CALTECH/MIT
VOTING TECHNOLOGY PROJECT

A multi-disciplinary, collaborative project of
the California Institute of Technology – Pasadena, California 91125 and
the Massachusetts Institute of Technology – Cambridge, Massachusetts 02139

TITLE Evaluating New Voting Technologies in Latin America

Name R. Michael Alvarez
University Caltech

Name Gabriel Katz
University Caltech

Name Julia Pomares
University London School of Economics

Key words:

VTP WORKING PAPER #93
December 14, 2009

Evaluating New Voting Technologies in Latin America

R. Michael Alvarez[*], Gabriel Katz[†], and Julia Pomares[‡]

December 14, 2009

*Professor of Political Science, California Institute of Technology. [†] PhD candidate, California Institute of Technology. [‡] PhD candidate, London School of Economics. Corresponding author. Email: j.s.pomares@lse.ac.uk. We thank our research partners from both the Argentina and Colombia pilot projects for their assistance with related research: Ernesto Calvo (University of Houston) and Marcelo Escolar (Universidad de Buenos Aires); Ricardo Llamosa and Hugo E. Martinez (CIDLIS-Universidad Industrial de Santander). We thank Josep Reniu for his comments. This paper is based in part on a presentation Alvarez provided as part of "Democracia Electoral: Hacia Una Nueva Agenda", Instituto Electoral Veracruzano: Xalapa, MX, October 16, 2009. Alvarez thanks Alfonso Ayala and Nathanial Persily for their comments about the presentation, and workshop participants for their questions and comments. Alvarez also thanks the Carnegie Corporation of New York, John S. and James L. Knight Foundation, and the Pew Charitable Trusts for their support of the research discussed in this paper.

Having remained virtually unchanged since the enactment of universal and secret suffrage at the end of the nineteenth century, voting procedures are undergoing a radical transformation in many countries through the introduction of electronic methods of voting. Almost 30 countries around the world are currently in process of testing or implementing electronic voting, and in at least 10 countries e-voting is the main method used to elect national representatives (Alvarez and Hall 2008; Pomares 2009).[1] Although it might be assumed that electronic voting would be more likely to arise in established democracies, e-voting has disseminated rapidly and extensively in the developing world. Two of the most populous democracies in the world, Brazil and India, are among the pioneers in switching to electronic voting (e.g., Rodrigues-Filho et al. 2006; Kumar 2008). Furthermore, one third of the countries testing electronic voting are in Latin America. What explains both of these trends?

Our argument is that new technologies offer a potential tool to mitigate electoral fraud and increase public trust in the efficacy and transparency of electoral processes in the region (Avgerou et al. 2009; Barrat 2006). In fact, this has been an important determinant for the adoption of electronic voting in the two countries of the region that currently use e-voting for all official elections, Brazil and Venezuela. For example, acording to the *rapporteur* to the Special Committee on the Security of Electronic Voting established by the Brazilian chamber of Deputies in 2007, "voting through voting machines began in Brazil in 1996 motivated particularly by the need to combat fraud." (p. 4, original in Portuguese). Anecdotal evidence also suggests that the lack of trust in the fairness and legitimacy of elections was also an important concern of Venezuelan authorities when switching to voting machines.[2]

But more than a decade after the introduction of electronic voting in Latin America, there is scant research on voters' opinions about e-voting along these dimensions and no analysis of their policy implications. This paper provides a first attempt to address these issues from a comparative perspective, using survey data from recent e-voting pilots conducted in Argentina and Colombia in which several different e-voting devices were tested. The data collected during the two field experiments allows us to study voters' assessments of electronic voting and their determinants, with special emphasis on the analysis of their opinions about the usability and reliability of the new voting technologies. In view of the opposing arguments about the convenience of implementing electronic voting systems in Latin America (Rezende 2003; Rodrigues-Filho et al. 2006) and the lack of empirical evidence informing this debate, our research can provide valuable insights about the implications of adopting the new voting technologies and their potential to enhance the quality of electoral processes in the region. The randomized experimental design used in the two pilots analyzed mitigates some of the problems that have plagued previous studies in this area, such as endogenous adoption of voting technologies and self-selection into different voting devices (Saltman, 2006; Herron and Wand 2007; Herron, Mebane and Wand 2008, Stein et al. 2008), while allowing for a more realistic and representative environment than laboratory experiments (Harrison and List 2004).

The spread of e-voting in Latin America

[1] This figure excludes those countries that trialled e-voting for non-political contests.

[2] Before the introduction of electronic voting, certificates of tabulation at the precinct level (*actas)* in Venezuela used to be call *mata-votos* ("votes killer") since it was an entrenched practice of poll authorities to decide how to distribute votes after the closure of election. The replacement of manual *actas* by e-voting was accompanied by changes in selection criteria of poll authorities.

