Collegio Carlo Alberto

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No. 153
October 2010

Carlo Alberto Notebooks

www.carloalberto.org/working_papers

Invalid Ballots and Electoral Competition*

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Abstract

We study how the closeness of electoral race affect the number of invalid ballots under the traditional paper-ballot voting technology. Using a large dataset from the Italian parliamentary elections in 1994-2001, we find a strong positive correlation between the closeness of electoral race and the fraction of invalid ballots. This correlation is not driven by voters' behavior, the biased actions of election officers, or the strategic pressure by parties. The theory that garners most support is that of unbiased election officers that increase their effort in response to higher (expected) closeness of electoral race, so as to reduce the likelihood of incorrectly adjudicating the victory. We also find large North-South differences in the patterns of invalid ballots: (i) electoral districts and municipalities in Southern Italian regions have a substantially higher level of invalid ballots, and (ii) the correlation between the closeness of electoral race and the fraction of invalid ballots is absent in the South. Social capital and organized crime explain these differences: once these two features are accounted for, the districts and municipalities in the South behave similarly to those in the North.

Keywords: invalid ballots, electoral competition, social capital, voting technology, Italian parliamentary elections.
JEL codes: D72, D73, D81, Z10

*The authors thank Enriqueta Aragones, Georg Kirchsteiger, Jim Snyder, and the participants of the seminar at Collegio Carlo Alberto for useful comments.

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"It's not the voting that's democracy, it's the counting" (Stoppard, 1972)

The performance of different voting technologies has been a key question in political science at least since the beginning of the 20th century (the earliest paper is Allen 1906; a brief review of the early research on voting technologies in Herrnson et al. 2005). The amount of scholarly contributions on this issue increased rapidly at the aftermath of the highly disputed outcome of 2000 Presidential elections in the United States, which was decided by a small number of votes in Florida, as well as vote count inconsistencies in several counties (see Caltech/MIT Voting Technology Project 2001, Knack and Kropf 2003, Ansolabehere and Stewart III 2005, Shue and Luttmer 2009, and references therein). The importance of understanding the performance of different voting technologies goes far beyond a particular election. Poorly functioning electoral institutions reduce the possibility of the electorate to express its political preferences and undermine citizens' trust in the democratic system. As Ansolabehere and Stewart III (2005) write, "Disputed elections can lower the perceived legitimacy of democratic elections, and some technologies might make it more likely to have disputed elections" (Ansolabehere and Stewart III, 2005, pg. 365).

In this paper, we study the traditional hand-counted paper-ballot voting technology. We concentrate on one feature: the number of invalid ballots, and how this number varies with the closeness of electoral race. We discuss several competing theories that generate testable predictions on this relationship. Using the data from the Italian parliamentary elections in 1994-2001, we find that the fraction of invalid ballots is strongly *positively* correlated with the closeness of electoral race. We find no evidence that this correlation is driven by voters' behavior, the biased actions of election officers (i.e. fraud), or the strategic pressure by parties. The theory that garners most support is that of unbiased election officers that increase their effort in response to higher (expected) closeness of electoral race, so as to reduce the likelihood of incorrectly adjudicating the victory. In other words, the traditional paper-based system seems to have an 'automatic safety control' that (at least to some extent) guarantees that the victor is announced correctly. However, this 'safety control' works only in the areas with sufficiently high levels of social capital.

Our findings have two important implications. First, provided that the level of social capital is sufficiently high, under the traditional paper-ballot system the election officers

scrutinize the ballots closer when the expected margin of victory of the winning candidate is narrower. This feature has the advantage of the 'automatic correction', which is absent under the machine-based voting technologies. Second, social capital plays a role not only for the active and responsible participation of voters and the disciplined behavior of politicians and public officials, but also for the behavior of other actors in the political system, such as election officers.

The literature on voting technologies can be divided into three strands. The first group of papers compares different voting technologies (punch cards, optical scanning, direct register electronic machines, etc.).

A seminal contribution in this group is Ansolabehere and Stewart III (2005). Using a county-level panel data for the United States elections from 1988 to 2000, the authors find that voting equipment/technology has a significant and sizeable effect on the number of "residual" votes (i.e. blank and invalid ballots). In particular, they find that the elections with traditional paper-based hand-counted ballots and optically scanned paper ballots exhibit the lowest number of residual votes, whereas the elections with direct register electronic machines and punch cards have the highest number of residual votes. This finding indicates that the conventional wisdom that the electronic equipment that is free from human-based vote counting that is subject to fatigue is actually wrong: this fatigue is counterbalanced by the higher reliability of manual vote counting.

Shue and Luttmer (2009) use the data from the 2003 California Recall Election to study the effect of adjacency (of the name of a minor candidate to that of a major one) on misvotes, i.e. the mistaken votes for the minor candidate. They find that the vote shares of minor candidates double when their names are adjacent to those of a major candidate. Moreover, this effect increases in precincts with more Democratic, Hispanic, low-income, non-English speaking, low-education, and young voters, and a major candidate whose voter base includes more voters from these categories faces a systematic electoral disadvantage. This literature, however, does not look at the behavioral effects and the cost-benefit calculations that is present in the manual vote counting, and how these might be related to the characteristics of the electoral race (in particular, closeness of the election).

The second strand of literature studies various forms of vote buying (see the collection of papers in Schaffer 2007). For instance, in a very interesting study of Chilean elections

before 1965, Baland and Robinson 2008 find that the introduction of the secret ballot in 1958 has effectively destroyed the "market" for votes that existed between landed aristocracy and agricultural workers, thus sharply decreasing the votes for the right-wing parties.

Finally, the third strand of literature studies ballot rigging (a good survey is Lehoucq 2003). Herron and Johnson (2003) look at the 2002 parliamentary elections in Ukraine. They exploit the fact that Ukraine has a mixed electoral system: in some precincts, the electoral system is proportional representation (PR), whereas in others it is single-member district (SMD). This difference creates different incentives for the incumbent political party to engage in ballot rigging, and the authors find that the data support this theory. Lehoucq and Molina (2002) study the accusation of ballot-rigging filed in Costa Rica, and find that such accusations where much higher in close-race districts. Note, however, that this finding does not necessarily imply that fraud is more frequent in close-race districts ('supply' side): it might as well be that, for equal number of rigged ballots, there are higher incentives for parties to file an accusation of ballot-rigging in close-race districts.

There are very few papers that explicitly study invalid ballots. Power and Garand (2007) analyze, using an aggregate-level panel-data analysis from 80 legislative elections held in 18 Latin American democracies between 1980 and 2000, the influence of three sets of factors on the number of invalid ballots: socio-demographic (literacy, education, wealth), institutional (electoral system and ballot structure), and political (alienation and protest). They find some support for all the three sets of factors: socio-economic factors (urbanization and income inequality) correlate with the number of invalid votes, institutional factors (compulsory voting, electoral disproportionality, and the combination of high district magnitude with personalized voting) increase the number of blank and spoiled ballots, whereas political factors such as political violence and the level and direction of democratic change also correlate with the fraction of invalid votes.

On the social-capital side, there is some literature studying the relationship between social capital measures and political behavior (a nice general survey of recent research on social capital is Sobel 2002). The works most closely related to our study are those that look at the political dimension of social capital in Italy. Putnam (1993) is a seminal study which finds that the measures of social capital across Italian regions are correlated with the experience of city-state self-governance in the Medieval times. Nannicini et al.

(2010) analyze the link between social capital and political accountability, using the data on the members of Italian Parliament between 1948 and 2001. They find that in districts with higher social capital, voters punish the misbehavior of politicians more severely. As a consequence, the episodes of misbehavior by politicians occur less frequently in districts with higher social capital.

1 Invalid Ballots: What Are They?

In any election, all ballots casted by voters belong to one of the three categories: valid, blank, or invalid (or spoilt). Typically, after the vote count is completed, the election administration reports the number of ballots belonging each category. A ballot is considered invalid if the voter's preference is not clearly stated (this includes, for instance, over-voting, i.e. casting more than one preference when only one preference is allowed) or the vote's secrecy is undermined (e.g. signing the ballot). The duty of an election officer is to invalidate any ballot on which the voter has drawn a sign which is different from a simple cross and any ballot on which a cross does not uniquely identify the voter's preference. These rules apply to most, if not all, democratic elections. The stated objective of this procedure is to avoid antidemocratic and illegal voting behavior.

The Institute for Democracy and Electoral Assistance, which maintains a database on parliamentary and presidential elections across most countries in the world, reports that the fraction of invalid votes for their entire dataset (which covers approximately 100 countries over the last 10 years) is around 3 percent. However, looking across countries (see Figure 1), we see large variation in this measure. In all the developed countries the fraction of invalid ballots is a single-digit number, typically below 5 percent. The number is much higher for the developing countries, with double-digit numbers in several developing countries, in particular in Latin America and Western Africa.

