of biometric ID machines in Ghana's 2012 elections were associated with the absence of election observers at polling stations—that machines were more likely to break down at stations without an election observer as well as in more closely contested constituencies. In Zambia, the fingerprints of over 10 percent of potentially eligible voters could not be captured by the machines (Evrensel 2010). During Ghana's 2012 elections biometric machines failed at 19 percent of polling stations (CODEO 2013). In Kenya's 2013 elections, the electronic polling book malfunctioned or failed at 55 percent of the polling stations at some point during the day (ELOG 2013). Problems with biometric voter verification were also reported in Nigeria's 2015 elections, including failure to verify the fingerprint of the incumbent President.[24]

Critics argue that technology can perpetuate an atmosphere of suspicion and mistrust by circumventing the human processes that have to work and have to be seen to work. Central components of the election are placed in a 'black box' that voters cannot observe or evaluate for fairness (Evrensel 2010). Contracting with foreign technology companies not just to deliver the biometric equipment, but also to manage and clean the vote database may weaken ownership of the electoral process and raise further concerns about its independence. Without an understanding of how the technology works, there is no basis for increased trust among political parties or for greater legitimacy among the electorate.

In short, there is no guarantee that the use of technology will result in cleaner, less disputed and more democratic elections. But it is possible to outline some circumstances under which its use is more likely to be useful and cost-effective. We consider three factors: the limited types of fraud that technology can address, the political will to hold clean elections, and implementation capacity.

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el-Rufai, a close adviser to General Buhari and a governorship candidate: "I think the card reader and the PVC have helped deepen democracy in Nigeria. Whatever one can say about INEC [the Nigerian Elections Commission], they must be commended for introducing the technology to improve the process." From: http://www.ft.com/intl/cms/s/0/182a947e-d7a6-11e4-849b-00144feab7de.html#axzz4AZ7mxKM7. In a similar vein, U.S. Ambassador James Entwistle was quoted after the poll: "Fortune favors the bold. Deciding to go hi-tech was absolutely the right thing to do." From: http://www.reuters.com/article/nigeria-election-technology-idUSL6N0WZ2JF20150402.

[24] Pre-election card reader testing indicated that the machines could fail to verify the fingerprints of as many as 41 percent of voters, leading to the decision to permit other forms of verification. However, they were far more successful in verifying voter cards and curbing multiple voting; according to the election commission, only a very small fraction of readers malfunctioned in this area. Nwangwu (2015) notes that in some cases polling officers unfamiliar with the machines failed to peel off the nylon film covers of the readers, raising the failure rate of fingerprint verification.

4.1 The Spectrum of Election Fraud

Biometric voter registration can improve the integrity of the voter roll and assist in preventing the registration of non-existent individuals. Pakistan's cleaning of the voter roll, for example, was based on a population register developed with strong biometric controls. It resulted in the removal of 15 million voters without verifiable identities, an additional 13 million with invalid identities as well as 9 million duplicates while adding 36 million new eligible voters (Malik 2014). The voter roll was also "liberated" so that citizens could check on their mobile phones to ensure that they had been registered. Reportedly, this facility responded to over 60 million queries.

However, technology does not avoid all the pitfalls of politically motivated registration efforts. The incumbent government may exclude certain groups by restricting registration offices to those areas where they expect their support to be strong or by requiring credentials which are more widely held by some groups than by others. It can change or reinterpret laws on who is considered a national and qualified to vote. In Cote d'Ivoire, the electoral code was revised ahead of the 1995 elections to bar anyone without two Ivorian-born parents from running for office, so disqualifying the leading opposition candidate Alassane Outtara. The government—with its support base in the country's Southwest—also refused to register those with "dubious nationality" during the 2000 elections, which disproportionately affected residents in the country's North. Excessively strict criteria for proving one's nationality for the purposes of voter registration led to further disenfranchisement of the poorest and youngest citizens (Piccolino 2015b).

Such forms of pre-election bias cannot be constrained by the use of technology. Voter intimidation can reduce the participation of an opponent's supporters, while vote buying can increase one's support base. Voters' choice between candidates can be influenced by rules on who is allowed to run, what financial and other support candidates may receive, and what campaigning tools and platforms they have access to. Such pre-election biases have been evident in Zimbabwe, where government and opposition parties have hugely unequal access to state media during campaigns. Opposition leaders and supporters have been imprisoned and tortured and militias linked to the governing ZANU-PF party have been reported to threaten villages with collective retribution should they vote for the opposition (Human Rights Watch 2014; Freedom House 2014; Moyo 2013).