Electronic voting systems have been increasingly used in Latin America since their introduction in Brazil in the mid 1990s. As seen in Table 1, 10 Latin American countries have implemented some kind of electronic voting system and an additional one, Panama, announced the roll out for the 2006 referendum but cancelled it shortly before the election.[3]

In most countries, the e-vote experience is non-binding and occurs in local elections, although Brazil (1996) and Venezuela (1998) have implemented automated voting systems in official elections. There seems to have been a 'contagion effect' in the region, insofar as the implementation of electronic voting in Brazil proved to be important for the spread of e-voting to other Latin American countries in the first half of 2000s. With the financial support from the Organization of American States (OAS), the Brazilian Electoral Supreme Court provided voting machines to conduct binding pilots in other countries in the region (Ecuador, Paraguay and Argentina). All of these experiences have been `supervised e-voting' elections in which voters go to the polling station and are asked to cast a vote on a computer, rather than `remote' e-voting. While the same type of direct recording electronic (DRE) device is currently in use country-wide in Brazil and Venezuela, countries in a testing stage have tried alternative electronic voting systems in different types of elections. [4]

[3] Of 18 Latin American countries, the countries that have not implemented e-voting (as of June 2009) are Chile, Uruguay, Guatemala, Nicaragua, Bolivia, Honduras and El Salvador.

[4] The first e-voting elections in Venezuela (1998-2000) used optical scanning systems.

Table 1: The road to e-voting (EV) in Latin America

Country	Type of implementation: Pilot (binding or not) or roll-out*	Type of election (Highest)	Year of first EV election/ pilot	% of registered e-voters (last election)	Type of EV
Argentina	Several binding and non binding pilots	National	2003	N/A	Several devices (including Brazilian DRE)
Brazil	Roll out for all types of elections	National	1991	100 (since 2000)	DRE (two terminals); one for voter registration and other for casting ballot
Colombia	Non binding pilots	Local	1992	N/A	Several devices
Costa Rica	Binding Pilot	Local	2002	2.3	
Dominican Republic	Planned to roll out in 2006 elections. Procurement did take place but was not implemented. Used in primary of incumbent party	Primary of governing party	2006	-	Brazilian DRE
Ecuador	Binding pilot. It was planned to continue in 2006 but was cancelled	Local	2004	0.7 (2004)	Brazilian DRE
Mexico	Non binding and binding pilots at several states; also used in internal elections of political parties	Provincial (State-level)	2003	N/A	Several devices
Panama	Election authorities announced roll out for 2006 Canal referendum but cancelled the implementation	-	-	-	-
Paraguay	Binding implementation at 2003 presidential election but went back to paper ballots in 2008	National	2001	53 (2003)	Brazilian DRE
Peru	Several non-binding and binding pilots	Provincial	1996	N/A	Brazilian DRE
Venezuela	Roll-out for all types of elections	National	1998	100 (since 1998)	Optical scanner (1998-2000); DRE (2004 onwards)

* *Roll out*: at least two consecutive binding national elections. Otherwise, it is categorized as *pilot*. The table excludes pilots for non-political contests (such as trials at universities)

The impact of voting technologies on voters' trust in elections

Despite this increasing trend towards the adoption of electronic voting in Latin America, there has been no systematic analysis of past e-voting experiences from a voter's perspective. Most research on this region has focused on Brazil, and is mainly theoretical or descriptive (Avgerou et al. 2009; Rezende 2003; Rodrigues-Filho et al. 2006). Although recent studies point to positive prospects of e-voting for boosting trust in election (e.g., Avgerou et al. 2009), there is no comparative analysis across the region, and the evidence on the influence of voters' individual characteristics and of different automated voting systems in this regard is quite scarce. Most work analyzing the interaction between citizens and automated voting systems is from the U.S. (Alvarez et al. 2008; Stewart 2009). This research uses survey data to examine voters' trust in the electoral process, and specifically their trust of electronic voting; generally these studies indicate that specific characteristics and types of automated voting systems might influence citizens' trust in the electoral process. This is consistent with the broader literature indicating that alternative voting technologies have different effects on voters' attitudes and electoral behavior (Herrnson et al. 2008).

In the same direction, several authors maintain that, *ceteris paribus*, providing electronic voting systems with a verifiable record of each vote, in particular a paper audit trail, can substantially increase citizens' trust in elections and by allowing them to check whether the ballots cast represent their true intent (Riera and Brown 2003; Alvarez and Hall 2008). By contrast, some scholars argue that a VVAT could in fact undermine voters' confidence in the electoral process in case of inconsistency between electronic and paper records (Herrnson et al. 2008). Although empirical evidence shows that there is no improvement in voter satisfaction as a consequence of paper audit systems (Herrnson et al. 2008), we are not aware of systematic analysis of the impact of a voter verifiable paper trail on perceptions of trust in the election process.

In addition, previous studies also find that trust in new voting technologies is significantly affected by voters' characteristics such as age and levels of education (Alvarez, et al. 2008; Stewart, 2009). Similarly, the previous work tends to find that familiarity with technology improves perceptions of trust (Alvarez et al. 2008; Avgerou et al. 2009). However, using exit polls to examine opinions of electronic voting among voters in Belgium's 2003 federal election, Delwit et al. (2005) find that a significant proportion of highly educated voters were opposed to computer voting, and that this induced a slight lack of confidence in the automated voting procedure. In the same direction, Oostveen and van den Besselaar (2004) suggest that voters with greater computer skills might be more aware of the potential vulnerabilities of ICT-based voting technologies and therefore less trusting. Also controversial in the literature is the potential disenfranchisement of those less familiar with technologies. Some have noted that computer voting could unduly slant election results in favour of particular groups of voters to the detriment of others (Coleman 2004). In this sense, Rodrigues-Filho et al. (2006) have expressed concerns that the implementation of electronic voting in Latin America might deepen the digital divide in the region and entail negative consequences for democratic representation.