2 Competing Theories

If the number of invalid ballots is not driven by entirely random and idiosyncratic factors (e.g. distraction of individual voters or election officers), what are the potential causes that can influence their number relative to the total number of votes casted in an election? Below we describe different competing theories of invalid ballots in a two-party election.

The empirical predictions of these models differ substantially, and our empirical analysis will be able to verify which of these theories is supported by the data from the Italian legislative elections between 1994 and 2001.

2.1 Voters

The first theory that can explain the variation in the fraction of invalid ballots is that of the rational behavior of voters. We will thus consider a simple cost-benefit analysis of individual voter's decision. Suppose that filling out the ballot requires some concentration, and filling it out correctly has some attention cost. Moreover, suppose that the probability of making a mistake (and, therefore, submitting an invalid ballot) decreases with the attention allocated by the voter.

Next, consider the benefit side. If the voter prefers one candidate over the other, she might perceive a benefit from feeling that her vote helped to increase the chances of victory of her preferred candidate. This might be justified by either the fact that a voter considers her probability of being pivotal (see Ch. 14 in Mueller 2003), or - more realistically - by the fact that the voter might feel the moral duty to "do her part" in helping her preferred party to win (as in the models by Feddersen and Sandroni 2006b,a).

The higher is the expected margin of victory of one of the candidates in the district, the lower is the voter's expected benefit of casting a valid vote. Given that the margin of victory does not affect the cost side, the higher is the margin, the lower is the attention that the voter devotes to casting a valid vote, and thus the higher is the probability of submitting an invalid ballot.

We thus obtain the following simple hypothesis:

Hypothesis V. *Higher margin of victory is positively correlated with the fraction of invalid ballots.*

2.2 Protest

A related (but motivationally different) theory is that of voter protest. Voters might have feelings about the choice that they are facing, and may act in the voting booth in reaction to these feelings. For instance, Brighenti (2003) analyzes a selection of invalid ballots in a regional election in Italy, and finds that a part of the invalid ballots

report emotionally-charged (typically, negative) messages written by voters on their ballots. These are examples of voluntary invalidation.

If the expected margin of victory is sufficiently large, some of the voters that support the losing candidate might feel that, de facto, their electoral choice is severely constrained. If this triggers negative emotions in them, some of the voters might voluntarily invalidate their ballots. Another related possibility is that of expressive voting (Brennan and Lomasky, 1993; Schuessler, 2000). If voters want to express their general discontent about the political system, they might want to cast an invalid ballot as a protest. At the same time, each voter might have a political preference for some party. The closer is the electoral race, the higher is the opportunity cost of invalidating the ballot to express one's discontent. In both cases, we should observe a positive correlation between the margin of victory and the fraction of invalid ballots.

Hypothesis VP1. *Higher margin of victory is positively correlated with the fraction of invalid ballots.*

Some of the voters might express their feelings by leaving their ballots blank. Then, the fraction of invalid ballots and that of blank ballots should be correlated. Based on this intuition, we will use the fraction of blank ballots as a regressor, and this should allow us to partially capture the voter protest.

Moreover, if voters invalidate their ballots voluntarily in reaction to the perceived lack of electoral choice, a higher number of candidates should mitigate this perceived lack and thus be negatively correlated with the fraction of invalid ballots.

Hypothesis VP2. *Higher number of candidates is negatively correlated with the fraction of invalid ballots.*

2.3 Unbiased election officers

Another possibility is that election officers act rationally. Let's consider first the case in which an officer does not prefer one candidate over the other. The problem of the officer can be then as follows.[1]

Suppose that each officer considers all the ballots that have to be counted one by one. Each ballot that he scrutinizes can be either valid or invalid. The objective of the unbiased election officer is to minimize the likelihood that the victory is incorrectly

[1]In the Appendix, we present a formal model, the intuition for which we describe in this sub-section.

adjudicated to the candidate that, in reality, has fewer valid ballots in her favor. However, election officers might make mistakes. There are two types of error that the officer might commit. Type I error consists in invalidating a truly valid ballot. Type II error consists in counting as valid a ballot which is in reality invalid. Given that the type I error is very unlikely to happen (one can hardly spot a non-existent irregularity in a ballot which has been correctly filled by the voter), let's assume such errors away. Instead, the type II error - missing an existing irregularity - is much more important. Moreover, the likelihood of this error is affected by the effort that the officer exerts. These type-II errors might jeopardize the true outcome of the elections if they are sufficiently numerous as compared to the difference in the number of valid votes between the two candidates.[2]

In other words, the officer exerts the effort of attention to minimizes the number of type-II errors. However, the effort is costly, and the higher is the number of ballots to scrutinize, the higher is the incremental cost of effort. On the other hand, the risk of jeopardizing the election outcome depends on the expected margin of victory: the higher is this margin, the less it is likely that a given number of type-II errors influence the election outcome.

The rational officer chooses the level of effort that equates the incremental cost of effort to its incremental benefit. If the expected margin of victory increases, the benefit of effort falls, and thus the officer puts lower effort. This, in turn, implies a lower number of truly invalid ballots that are counted as invalid. We thus obtain the following

Hypothesis U1. *Higher margin of victory is negatively correlated with the fraction of invalid ballots.*

Let's now consider the effect of a variation in turnout. Given that the number of election officers is fixed (i.e. it is not adjusted on the basis of turnout), a higher number of voters showing up at the polls implies a higher number of ballots that each officer has to scrutinize. This means (under the standard convexity assumption on the cost function) that the incremental cost of effort increases. The officer then finds it optimal to reduce the effort that she puts in scrutinizing the ballots, which, in turn, leads to a lower fraction of invalid ballots. We can thus formulate the following

[2]This implicitly assumes that the election officer acts taking into account the worst-case scenario: that, if let pass, all the invalid ballots are counted as votes for the same candidate. While this assumption is clearly unrealistic in its pure form, our reasoning remain valid as far as the election officer considers as possible a scenario sufficiently close to the worst case.

Hypothesis U2. *Higher turnout is negatively correlated with the fraction of invalid ballots.*

2.4 Biased election officers

Now consider the case of an election officer that prefers one candidate to the other, and decides on taking the risk of invalidating some of the the valid ballots that are in favor of her less-preferred candidate, in order to increase the probability of victory of her preferred candidate. Researchers has been concerned with this possibility for a long time. In his analysis of voting in the U.S. elections, Harris (1934) writes:

> "The use of paper ballots undoubtedly is conducive to voting frauds. The paper ballots must be counted by hand, frequently requiring several hours or longer, under conditions late at night which are likely to facilitate frauds. The election officers are quite exhausted after the long day at the polls, and are not fit to carry on the count for hours afterwards. The watchers are likely to leave if the count lasts for hours, and various short cuts may be used. In the confusion, poor light, mingling of ballots, etc., it is easy for ballots to be altered or substituted, and for the count to be falsified. If the ballot is short and the count can be completed within a very few hours, these dangers are not present" (Harris, 1934, pg.380)

Since electoral fraud is an illegal activity, it implies the risk of getting punished if the illegal action of the election officer is discovered. Then, the decision problem of the officer can be described as follows. Each incremental valid ballot that the officer invalidates increases the risk of getting caught. Moreover, it is plausible to assume that this risk increases more than proportionally with each additional ballot. If the officer invalidates just a few valid ballots, the likelihood that the authorities discover this misbehavior are very low. However, if she invalidates a few more ballots, this likelihoods starts to increase relatively quickly, as - for instance - the discrepancy of the election outcomes with exit polls starts to increase.

On the benefit side, the biased officer wanting to increase the likelihood that her preferred party wins the election understands that this likelihood is large when the expected margin of victory of one candidate over the other is slim. Contrarily, when the expected

margin of victory is wide (either in favor of her preferred candidate or against), additional invalidated ballots do not contribute to increasing this likelihood. Given that the risk of getting caught for invalidation does not depend on the expected margin of victory, wider expected margin of victory implies lower number of invalidations by the biased officer. We can thus formulate the following

Hypothesis B1. *Higher margin of victory is negatively correlated with the fraction of invalid ballots.*

Hypotheses U1 and B1 give the same predictions. Thus, to discern empirically between the two theories (unbiased and biased officers), we need an additional testable hypothesis.

Suppose that different districts or regions differ in terms of their social capital. This has two implications for the behavior of the election officer. Consider, for instance, the biased officer in a region with low social capital. If there is also some personal moral cost of mis-behavior, this cost probably is correlated with social capital. On the benefit side, it is also more likely (see Banfield and Banfield 1958) that in regions with lower social capital, corrupt officers depend relatively more on the rents generated through the capture of the electoral process. Both of these channels imply that the relationship between the expected margin of victory and the number of invalid ballots should be stronger in the regions with lower social capital.

