THE FINGERPRINTS OF FRAUD: EVIDENCE FROM MEXICO’S 1988 PRESIDENTIAL ELECTION

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Abstract

This paper unpacks the formal and informal opportunities for fraud during the 1988 presidential election in Mexico. In particular, I study how the alteration of vote returns came after an electoral reform that centralized the vote-counting process. Using an original image database of the vote-tally sheets for that election, and applying Convolutional Neural Networks (CNN) to analyze the sheets, I find evidence of blatant alterations in about a third of the tallies in the country. The empirical analysis shows that altered tallies were more prevalent in polling stations where the opposition was not present and in states controlled by governors with grassroots experience of managing the electoral operation. This research has implications for understanding the ways in which autocrats control elections as well as introducing a new methodology to audit the integrity of vote tallies.

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1 Introduction

Elections are the norm to reach public legitimacy in modern dictatorships. Far from regulating competition for power, authoritarian elections regulate access to spoils (Magaloni, 2006; Blaydes, 2011), mitigate intra-regime conflicts (Geddes, 2006; Boix and Svolik, 2013), and gather information about the incumbent’s popularity (Lust-Okar, 2005; Brownlee, 2007; Cox, 2009; Malesky and Schuler, 2011). Autocrats working to achieve any or all of these goals hold elections to enhance public legitimacy by allowing the opposition to compete and by establishing a basic level of fairness in the process (Lindberg, 2006; Mylonas and Roussias, 2007; Beaulieu, 2014). A regime’s success in masking its authoritarian nature varies from case to case, but all dictators who hold elections aspire to balance liberal concessions to the opposition with subtle control of the electoral process (Gandhi, 2008; Magaloni, 2008; Schedler, 2013).

Much less attention has been paid to the specific role that electoral institutions have on authoritarian stability. The literature on comparative politics provides evidence on how dictators tailor electoral institutions to their liking (Díaz-Cayeros and Magaloni, 2004; Levitsky and Way, 2010; Higashijima and Chang, 2015). At the same time, recent works demonstrate that authoritarian elections are frequently marked by electoral fraud (Birch, 2012; Simpser, 2013; Little, 2015; Rozenas, 2015). But if dictators contravene the rules they created in first place, do electoral institutions shape the opportunities for fraud or they are a mere façade for the autocrat to control the outcome?

This paper explores the opportunities for electoral manipulation using new data on the 1988 presidential election in Mexico. In particular, I focus on the incentives to alter the vote tallies after an electoral reform that allowed district officials to recount and amend the results from polling stations. While this reform centralized the opportunities for electoral manipulation, the ultimate execution of fraud depended on the resources available to the governors of each state, who had the task of coordinating and monitoring the performance of election officials under their jurisdiction. To understand the informal
incentives to commit fraud at the sub-national level, I analyze the variation in governors’
electoral experience and personal ties to the presidential candidate. Working at the in-
terface between formal and informal politics allows me to look for the constraints and
opportunities involved in manipulating the election results during the vote-aggregation
process.

I document the extent of aggregation fraud in the election using a novel database
with images of more than 50,000 vote tallies available for the election. Using Convo-
lutional Neural Networks (CNN)—a computer-aided detection system used for image-
recognition problems—I identify blatant alterations in about a third of the vote tallies in
the country. A complementary analysis suggests that these alterations were more likely
to occur in tallies from polling stations where the opposition was absent, and in the ju-
risdicitions of the governors who had expertise in leading the electoral operations for the
ruling party.

This paper sheds light on the formal and informal opportunities for electoral fraud
during the vote-aggregation process (Myagkov, Ordeshook and Shakin, 2009; Ofosu and
Posner, 2015; Callen and Long, 2015; Ferrari and Mebane, 2017). The results demonstrate
that the inflation of vote returns occurred at the crossroads of the constraints established
by the electoral institutions and the informal incentives for governors to mobilize local
agents. Moreover, the findings provide evidence of the formal and informal conditions for
local officials to execute fraud (Ziblatt, 2009; Reuter and Robertson, 2012; Martinez Bravo,
2014; Mares, 2015).

The study also assesses the integrity of the vote tallies by introducing a CNN model
that can be used in the analysis of any contemporary election. The proposed approach
complements recent developments that look for statistical anomalies in vote returns (Myagkov,
Ordeshook and Shakin, 2009; Beber and Scacco, 2012; Mebane, 2015; Rozenas, 2017). In
particular, this work is most similar to the few works applying machine learning to iden-
tify patterns of electoral manipulation (Cantú and Saiegh, 2011; Montgomery et al., 2015;
Levin, Pomares and Alvarez, 2016). However, I depart from the aforementioned literature by using the images of the tallies, rather than their vote sums, to understand the data-generating process behind the electoral irregularities.

The final contribution of this article is the documentation of an overlooked electoral irregularity in a prototypical example of how authoritarian governments control electoral outcomes (Schedler, 2002a; Levitsky and Way, 2010; Chernykh and Svolik, 2015). Prior research on the 1988 election in Mexico has focused on its consequences for the country’s gradual democratization process (Bruhn, 1997; Eisenstadt, 2004; Magaloni, 2006; Greene, 2007). Nevertheless, to this date there is little evidence of the existence and scope of fraud in this election. This paper analyzes for the first time the results of all the polling stations open on July 6, 1988, and shows that most of the electoral irregularities took place at the district councils.

The structure of the rest of the paper is as follows. Section 2 provides a brief contextual background for the 1988 election in Mexico, describing the structural and institutional conditions for this election, as well as describing the main irregularities documented in the literature. Section 3 defines the conditions in which aggregation fraud is more likely to occur and provides qualitative evidence from the study case. Section 4 describes the methodology and presents the results of the classification of all the images in the database. Using this classification as the dependent variable, Section 5 proposes the theoretical expectations and explores the determinants of this fraud technology. Finally, Section 6 summarizes the findings and provides suggestions for future research.

2 Mexico 1988

2.1 Contextual Background

For most of the twentieth century, elections in Mexico were an instrument to the official party to “rule perpetually and rule with consent” (Przeworski et al., 2000, p. 26). Al-
though multiparty elections were held uninterruptedly, a complex system of formal institutions and informal arrangements permitted the Institutional Revolutionary Party (PRI) to win all the Senate, gubernatorial, and presidential elections from 1929 until 1988 (Scott, 1964; Johnson, 1978; Langston, 2017). The strength of the official party relied on the legitimacy gained by competing in elections and the uneven playing field for the opposition parties (Schedler, 2002a, p. 37; Levitsky and Way, 2010).

By the second half of the 1980s, however, the PRI’s invincibility started to shatter. The popularity of the official party gradually waned as a new generation of urban citizens, unfamiliar with the country’s economic boom thirty years earlier, reached the voting age (Craig and Cornelius, 1995). The erosion of the regime’s public support intensified with the financial crisis of the early 1980s, which saw it lose support from popular sectors and the businesspeople (Bruhn, 1997; Haber et al., 2008). Discontent with the government and the official party became evident during the 1985 legislative election, where the PRI’s vote share dropped to a new low of 64% (Molinar, 1991).

And yet, the most critical weakening factor for the regime may have sprung from within the PRI itself. In the early 1980s, a group of young party members with more technical skills than political experience began occupying top positions in the federal administration (Camp, 2014, p. 134-137). The gradual influence of this group within the party faced hostility from the traditional political bosses, who opposed the new pro-market policies promoted by the government (Langston, 2017). The intra-party disagreements escalated in 1987, when a handful of prominent PRI members spoke out against the government’s orthodox measures to deal with the economic crisis and the lack of democracy within the party. When the president and party authorities did not attend the demands, the dissident group left the PRI a year before the presidential election; this was the most critical split in the party since 1940 (Magaloni, 2006).
2.2 Electoral process

The 1988 presidential race pitted the PRI’s Carlos Salinas against two main candidates campaigning from opposite sides of the ideological spectrum.\(^1\) On the left, a number of small parties and civic organizations created the Democratic National Front (FDN) to endorse Cuauhtémoc Cárdenas’s candidacy. Cárdenas, who led the PRI’s splinter a year earlier, aimed this campaign toward an electorate frustrated by declining living standards and governmental corruption (Smith, 1989; Bruhn, 1997). On the right, the National Action Party (PAN) nominated Manuel Clouthier, whose campaign targeted middle-class voters disappointed with the country’s economic policies (Shirk, 2001; Wuhs, 2014). Facing unequal campaign resources and biased media coverage (Reding, 1988; Oppenheimer, 1996, p. 132; Lawson, 2002, p. 52; Greene, 2007), both opposition candidates focused on mobilizing the protest vote and emphasizing that a PRI defeat was the first step toward democratizing the country (Domínguez and McCann, 1996).