Finally, besides technical differences between alternative e-voting devices and voters' individual characteristics, prior research suggests that the perceived legitimacy of election authorities and the quality of election administration can substantially affect voters' trust in electronic voting (Avgerou et al. 2009; Stein et al. 2008). In this vein, Avgerou et al. (2009)

maintain that the positive predisposition of Brazilian citizens towards the institutional actors in charge of the election administration played an important part in the successful adoption of electronic voting in that country.

The lack of empirical evidence concerning voters' views of e-voting in Latin America, coupled with the fast spread of computerized voting in the region, highlights the importance of assessing the potential impact of the new technologies on citizens' trust in the electoral process. Based on previous findings, we expect that Direct Recording Electronic (DRE) users are less confident than those casting a vote through an optical scanner, and that the addition of a voter verifiable paper trail exerts a positive impact on trust in the election process. While we also expect individual characteristics such as age and education to positively impact on voters' confidence in e-voting, some studies (Oostveen and van den Besselaar 2004; Delwit et al. 2005) raise some doubts about the direction of these effects. Overall, we have no clear expectations about the degree of trust in the new technologies among Latin American voters.

In order to test these hypotheses and, more generally, to analyze the degree of confidence Latin American voters place in electronic voting and their opinions of the new automated technologies, we analyze data from two recent pilot studies conducted in Argentina and Colombia. This allows us to examine the impact of alternative e-voting technologies on voters' trust in elections while controlling for relevant socio-demographic characteristics shown to affect confidence in electoral processes.

E-voting pilots in Argentina and Colombia

Argentina and Colombia have recently conducted large-scale pilot projects aimed at testing different electronic voting technologies and evaluating users' attitudes towards the new voting procedures.[5] In 2004, a modification in Colombian electoral law opened the possibility of adopting an automated voting system in the country and regulated its implementation. In order to explore the feasibility of introducing e-voting in official elections, a nation-wide e-voting pilot was conducted in 2007 by Colombia's Electoral Authority (*Consejo Nacional Electoral*) and the Center for Software Research and Development from the *Universidad Industrial de Santander*.

In Argentina, on the other hand, the national electoral law does not allow for electronic voting but as a consequence of the decentralized election administration system, each of its constituent units can reform its election law to allow for voting machines for provincial and local elections.[6] The e-pilot under analysis was conducted in the City of Buenos Aires led by the *Dirección Electoral* of the Government of the City of Buenos Aires and the supervision of a team of political scientists, geographers, and computer scientists who were charged with the responsibility of designing the experiment.

As in many countries in Latin America, public trust in elections and electoral authorities in both countries is relatively low. Only 47% of Argentine respondents in the 2006 *Latinobarómetro* survey believed the elections in the country to be free and fair.

[5] The description of the pilots conducted in Argentina and Colombia draws heavily from Calvo, et al. (2009) and Alvarez, et al. (2009), respectively. More information on the pilots can be found there.

[6] Over the last five years, several Argentine provincial legislatures passed legislation to allow for the replacement of paper ballots in provincial and local elections. Although there have been several legislative proposals at the City of Buenos Aires, enabling legislation has not been passed yet. That is why the e-voting pilot under analysis was not part of the official election.

Though this figure is above the regional average (41 per cent) it is well behind the two countries which rank at the top (Uruguay and Chile) that exhibit more than 70 per cent. The results of the same survey for Colombia show a quite extremely low figure: only 29 per cent of respondents perceive elections in their country are clean (Latinobarómetro Report 2006, p. 18).[7]

The two pilots under analysis share many features. Both were mock elections in which voters were randomly assigned to one of the four types of voting machines under assessment. Also, although they were both non-official they were organized close to a general election in order to capitalize on the nationwide `political climate' to encourage participation in the experiment. The Argentine pilot was conducted during the 2005 national legislative election. The e-pilot organized in the city of Buenos Aires included 14,800 participants in 43 polling stations randomly distributed throughout the city. After voting in the official election, randomly chosen participants voted in a second non-compulsory election in which they cast a vote for the election for national representatives and another for the election of state legislators. The Colombian pilot took place in October 2007, the day before country-wide municipal elections. The field study was conducted in nine locations in three cities: Bogota, Pereira and San Andres. Voting booths were installed in three shopping malls in each city, selected due to their geographical location, to guarantee a diverse pool of potential subjects. Citizens in each of the testing locations were invited to take part in a mock election in which they had to choose one candidate for president and one for the senate, with a total of 2,294 participants in the test.

Participation in each pilot was voluntary.[8] The only eligibility requirement was to be older than 18 years of age and being able to provide a valid form of identification; registration and inscription procedures were analogous as those used in official elections. Participants were randomly assigned to one of the four voting machines available in each testing location and received the instructions and a five-minute training needed to operate it. After casting a vote, participants were asked to provide basic socio-demographic information - age, education, gender - and to complete a survey containing questions dealing with usability issues of the devices tested as well as with their general perceptions about electronic voting. In the Buenos Aires pilot, a sub-sample of 3,084 participants was randomly chosen to answer a longer exit poll, inquiring their familiarity with technology, political participation, education, and political information. Some of the survey items were identical in both pilots, while some others are not directly comparable. We take these differences into account when discussing the empirical results.[9]

---

[7] Country-specific surveys report higher trust rates though still low. In 2005, an opinion poll by the Universidad de los Andes (Universidad de Los Andes 2005) showed that the National Electoral Authority ranked at the bottom of Colombian institutions in terms of citizens' confidence: only 53.2% of respondents in declared to trust elections, while the level of confidence in the electoral authority was even lower (48.6%).