Hypothesis B2. *The negative correlation between the margin of victory and the fraction of invalid ballots is stronger in districts (or regions) with lower social capital.*

2.5 Parties

In all the theories described above, the political parties are passive. However, parties are likely to act strategically, hoping to influence the electoral outcome during the vote count. In particular, given that party representatives are allowed to be present at the vote counting, and the total number of representatives that each party has is normally limited, parties are likely to allocate their representatives in districts that give them the highest expected return.

Clearly, allocating representatives into the districts that are won or lost almost for sure (i.e. those with wide expected margins of victory) makes little strategic sense. Thus, parties allocate disproportionately more representatives in districts that are uncertain, and where even a few votes counted mistakenly might imply winning or losing the par-

liamentary seat. Then, in a two-party elections, if both parties act similarly, we should expect that ballots are scrutinized much more closely in the districts with lower victory margins. For the reasons described in Section 1.2, this would also imply a higher number of ballots invalidated. We can thus formulate the following

Hypothesis P1. *Higher margin of victory is negatively correlated with the fraction of invalid ballots.*

Again, hypotheses U1, B1, and P1 give the same prediction. To distinguish empirically between these competing theories, we need to consider the number of candidates. Each party does not typically run for the parliamentary seat in every district. Thus, it is reasonable to assume that a higher number of candidates reflects a higher potential number of party representatives assisting the vote count. Therefore, if the variation in the number of invalid ballots is driven by the variation in the pressure that party representatives put on election officers, we should observe a positive correlation between the number of candidates and the fraction of invalid ballots.

Hypothesis P2. *Higher number of candidates is positively correlated with the fraction of invalid ballots.*

Table 1 summarizes the empirical predictions of the competing theories.

3 Italian Electoral System in 1994-2001

In this section, we describe the political and institutional context from which our data comes. We analyze electoral data from the three Italian parliamentary elections (1994, 1996, and 2001) that were based on a majoritarian system. We restrict our dataset for this period because these elections exhibit a natural measure of the closeness of the electoral competition: the margin of victory between the first and the second candidate.

For three legislatures, the ones that started in 1994, 1996, and 2001, Italian citizens elected their representatives using a two-tier system (75 percent of representatives via the majoritarian system and the remaining 25 percent via the proportional system). Before 1994 and after 2001 the entire Italian electoral system was proportional. We use data on the elections of the lower chamber of the Parliament, i.e. the House of Representatives (*Camera dei Deputati*).

On election day, each voter received two ballots: one to cast a vote for a candidate in

her single-member district, and another to cast a vote for a party list in her larger proportional district. Figure 2 shows a typical ballot, for the majoritarian and proportional-representation systems in Italy. In the districts with the majoritarian system, the voter has to put a cross on the name of the candidate of her preference, whereas in the districts under the PR system, she has to put a cross on the party/coalition symbol.

475 out of the 630 House members were elected in single-member majoritarian-election districts, while the rest was elected from closed party lists in 26 multiple-member districts (with 2 to 12 seats per district).[3] We focus on these 475 majoritarian-election single-member districts.

To understand the variation in invalid ballots across the Parliamentary districts, one first needs to know how the polling stations operate. Elections take place on Sunday between 8 AM and 10 PM, and on Monday between 7 AM and 3 PM. As soon as the elections end (i.e. Monday afternoon), election officers start counting the ballots. The counts typically last uninterrupted until Tuesday morning.

Each polling station has 3 types of election officers: the president of the polling station, a secretary, and four canvassers.[4] Party list representatives, at most two for each list, can also participate at the vote count. At least three election officers, including the president or the vice-president (chosen by the president among the canvassers), have to be present through the entire count. The president of the polling station decides (after consulting the canvassers) on the outcome of any disputes related to the vote count, including those about the validity of a ballot. She then registers her provisional decision (the Parliament has the last word about official protests). The secretary keeps the official record about all the electoral activities. At the end of the counting all members of the polling stations sign the record. Both the election officers and party list representatives can contest ballots, i.e. question the validity of the count of particular votes.

Delegates of the party list can nominate two party-list representatives for each polling station. Representatives are allowed to be present during the whole electoral process and to add comments into the official record. Until 2004 they were also allowed to keep

[3]For the Senate (*Senato*) elections, instead, voters received only one ballot to cast their vote for a candidate in a single-member district, and the non-elected candidates with the highest numbers of votes in the 232 majoritarian districts were later assigned to the remaining 83 seats according to the proportional-representation rule.

[4]See Article 34 of the Electoral Law (*Testo unico delle leggi per l'elezione della Camera dei deputati*), approved with the Decree of the President of the Republic on 30 March 1957 (No. 361).

track of voters. When working in the polling stations election officers receive a monetary compensation of approximately 100 euros. Moreover, both election officers and party representatives are compensated by their employers with (at most) 3 days of paid leave.

The polling starts with signing and stamping of ballots by the election officers. After all voters cast their ballots, election officers start counting the ballots, one by one. Voters are instructed to put just one sign on each ballot (and no other mark). The rationale for this is to keep the votes secret. Any sign that is different from a simple "x" could represent a signal about the vote. These additional signs (made by mistake or, sometimes, on purpose) represent the major reason for ballot invalidation.

4 Data

We extracted information on three majoritarian parliamentary elections from the *Atlante Storico-Elettorale d'Italia* (Corbetta and Piretti, 2008). An observation in our dataset represents the smallest level of aggregation of polling stations available, that is the smallest unit between a municipality and a district. We define these as electoral units.

Italy is divided into 475 electoral districts, which roughly reflect the population density. Larger cities have several districts: for instance, the municipality of Rome has 24 and the municipality of Milan has 11. Often, several municipalities (there are more than 8,000) belong to the same district.

Table 2 presents the summary statistics for the key variables used in our empirical analysis. Overall, our dataset contains 23,126 geographical units (by year) observations. 26.3 percent (9,782 observations) are located in the Southern regions (Molise, Campania, Puglia, Basilicata, Calabria, Sicily, and Sardinia). The main two coalitions lead the electoral competition in most geographical units (38 percent the center-right one and 36.2 percent the center-left one). We observe a strong party incumbency effect: in 94.4 per cent of cases, the incumbent coalition leads the competition. Regarding incumbent politicians, the picture is somewhat different: in 46.5 percent of cases the voting ballot contains the name of the incumbent politician, and in more than half of such cases (or in 26.4 percent of the total), the incumbent politician leads. The number of candidates vary across districts. On average, a voter is confronted to a ballot with 4.14 candidates. Turnout rate is relatively high (which has been a traditional characteristic of Italian

elections): in a typical district, 82 percent of all eligible voters participate.

Our main variable of interest, i.e. ballots reported as invalid, represent a relatively small but nevertheless non-negligible fraction of votes. On average, in a typical district or town, 3.9 percent of all the ballots is reported as invalid. We also see that there is substantial variation in this measure: the standard deviation is 2.2 percent. In 66 units there are zero invalid ballots, while the highest number in our dataset is 57 percent.

Figure 3 and Table 4 indicate that the fraction of invalid ballots varies substantially both across space and time. Southern regions exhibit the highest levels of invalid ballots, followed by the North-West. The Northern and Cental regions exhibit the lowest levels of invalid ballots. The variability across time will allow us to control for unobserved time-invariant characteristics of our electoral units.

Table 2 shows that blank ballots represent a somewhat higher fraction of total votes (as compared to invalid ballots): in a typical district/town, 4.6 percent of ballots are blank. As discussed above, we will use this measure as a proxy for citizens' protest.

The average leading margin (i.e. the vote difference between the winning party/coalition and the party/coalition that arrived second) is 18.4 per cent. The variation in the margin of victory is substantial (14.8 percentage points). The district with the closest election in our dataset exhibits a vote difference of basically zero percent, whereas in the one with the largest margin, the winning candidate leads by 96.1 percent.

Figure 4 presents graphically the relationship between the margin of victory of the winning party (coalition) and the fraction of ballots reported as invalid (in the total number of ballots), for the entire country. Each point marked with a dot on the graph represents the fraction of invalid ballots for a given percentile of the margin of victory. For the levels of margin of victory that are close to zero, the fraction of invalid ballots varies between 4 and 4.5 percent. For margins of victory in the neighborhood of 40 percent (i.e. a landslide victory) the fraction of invalid ballots is slightly larger than 3 percent. The two largest percentiles of the margin of victory (65 and 95 percent) have the two lowest fraction of invalid ballots (around 2.5 percent). Overall, there is a clear negative correlation between the two variables: the larger is the margin of victory, the smaller is the fraction of invalid ballots.

Comparing Southern and non-Southern regions reveals a remarkable regional difference (see Figures 5 and 6). In the South, there is no correlation between the margin of victory

and the fraction of invalid ballots, whereas in the non-Southern regions, the negative correlation is extremely clear.