As soon as the voting started on July 6, 1988, opposition parties and news agencies gave accounts of wide-ranging irregularities taking place throughout the country. The incidents included, for example, polling stations opening with an undue delay (New York Times, July 7, 1988), stolen and stuffed ballot boxes (La Jornada, July 7, 1988), and destroyed ballots marked for Cárdenas (Los Angeles Times, July 15, 1988). Later that day, opposition candidates signed a letter documenting these and other irregularities—such as absent election officials, inflated voter rolls, and voters casting multiple ballots—and asked election officials to “reestablish the legality of the electoral process” (Cárdenas, Clouthier and Ibarra, 1989).

Doubts about the legitimacy of the process escalated after electoral authorities sud-

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\(^1\)Besides Cárdenas and Clouthier, there were three other opposition candidates on the ballot. Gumersindo Magaña from the Mexican Democratic Party, Rosario Ibarra from the Revolutionary Workers’ Party, and Heriberto Castillo from the Mexican Socialist Party. Castillo dropped out of the race a month before the election and endorsed Cárdenas’s candidacy. The vote shares for Magaña and Ibarra were 1% and 0.4%, respectively.
denly stopped publishing the results. A few hours after the polls closed, the first public vote tallies showed adverse results for the PRI’s candidate, triggering the anxiety of government officials (Anaya, 2008). The news of the preliminary results reached President Miguel de la Madrid, who—as he recognizes in his memoirs—urged Salinas to declare himself the winner of the election and instructed election officials to interrupt the public vote count (de la Madrid, 2004, p. 816). A few minutes later, the screens at the Ministry of Interior went blank, an event that electoral authorities justified as a technical problem caused by an overload on telephone lines (Castañeda, 2000, p. 83). Skeptical about the official explanation, opposition representatives urged election officials to continue with the public vote count after finding a computer in the building’s basement that continued receiving electoral results (Valdés Zurita and Piekarewicz, 1990). The sudden interruption of public information and the refusal of electoral authorities to release further results caused this incident to be referred to as “crash of the system,” suggesting that the interruption of the vote count allowed federal election officials in Mexico City to manipulate the final results.

Electoral authorities resumed the public vote count three days later, on July 10, when the official vote tabulation took place in each of the country’s 300 district councils. Later that day, officials announced the victory of the PRI’s Carlos Salinas with 50.4% of the vote, followed by Cárdenas with 31.1% and Clouthier with 17.1%. These results sparked multiple protests from opposition parties and citizens across the country. The confrontation over the official results, however, gradually weakened in part because of disagreements within the opposition (Gómez Tagle, 1990; Magaloni, 2010). This allowed the ratification of Salinas’s victory by the Chamber of Deputies on September 10, 1988.
3 Aggregation Fraud

The focus of this paper is to identify the alteration of the vote tallies by officials when adding up the vote totals from polling stations in the 1988 presidential election. This irregularity, referred to in other works as aggregation fraud (Callen and Long, 2015), is a prevalent problem in many modern elections and is a top concern of election observers and international election experts. In the case of the 1988 election in Mexico, the existence of this irregularity implies that the vote counts of the PRI’s candidate were inflated at district councils after electoral authorities received the results from the polling stations and before the officials reported the district vote totals to the Ministry of Interior in Mexico City. The existence of aggregation fraud in the 1988 election proposes an overlooked hypothesis for how electoral manipulation was carried out in this case.

The literature on electoral manipulation provides multiple accounts on the ways and consequences of aggregation fraud. Caro (1991, p. 391-395), for example, offers an astonishing description of how the Democratic political machine in southern Texas altered a tally in Jim Wells County to give Lyndon B. Johnson 200 extra votes and flip the result of the 1948 Senate primary election. In a study of the 2003 presidential election in Nigeria, Beber and Scacco (2012) find a similar handwriting style across multiple tally sheets and demonstrate that the last digits in vote totals significantly deviated from the uniform distribution, a pattern suggesting the alteration of the electoral results. Myagkov, Ordeshook and Shakin (2009) detail the inflation of vote returns in contemporary Russian elections and describe the incentives for local bosses to falsify the tallies under their jurisdiction. In a carefully designed field experiment, Callen and Long (2015) photographed and compared a random sample of tallies at several stages of the 2010 parliamentary elections in Afghanistan. The authors find discrepancies on the vote results in 78% of the observations.

The prevalence of aggregation fraud in modern elections suggests its efficiency for

\(^2\)See, for example: Democracy International (2011) and USAID (2015).
modifying vote results over other fraud resources. At one end of the process, incumbents can delegate the execution of fraud to an army of vote agents who are able to manipulate results at the polling-station level. Scholarly work provides examples of electoral manipulation carried out by numerous agents—represented as local employers (Lehoucq and Molina, 2002; Mares, 2015) or party bosses (Key, 1949)—with enough experience on the ground to deliver votes in an effective and concealed way. Although decentralized fraud relies on a group of experts in producing votes, this strategy faces two of drawbacks. First, when local party agents can ultimately define the outcome of an election, they can leverage their importance by demanding excessive material or political benefits from the central party (Schattschneider, 1942, p. 162). Second, this fraud technology requires the party to closely supervise and coordinate the activities of the agents. In the absence of monitoring resources, agents are likely to undersupply fraud when the party needs it the most (Rundlett and Svolik, 2016).

At the other end of the process, the incumbent can opt for centralized manipulation and rig the final results just before their official announcement. In this case, electoral fraud is carried out by a handful of top-level officials whose decisions determine on the final outcome. Consider, for example, the case of Ukraine’s Central Electoral Commission in 2004, whose decision to invalidate the votes in three districts flipped the outcome of the presidential election (Birch, 2012, p. 123-130). Although it gives the incumbent greater control over the election outcome, centralized manipulation is more likely to be noticed by the opposition and electoral observers (Simpser, 2013). The blatancy of this irregularity, therefore, can carry “legitimacy costs” related to social unrest (Tucker, 2007; Davecker, 2012; Beaulieu, 2014) or penalties from the international community (Hyde, 2011; Kelley, 2012). Therefore, centralized irregularities at the end of the process should be considered only as a “last resort” for electoral manipulation (Birch, 2012, p. 131).

In comparison with highly localized or highly centralized manipulation, aggregation fraud allows the political elite to rely on a compact group of decentralized agents, each
of them contributing to modify the outcome on the aggregate. This type of fraud is usually performed by a reduced number of middle-level officials with the expertise to carry out manipulation and who have close links with the candidates (Callen and Long, 2015). Given the perpetrators’ skills and their membership in the network, the ruling elite benefit from electoral manipulation in a more efficient way.

3.1 Aggregation Fraud in Mexico’s 1988 Presidential Election

Before presenting the evidence of this irregularity for the case study, it is important to understand its data-generating process. Beginning at 6 p.m. on Election Day, poll workers counted the ballots and recorded the polling station results in the presence of party representatives, who signed and got a carbon copy of the tally sheet. After finishing the vote count, poll workers delivered the electoral material to one of the country’s 300 district councils, where election officials received the material and reported the preliminary results via telephone to the Ministry of Interior in Mexico City (Valdés Zurita and Piekarewicz, 1990). Despite the interruption of the national vote count, district councils continued receiving the tallies that were used three days later for the official vote tabulation.