[8] Note that voting is compulsory in Argentina and not in Colombia.

[9] The survey items from the 2005 Argentine e-voting pilot were: (I) *Are you confident that your vote was registered as intended?* (1=not at all confident, 4= very confident); (II) *How easy was to use this voting machine?* (1= not at all easy, 4=very easy); (III) *Were you able to vote for you preferred option?* (0 = no, 1 = yes); (IV) *Would you like to vote electronically in real elections?* (0 = no, 1 = yes); (V) *Would you like to replace the traditional voting system with the electronic voting system?* (1= totally disagree, 4 = totally agree). Responses to questions 1, 2, and 5 were dichotomized in order to enhance comparability with the Colombian pilot. The survey items from the 2007 Colombia e-voting plot were: (I) *Are you confident that your vote was registered as intended?* (0 = no, 1 = yes); (II) *E-voting is easier than the traditional voting system* (0 = no, 1 = yes); (III) *Correcting voting mistakes is easier under the new system* (0 = no, 1 = yes); (IV) *E-voting is*

The voting machines tested in each pilot

Each pilot tested four different voting devices. While all the prototypes in the Colombian pilot were supplied by private vendors, the Buenos Aires government designed the software and hardware of the e-vote devices.[10] Due to the large sample sizes and the randomized experimental designs used in the two pilots, there were no systematic differences in the distribution of voters' personal characteristics across prototypes in each testing location.

Argentine pilot

Two direct recording electronic (DRE) devices and two optical scan (OS) systems were tested in the Argentine pilot. *Prototype 1* was a direct recording electronic design with two separate modules: a screen in the first module allowed voters to review the lists of candidates, and a numerical keypad was used to register the vote. *Prototype 2* was a touch-screen DRE machine: voters could scroll and select party lists directly by tapping onto the screen. Unlike *Prototype 1*, this second DRE device produced a voter verifiable paper trail. Both DRE devices were equipped with smart card readers.

Prototype 3 was an OS prototype located inside a voting booth, providing a higher degree of privacy. This prototype required separate ballots for each race: The ballots corresponding to different parties were stacked on tables placed inside the voting booth. The voter would pick a ballot and introduce it into a rolling scanner that displayed the selected party on the screen, and would then proceed to confirm her selection. Finally, *Prototype 4* was an optical scan device with a single ballot listing all parties' names and their numbers. The voter marked her preferences for each race with a pencil and then introduced the ballot into a scanner located next to the election desk.

For each prototype, participants voted for national representatives first and local legislators second. All four prototypes asked voters to confirm their choices at the end of the process, preventing over and under-counts and thus avoiding problems related to the effect of residual votes on election outcomes (Kimball and Kropf 2008; Frisina et al. 2008). Consistent with Argentine legislation, participants could, however, cast blank ballots, so they were not forced to vote for a party in any of the two races.

Figure 1

---

more reliable than the traditional paper-based voting system (0 = no, 1 = yes); (V) *I am more confident that my votes will be counted under the new system* (0 = no, 1 = yes).

[10] Except for the hardware of one of the four prototypes (*Prototype 4*), which used off-the-shelf technology. This prototype was available in 14 polling locations.