Table 4 describes the differences in the key variables between Southern and non-Southern regions. Consistent with Figure 3, we observe that districts in the South have a higher fraction of invalid ballots (3.3 percent versus 4.7 percent). The differences in blank ballots are similar. Turnout is substantially higher in the non-Southern regions (86.4 versus 75.9 percent). Right-wing coalition does comparatively better in the non-Southern regions, whereas the stronghold of the left-wing coalition seems to be in the South. Incumbent party leads more often in the North. However, concerning the behavior and performance of incumbent politicians, the opposite is true: incumbent politicians participate more in the South (the likelihood of incumbent politician leading is thus proportionally similar across the two parts of the country). Elections seem to be more competitive in the South: average margin of victory in the South is 15.9 per cent, whereas in the North it is 20.2 percent.

5 Empirical Specification and Results

Next, we proceed to test empirically the competing theories that we have described above. Our empirical specification is as follows:

$$\log n^v = a + b_1 \log d^e + b_2 \log n + b_3 \log n^b + c_1 N + c_2 \mathbf{X} + e, \tag{1}$$

where n^v denotes the fraction of invalid ballots, d^e is the realized leading margin of the first candidate over the second (which serves as a proxy for the *expected* margin of victory), n is the total number of ballots (which corresponds to the turnout level), n^b is the fraction of blank ballots, $\mathbf{X}$ is the vector of other controls that we will use to evaluate the robustness of the results and e is the error term, which we assume to be normally distributed with zero mean and constant variance.

Column 1 in Table 5 shows the estimated coefficient in a regression (in logs) of the fraction of invalid ballots with the leading margin as the only explanatory variable. This elasticity is equal to -7.6 percent.[5] This implies that one standard deviation increase in

[5]The seemingly low elasticity is driven by the standard deviation of invalid votes being 10 times smaller than the standard deviation of the leading margin.

the leading margin reduces the fraction of invalid votes by 0.25 of a standard deviation, i.e. a quantitatively large effect.

The coefficient on the leading margin is negative and statistically significant at 1% level. This means that in the municipalities/districts where the electoral competition is weaker, the fraction of invalid ballots is lower. This coefficient remains negative and significant at 1% level in all the specifications of Table 5. Thus, we find support for the hypotheses U1, B1, and P1, and the data rules against the hypotheses V and VP1. In other words, we do not find support for the theory that voters increase their attention (and thus are less likely to submit invalid ballots) when the electoral competition intensifies, and neither can we support the theory that the increasing voter protest when the electoral competition is weakened drives up the fraction of invalid ballots.

As discussed in the theoretical section, several other variables might influence the number of invalid ballots. In Column 2, we report the results of a regression in which we additionally control for turnout, the fraction of blank ballots, and the number of candidates. Blank ballots - which plausible captures to some extent the level of voters' protest - is positively correlated with the fraction of invalid ballots and, across all specifications, the elasticity is approximately one-fourth. The coefficient on the margin of victory remains negative and significant, implying that even when we account for the protest votes, the electoral competition still has an effect on invalid ballots.

We find that turnout is strongly negatively correlated with the fraction of invalid ballots. This gives support for the hypothesis U2. However, given that the elections in the South have historically both a higher fraction of invalid ballots and a lower turnout, we run an alternative regression (whose results are reported in Column 3), which includes the South dummy. Once we control for the North-South difference in invalid ballots, the correlation between turnout and the fraction of invalid ballots decreases from -0.69 to -0.28. This indicates that a part of the correlation is purely driven by some characteristic of the Southern politics. Nevertheless, the gradient on the leading margin remains highly significant and does not decrease substantially in size. In the regression of Column 3 we have also added year dummies. We observe that, as compared to the 1994 elections, the fraction of invalid ballots in the 1996 elections increased substantially, whereas we find no such difference in the 2001 elections.

Next, we address the question whether the political outcome can predict the fraction

of invalid votes. The results of this analysis are reported in Columns 4 and 5. The findings in Column 4 suggest that the victory of the incumbent party does not affect the fraction of invalid ballots.[6] Whether the leading party is right or left-wing also has no impact on the number of invalid ballots (Column 5).

The electoral-competition gradient shown in Table 5 is the average effect of more intense electoral competition on the number of invalid ballots. The next step in our analysis is t refine this finding by exploring the determinants of this gradient. We report our findings in Table 6. Column 1 indicates that the gradient becomes steeper when turnout increases, and that this effect is robust (see Column 4) to allowing the slope to differ between the districts in the Southern and the non-Southern regions, as well as in terms of the number of candidates running for the election. In Column 2, we see that the gradient is weaker in the Southern districts. Given that the values of social-capital measures for Southern Italy are significantly lower than those for the Northern and Central Italy (see Putnam, 1993; Guiso et al., 2004), this implies that we find no support for the theoretical hypothesis B2. Column 3 shows that the gradient becomes smaller as the number of candidates (and subsequently that of party representatives) increases. If the hypothesis P1 were valid, we would observe that in close races the number of invalid votes *increases* with the number of party representatives. Our findings cast doubts on the validity of the hypothesis P1. The leadership of the incumbent party also does not affect the gradient.[7]

Several further results are worth mentioning. First, controlling for all the interactions, we see that turnout is the main driver behind the differential gradient between the South and the North. Second, once we control for the interaction of turnout and the margin of victory, the number of candidates ceases to be correlated with the fraction of invalid ballots. Finally, the last column shows that controlling for turnout at national referenda at the province level (which is a frequently used measure of social capital), the absolute value of the coefficient on turnout in the majoritarian race decreases substantially and loses its statistical significance. We interpret this as a sign that the gradient depends on the level of civic duty of election officers, which is correlated with the overall level of social

[6]The regression of Column 4 is done with data only from the years 1996 and 2001, given that there is no information on party incumbency for the 1994 elections (the first year of majoritarian elections).

[7]We do not report this result, to economize on space. The complete regression table is available upon request.

capital at the province level.

Table 7 reports the results of regressions in which we have added as controls the electoral-unit and the leading-candidate fixed effects. Our aim in this is to verify whether the leading-margin gradient that we have identified above is not just driven by some time-invariant electoral unit (in particular, municipality) characteristic, implying that that some units had closer races than others in all the three elections (and, at the same time, higher fractions of invalid votes). Controlling for more than 8000 electoral-unit fixed effects identifies the leading-margin elasticity of the fraction of invalid ballot *within electoral units* over time. The elasticity decreases from -5 percent to -2.8 percent (and the coefficient remains statistically significant at 1% level). While the coefficient on blank ballots remains basically unchanged, the coefficient on voter turnout loses its significance. A likely cause is the fact that voter turnout is a relatively stable characteristic and varies relatively little over time within municipality. Column 2 shows that even controlling for electoral-unit fixed effects, the interaction between the margin of victory and voter turnout remains highly significant. In Columns 3 and 4 we control for individual leading-candidate fixed effects. Controlling for leading-candidate fixed effects does not alter the result on the margin of victory (with respect to the results of regression with the electoral-unit fixed effects). This suggests that the elasticity of the margin of victory is robust to the inclusion of candidate characteristics.

Table 8 addresses the North-South divide that we observe in descriptive statistics and figures. The first column replicates the results from Column 3 of Table 5, i.e. a simple OLS regression with a dummy for the South. The coefficient on the South dummy is what we will try to explain by adding province-level information on economic outcomes in Column 2, measures of social trust in Column 3 and an index for the presence of organized crime in the Columns 4 and 5. The elasticity with respect to the employment rate is always negative, highly significant, and close to -1, while that with respect to income per capita is not significantly different from 0. Among the several measures of social capital that we employ (we do not report all the regression results, to economize on space), the one that relates strongest to invalid ballots is the turnout at national referenda. The elasticity of invalid ballots with respect to this measure is negative, large (in absolute value), and statistically significant. Adding this single proxy for civic duty lowers the coefficient on the South dummy from 19 to 8 percent, and the coefficient loses

its significance. This suggests that civic duty captures most of the "South effect". The other frequently used measures of social capital (the presence of voluntary associations, blood donations, the percentage of differential waste) have no power in explaining the variation in invalid ballots.

Organized crime is known to be heavily present in most Southern regions. The Camorra around Naples, the Mafia in Sicily, the 'Ndrangheta in Calabria and the Sacra Corona Unita in Puglia regularly try to influence local and national politics, directly and indirectly. Vote buying would certainly be an instrument to manipulate elections, and adding particular signs on the ballots would be one way for voters to signal their voted preference. If this were the case, and some of these votes were invalidated, we would expect this to show up in our data.