The formal structure of the Mexican electoral administration was concentrated in the hands of the federal executive, which directly assigned the officials at the Federal Electoral Commission (CFE) and poll workers across the nation (Molinar, 1991; Woldenberg, 2012). Furthermore, an electoral reform in 1987 shaped the incentives for aggregation fraud in two ways.³ First, the amended law provided the PRI with the default majority of votes in every district council, outnumbering those from the opposition by 19 to 12 seats (Krieger, 1990; Valdés Zurita and Piekarewicz, 1990). Second, the reformed law entitled district-level authorities to recount the votes of polling stations in their jurisdiction

³For a detailed description of the electoral reforms in the 1980s see Klesner (1997), and Eisenstadt (2004, p. 42-44)
(Klesner, 1997, p. 44). Both changes in the rules gave party officials the legal faculty to amend vote tallies without the opposition’s approval (Gómez-Tagle, 1993).

The electoral operation in Mexico during the PRI’s hegemonic regime was performed by an informal chain of command leaded by the interior minister, who managed the election process and held governors’ performance accountable. Governors, in turn, were responsible for winning elections in their respective states, a goal that required them to mobilize local brokers and to monitor election officials (Langston, 2017, Chapter 3). The 1988 election, however, departs from this description in two ways. First, the gradual entitlement of technocrats within the PRI structure allowed bureaucrats without political skills and electoral experience to fill the governor’s post in several states (Centeno, 2004). These inexperienced executives, however, lacked the means to mobilize local agents on Election Day and deliver the expected results (Anaya, 2008, p. 15). Second, the interior minister had wanted but did not get the PRI presidential nomination, causing him not to coordinate governors’ electoral operation (Castañeda, 2000, p. 78-79). The bitterness of his losing not being selected led the minister to focus on his formal task of administering the electoral process, while leaving to the side his informal, yet critical, role of leading the electoral machine. The absence of the Ministry of Interior as the leader of the electoral operation left the control of electoral results to a few governors with the expertise and motivation to deliver votes in an effective way.

Anecdotal evidence suggests the way in which aggregation fraud took part during the tabulation of the votes. For example, Preston and Dillon (2004) describe the manipulation of vote tallies in a district council on July 10, 1988:

An official would page through the pile of precinct tallies one by one, calling out in a loud voice—in Spanish, cantando—the votes for each candidate as a secretary wrote the totals onto the district spreadsheet. (...) Each time Salinas’s votes from a precinct were read out loud, the PAN representative complained, the district committee secretary was adding a zero to Salinas’s total on the
spreadsheet, changing 73 votes for Salinas to 730 votes, for instance. (p. 172)

The amendments to the tallies’ vote totals became evident when opposition representatives compared the results that they recorded at the polling stations on Election Day with the few official results published at the polling-station level. Consider the following quote from a member of the Popular Socialist Party describing the discrepancies in the results documented in the Eighth District of Puebla:

In polling station number 2, the PRI obtained 232 votes, as it appears in the certified copy provided to the political parties. However, Mr. Carlos Olvera, the president of the Electoral Committee in the District, submitted an apparent altered tally during the official vote count on Sunday the 10th, recording 1,422 instead of 232 votes. (...) In polling station number 3, the PRI actually got 184 votes, but the altered tally gives it 2,488. The real vote tally of polling station No.4 shows 154 votes for the PRI, but the false tally shows 720. Meanwhile, the the real number of votes for the Popular Socialist Party got 240 but the false tally gave it only 140. (Senado de la República, 1988, p. 115)

The most straightforward way to assess the validity and extent of these examples would be to compare the votes in every ballot box with the results reported by election authorities. Unfortunately, this comparison turns out to be impossible as authorities only published the results at the district level and the government destroyed the ballots in 1992. Nevertheless, a close inspection of the vote tallies for the 1988 election shows that numbers were changed. Figure 1 provides a few examples of vote tallies with vote totals alterations. The examples at the top present crossed-out numbers as well as inconsistencies in ink color and handwriting. Meanwhile, the images at the bottom illustrate those altered tallies involving number insertions that have irregular slants and different pressure. The next section presents quantitative evidence for this irregularity and estimates the overall prevalence of the altered tallies in the election.
Figure 1: Examples of vote tallies with alteration in their numbers. Mexico, 1988

(a) Guerrero, District X

(b) Nayarit, District II

(c) Puebla, District VI

(d) Veracruz, District VII
4 Analysis

This section introduces a methodology to identify alterations to the vote results reported in the tally sheets. To accomplish this task, I apply Convolutional Neural Networks (CNN), a computer algorithm able to learn visual patterns and then classify new images (LeCun et al., 1990; Hastie, Tibshirani and Friedman, 2009). Emulating the learning capacity of the human brain, a CNN model gleans patterns from its interconnected units, or neurons, which activate when detecting a specific feature in an image. Applications of this method have expanded to multiple fields, including object classification in photographs (Ciresan et al., 2011; Krizhevsky, Sutskever and Hinton, 2012), handwriting identification (LeCun et al., 1998), and human face recognition (LeCun, Kavukcuoglu and Farabet, 2010).

For the specific goal of this paper, a CNN classifier serves three purposes. First, it complements recent developments in electoral forensics by exploring the data generating process behind statistical oddities in vote returns. Second, this approach proposes an unbiased assessment of important issues such as the integrity of an election. Finally, computerized classification excels at the tedious exercise of classifying thousands of tallies—a labor that may yield to inattention and impatience from human coders (Hoque, el Kaliobly and Picard, 2009; Grimmer and King, 2011).

Notwithstanding its advantages, it is worth mentioning that the irregularities identified by the CNN are not exhaustive. While the model distinguishes a specific type of fraud associated with the deliberate alteration of vote tallies, this approach may not identify irregularities that originated from a different process, such as the manipulation of results before they were recorded them in the tally or the replacement of an original tally with a new one.\textsuperscript{4} This approach, therefore, estimates the lower bound for the proportion

\textsuperscript{4}Consider, for example, the case of the results for the legislative election in Durango’s Second District, where the PRI won all the votes in most polling stations. However, the results from one polling station give the PAN all votes in the congressional deputy election but not even a single vote in the presidential or Senate election. In words of a PAN
of fraudulent tallies, and its results may complement alternative approaches for analyzing the data.

I describe below the classification of the vote tallies in four steps. First, I collected, organized, and pre-processed the tally images and their respective vote results. Second, I inspected a subset of images and identified those with potential alterations in their numbers. Third, I used the labeled images to train and fine-tune the CNN model. Finally, I used the trained model to label the rest of the images in the database.

4.1 Data Collection

This paper presents new data from more than 53,000 polling stations opened on July 6, 1988, whose respective vote tally sheets are stored at the National Archive in Mexico City.\(^5\) The data collection and digitization process produced two databases. The first one contains the images of all the vote tallies from the 1988 election.\(^6\) With the help of two research assistants, I photographed, digitally edited, and organized by electoral district every vote tally available in the archive. To minimize the noise of the images during the classification stage, I manually cropped every picture to include only the area of the image that contains the vote returns, as the examples in Figure 1 illustrate.

The second database includes the vote returns at the polling station level for every can-

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\(^5\)The closest analyses using this data are Barberán et al. (1988) and Báez Rodríguez (1994). The first one is a study by a group of scholars and political activists—Cuauhtémoc Cárdenas himself included—analyzing the results of a sample of 30,000 polling stations that election officials made available to opposition parties. However, it remains unclear whether the sample is representative of all the polling stations in the country and the data used for this work became unavailable after the one of the authors died (Personal communication with two of the authors, January 2016.). The second one presents the results of a quantitative analysis using a “computerized retrieval system” at the National Archive. However, staff members at the Archive denied the existence of such information (Eisenstadt, 2004, p. xi-x). Moreover, the author acknowledges the impossibility to replicate the results from the analysis (Personal communication with the author, June 2015.).