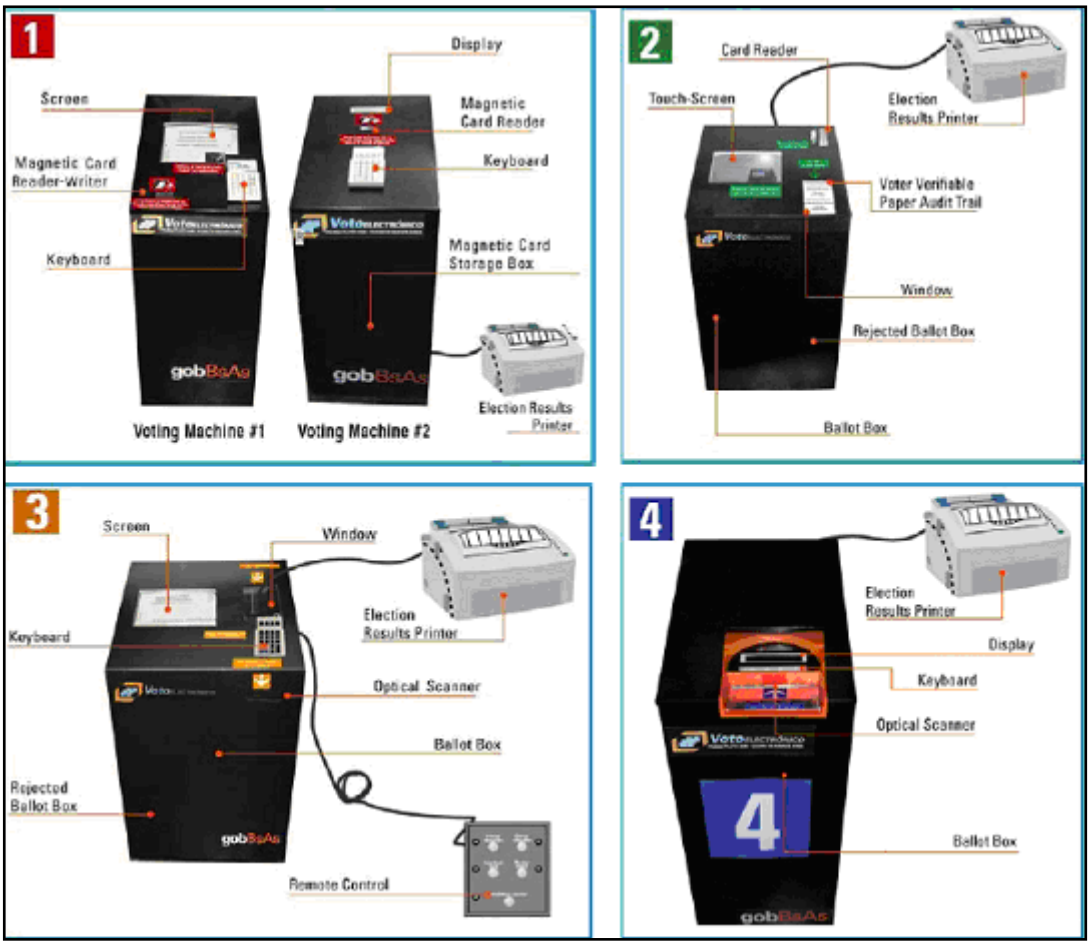

Figure 1 plots the four prototypes tested in Buenos Aires' 2005 e-voting pilot.

Colombian pilot

The first three prototypes tested were touch-screen direct recording electronic (DRE). After inserting a smart card into the reader attached to the terminals, participants were presented with the name, number and logo of seven parties running candidates for office in the presidential and the senate race, as well as the names of the candidates running for President (4) and for the Senate (58 in total), sorted according to the party number and the candidates' personal code.[11] Voters could scroll and select their candidates - one for each race - by tapping onto the screen. Before registering the vote, users were asked to confirm their choices at the end of the process; only at this review stage could they stop, change or cancel the vote. After the confirmation, the information was digitally stored in the machine. Overvotes - e.g., ballots selecting more than one candidate for the presidential or senate race - were not admitted by any of these prototypes: the voter was notified of the mistake and requested to correct it in order to proceed with the vote.

There were two primary differences between these DRE devices. First, unlike *Prototype 1*, both *Prototypes 2* and *3* had voter-verifiable audit trails. Second, although voters using the three DRE devices could set the ordering of voting for each race - unlike in

[11] Candidate names were fictitious.

the Argentine pilot – the procedure followed varied across prototypes. Under *Prototype 1* the participant had to select the order in which she wanted to vote - i.e., in the presidential or senate election - prior to casting a ballot using an electronic card connected to the voting machine. In contrast, voters using *Prototypes 2* and *3* could move through the screen to switch between the two races.

Figure 2

Figure 2 plots the four voting prototypes tested in Colombia's 2007 e-voting pilot.

The last prototype, *Prototype 4*, was an optical scan (OS) device not equipped with a smart card reader. The staff supervising the test provided each participant with a paper ballot including all the relevant information (party name, logo, number, and the complete list of candidates for each race). Voters marked their preferences for the presidential and senate race with a special pencil on the paper ballot and introduced it into the scanner. The only possibility of changing the vote once the ballot was introduced into the scanner was if the voter had cast an invalid vote or left the ballot blank. In both cases, the voter was notified of the potential mistake, and had the option of correcting it or casting the vote

anyway. In the case of a spoiled ballot, correcting the mistake required the user to approach the staff supervising the pilot, request a new ballot and start the process over again.

The impact of electronic voting on voters' trust in the election process

In order to assess voters' opinions about the usability and reliability of the different e-voting prototypes tested and their confidence in electronic voting, we used survey data from the 2,294 participants in the Colombian pilot and the sub-sample of 3,084 participants in the Argentine pilot.

Following Alvarez, et al. (2008), we define trust in the electoral process as the confidence voters have that their ballot is recorded accurately. Hence, our main dependent variable of interest is built based on participants' response to the survey item: *"Are you confident that your vote was registered as intended?"* The wording of the question was the same in the surveys administered during the two pilot tests, although in Colombia participants were asked to provide a 'yes' or 'no' answer, while in Argentina the response was coded on a four-point scale ranging from "I am absolutely sure it was not" to "I am absolutely sure it was". In order to make the results from both surveys comparable, we recoded the responses from the participants in the Argentine pilot to a binary scale (which does not affect the primary substantive results).

Table 2 reports the percentage of positive responses to the confidence question in each country, discriminated by demographic characteristics (age, education, gender). A striking result is the virtually unanimous confidence levels among participants in both pilot tests: overall, almost 94 per cent of respondents in the two field experiments stated that they were positive their vote had been recorded as intended. These confidence rates are higher than those found by studies from the U.S. (Alvarez et al. 2008; Stewart 2009) as well as from European elections (Delwit et al. 2005). However, these other studies are based on official elections, while our study uses data from a mock election.[12] Nonetheless, the fact that neither of these countries has not adopted e-voting yet makes this finding quite remarkable insofar as beliefs of trust might be expected to be negatively affected by users´ lack of familiarity and by the novelty of new voting mechanisms (Alvarez, et al. 2008). In both pilot tests, older participants (those over 50) tended to be more confident that that their vote was recorded as intended than younger ones. In the case of Colombia, the difference in confidence levels between oldest and youngest respondents is larger than 4 percentage points, and is strongly statistically significant.[13] This positive relationship between age and trust is consistent with previous research on the US and Europe (Delwit et al. 2005; Alvarez, et al. 2008). In line with the argument in Oostveen and van den Besselaar (2004), it might be explained by the fact that younger people have probably higher levels of computer skills and can thus be more critical about security issues than people who lack the knowledge to detect potential threats to computer security and verifiability. This might also explain the negative association between trust and education levels in Colombia, where respondents with university education were on average 0.3 less likely to trust that their vote

[12] As a consequence of the non-binding character of the experiments, positive views could be the result of self-selection or of the hypothetical nature of the question (in the Colombian case), and thus positive attitudes towards e-voting might, at least in part, driven participation in the pilot.