In Column 4, we report the results of the regression in which we additionally control for the presence of organized crime. We have constructed this index in the following way. We calculated the province-level average of the (standardized) value of the number of principal crime types and of the standard deviation of these crime types. Our aim is to capture not simply the level of crime but also its variation over time (given that the most successful mafia organizations use threats of violence - and not actual violence - to advance their objectives). The types of crime that we use are: homicides accounted for by mafia, extortions, kidnappings, and criminal organization (*associazione mafiosa*). Next, we normalize this average in such a way that all the values lie between 0 and 1. Figure 7 shows the distribution of the mafia index at the region level. Compared to the least mafia-infested province (Vicenza), the most infested one (Reggio Calabria) has 18 per cent more of invalid votes. Column 5 shows that this effect is robust to the inclusion of region dummies. This means that even within regions, at the districts in the provinces where mafia is more present the fraction of invalid votes is larger.

We also ran a regression adding as a regressor the interaction between the mafia index and the leading-margin (results not reported here; available upon request). We found no evidence of a differential gradient depending on the presence of mafia. This implies that the presence of organized crime might only increase the number of protest votes, without actively influencing the electoral count.

Once the lower level of social capital and the higher level of organized crime are accounted for, the political behavior in terms of the level of invalid ballots does not seem

to differ between the districts in the Southern and non-Southern regions.

6 Conclusion

We study how the closeness of electoral race affects the number of invalid ballots, under the traditional paper-ballot voting technology. We discuss several competing theories that can explain this correlation: based on the behavior of voters, on biased and unbiased election officers, and on the political parties. Using a large dataset from the Italian parliamentary elections in 1994-2001, we try to disentangle these competing theories.

Our first major finding is establishing a strong, robust positive correlation between the closeness of electoral race and the fraction of invalid ballots. We find no evidence that this correlation is driven by voters' behavior or the biased actions of election officers. The theory that garners most support is that of unbiased election officers that allocate their effort to reduce the likelihood of incorrectly adjudicating the victory.

Second, we find a large North-South gap in the fraction of invalid ballots: electoral districts and municipalities in Southern Italian regions have a substantially higher level of invalid ballots. Moreover, the link between the closeness of electoral race and the fraction of invalid ballots seems absent in the South. The low level of social capital and high level of organized crime explain these differences: once these two features are accounted for, the districts and municipalities in the South behave similarly to those in the North.

What do our findings imply? Considered together with the results of Ansolabehere and Stewart III (2005), they suggests that the traditional paper-based ballot system performs better than other systems, in terms of the reliability and resistance to errors. Ansolabehere and Stewart III (2005) find that the paper-based system exhibits the lowest rate of uncounted votes. We show that the paper-based system seems to have an 'automatic safety control' that increases the likelihood that the victor is announced correctly. This system functions thanks to the increased attention that the counting officers allocate to tracking the truly invalid ballots when the electoral race becomes closer.

However, we also find that this 'safety control' system functions only in the areas with sufficiently high levels of social capital. This implies that social capital is important not only for the participatory behavior of voters (as noted by Putnam 1993 and Alesina and Giuliano 2009) and the quality of the political class (as discussed by

Caselli and Morelli 2004), but also for the political players, such as election officers, that oversee the correct functioning of the representative democracy.

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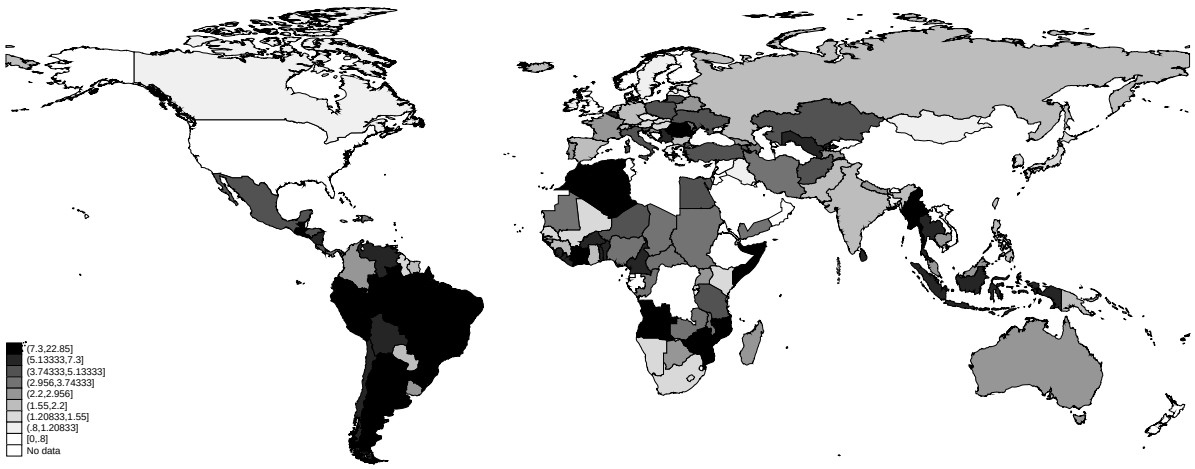

Figure 1: Fraction of Invalid Ballots Around the World (IDEA)

NOTE.– Countries are divided into 9 percentiles. The data comes from the Institute for Democracy and Electoral Assistance and refers to the parliamentary elections.