\(^6\)See Figure A in the Appendix for an example.
didate. This information was entered by a team of professional data coders and double-supervised by the coding team manager and me. The data-entry process proved impossible for a handful of images with faded writing or inadequate contrast. The total number of observations in the database, thus, is 53,249. As Table A in the Appendix shows, these vote totals are very similar to the official total votes reported at the national and district level. The resemblance validates the information of my database and suggests that any electoral manipulation occurred before officials compiled the results from the vote tallies. Table B in the Appendix provides descriptive statistics of the database.

4.2 Data splitting

After preprocessing the images, I divided the database into three parts: a training set, a validation set, and a test set. The first two sets came from a sample of 1,050 images that I inspected and labeled as either “with alterations” (WA) or “without alterations” (WOA), ending up with 525 images for each class. The training set contains 900 of these images, which I use as inputs to fit my CNN model. The remaining 150 images constitute the validation set, which I use to verify the accuracy of my model. Finally, the test set contains almost 52,300 unlabeled images that help me to estimate the overall rate of aggregation fraud.

To identify those tallies assigned to the WA class, I first used qualitative evidence from interviews and legislative debates to find districts where aggregation fraud had been reported. Then I inspected the tallies from those districts and labeled as WA those images showing alterations suggested by the primary sources, such as the cross-outs or number insertions illustrated in Figure 1. The examples labeled as WOA were selected from

7The qualitative information includes interviews in January 2016, with José Newman, director of the Federal Electoral Commission (CFE) from 1982-1989 as well as Jorge Alcocer and Leonardo Valdés, representatives of the Mexican Socialist Party (PMS) in the CFE (1986-1991). I also reviewed the stenographic record of the debates in the Chamber of Deputies to certify the election (Senado de la República, 1988).
images that did not present alterations in their numbers. To make sure that the model distinguishes the altered tallies by their amendments rather than by vote results, the sample of WOA files include images where the PRI won all the votes but where there are no clear patterns of alterations in their numbers, as Figure B in the Appendix shows.

I verified the reliability of the labels in two different tests. The first one used crowdsourcing to compare the labels provided by 200 respondents recruited through Amazon’s Mechanical Turk (MTurk) for an online survey fielded in February 2017. The survey asked respondents to identify tallies they perceived as altered from a random sample of 10 images. A second check recruited five undergraduate students at the University of Houston, who were asked to identify altered tallies from a random sample of 50 images. In both tests, subjects were never informed of the labels I had assigned to each of images. The details of each experiment are available in the Appendix. The overall results show a substantial agreement with the original labeling.\footnote{Youden’s J statistic numbers were 0.28 and 0.48, respectively.}

\section{Classifier Training}\label{sec:classifier-training}

The learning phase consists in allowing the CNN model to absorb the information of the training set by passing random batches of images through the network. Each iteration gradually calibrates the model’s inferences of the features that distinguish each class. Figure 2 illustrates the network architecture of the model, and it is fully specified in Table C in the Appendix.

To train the network, every image is first transformed into a numerical array of pixel values. These inputs pass through a first convolutional layer, which contains 32 filters, or neurons. Each of these filters slides across every $3 \times 3$ pixel area of the image looking for basic features, such as a straight line, an edge, or a curve. The 32 different image representations are then used as inputs for the second convolutional layer, which also contains 32 filters. These filters slide across each representation searching for more complex fea-
Figure 2: Network Architecture

Notes: Figure 3 illustrates the CNN structure applied to identify images of the vote tally sheets with alteration in their numbers. The inputs of the images consist in numerical arrays of $3 \times 227$ (height) $\times 227$ (width) pixel values. The network contains six convoluted layers of 32, 32, 64, 64, 128, and 256 filters, respectively. A fully description of the network is described in Table C in the Appendix.

Features, such as the combination of curves or straight lines, producing $32 \times 32 = 1024$ new image representations. This process repeats through four more convolutional layers, each of them gradually looking for higher-level features of the images in larger regions of the pixel space.

The resulting image representations from the last convolutional layer are transformed into a unidimensional vector and sent to three fully connected layers that gradually glean the features more likely to correlate with each class. This learning process involves a procedure called backpropagation, which passes the image back and forth to adjust the precision of the model’s predictions. Every time a training image passes through the network, the model estimates the respective probabilities for the tally to belong to each
class. These probabilities determine the value of the loss function, or the cost incurred by those predictions after comparing the true image’s label. The lower the value of the loss function, the better the accuracy classification of the model. To decrease this value, the image passes back through the network, allowing the model to identify the features that contributed to an incorrect prediction and to calibrate its filters’ weights accordingly.

I trained the network for 250 epochs, wherein each epoch stands for a set of forward and backward passes for all images in the training set. After every epoch, I trace the accuracy rates of the model in the validation set and saved its weights when there was an improvement in the loss value. The final model thus contains the model weights that reported the highest prediction accuracy in the validation set.

A common concern of using CNN is the risk of overfitting, which occurs when the model “memorizes” image features that are not generalizable outside the training set. I tackle this problem in two ways. First, I use data augmentation to artificially increase the size of my training set. This technique produces new images derived from random shears, flips, rotations, and zooms of the original pictures (Chatfield et al., 2014). Second, I include a set of dropout layers to block a random set of filters throughout my network. The inclusion of these layers during the training process detracts the model from focusing on specific filter activations and instead consider those features that can be generalizable to multiple images (Srivastava et al., 2014).

A final concern has to do with the political sensitivity of incorrectly assessing the integrity of a given vote tally. The predicting inaccuracies of the model face two types of misclassification: labeling as WA those tallies with no clear patterns of manipulation (Error Type I) or labeling as WOA those tallies with potential altered features (Error Type II). Faced with this trade-off, I chose to minimize the first error type. In other words, the classifier would label a tally as altered only when its probability of belonging to the WA category is at least twice its probability of belonging to the WOA category. This conservative approach thus labels a tally as WOA when its estimated probabilities are too close to
Table 1: Confusion Matrix for Classification

<table>
<thead>
<tr>
<th>True Label</th>
<th>Without alterations</th>
<th>With alterations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without alterations</td>
<td>0.94</td>
<td>0.06</td>
</tr>
<tr>
<td>With alterations</td>
<td>0.17</td>
<td>0.83</td>
</tr>
</tbody>
</table>

Notes: Table 1 shows the mean accuracy rates of the classification model using 10 repeated random sub-samples of 150 images. The standard deviation values for the accuracy rates on the clean and fraudulent images are 0.03 and 0.04, respectively. The overall accuracy rate is 0.89 with a mean loss value of 0.30.

call, minimizing the number of false positives in the model.

To evaluate the accuracy of the model, I compare the predicted labels with the ones I assigned *ex-ante* for the images of the validation set using Monte Carlo cross-validation (Johansson and Ringnér, 2007). This test generates 10 random splits of the labeled images into training and validation data. For each split, I fit the model into the training data, test its precision on the images from the validation set, and record its corresponding accuracy. The results on Table 1 show that the average accuracy rate of the CNN model over the 10 samples is 89%, and that its precision varies across classes; whereas 83% of the tallies with alterations are correctly classified, the accuracy rate for the tallies without alterations is 94%. The differences in the classification are due to the priority of minimizing the number of false positives at the cost of increasing the produced false negatives.

4.4 Classification

The final step uses the trained model to classify the almost 52,500 images in the test set. The results from this stage help me estimate the overall rate of manipulated tallies in the election and provide descriptive statistics to assess the validity of the findings.

After classifying all the tallies in the database, the rate of images exhibiting patterns consistent with the WA class is 37%. This finding suggests that there were alterations in about 19,000 vote tallies throughout the country. Moreover, a close inspection of the
results suggest that the distribution of those tallies was uneven across the country. As Figure 3 shows, the state-level rates of altered tallies range from less than 5% in Mexico City to 78% in the state of Puebla.