[13] The p-values of the tests for equal probabilities (Newcombe, 1988) across age ranges in Colombia is smaller than 0.01. In the case of Argentina, the hypothesis of equal probabilities cannot be rejected at the usual confidence levels.

had been accurately recorded than those with secondary education or less. While subjects with a university degree were also slightly less confident than those without college education in Argentina, differences in this case were again not significant at the usual confidence levels.

Table 2. Percentage of positive responses to the survey question

"Are you confident that your vote was registered as intended?"

Individual variable		Argentina	Colombia
Age	18-29	94.22	91.76
	30-50	92.40	94.51
	>50	94.32	95.87
Education			
	Primary or less	91.26	98.94
	Secondary	94.29	95.47
	University	93.44	92.64
Gender	Female	93.26	93.45
	Male	93.85	94.77
Whole sample		93.58	93.99
N		3,084	2,294

Figure 3 complements the information provided in Table 2, plotting the proportion of positive responses to the confidence question in the two pilot studies, discriminated by relevant prototypes' characteristics. A common pattern observed in both experiments is that the percentage of participants who believed that their vote had been recorded as intended was higher under the direct electronic (DRE) than under the optical scan (OS) devices. In Argentina, 94.1% of those using DRE machines (*Prototypes 1* and *2*) answered positively to the confidence question, while 92.5% of those using the two OS devices (*Prototypes* 3 and *4*) did so. The hypothesis that the proportion of positive responses is equal for the DRE and the OS devices, however, cannot be rejected at the usual confidence levels (Newcombe 1988). Similar results hold when comparing the proportions between the DREs with and without audit trail, and between them and the OS machines.[14] In the case of the Colombian pilot, the differences between the DREs with and without an audit trail and the OS machines were strongly significant, but the hypothesis that the audit trail had no effect on voters' trust in the election could not be rejected at the 0.05 level.[15]

Figure 3

[14] Differences between the two OS devices (*Prototypes* 3 and 4) were also not significant at the 0.05 level.
[15] Similarly, we found no statistically significant differences between audit trails printed on paper or on the screen.