On Election Day, biometric voter verification can prevent multiple voting or impersonation of another voter by an individual and can also be used retroactively to detect fraud[25]. The analysis of inked fingerprints required to vote in Pakistan's election revealed massive fraud, including a case of one man voting over 300 times from a voting facility reserved for women (Malik 2014). If the number of verified voters at a polling station is compared to the number

[25]As mentioned in Section 1, only very few biometrics-assisted elections have implemented systems that enabled real-time verification of voters on Election Day and it has often been accompanied by technological issues. While real-time voter verification does not require connectivity (voter ID cards can store biometric information and match it against the holder of the ID at the polls offline), real-time prevention of multiple voting would require continuous (online) communication with the voter database. This is often very difficult.

of ballots cast, biometric authentication can also help prevent ballot stuffing, one of the most common forms of electoral fraud in developing countries.[26]

Nonetheless, votes can be intentionally miscounted, vote tallies altered or simply ignored. Legitimate complaints about the electoral process may go unaddressed and/or unfounded claims and complaints may be given credit as a result of undue political influence. These issues, too, are beyond the scope of biometric voter registration and verification technologies. There is also the risk that as technology reduces opportunities for certain types of fraud, contenders may simply shift their manipulation strategies to areas less affected, such as voter intimidation or vote buying.

Thus, biometric voter registration can make the most difference where the integrity of the voter roll has been severely compromised, while biometric voter verification at the polls will likely contribute most where voter impersonation, multiple voting, and—when coupled with voter counting—ballot stuffing are expected to pose problems. But technology will be ineffective where there is no political will to hold a clean election.

4.2 Political Will

If political will is essential for its effectiveness, can technology actually be useful? Will it only be effective when it is not needed? If so, how to account for the cases when it actually seems to have made a difference? We consider three types of situation.

a) Countries with a long-established tradition of peaceful elections and transitions of power. In these, there is little room for technology to boost the credibility of elections. Voters have a high degree of trust in the electoral process, the 'rules of the game' are widely accepted by all political parties and credible institutions are at hand to resolve disputes peacefully. If we expect no violence at all, the 'ideal' cost of additional technology is zero.

b) Countries where important political actors are not prepared to accept the possibility of free and fair competition or an adverse outcome. Technology will be ineffective. Long before elections, potential voters will have been disenfranchised, the political opposition suppressed and its access to media curtailed. In these conditions the election result cannot be credible with or without the use of technology.

c) The intermediate case: political candidates value the legitimacy conferred by an election that is recognized both domestically and internationally as largely free and fair. The opposition is active and has access to the media and there is reasonable consensus on who is eligible to vote. Even though there may be efforts to subvert the election, evidence of overt fraud is seen as a political liability.

[26] Simply comparing the number of officially registered voters to the number of ballots cast can also reveal the most egregious cases of ballot stuffing, should the number of ballots exceed the total of those registered. Comparing the number of verified voters on Election Day to the ballots cast is more precise.

This third case is the most favorable for the use of technology, as a complement to other factors rather than a substitute. It can help build voter's trust in the elections—as shown by the opinion surveys of Ghana and Pakistan—increase the legitimacy of the process, and so reduce the probability of disputes and the likelihood that they will turn violent. From the spread of cases in Table 1, a number of African elections appear to fall within this category.

It is important to note that even where the political and country context is favorable, trust can sometimes be strengthened by other means such as voter information and education campaigns (Yard 2010) or through reinforcing the independence of institutions in charge of arbitrating electoral disputes. Low-tech approaches to tackling fraud, such as using indelible ink to mark voters' fingers, can also help to prevent multiple voting under certain circumstances.[27]

4.3 Implementation Capacity

The successful deployment of technology is also contingent on at least a minimum of administrative and logistical capacity. Its use depends on a country's pre-existing infrastructure: roads to deliver biometric kits, electricity to power card readers and scanners (though new kits include solar as an option), reliable broadband or mobile networks to transmit data for de-duplication and to submit results, a robust data system to store, verify, and tally the data received, trained staff to operate the equipment and perform troubleshooting if issues occur.

Performance testing is also essential but sometimes not done before the start of the registration process or voting. This is often due to delays associated with procurement. Low-quality hardware may be purchased or even good-quality equipment may malfunction if used in an operating environment it was not designed for—a particular problem given the time-bound nature of elections. The resulting delays and confusion—which may not be seen as negative by some political interests—can undermine the electorate's trust, give rise to accusations of electoral fraud, and thus aggravate the very problems it was supposed to prevent. Many of these problems can be avoided by allowing sufficient time to establish the feasibility of different solutions in the given country context and to carry out the procurement and delivery of equipment (UNDP 2010).