The findings are consistent with the anecdotal and indirect evidence available about the election. As the map in Figure 3 illustrates, most of the tallies with alterations are placed in the south of the country, a region distinguished by its legacy of subnational authoritarian enclaves during the last decade of the twentieth century (Cornelius, 1999; Gibson, 2013). The results are also consistent with previous estimations of electoral manipulation at the subnational level. For example, Simpser (2012) compares the PRI’s vote shares before and after the electoral reforms during the 1990s, identifying Jalisco, Chihuahua, the State of Mexico, and Baja California among the states with the lowest levels of manipulation. By contrast, the states associated with the largest rates of manipulation include Tlaxcala, San Luis Potosí, and Querétaro.

The results at the state level also provide a potential explanation for the career paths of many governors after the 1988 election. Governors who were promoted to top-level positions in the PRI or the federal government—such as in Zacatecas, Tlaxcala, and Veracruz—represented states with the largest rates of aggregation fraud during the 1988 election.9 By contrast, during his first year in office, President Salinas removed three governors coming from states with the lowest rates of altered tallies: Baja California, Michoacán, and the State of Mexico.10

As an additional validation check for the labels, I used the database of electoral results at the polling-station level, described in subsection 4.1, to determine whether the vote returns between the clean and altered tallies differ. The top, middle, and bottom plots of Figure 4 show the vote share distributions for Salinas, Cárdenas, and Clouthier, respec-

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9The governors who were promoted to top-level positions were: Genaro Borrego in Zacatecas, Beatriz Paredes in Tlaxcala, and Fernando Gutiérrez Barrios in Veracruz.
10The removed governors were: Xicoténcatl Leyva Mortera in Baja California, Luis Martínez Villicaña in Michoacán, and Mario Ramón Beteta in the State of Mexico.
Figure 3: Rates of tallies classified as altered by state.

Notes: This figure shows the proportion of tallies in every state classified by the CNN as altered. The left plot relates these proportions with the vote share of Salinas in a given state. The gray dot represents the result at the national level.
tively, with the solid and dashed lines representing the densities of the clean and fraudulent tallies. The top plot shows the vote share distributions for PRI’s Salinas, whose vote shares among the tallies classified as clean show a unimodal distribution with a mean of 0.47. In the case of the opposition candidates, the clean tallies show bimodal distributions of their vote share, with a mode close to 0 and a second mode close to 0.50 for Cárdenas and 0.15 for Clouthier.

The fat right tail for the Salinas’ vote share distribution in the clean tallies suggests the existence of other manipulation techniques that are overlooked by the methodology described above. About half of the tallies classified as clean and showing vote shares for Salinas above 90%: Durango, Veracruz, Chiapas, and Guerrero. Furthermore, out of every five tallies classified as clean and showing vote shares for Salinas above 90%, only two have a signature of any party representative from the opposition.

The fact that many unaltered tallies show very low vote returns for opposition candidates is consistent with previous works suggesting the territorial concentration of electoral support of the opposition candidates (Domínguez and McCann, 1996; Greene, 2007). The largest rates of clean tallies showing vote shares below 10% for Cárdenas are in the northern region of the country, where the PAN was more likely to obtain the support from voters against the regime. Similarly, Clouthier received his lowest vote shares in unaltered tallies in Cárdenas strongholds, such as Veracruz (44%), Michoacán (64%) and Hidalgo (71%).

If the methodology identifies random alterations or accidental errors on the tallies, the vote share distributions between classes would look very similar. However, Salinas’s vote shares in the altered tallies significantly differ from those in the clean tallies. Among the images classified as altered, the vote share for Salinas has a median value of 0.65 and a mode close to 1. This comparison suggests not only that the altered tallies present larger vote shares than those tallies without alterations, but also that many of them gave Salinas almost unanimous support. For Cárdenas, the vote shares are considerably lower among
Figure 4: Distribution of vote shares for each of the candidates. Mexico, 1988.

Notes: The plots show the density distribution of the vote shares for the three main candidates of the 1988 election. Each line type corresponds to the classification of the vote tally sheet using the CNN classifier.
the tallies classified as fraudulent than in those classified as clean, as the median values for the distributions are 0.10 and 0.33, respectively. Moreover, while the vote shares for the clean tallies follow a bimodal distribution, with a higher mode close to 0.5, the vote share distribution of the fraudulent tallies has a unique mode close to 0. Similarly, Clouthier’s median vote shares are about 0.14 in the clean ballots and only 0.04 among those classified as fraudulent.

In sum, the CNN model is a useful tool to unveil the overall extent of aggregation fraud. For the specific case of the 1988 presidential election in Mexico, the results suggest that amendments of vote totals occurred in about a third of vote tallies. This finding confirms the anecdotal evidence of aggregation fraud and supports the conjecture that the institutional setup allowed election officials to inflate the vote returns.

5 The Determinants of Aggregation Fraud

This section explores the contextual characteristics of the tallies classified as fraudulent. To accomplish this task, I conjecture that aggregation fraud is more likely to affect the tallies from polling stations where opposition agents were absent and where local elites had more resources and incentives to coordinate the irregularities. I propose below the hypotheses to be tested, describe the set of variables used for this analysis, and discuss the results.

5.1 Theoretical Expectations

The overarching hypothesis in this paper is that the opportunities for aggregation fraud appear within the boundaries set by the electoral institutions, and its ultimate execution depends on the resources available for local perpetrators to inflate vote counts. For the Mexican case, Section 3.1 describes the consequences of an electoral reform that concentrated the vote aggregation process in the hands of district officials. However, as the
results in Figure 3 show, the prevalence of aggregation fraud was uneven across regions. I explain the variance in this irregularity by the presence of the opposition, and the characteristics of the networks required to manipulate vote tallies.

The first expectation is that aggregation fraud was less likely to occur in the presence of opposition agents. This conjecture follows the existing works on the deterring effects of election monitoring at the polling stations, where the costs of committing fraud increase with the presence of opposition and independent agents (Hyde, 2007; Ichino and Schundeln, 2012; Asunka et al., Forthcoming). As a result, perpetrators displace their fraud efforts to places unreachable to observers other than those supporting the political machine.

I extend this logic to the case of aggregation fraud and suggest that the deterrent effects of opposition representatives persist across further stages of the electoral process. In particular, district officials were less likely to modify vote totals of tallies originally recorded in the presence of opposition representatives, who could provide first-hand evidence of the differences between the official results and those registered at the polling station. In this case, the incentives for election officials to alter the tallies filled in presence of the party representatives decreased after the 1987 electoral reform. This reform recognized for the first time the legal figure of the party representatives and said the expulsion of party representatives from a polling station constituted as reason to nullify the votes of the polling place (Barquín, 1987, p. 52). Since the amended code strengthened the role of party representatives to monitor the process and witness the tabulation at the polling stations, election officials had stronger incentives to amend the results of those tallies from polling stations where opposition party representatives were absent.

The second expectation has to do with the influence of local power elites on the prevalence of aggregation fraud. As evidence from Russia (Myagkov, Ordeshook and Shakin, 2009; Kalinin and Mebane, 2011; Reuter and Robertson, 2012) and Indonesia (Martinez Bravo, 2014) show, electoral irregularities were carried out by subnational authorities, who took
this election as an opportunity to signal their loyalty to the central government. The resources and incentives to manipulate the electoral result, however, may vary across jurisdictions (Schattschneider, 1942; Key, 1949). Some local elites may have more experience and resources to coordinate the electoral operation. Others, meanwhile, may have greater personal and career-based incentives to signal their loyalty to the central government. Therefore, the local execution of fraud depends on the resources available to the local elites for delivering votes in an effective way.

To verify this conjecture, I take advantage of the intrinsic characteristics of the state governors during the election. As Section 3.1 describes, the electoral operation in Mexico during the hegemonic party period was organized in every state by the governor who, at the same time, was accountable to the minister of interior. The fact that the minister of interior relinquished his oversight duty in 1988 left the success of the electoral operation to the capacity and motivation of the governors to deliver votes.