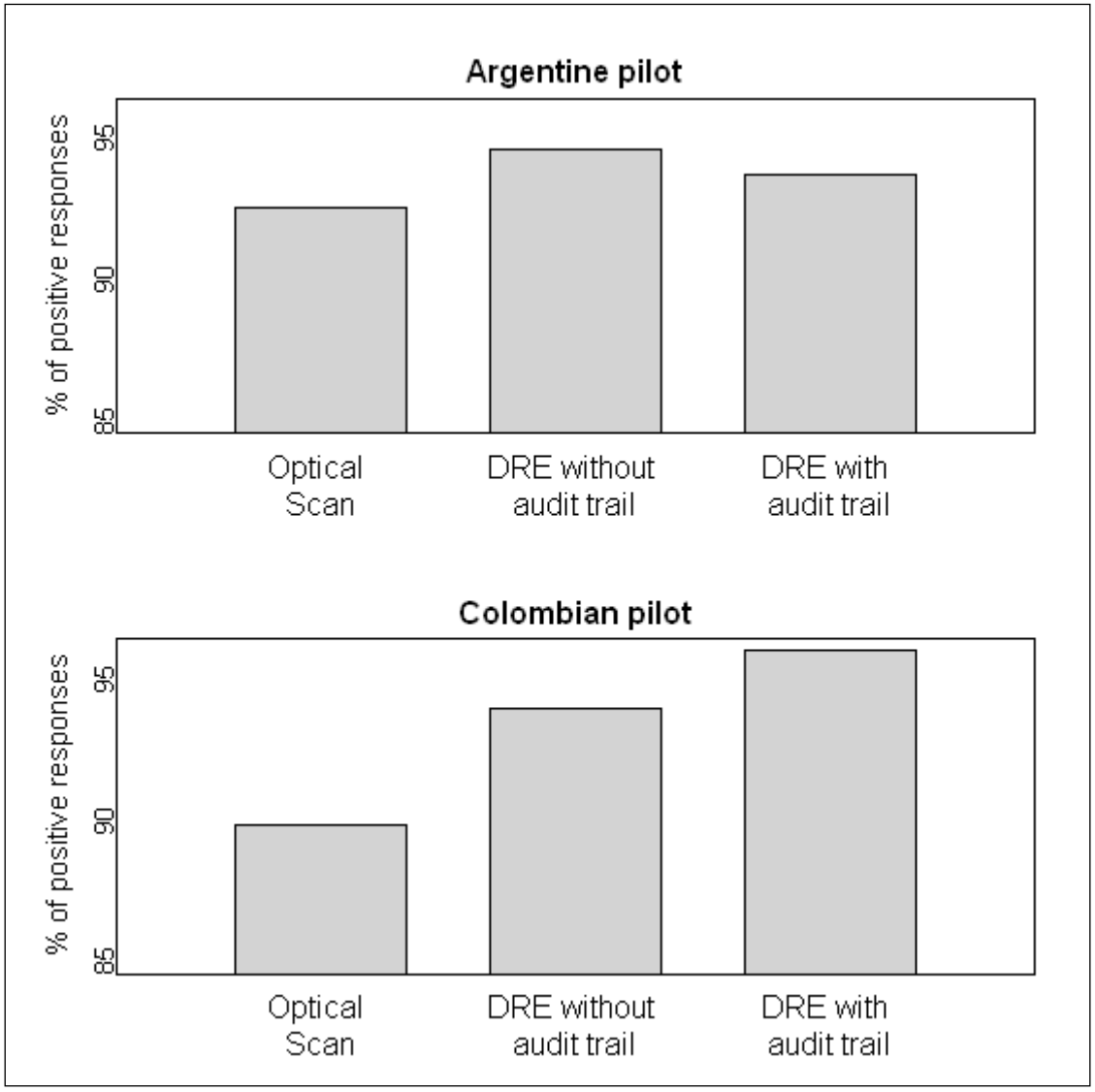

Figure 3 plots the percentage of participants stating that they were confident their vote was registered as intended in the two pilot studies analyzed.

Table 3, in turn, presents the percentage of positive responses to a usability question included in the surveys administered after each pilot, discriminated by prototypes.[16] As noted in Section 2, previous research has found a positive correlation between perceived ease of use and trust in electronic voting (Delwit et al. 2005). The comparison of the percentages in Figure 3 and Table 3 shows that this relationship is also seen in the Argentine and Colombian e-voting pilots. In Argentina, the percentage of positive responses to a question asking participants whether they thought voting was easy with the e-voting prototypes was significantly higher among subjects using the two DRE devices than between those using the OS machine. In the case of Colombia, the emphasis of the

[16] See Alvarez, et al (2009) for a more detailed discussion of these data, and for the results of multivariate analysis.

survey was on assessing the perceived ease of use of the new voting devices *vis-a-vis* the traditional paper ballots. As shown in Table 3, the proportion of respondents who stated that voting was easier under the new technology than under the manual method was fairly similar across prototypes. However, the percentage of respondents who found that correcting mistakes was easier is 15 points higher for participants using the DRE machines than for those using the OS device. This result is in fact hardly surprising, since the OS machine (*Prototype 4*) is the one that more closely resembles the paper ballot system in this regard and, as described in Section 3, the procedure that had to be followed in order to correct voting errors was considerably more complex than under the three DRE devices.[17]

Table 3. Percentage of positive responses to usability questions

Prototypes	Argentina	Colombia	
	How easy was to use this voting machine? (Easy + Very easy)	*Correcting mistakes is easier using e-voting machines*	*E-voting is easier than the traditional voting procedure*
Optical Scan	79.5	72.2	94.4
DRE without audit trail	84.8	97.1	94.1
DRE with audit trail	85.7	96.2	94.5
N	3,084	2,294	2,294

Finally, some of the questions included in the surveys allow us to compare participants' attitudes toward e-voting *vis a vis* the conventional paper-ballot system (see Alvarez et al. 2009). Specifically, subjects in the Colombian pilot were explicitly asked if they felt that electronic voting was more reliable than the traditional system and whether they were more confident that their ballots would be counted under the new system. This enables us to contrast the perceived trustworthiness of electronic voting relative to the traditional manual system currently in place in the country. A direct comparison of participants´ degree of confidence in the two alternative voting systems is not possible in the case of Argentina. However, subjects in the Buenos Aires pilot were asked whether they would like to use electronic voting devices in real elections, and if they would like to replace the manual system with the new e-voting technologies in real elections. Although responses to these two questions are not necessarily driven by the perceived reliability of the e-voting prototypes and might be affected by other considerations (e.g., costs, waiting time), they do provide additional insights into participants' general opinions about the new technologies. All together, participants' responses to these additional sets of questions suggest a strong support for electronic voting *vis a vis* the traditional method currently in

[17] Again, no statistically significant differences were found in the proportion of positive responses between the DRE machines with and without audit trails.

place in Argentina and Colombia. More than 85% of the subjects in the Colombian pilot felt that e-voting was more reliable than the paper-based system, and an even larger proportion stated that they were more confident that their ballots would be counted with the new voting technology.

Conclusions

Analyzing the impact of electronic voting technologies on voters' trust in the electoral process seems extremely relevant at a time when Latin American election authorities are considering switching to e-voting with little systematic evaluation on the consequences of the introduction of these new voting procedures. Using data from two field e-voting experiments conducted in Argentina and Colombia, this paper provides insight into the prospects of new technologies for increasing trust in the election process.

Our findings point to a high level of trust in electronic voting by both Argentine and Colombian participants in experiments. In line with previous research on American elections (Herrnson et al. 2008), we showed that the type of electronic voting method is not a minor issue. Quite the contrary, although levels of trust are extremely high irrespective of type of technology, there are significant differences regarding their impact on voters' perceptions of trust. Nonetheless, unlike previous evidence on the U.S., we found that DRE devices prompt higher levels of trust that ballots are counted than paper-based optical scanners, and that a voter verifiable paper record does not seem to provide an improvement. These findings have academic and policy implications. First, insofar as electronic voting technologies evolve at a fast speed, there is a need for a better understanding of the specificities of each type of technology and avoid broad generalizations about electronic voting. Second, we should be more cautious when extrapolating findings from established democracies to other contexts. Whereas in the U.S. the debate over the plausibility of providing a paper verified mechanism might be important in the aftermath of 2000 elections, its replication in other contexts deserves in-depth evaluation. Also, our study finds that the individual characteristics of voters, especially age and education levels, affect voters' confidence in electronic voting. Our results in this regard, however, provide little support for the hypothesis that the introduction of automated voting systems in Latin America could impose considerable barriers for effective electoral participation among older and less educated voters. Overall, we find evidence of strong support for electronic voting among participants in the two e-voting pilots under analysis.