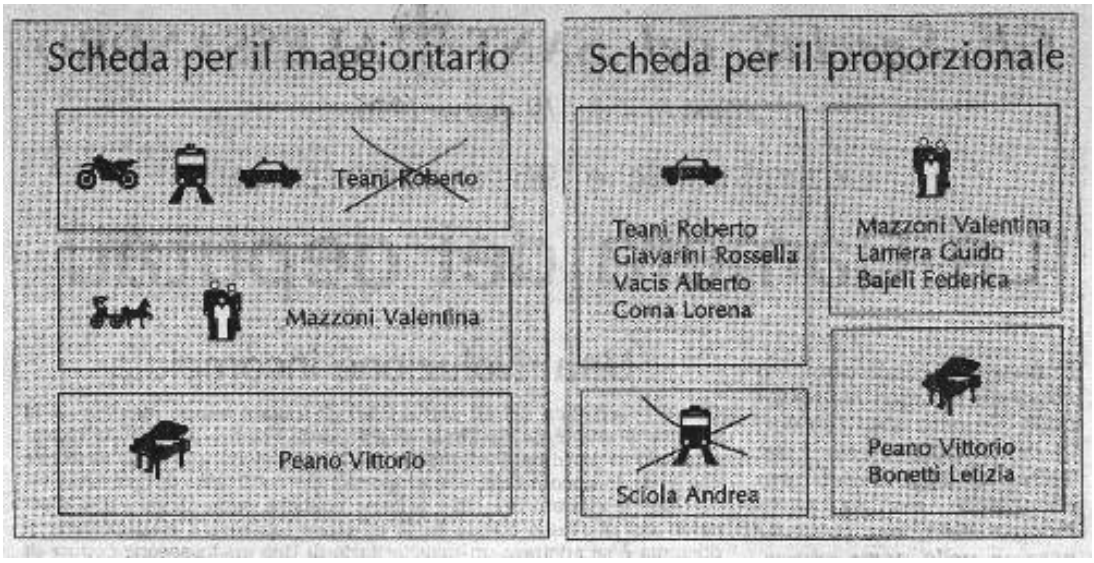

Figure 2: A Typical Ballot

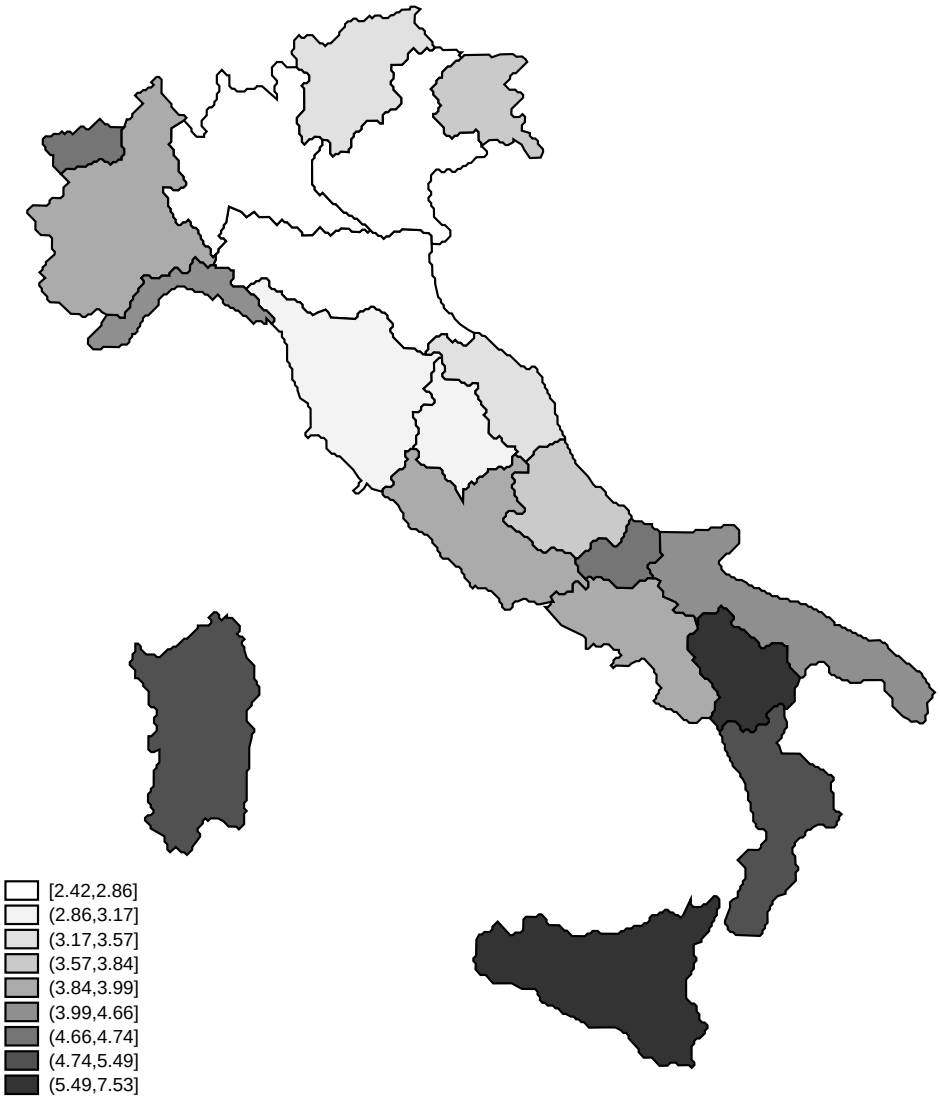

Figure 3: Geographical Distribution of Invalid Ballots

NOTE.– Regions are divided into 9 percentiles. The invalid ballots refer to the majoritarian races.

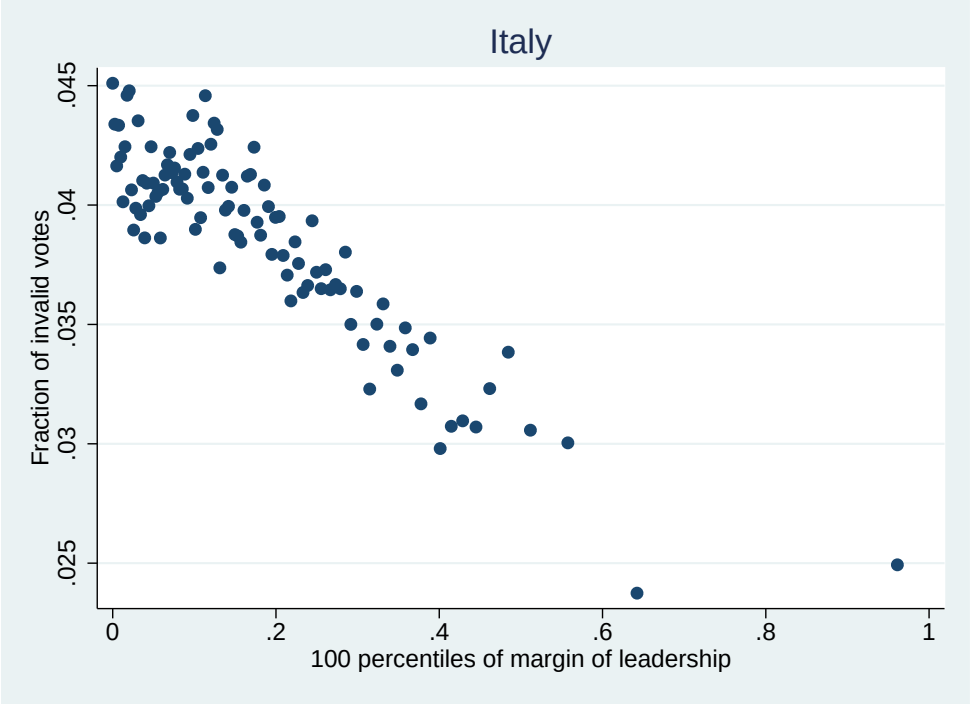

Figure 4: Fraction of invalid ballots by percentile of leading margin. Italy

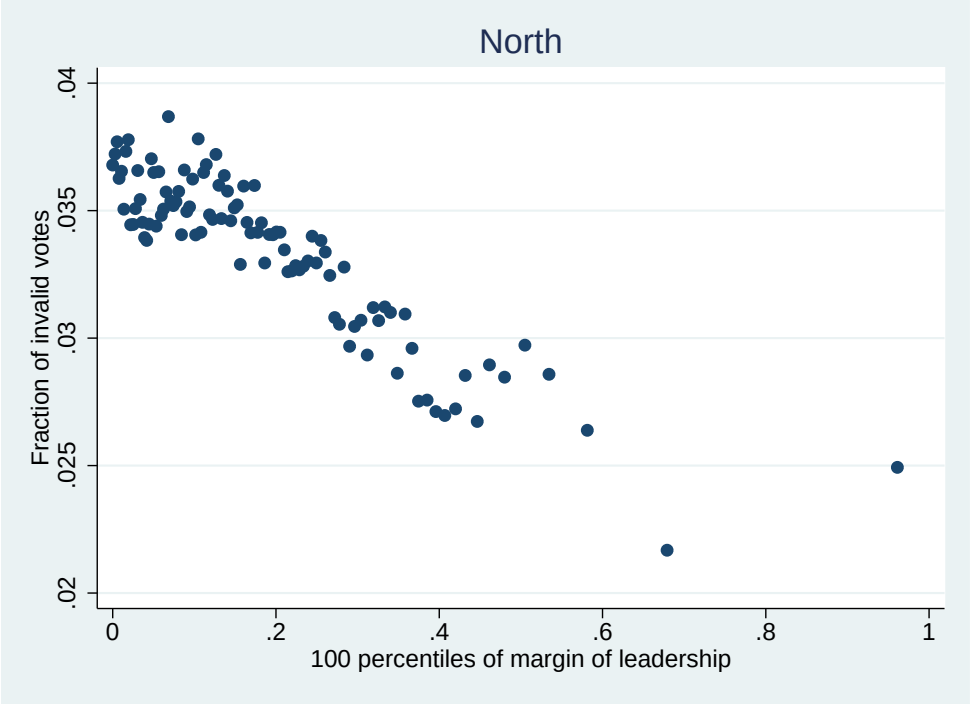

Figure 5: Fraction of invalid ballots by percentile of leading margin. North Italy.

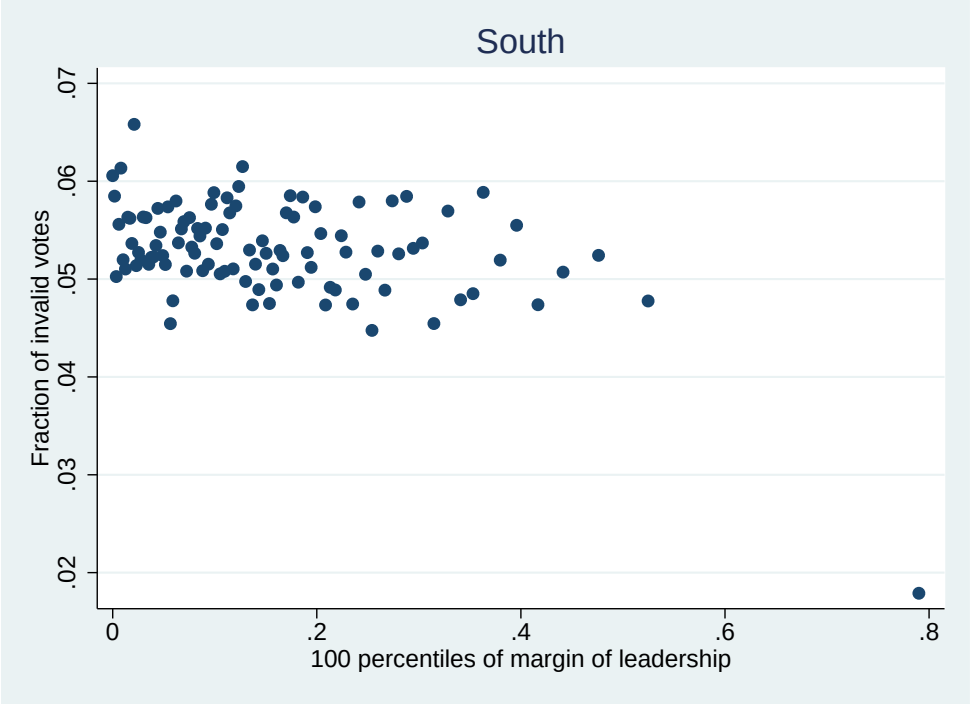

Figure 6: Fraction of invalid ballots by percentile of leading margin. South Italy