I expect then to observe larger rates of aggregation fraud within the jurisdiction of governors with previous electoral expertise. During the late 1980s, the pool of Mexican governors was a mix of two types of politicians. On the one hand, there was a group of young governors with technical skills but without the practical knowledge on how to manage an election (Camp, 2014, p. 134-137). On the other hand, there was another group of traditional political figures who advanced their political careers by working for the party at the grassroots. Many of the governors in the last group learned the various ways to deliver votes by running for election and holding multiple elective offices. We can then expect that those governors who had a previous elected position were more aware of what was necessary to lead an electoral operation and were more likely to use aggregation fraud to favor the incumbent party.

A related expectation is that the altered tallies were more likely to appear under the jurisdiction of governors with personal ties with the presidential candidate. An alternative explanation for vote operators’ efforts relies on their personal motivations for helping the
candidate win (Frye, Reuter and Szakonyi, 2014; Callen and Long, 2015; Larreguy, Montiel and Querubin, Forthcoming). During the hegemonic party period, the career of a politician was defined by his affiliation to a political clique, or camarilla, which bonded the loyalty of its members to a specific leader in exchange for patronage jobs (Smith, 1979, p. 50-51; Camp, 2014, 128-139). Even when all governors in 1988 were members of the official party, only a few of them belonged to the same intra-party group led by Carlos Salinas. Therefore, if the prevalence of aggregation fraud in each state depended on the governor’s ties with the presidential candidate, there should be more altered tallies in those states led by members of Salinas’s political group.

5.2 Measures

I measure the explanatory variables as follows. First, No Opposition Representative is a binary variable indicating whether the tally lacks the signature of at least any representative from the opposition. As the first theoretical expectation describes, election officials were more likely to modify the vote returns of those tallies where results were not recorded at the polling station by the opposition. Moreover, I build two variables regarding the characteristics of the state governors. Governor’s Experience indicates whether the state executive had previously held an elected public office. The information for this variable comes from the Dictionary of Mexican Political Biographies (Camp, 2011), and I coded as 1 those tallies in states where governors were previously elected as Mayor, Deputy, or Senator, and 0 otherwise. Also, Camarilla identifies those governors within Salinas’s political group. This information comes from Centeno (2004), who identifies 40 top-level officials in the Salinas’s camarilla, out of which 7 were governors on the 1988 election.\footnote{See Centeno (2004, p. 166) for more details on the classification of this variable.}

I consider alternative explanations on how fraud was carried out by including a battery of control variables. First, it could be the case that the number of altered tallies in a district depends on the popularity of the incumbent party. The literature of electoral ma-
nipulation suggests that irregularities more commonly appear in tight races because they yield larger marginal returns on the final outcome (Lehoucq, 2003; Mares, 2015; Golden et al., 2015). I then operationalize the popularity of the incumbent party in two ways. PRI 1985 denotes the PRI’s district vote share during the 1985 legislative elections. A potential concern in using this measure is that these results are plagued with irregularities similar than those documented three years later, creating bias in the estimations. Alternatively, I use the proportion of survey respondents in every state who identified with the PRI three weeks prior to the election day (PRI’s Support from Polls). The data from this variable comes from a survey of 4,414 respondents fielded during June 6-17, 1988, and published by La Jornada newspaper a day before the election (La Jornada, July 5, 1988a).

The analysis also accounts for the possibility that the alteration of the tallies was not accomplished at the district councils but rather at the polling stations by the incumbent party’s manpower. The territorial base of the PRI relied on its affiliated workers’ unions, which displayed their manpower and resources on election day in exchange for political positions within the party (Murillo, 2001; Langston, 2017). However, given their resource constraints, unions concentrated their electoral efforts in those districts where the party endorsed the candidacy of a union member for a legislative seat (Langston and Morgenstern, 2009). To consider this possibility, Union membership identifies those districts where the PRI nominated a union leader as a legislative candidate. If the tallies were altered at the polling stations, those tallies classified as fraudulent would come from districts where the PRI had enough human resources to accomplish it, causing the presence of union candidates to correlate with the extent of fraud. The data for this variable comes from Langston (2017).

Next, it could also be the case that the aggregation fraud operation was not led by the governors but instead by those election officials with the most loyal ties to the federal executive. To test for this possibility, and following a similar approach by Reuter and Robertson (2012) and Martinez Bravo (2014), Reappointment identifies those districts that
had any reappointments of election officials during the six months prior to the election. Since district election officials were directly appointed by the minister of interior, any reappointment prior to the election would suggest the nomination of an agent closer to the federal executive. The information from this variable comes from reviewing all the issues of the *Diario Oficial de la Federación*, Mexico’s equivalent to the U.S. *Federal Register* or the Canada *Gazette*, from January 1 to July 5, 1988.

I also consider two contextual factors that may affect the probability of observing alterations in a vote tally. *No Poll Worker’s Signature* is a binary variable that accounts for those tallies with no signatures of the election officials at the polling station. Tallies without signature suggest a replacement, rather than an amendment of the vote results. I expect then that the vote returns from tallies with no signatures are less likely to present alterations in their numbers. A final factor that may explain electoral fraud is whether it occurred in a rural place. As the literature on Mexican politics suggests, electoral irregularities were more difficult in urban areas than rural ones, where the opposition had fewer resources to monitor polling stations and brokers had greater control over voters (Molinar, 1991). To account for this possibility, *Rural* is the proportion of citizens in the district living in communities with fewer than 50,000 inhabitants. I built this variable by aggregating to the district level the municipal information available for the 1990 census.\textsuperscript{12}

5.3 Results

Given the binary nature of my dependent variable and the nested structure of the data, I specify a multilevel binomial logit-link model with district and state random effects. Table 2 summarizes the main results. Models 1 and 2 show the estimates of the main explanatory variables with and without controls, and Model 3 tests the robustness of the results under an alternative variable specification.

\textsuperscript{12}Given the multiple sample problems of the 1980 census, I used the 1990 census data as a proxy of the rural population in 1988 rather than interpolating the data between the two data sources. I thank Alberto Díaz-Cayeros and René Zenteno for pointing this out.
Table 2: Explaining the Characteristics of the Altered Vote Tallies. Mexico, 1988.

<table>
<thead>
<tr>
<th>Dependent variable: Altered Vote Tally</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Opposition Representative</td>
<td>0.373***</td>
<td>0.372***</td>
<td>0.371***</td>
</tr>
<tr>
<td>(0.025)</td>
<td>(0.045)</td>
<td>(0.045)</td>
<td></td>
</tr>
<tr>
<td>Governor’s Experience</td>
<td>0.784*</td>
<td>0.737*</td>
<td>0.667*</td>
</tr>
<tr>
<td>(0.340)</td>
<td>(0.308)</td>
<td>(0.279)</td>
<td></td>
</tr>
<tr>
<td>Camarilla</td>
<td>0.356</td>
<td>0.205</td>
<td>0.161</td>
</tr>
<tr>
<td>(0.419)</td>
<td>(0.267)</td>
<td>(0.259)</td>
<td></td>
</tr>
<tr>
<td>PRI 1985</td>
<td>0.052</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.606)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Poll Workers’ Signature</td>
<td>-0.038</td>
<td>-0.037</td>
<td></td>
</tr>
<tr>
<td>(0.087)</td>
<td>(0.086)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reappointment</td>
<td>0.004</td>
<td>0.018</td>
<td></td>
</tr>
<tr>
<td>(0.147)</td>
<td>(0.147)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Union membership</td>
<td>-0.051</td>
<td>-0.048</td>
<td></td>
</tr>
<tr>
<td>(0.077)</td>
<td>(0.075)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>0.491</td>
<td>0.493</td>
<td></td>
</tr>
<tr>
<td>(0.267)</td>
<td>(0.259)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRI’s Support from Polls</td>
<td></td>
<td></td>
<td>1.857***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.711)</td>
</tr>
<tr>
<td>Constant</td>
<td>-1.115***</td>
<td>-1.400***</td>
<td>-2.205***</td>
</tr>
<tr>
<td>(0.287)</td>
<td>(0.455)</td>
<td>(0.490)</td>
<td></td>
</tr>
</tbody>
</table>

\[
\sigma_{district} \quad 0.841 \quad 0.818 \quad 0.819 \\
\sigma_{state} \quad 0.698 \quad 0.621 \quad 0.561
\]

<table>
<thead>
<tr>
<th>Observations</th>
<th>Districts</th>
<th>States</th>
<th>Log Likelihood</th>
<th>(\chi^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>53288</td>
<td>300</td>
<td>32</td>
<td>-27374.42</td>
<td>230.42</td>
</tr>
<tr>
<td>53288</td>
<td>300</td>
<td>32</td>
<td>-27369.80</td>
<td>104.36</td>
</tr>
<tr>
<td>53288</td>
<td>300</td>
<td>32</td>
<td>-27367.64</td>
<td>111.76</td>
</tr>
</tbody>
</table>

Notes:
Entries are logistic regression coefficients and standard errors. The dependent variable is a binary indicator for a vote tally was classified as altered. *** is significant at the 0.1% level; ** is significant at the 1% level; and * is significant at the 5% level.
The results for *No Opposition Representative* are positive and statistically significant, suggesting that a tally coming from those polling stations with no signatures from at least one opposition party agent is more likely to present alterations in its vote returns. The size of this coefficient is quite consistent across models, 0.37, which the logit model translates to a probability increase for a tally being altered of about 7%.