Some limitations of our study should be taken into account for future research on this topic. First, whereas the upside of the randomized character of the two experiments under study lies in reducing the effects of self-selection, the fact that voters were asked to evaluate a non-official contest might have relaxed their scepticism and awareness about the implications of an ICT-mediated vote. Further research should examine voters' perceptions in those countries already implementing e-voting in Latin America – e.g, Brazil and Venezuela - and in countries with markedly low levels of voters´ confidence. Second, previous studies have shown that perceptions of trust in the fairness of the election are mediated by confidence in electoral authorities (Avgerou et al. 2009). Investigation into this issue needs consideration, especially in the context of recent concerns about the negative impact of several disputed elections on the perceived legitimacy of election administration institutions (Whitehead 2007).

Finally, further research is needed on the impact of other individual characteristics such as race, political ideology and socio-economic status on voters' confidence in e-voting. In particular, given the large differences in socio-economic conditions among citizens both between and within Latin American countries, this should be an area of thorough investigation. Based on our findings about a positive association between ease of use and trust, and drawing on previous scholarship on the US (Alvarez, et al. 2008), it could be expected that voters with a lower socioeconomic status would show lower levels of trust. However, since we found in the analyses reported here that confidence in election processes decreases with education, the relationship between education and confidence is unclear. This is a question of chief importance for discerning whether switching to electronic voting might boost or hamper trust in election processes in the region.

References

Alvarez, R. Michael , Thad E. Hall, and Morgan H. Llewellyn. 2008a. "Are Americans Confident Their Ballots Are Counted?" *Journal of Politics* 70 (3):754–66.

Alvarez, R. Michael, Gabriel Katz, and Julia Pomares. 2009. "Up to the promise? The Impact of Electronic Voting on Trust in the Election Process in Latin America" *CALTECH/MIT Voting Technology Project Working Paper #89*.

Alvarez, R.Michael, and Thad E. Hall. 2008. *Electronic Elections: The Perils and Promises of Digital Democracy*. Princeton: Princeton University Press.

Avgerou, Chrisanti, Andrea Garzaroli, Angeliki Poulymenakou, and Nicolau Reinhard. 2009. "Interpreting the Trustworthiness of Government Mediated by Information and Communication Technology: Lessons from Electronic Voting in Brazil." *Information Technology for Development* 15 (2):133–48.

Barrat, J. 2006. "A preliminary question: Is e-voting actually useful for our democratic institutions? What do we need it for?" In *Electronic Voting 2006*, ed. R. Krimmer and R. Grimm. Bonn: Gesellschaft fur Informatik.

Coleman, S. 2004. "Internet Voting and Democratic Politics in an Age of Crisis." In *The European Union and E-voting.* , ed. A. Trechsel and F. Mendez. London: Routledge.

Frisina, Laurin, Michael C. Herron, James Honaker, and Jeffrey B. Lewis. 2008. "Ballot Formats, Touchscreens, and Undervotes: A Study of the 2006 Midterm Elections in Florida." *Election Law Journal* 7 (1):25-47.

Harrison, G., and J. A. List. 2004. "Field Experiments." *Journal of Economic Literature* 42:1013-59.

Herrnson, Paul S., Richard G. Niemi, Michael J. Hanmer, Benjamin B. Bederson, and Frederick C. Conrad. 2008. *Voting Technology. The Not-So-Simple Act of Casting a Ballot*: Brookings Institution Press.

Kimball, David C., and Martha Kropf. 2008. "Voting Technology, Ballot Measures, and Residual Votes." *American Politics Research* 36 (4):479-509.

Newcombe, R. G. 1988. "Two-Sided Confidence Intervals for the Single Proportion: Comparison of Seven Methods." *Statistics in Medicine* 17:857–72.

Pomares, Julia. 2009. "The Adoption of Electronic Voting from a Comparative Perspective: Are Political Actors Following General or Distributive Interests?"

Rezende, P.A. 2003. "Electronic Voting Systems - Is Brazil ahead of its time?" Denver: First Workshop on Voter-Verifable Election Systems.

Riera, Andreu, and Paul Brown. 2003. "Bringing Confidence to Electronic Voting." *Electronic Journal of e-Government* 1 (1):43-50.

Rodrigues-Filho, J., C.J. Alexander, and L.C Batista. 2006. "E-Voting in Brazil - The Risks to Democracy. In: Electronic Voting." In *Electronic Voting 2006*, ed. R. Krimmer and R. Grimm. Bonn: Gesellschaft fur Informatik.

Stein, Robert M., Greg Vonnahme, Michael Byrne, and Daniel Wallach. 2008. "Voting Technology, Election Administration, and Voter Performance." *Election Law Journal* 7 (2):123-35.

Stewart, Charles III. 2009. "Election Technology and the Voting Experience in 2008." *CALTECH/MIT Voting Technology Project Working Paper #71*.

Whitehead, Laurence. 2007. "The Challenge of Closely Fought Elections." *Journal of Democracy* 18 (2):14-28.