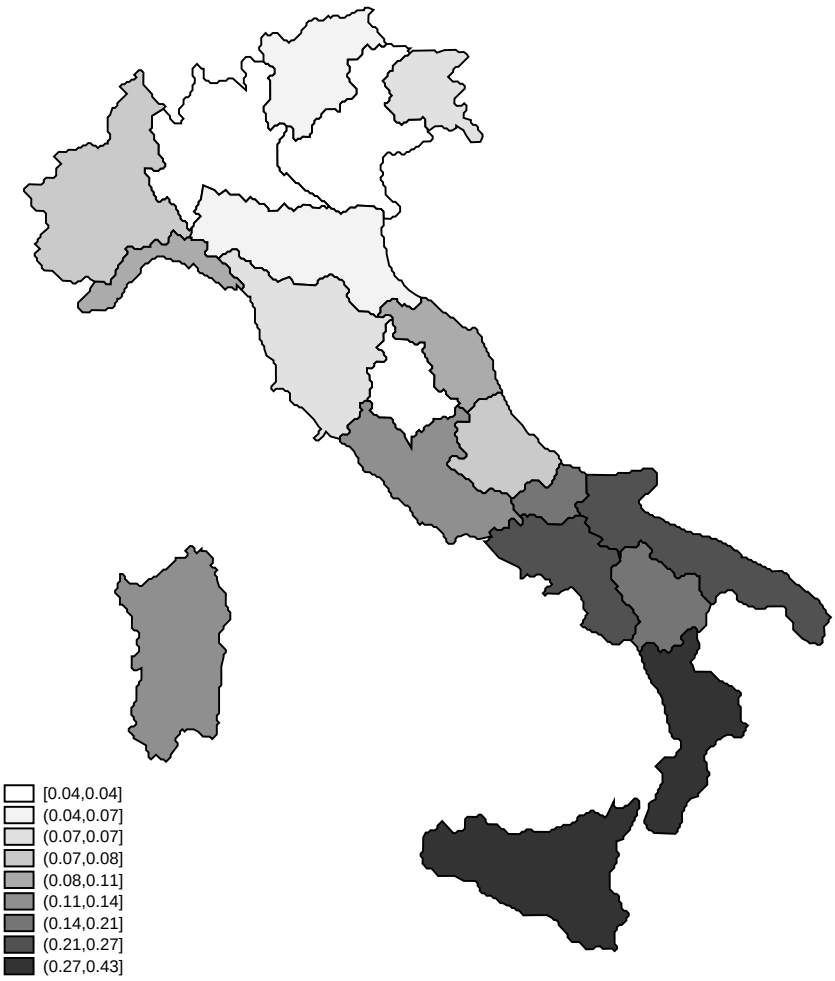

Figure 7: The Mafia Index

Table 1: Theoretical Hypotheses

Theory	Correlation between the fraction of invalid ballots and: Margin of victory	Turnout	Number of candidates
Voters	positive	-	-
Protest	positive	-	negative
Unbiased officers	negative; stronger in districts with higher social capital	negative	-
Biased officers	negative; stronger in districts with lower social capital	-	-
Parties	negative	-	positive

Table 2: Summary statistics

Variable	**Mean**	**Std. Dev.**	**N**
South	0.263	0.44	23126
Center	0.16	0.367	23126
Right coalition leads	0.38	0.485	23126
Left coalition leads	0.362	0.481	23126
Incumbent party leads	0.944	0.23	15026
Invalid ballots	0.039	0.022	23126
Blank ballots	0.046	0.022	23126
Number of candidates	4.136	1.005	23126
Turnout	0.820	0.109	23126
Leading margin	0.184	0.148	23126

Table 3: Fraction of Invalid Ballots by Region and Over Time

Region	1994	1996	2001
Abruzzo	3.7%	4.7%	3.2%
Emilia-Romagna	2.2	2.6	2.4
Friuli-Venezia Giulia	3.0	3.9	4.4
Lazio	4.1	4.3	3.3
Liguria	3.9	4.6	3.5
Lombardia	2.2	2.8	3.5
Marche	3.3	3.8	2.9
Piemonte	3.6	4.1	4.1
Toscana	2.9	3.5	2.8
Trentino-Alto Adige	3.5	3.8	3.5
Umbria	3.4	3.3	2.8
Valle d'Aosta	3.9	4.9	5.4
Veneto	2.6	2.8	3.2
North	3.0	3.5	3.5
Basilicata	8.5	8.0	5.0
Calabria	6.0	6.2	4.3
Campania	4.3	4.5	3.2
Molise	4.8	6.1	3.9
Puglia	5.2	5.3	3.6
Sardegna	5.3	5.9	3.5
Sicilia	7.8	8.5	6.6
South	5.8	6.1	4.3

Table 4: North-South Summary Statistics

	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**
	North Italy		South Italy	
Right coalition leads	0.470	0.499	0.257	0.437
Left coalition leads	0.248	0.432	0.517	0.500
Incumbent party leads	0.952	0.213	0.918	0.275
Incumbent participates	0.397	0.489	0.563	0.496
Incumbent leads	0.232	0.422	0.311	0.463
Invalid ballots	0.033	0.015	0.047	0.026
Blank ballots	0.040	0.018	0.055	0.025
Number of candidates	3.954	0.831	4.383	1.157
Turnout	0.864	0.073	0.759	0.119
Leading margin	0.202	0.161	0.159	0.125
N	13344		9782	

NOTE.– The variables about the incumbent have 8,848 observations in North and 6,178 in the South.

Table 5: Log-Fraction of Invalid Ballots Regressions.

	(1)	(2)	(3)	(4)	(5)
	log-Invalid ballots				
log-Leading margin	-0.076***	-0.066***	-0.051***	-0.034***	-0.051***
	(0.007)	(0.007)	(0.006)	(0.008)	(0.006)
log-Turnout		-0.692***	-0.279***	-0.286***	-0.279***
		(0.096)	(0.071)	(0.073)	(0.071)
log-Blank ballots		0.287***	0.239***	0.193***	0.239***
		(0.021)	(0.019)	(0.019)	(0.018)
Log-N. of candidates		-0.065*	-0.069	-0.056	-0.069
		(0.034)	(0.049)	(0.055)	(0.049)
South			0.318***	0.226***	0.318***
			(0.034)	(0.036)	(0.035)
Year 1996			0.114***	0.096***	0.114***
			(0.019)	(0.020)	(0.019)
Year 2001			0.020		0.016
			(0.020)		(0.020)
Incumbent party leads				-0.004	
				(0.024)	
Right coalition leads					-0.005
					(0.020)
Observations	23003	22982	22982	14914	22982
R-squared	0.031	0.180	0.246	0.164	0.246

NOTE.– Standard errors are clustered at the district level. There are 475 majoritarian districts.

Table 6: Log-Fraction of Invalid Ballots Regressions.

	(1)	(2)	(3)	(4)
	log-Invalid ballots			
log-Leading margin	-0.077***	-0.062***	-0.121***	-0.116***
	(0.011)	(0.009)	(0.027)	(0.028)
log-Turnout	-0.278***	-0.271***	-0.280***	-0.275***
	(0.070)	(0.070)	(0.070)	(0.070)
log-Blank ballots	0.239***	0.240***	0.240***	0.240***
	(0.019)	(0.019)	(0.019)	(0.018)
Log-N. of candidates	-0.068	-0.067	-0.069	-0.067
	(0.049)	(0.049)	(0.048)	(0.049)
South	0.317***	0.323***	0.322***	0.322***
	(0.034)	(0.034)	(0.034)	(0.034)
Year 1996	0.107***	0.106***	0.112***	0.103***
	(0.019)	(0.020)	(0.019)	(0.020)
Year 2001	0.015	0.015	0.020	0.014
	(0.020)	(0.020)	(0.020)	(0.020)
log-Leading margin ×				
log-Turnout	-0.128***			-0.090***
	(0.033)			(0.034)
South		0.039***		0.019
		(0.011)		(0.012)
Log-N. of candidates			0.051***	0.030
			(0.019)	(0.020)
Observations	22982	22982	22982	22982
R-squared	0.248	0.248	0.247	0.248

NOTE.– Standard errors are clustered at the district level. There are 475 majoritarian districts.

Table 7: Log-Fraction of Invalid Ballots Fixed Effects Regressions.