The results also provide evidence that the characteristics of the governors leading the electoral operation affected the likelihood of observing an altered tally in the district. The coefficient for *Governor’s experience* is positive and statistically significant. Among those tallies under the jurisdiction of governors with previous electoral experience, their probability of presenting alterations is about 14% larger than in those tallies from states with electorally unexperienced governors. In contrast, although the sign of *Camarilla* is positive across specifications, its estimated value is not statistically different from zero. These results suggest that the extent of aggregation fraud in this election can be explained by the governors’ resources available but not by their personal ties to the presidential candidate.

As Models 2 and 3 show, the results hold after including the control variables that account for alternative explanations. The evidence is inconclusive regarding the relationship between the PRI’s electoral strength and the prevalence of aggregation fraud at the district level, for the coefficient estimate of *PRI 1985* is negligible and non-significant. On the other hand, Model 3 shows that when substituting that variable for *PRI’s Support from Polls*, the estimate is positive and significant, suggesting that the altered tallies were more frequent in those districts with the largest vote shares.

Against the documented evidence of electoral irregularities in the rural areas of the country (Molinar, 1991; Fox, 1994; Simpser, 2012), the effect of *Rural* is not statistically different from zero. This finding suggests that the generating process of irregularities on the tallies was not exclusive in rural areas or through the coercion of voters. The sign of *No poll workers’ signature* is consistently negative, yet it is not statistically different from
zero. One potential explanation is the relatively small share of tallies with this characteristic, about 3 percent of the observations, which makes this effect insufficient to reliably estimate its effect. Similarly, the coefficients for Union present no statistically significant effect, providing no evidence that aggregation fraud was more likely to occur in those districts where unions provided manpower during on Election Day. Finally, Reappointments show estimates not statistically different from zero. Suggesting no differences in the rates of altered tallies between those districts with and without officials reappointments.

The results above are suggestive of the ways that aggregation fraud was carried out. In order to inflate the results in an effective way, the alterations of the tallies were more likely to occur where the opposition was unable to cross-check the results and those states with a governor with the experience to lead and coordinate the operation. These findings provide evidence of the opportunities for perpetrators to use this fraud technology.

6 Conclusion

In his memoirs, President Carlos Salinas (2002) defends the legality of his victory in the 1988 election based on two facts. First, the results reported by electoral authorities emanate from the vote sums in the tallies, which were filled out in the presence of opposition party representatives in 72% of the polling stations. Second, the results of the polling stations are publicly available for corroboration. In the words of Salinas, “The actas (vote tallies) stored in the National Archives confirm that the 1988 presidential elections are fully documented” and validate his triumph in an election with “the major mobilization to monitor the election that the opposition had in fact achieved” (p. 942-943).

This paper verifies both claims for the first time by examining the more than 50,000 tallies available in the National Archive. The analysis confirms that, indeed, the results announced on July 9, 1988, mirror those recorded in the tallies. But the assessment of the integrity of the election does not end there. Using recent developments in deep learning
and image analysis, I identify amendments of the vote returns in about a third of the tallies. These alterations were more likely to appear in places where the opposition was absent and within the jurisdiction of governors with enough experience to coordinate the inflation of vote totals in an efficient way.

The results illustrate the formal opportunities for aggregation fraud after an electoral reform that centralized the vote aggregation process and entitled district officials to amend vote returns. Moreover, the electoral reform allowed party representatives to be present at the polling stations, displacing the irregularities to places where the opposition was absent. On the other hand, informal opportunities for fraud appealed those governors with the expertise to mobilize and coordinate the work of election officials in their jurisdictions. The results illustrate the dynamics of electoral institutions in autocracies, which develop from the tension between the demand of opposition parties to guarantee democratic uncertainty and the desire of autocrats to retain control over electoral outcomes (Schedler, 2002b, p. 109).

While this study focuses on one of the most prototypical cases of electoral authoritarianism, the theoretical implications of the findings are generalizable beyond Mexico’s hegemonic regime. The prevalence of manipulation and biased institutions has afflicted many contemporary elections. In many of these cases, governments use elections to legitimate their regime while keeping full control of the electoral result. The emphasis of this paper on the interaction between formal and informal incentives for fraud may inform the dynamics of current electoral authoritarian cases involving authoritarian regimes.

Finally, this paper proposes an approach to identify electoral irregularities that can be applied anywhere. The methodology is designed to complement existent developments on electoral forensics by focusing on the data-generating process behind statistical anomalies in vote returns. Policy practitioners and scholars can use this test to audit the integrity of tallies of any election. In fact, it is worth emphasizing that the methodology I propose will become more accurate as it gathers more images from other elections and
accumulates the input from experts on the topic. This method, therefore, should be seen as a steppingstone to identify electoral fraud in cases where, despite their efforts to keep the irregularities hidden, the perpetrators left their fingerprints on the available evidence.
References


## Supplementary Tables

### Table A: Vote Results

<table>
<thead>
<tr>
<th></th>
<th>Salinas</th>
<th>Cárdenas</th>
<th>Clouthier</th>
<th>Total Votes</th>
<th>Polling Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vote Tallies</td>
<td>9,294,147</td>
<td>5,314,667</td>
<td>3,269,208</td>
<td>18,207,388</td>
<td>52,288</td>
</tr>
<tr>
<td></td>
<td>(0.510)</td>
<td>(0.292)</td>
<td>(0.179)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Official Data</td>
<td>9,641,329</td>
<td>5,956,988</td>
<td>3,267,159</td>
<td>19,145,012</td>
<td>54,493</td>
</tr>
<tr>
<td></td>
<td>(0.503)</td>
<td>(0.311)</td>
<td>(0.171)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Notes:* This table compares the vote total and vote shares of the three main candidates using the official results and the information from the tally sheets. Vote shares are in parenthesis.