5. Harnessing Voter Registration for a More Sustainable ID System

One-off exercises that have to be repeated each election and that fail to seize the potential of voter registration for building a broader civil registration and identification system are also very wasteful. Voter registration drives can be astonishingly successful in registering a large number of the population. Competitive elections drive interests across the political spectrum to register voters. This could provide a unique opportunity to lay the foundation of a

[27] It may not be effective when there is complicity from the election officials manning the polls. See Malik (2014) on multiple voting in Pakistan.

digitized central registry and a connected, multi-application, ID system. In Ghana, a country with weak civil and national registration, the 2012 biometric voter registration managed to register over 14 million people in 40 days.[28] In the run up to Nigeria's 2015 elections over 67 million people were registered and issued voter cards; in contrast, only 6 million had been enrolled in the country's longstanding national e-ID program.[29] In Tanzania 23.2 million were registered for the 2015 election in only 4 months compared with 2.4 million for the National ID program over four years. Initiated in 2011, the National ID had been expected to form the basis for the 2015 voter roll but its rollout had been far too slow.

Voter drives may even divert attention and funding from the development of a financially sustainable national identification system based on improved civil registration that can form the basis for the voter roll at much lower costs**.** The annual operating costs of RENIEC and NADRA, the identification authorities in Peru and Pakistan, are around 0.6 percent of GDP per year.[30] Both entities have close to 100 percent adult coverage, and their costs are largely covered by fees levied on users, such as banks, to authenticate clients. Voter rolls in these and many other countries are based on national registration. With unique (biometrically de-duplicated) national identities the voter rolls are automatically de-duplicated. Another useful cost comparator is South Africa, which has continuous voter registration as well as an extensive civil registration and ID program. Direct technology related costs are about $24 million or $1/voter for a five year election cycle, which encompasses one general election as well as one round of municipal elections. [31]

How can the momentum of voter registration be harnessed to support a sustainable system? One option is to base the national population register and ID system in the election authority itself. Bangladesh is currently implementing this approach, converting its voter roll into the basis for a National ID. While it has worked in some cases—RENIEC in Peru, for example, started out from a basis of voter registration—it is not an ideal solution, since the mandate of an election authority is very different from that of a national registry. Voter rolls are updated only periodically as needed for elections, and there is no incentive to register non-voters. Hasty mass voter registration permits only a low level of due diligence in screening applicants and verifying their information. Moreover, most countries already have institutional and legal structures in place to implement civil registration and identification programs even though implementation may not be highly advanced in these areas.

[28] The integrity of the resulting voter roll has since been questioned given the unusually high share of the population who was eligible to vote (56 percent). See: http://www.ghanaweb.com/GhanaHomePage/NewsArchive/Why-Ghana-Has-Probably-the-World-s-Worst-Voters-Register-313424

[29] As of February 2015

[30] Calculations in Gelb (2016) based on data in Atick (2014).

[31] Includes expenditures in the following categories: purchase of equipment and software, rented equipment, computer services/ wide area network. For 2014, we include 'connectivity and communications' as no separate computer services costs were listed. Source: South Africa's Independent Electoral Commission: Annual Reports. Total costs are around $550 million for 25 million voters ($22/voter) over the course of five years. While this may seem high, wages in South Africa are a multiple of their levels in low-income countries and constitute about half of spending.

A preferred approach is "backward integration"—a commitment to ensure that identification assets created by voter registration are made available to strengthen the civil registration system and the population register. This requires the legal authority to transfer data after the election, interoperability between the voter and population registers to ensure that the data can be integrated and adequate quality of voter data. It also requires that the technology used for voter registration be compatible with that used for national registration, so that the costly biometric voter registration kits can be reemployed. Tanzania is currently implementing such a process. The aim is to integrate the 22.3 million voter records into the NIDA (National Identification Authority) database to produce a unified registry. This, it is hoped, will result in a single identity system with high adult coverage but with two (linked) credentials: the voter card and the national ID card. Over time, as the information from the voter roll is upgraded to conform to that of the national program, the voter cards can be phased out. Subsequent voter rolls can then be based on the integrated ID system.

6. Conclusions and Implications for Policy

Elections have emerged as a costly and controversial area for the application of biometric technology in developing countries and one where it is particularly difficult to frame a general conclusion regarding success or failure. Evidence on both sides is heavily anecdotal and case-specific and each case is unique. Losers benefit from discrediting the technology while winners may invoke its support for otherwise flawed elections. In either case, expensive one-off voter registrations, often heavily supported by donors, are neither cost-effective nor sustainable.