	(1)	(2)	(3)	(4)
	log-Invalid ballots			
log-Leading margin	-0.028***	-0.006	-0.026***	-0.043**
	(0.004)	(0.024)	(0.003)	(0.017)
log-Turnout	-0.253	-0.262	0.044	0.046
	(0.239)	(0.239)	(0.050)	(0.050)
log-Blank ballots	0.262***	0.262***	0.212***	0.212***
	(0.026)	(0.026)	(0.012)	(0.012)
Log-N. of candidates	-0.052	-0.051	1.426	1.403
	(0.046)	(0.046)	(2.323)	(2.339)
Year 1996	0.134***	0.132***		
	(0.021)	(0.021)		
Year 2001	0.033	0.030		
	(0.031)	(0.031)		
log-Leading margin ×				
log-Turnout		-0.106***		-0.048*
		(0.033)		(0.026)
South		-0.015		-0.027***
		(0.011)		(0.007)
Log-N. of candidates		-0.029*		0.011
		(0.017)		(0.013)
Electoral unit fixed effects	yes	yes	no	no
Leading candidate fixed effects	no	no	yes	yes
Observations	22982	22982	22982	22982
R-squared	0.738	0.739	0.568	0.569

NOTE.– Standard errors are clustered at the district level. There are 475 majoritarian districts. There are 8,224 electoral units fixed effects, 2,476 leading candidate times year fixed effects, and 3,335 pair times year fixed effects.

Table 8: Explaining the North-South Divide in the Log-Fraction of Invalid Ballots.

	(1)	(2)	(3)	(4)	(5)	(6)
	log-Invalid ballots					
log-Margin of leadership	-0.051***	-0.048***	-0.047***	-0.046***	-0.045***	-0.046***
	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
log-Turnout	-0.279***	-0.232***	-0.087	-0.081	-0.079	-0.007
	(0.071)	(0.069)	(0.073)	(0.073)	(0.078)	(0.057)
log-Blank ballots	0.239***	0.219***	0.216***	0.208***	0.207***	0.220***
	(0.019)	(0.019)	(0.019)	(0.018)	(0.018)	(0.015)
Log-N. of candidates	-0.069	-0.053	-0.054	-0.046	-0.056	-0.049
	(0.049)	(0.042)	(0.042)	(0.042)	(0.042)	(0.036)
South	0.318***	0.189***	0.078	0.061	0.070	
	(0.034)	(0.050)	(0.061)	(0.059)	(0.058)	
D1996	0.114***	0.119***	0.121***	0.125***	0.121***	0.139***
	(0.019)	(0.016)	(0.016)	(0.016)	(0.016)	(0.015)
D2001	0.020	0.015	0.020	0.021	0.013	0.032
	(0.020)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
log-GDP per capita		0.036	0.155	0.128	0.288**	-0.041
		(0.114)	(0.114)	(0.123)	(0.120)	(0.110)
Mafia index					0.184*	0.201***
					(0.110)	(0.064)
log-Employment rate		-1.138***	-1.074***	-0.925***	-1.171***	-0.514**
		(0.212)	(0.211)	(0.232)	(0.236)	(0.251)
log-Recreation associations				0.182	-0.098	-0.371**
				(0.232)	(0.257)	(0.189)
log-Volontary work associations				-0.092	0.155	0.300
				(0.238)	(0.261)	(0.192)
log-Percentage of differential waste				-0.039	-0.060**	0.013
				(0.025)	(0.025)	(0.027)
log-blood donations				0.031	0.040*	-0.034
				(0.020)	(0.020)	(0.024)
log-Turnout in National Referenda			-0.774***	-0.888***	-0.832***	-0.459**
			(0.200)	(0.202)	(0.227)	(0.180)
Region fixed effects	No	No	No	No	No	Yes
Observations	22982	21594	21594	21594	20425	20425
R-squared	0.246	0.275	0.283	0.289	0.301	0.379

NOTE.– Standard errors are clustered at the district level. There are 475 majoritarian districts.

7 Apppendix

In this Appendix, we construct a simple formal rational-choice model of the behavior of an unbiased returning officer, along the lines of the argument developed in Section 2.3.

The officer's objective function is to maximize her utility, which consists of two terms. The first term captures the fact that she wants to reduce the risk of jeopardizing the true outcome of the elections. The probability of this event depends negatively on the effort exerted by the officer when scrutinizing the ballots. The second term represents the standard convex cost of effort.

Let's denote with n the number of true invalid ballots. Faced with a ballot (valid or invalid), the officer might commit one of the two type of errors. Type I error consists in invalidating a valid ballot. Type II error consists in counting as valid a ballot which is truly invalid. Given that the type I error is very unlikely to happen (one can hardly spot an inexistent irregularity in a ballot correctly filled by the voter), we will assume these errors away. Instead, the type II error, i.e. missing an existing irregularity, is much more important and the probability of this error is affected by the effort that the officer exerts. Let's denote this probability with p.

These type-II errors might jeopardize the true outcome of the elections if they are sufficiently numerous as compared to the difference in the number of valid votes between the two candidates with the highest number of votes. Let's denote with d and d^e the true and the expected difference in the number of valid votes between the two candidates, respectively. Let's assume, moreover, that

$$d = d^e \varepsilon, \tag{2}$$

where ε is the noise which is a random variable drawn from a uniform distribution:

$$\varepsilon \sim U\left[1 - \frac{1}{2\phi}, 1 + \frac{1}{2\phi}\right]. \tag{3}$$

Then, the problem of the officer can thus be written as:

$$\max_x U = -\Pr\left[np(x) > d\right] - c(x, \alpha), \tag{4}$$

where α is the parameter that captures the election-specific objective difficulty of scrutinizing the ballots (for instance, it is higher in a district with a larger number of candidates).

Using (2) and (3) in (4), and dropping the constant terms, the problem becomes

$$\max_{x} -\frac{\phi}{d^e} np(x) - c(x,\alpha). \tag{5}$$

The first-order condition of this problem is

$$-\frac{\phi}{d^e} np'(x) = c_x(x,\alpha). \tag{6}$$

The left-hand side is the marginal benefit of effort, measured in terms of reduced risk of jeopardizing the true election outcome. Higher effort reduces the probability of error by $\left(-\frac{dp}{dx}\right)$, for each invalid ballot. Given that there are n truly invalid ballots, this translates into $n\left(-\frac{dp}{dx}\right)$ less miscounted ballots. The lower is the expected vote difference between the two candidates with the highest number of votes (lower d^e) and the higher is the precision of the estimate of the vote difference (higher ϕ), the higher is the effect of this reduction in miscounted ballots on the risk of jeopardizing the true election outcome. The right-hand side simply represents the increasing marginal cost of effort.

From (6), we easily get the comparative static results on the optimal effort of the officer:

$$x^* = x(\overset{+}{\phi}, \overset{-}{d^e}, \overset{+}{n}, \overset{-}{\alpha}). \tag{7}$$

Higher number of truly invalid ballots and a higher precision of the estimate of the vote difference increase the effort of the officer. Higher expected vote difference and the steeper increase in the cost of effort reduce the effort of the officer.

In order to get closed form solutions for x^*have a tractable empirical specification we assume that $p(x)$ has the shape of the exponential cumulative distribution $1 - e^{\lambda x}$, with $\lambda > 0$, and that the cost function has the shape of an exponential function $c(x,\alpha) = e^{\alpha x} - 1$, with $\alpha > 0$. Without loss of generality, we assume that $\alpha > \lambda$. The shape of these functions is ideal, as it captures the decreasing returns to effort for the probability of committing type II errors, and the more than proportional cost of effort. With these functional forms the first order conditions is:

$$\frac{\phi}{d^e} n\lambda e^{\lambda x} = \alpha e^{\alpha x},$$

and solving for x^*

$$x^* = \frac{1}{\alpha - \lambda} \log\left(\frac{\phi n \lambda}{d^e \alpha}\right)$$

Empirically, we do not observe the officer's effort, but only the number of ballots reported as invalid. In terms of our model, denoting this number as n^v, we get

$$n^v = n\left[1 - p(x^*)\right] = n^v(\overset{+}{\phi}, \overset{-}{d^e}, \overset{+}{n}, \overset{-}{x}). \tag{8}$$

or

$$\begin{aligned} \log n^v &= \log n + \lambda x^* = \log n + \frac{\lambda}{\alpha - \lambda} \log\left(\frac{\phi n \lambda}{d^e \alpha}\right) && (9) \\ &= a + b_1 \log d^e + b_2 \log n + e, && (10) \end{aligned}$$

where $a = -\frac{\lambda}{\alpha-\lambda}\log\alpha$, $b_1 = -\frac{\lambda}{\alpha-\lambda}$, and $b_2 = \frac{\alpha}{\alpha-\lambda}$, and e is an unobserved component equal to $\frac{\lambda}{\alpha-\lambda}\log\phi$.

This result allow us to formulate the following testable hypotheses.

Hypothesis A1. Higher vote difference (between the two candidates with the higher number of votes) negatively correlates with the number of reported invalid ballots, $b_1 = -\frac{\lambda}{\alpha-\lambda} < 0$.

Hypothesis A2. Higher number of invalid votes positively correlates with the "true" number of reported invalid ballots, $b_2 = \frac{\alpha}{\alpha-\lambda} > 0$.

Finally, note that when α is large (i.e. when the cost function is steeper) the number of invalid votes decreases.