### Table B: Summary Statistics on the Information from the Vote Tally Sheets

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salinas (PRI)</td>
<td>53288</td>
<td>174.413</td>
<td>208.27</td>
<td>0</td>
<td>6080</td>
</tr>
<tr>
<td>Clouthier (PAN)</td>
<td>53288</td>
<td>61.35</td>
<td>106.14</td>
<td>0</td>
<td>4436</td>
</tr>
<tr>
<td>Ibarra (PRT)</td>
<td>53288</td>
<td>2.18</td>
<td>12.10</td>
<td>0</td>
<td>592</td>
</tr>
<tr>
<td>Castillo (PDM)</td>
<td>53288</td>
<td>4.00</td>
<td>17.03</td>
<td>0</td>
<td>1802</td>
</tr>
<tr>
<td>Cárdenas (FDN)</td>
<td>53288</td>
<td>99.73</td>
<td>131.65</td>
<td>0</td>
<td>2280</td>
</tr>
<tr>
<td>Total Votes</td>
<td>53288</td>
<td>349.76</td>
<td>303.57</td>
<td>29</td>
<td>9429</td>
</tr>
<tr>
<td>PRI Agent</td>
<td>53288</td>
<td>0.62</td>
<td>0.47</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>PAN Agent</td>
<td>53288</td>
<td>0.50</td>
<td>0.50</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>FDN Agent</td>
<td>53288</td>
<td>0.47</td>
<td>0.50</td>
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<td>1</td>
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<td>PDM Agent</td>
<td>53288</td>
<td>0.09</td>
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<td>1</td>
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<td>0.25</td>
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<td>0.32</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

*Notes:* This table reports summary statistics for the information obtained from the vote tally sheets. The unit of observation is the polling station. The information of party agents and poll workers’ signatures are dummy variables that equal 1 for each observation where the individual signed the tally sheet.
B Experiment Description

The survey experiment discussed in Section 4.2 used Qualtrics survey technology with two population samples. The respondents for the first sample were recruited through Amazon’s Mechanical Turk via a HIT advertised as “Find altered tallies. A 15 minute survey” Respondents were restricted to those in the United States with HIT approval rates greater than or equal to 95% and at least 1,000 HITs approved. Respondents were provided $1.70 compensation for taking the survey. Survey data from 200 respondents was collected on February 14, 2017. Each respondent was presented with 10 random images from the Training Set and were asked to identify those files that present alterations in their numbers. The average response time was 7.4 minutes (SD=2.8 minutes) and 62% of the respondents correctly answered the attention check.

The second sample used the answers of 4 students at the University of Houston. Students’ responses were collected during March 14 and July 8, 2017. Each respondent got a sample of 50 random images from the Training Set and were asked to identify those files that present alterations in their numbers. Respondents received $15 compensation for taking the survey. The average response time was 92 minutes (SD=56.4 minutes). 75% of the respondents correctly answered the attention check. This experiment was Neither Amazon Turk respondents nor undergraduate students were informed about the label that the images were originally assigned.

Both studies were approved by the University of Houston Institutional Review Board (STUDY00000131 and STUDY00000301).
Figure A: Example of a Digitized Vote Tally Sheet. Mexico, 1988
<table>
<thead>
<tr>
<th>District IV</th>
<th>District V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiapas</td>
<td>Campeche</td>
</tr>
<tr>
<td>Durango</td>
<td>Nuevo Leon</td>
</tr>
</tbody>
</table>

Figure B: Examples of vote tallies with no alteration in their numbers. Mexico, 1988
D Network Structure
<table>
<thead>
<tr>
<th>Layer (type)</th>
<th>Output Shape</th>
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</thead>
<tbody>
<tr>
<td>Zero Padding 2D</td>
<td>(3, 233, 233)</td>
</tr>
<tr>
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<td>(32, 229, 229)</td>
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<tr>
<td>Activation (ELU)</td>
<td>(32, 229, 229)</td>
</tr>
<tr>
<td>Pooling 2D</td>
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</tr>
<tr>
<td>Zero Padding 2D</td>
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<tr>
<td>Convolution 2D</td>
<td>(32, 118, 118)</td>
</tr>
<tr>
<td>Batch Normalization</td>
<td>(32, 118, 118)</td>
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<tr>
<td>Activation (ELU)</td>
<td>(32, 118, 118)</td>
</tr>
<tr>
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<tr>
<td>Convolution 2D</td>
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</tr>
<tr>
<td>Batch Normalization</td>
<td>(64, 63, 63)</td>
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<tr>
<td>Activation (ELU)</td>
<td>(64, 63, 63)</td>
</tr>
<tr>
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<tr>
<td>Zero Padding 2D</td>
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<tr>
<td>Convolution 2D</td>
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</tr>
<tr>
<td>Batch Normalization</td>
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<tr>
<td>Activation (ELU)</td>
<td>(64, 35, 35)</td>
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<tr>
<td>Pooling 2D</td>
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<tr>
<td>Zero Padding 2D</td>
<td>(64, 23, 23)</td>
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<tr>
<td>Convolution 2D</td>
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</tr>
<tr>
<td>Batch Normalization</td>
<td>(128, 21, 21)</td>
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<tr>
<td>Activation (ELU)</td>
<td>(128, 21, 21)</td>
</tr>
<tr>
<td>Pooling 2D</td>
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<td>Zero Padding 2D</td>
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<tr>
<td>Convolution 2D</td>
<td>(256, 14, 14)</td>
</tr>
<tr>
<td>Batch Normalization</td>
<td>(256, 14, 14)</td>
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<tr>
<td>Activation (ELU)</td>
<td>(256, 14, 14)</td>
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<td>Activation (ELU)</td>
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<td>Dropout</td>
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<tr>
<td>Dense</td>
<td>(1)</td>
</tr>
<tr>
<td>Activation (sigmoid)</td>
<td>(1)</td>
</tr>
</tbody>
</table>
D.1 Specifications

Zero Padding: Zero padding adjusts the input volume by placing zeros around the image border. This technique prevents that the information at the borders of the image would be “washed away” after passing through the convolutional layer. It also allows the use of deeper networks because it slows down the volume size of the image.\(^{13}\)

Convolution: Every time the image passes through a convolutional layer, each of its filters slides across every 3 × 3 pixel area of the image looking for basic features, such as a straight line, an edge, or a curve. The output of each filter generates a new representation of the image.

Activation (ELU): ELU stands for Exponential Linear Unit and is used during the convolution operation to identify positive values of the image input. Unlike other activation units—e.g., the Rectified Linear Units (ReLU) or the Parametrized Rectified Linear Units (PReLU)—ELUs consider negative values, which improves learning in a very efficient way (Clevert, Unterthiner and Hochreiter 2016).

Pooling: Pooling layers gradually reduce the spatial dimension of the input image by decreasing its number of parameters. They work by downsampling every depth slice in the image by 2 units of both width and height, reducing the number of parameters by 75%. The purpose of this layer is to speed the convolution process as the image goes deeper through the network. It also reduces overfitting by forcing the computer not to focus on the exact location of a feature but, instead, on its relative location to other features (Scherer, Müller and Behnke 2010).

Batch Normalization: The goal of normalization is to transform the outputs of the convolu-

\(^{13}\)http://cs231n.github.io/convolutional-networks/.
lutional layers to parameters with zero mean/unit variance. This transformation allows the layer activations to be appropriately handled by any optimization method during the training phase. The goal of this technique is to avoid the network to focus on outlying activations and to speed its learning (Ioffe and Szegedy 2015).

**Dropout:** Dropout layers are included to reduce overfitting during the training stage. As its name suggests, these layers “drop out” a random set of activations in the layer. This function forces to provide the right classification based in more than one specific activation (Srivastava et al. 2014). The model included three dropout layers, each of them blocking 20%, 30%, and 50% of the neurons before moving to its respective fully connected network.

**Dense:** The resulting image representations from the last convolutional layer are transformed into a unidimensional vector and sent to three fully connected layers that gradually glean the features more likely to correlate with each class. The first vector has 2048 Exponential Linear Units, which then pass to a second vector with 512 Exponential Linear Units. The outputs of the second layer are sent to a third vector with only one unit which makes whether the image has been altered.

**Activation (sigmoid):** The last activation layer has a function of form \( f(x) = \frac{1}{1+exp^{-x}} \). It therefore follows an S-shaped curve and produces value outcome between 0 and 1.

The model is compiled using a binary cross-entropy loss function. This function is the standard choice for binary classifications and it aims to maximize the accuracy of the predicted labels. The loss function is estimated as \( Loss = -\frac{1}{N} \sum_{n=1}^{N} [y_n \log(\hat{y}_n) + (1-y_n) \log(1-\hat{y}_n)] \), where \( y \) and \( \hat{y} \) are the vectors for the true and predicted labels, respectively (Rubinstein and Kroese 2004). During the learning process, the model uses an gradient descent
optimizer that calibrates the filter weights to gradually minimize the loss function. In particular, I use the Adadelta algorithm, which does not requires to specify a learning rate for the gradient to reach the local minimum (Ruder 2016).

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**References:**