This paper offers an analysis of the use of the technology and suggests some criteria that can be applied to increase the chances of success as well as help harness the momentum of voter registration to strengthen permanent systems for registration and identification.

First, even rough comparisons indicate that the economic and human costs of heavily disputed elections that are quite likely to result in violence are very large relative to the (high) cost of technology as applied in a number of developing countries. The probability that results will be disputed does appear to be closely related to whether the election is seen by domestic and international observers as free and fair. It is therefore understandable that donors have tried to help ensure the integrity of elections even with serious reservations on whether their support will prove effective. If support can help to boost the credibility of an election and reduce the probability of violent disputes by only a few percentage points, the payoff will probably exceed the cost. This is not to say, of course, that technology is necessarily the best or most cost-effective way of achieving this result.

Second, the probability of a favorable impact will be higher if some basic prerequisites are in place. They include consensus on who is a national and eligible to vote and a commitment to support open political campaigning and access to media. There is little point in supporting a biometric voter roll or biometric voter authentication at the polls if large segments of the electorate have been disenfranchised or the opposition has been severely suppressed. Countries requesting assistance to finance the use of technology should be screened by such

criteria. Donors should also take into account the views of opposition parties on whether the approach, if it actually worked, would resolve the most serious credibility problems. If these conditions are not satisfied technology cannot be a positive factor: it will rather be "a solution looking for a problem." Donors should also insist on open technical standards and procurement, and a timeframe that permits reasonable testing, training, public information and deployment.

These criteria would probably constrain large-scale financial support for the deployment of technology away from the most difficult cases where there is not much hope for a free and fair election and towards a middle category of countries where the credibility of the election is seen by all parties as important. They also raise the possibility of a more competitive process of allocating support, with countries offering clear commitments and a business plan as a condition to be eligible to bid for financial assistance from a pool of resources.

The third conclusion of the paper is that financial support for high-tech elections should be conditional on an agreed plan to use the resulting identity assets to strengthen the core systems of civil registration and identification. Countries will need to have an appropriate legal framework in place to permit this; procurements should require technical standards for equipment and data that enable them to be integrated into the core system. The forces of competitive electoral politics should be harnessed to strengthen permanent systems rather than distract from them.

In short, recent experiences with the use of biometric technology in elections suggest that—under certain circumstances—it can contribute to cleaner, more widely accepted, and less violent elections. But the full range of its potential benefits, particularly the opportunity to provide an official identity for millions within a short timeframe, too often remain unexploited. Bridging this gap would enable countries' and donors' investment in biometrics to go from 'potentially wasteful' to 'definitely high-return'.

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Annex

Table A1
Cost of Elections

Country	Year	Cost (election)	Cost (voter registration)	Cost (biometric technology)	Registered voters	Biometrics per capita cost	Total election per capita cost	Number of biometric kits/equipment
Benin	2011	?	$51,704,000	$12,950,660	4,483,000	$3.57	$14.2	3215 kits
Burkina Faso	2012	$58,000,000		$23,000,000	4,365,000	$5.27	$13.3	3500 kits
Cameroon	2013	$39,000,000		$15,000,000	5,481,226	$2.74	$7.1	1200 kits
Cote d' Ivoire	2010	$330,000,000		$266,000,000	5,780,000	$46.02	$57.1	
DRC	2011	$360,000,000	$94,797,844	$58,000,000	32,024,640	$0.94	$31.2	9500 kits[32]
Ghana	2012	$124,000,000		$70,000,000	14,031,793	$4.99	$8.8	7150 kits
Kenya	2013	$325,000,000	$149,700,000	$93,800,000	14,350,000	$6.54	$22.6	15,000 kits
Mali	2013	$50,000,000		$14,300,000	6,800,000		$7.4	
Nigeria	2015	$627,000,000		?	67,422,005		$8.9	
Sierra Leone	2012	$25,000,000		$10,000,000	2,701,299	$3.7	$14.8	800 kits
Tanzania	2015	$120,000,000		$72,000,000	23,161,440	$3.1	$5.2	8000 kits
Zambia	2011	$67,600,000	$14,700,000	?	5,167,154	$2.84	$13.1	1000 kits

Sources of Election Costs for Table A1

All voter registration figures come from the Institute for Democracy and Electoral Assistance's (IDEA) Voter Turnout database. This data can be retrieved from: http://www.idea.int/vt/index.cfm.

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