Why Chads?
Determinants of Voting Equipment Use in the United States*

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ABSTRACT

Contrary to widespread belief, voting machines of older types, such as lever and punchcard systems, are not used in counties with lower income - and newer machines, such as optical scanners and electronic machines, are not used in richer counties. We provide an economic explanation for this and other regularities of voting equipment usage in the U.S. We present a model in which, all other things being equal, a) the adoption of a new technology is more likely in richer and larger counties; b) the adoption of a new technology is less likely the more advanced is the technology already adopted in the county. We argue that the net benefits from adopting the more advanced optical or electronic machines after 1980 were not high enough to induce a technological upgrade in those (relatively richer and larger) counties that had adopted punchcard machines in previous decades. By contrast, net benefits from newer technologies were high enough to induce their adoption in relatively poorer and smaller counties that had not yet mechanized or computerized their voting system. Estimates of historical determinants of voting equipment choice support our hypothesis. In particular, the probability of using punchcard machines in the 1990s is positively related to a county's income in the 1960s, when punchcard machines were first introduced. When the effect of

past income is controlled for, the effect of more recent levels of income on the probability of using punchcard machines becomes negative.

1 Introduction

The bizarre turn of events that followed the November 7, 2000 presidential election brought unprecedented attention to the use of different voting equipment in the United States. In particular, the reading of punchcard ballots in a few Florida counties became the subject of heated legal disputes that ended with a controversial U.S. Supreme Court ruling on December 12, 2000. During the Florida crisis the media was filled with detailed reports on the mechanics of different voting equipment. Colorful expressions, such as "hanging chads" and "pregnant chads," entered the national vocabulary.[1] That crisis has spurred an ongoing debate on voting equipment choice and election reform. Proposals to develop national or state standards for conducting elections and to fund voting equipment upgrades have been introduced in the U.S. Congress and in numerous state capitals. Voting equipment has moved from being a minor, local aspect of elections to representing an important national issue.

A striking aspect of voting equipment usage in the U.S. is its heterogeneity. All sorts of systems are used across the nation. American voters mark paper ballots, pull levers, punch cards, fill optically-readable forms, or touch electronic screens. Data obtained from Election Data Services (EDS) show the following distribution of voting equipment types across counties in 1999: optical scanners 38.8 % of counties; punchcard machines 20.2 %; electronic machines 8.2 %; lever

[1] For an explanation of this terminology, see Section 2.

machines 15.3 %; paper ballots 13.1 %. The distribution as a percentage of registered voters was: punchcard machines 34.1 %; optical 27.6 %; lever 18.5 %; electronic 9.1 %; paper 1.6 %.[2]

The machines currently in use are based on technologies spanning over a century. Optical and electronic machines have been adopted since the late 1970s. Punchcard voting machines were first introduced in 1964. Lever machines were first used in statewide elections in 1892. In fact, virtually *each* type of voting equipment ever introduced in the U.S. since the 19th century is still used somewhere in the country.[3] More detailed information on the history and characteristics of voting equipment is reported in Section 2.

Such heterogeneity is partly the result of decentralization. While many other democracies have unified national voting systems, in the U.S. choices over voting equipment are highly decentralized - mostly at the county and municipal level.[4] This situation raises an important question: What explains the use of different voting equipment? Why do some counties use punchcard machines (or even older lever machines, or just paper ballots), while other counties use more advanced optical scanners or electronic machines? In a nutshell, Why Chads?

The question is worth addressing for at least two reasons:

[2] The remaining 4.5 % of counties, containing 9.1 % of registered voters, used 'mixed systems' (i.e., two or more types of equipment).

[3] Our main source for historical information is the Federal Election Commission (www.fec.gov/elections.html).

[4] Heterogeneity is only minimally reduced within states. In Pennsylvania, Virginia and several other states *each* type of available equipment is used by one or more counties.

1) Voting equipment matters. While the Supreme Court decision in December 2000 ended the legal battle over the recounting of votes in a few Florida counties, the debate over the causes and consequences of voting equipment choice is not over. In a way, it just started, and is here to stay. Such debate can certainly benefit from more accurate and systematic information about the determinants of voting equipment use.

2) By learning about the determinants of voting equipment use across U.S. counties, we can obtain more general insights on the adoption of innovation by public authorities. For decades all over the U.S. local authorities have quietly run a fascinating natural experiment on the adoption of technological innovation in vote-tallying. From it we may learn something useful about the way innovations in general are (or are not) adopted across different jurisdictions.

Why do some counties use older voting machines while others use more updated ones? Vice-President Al Gore among others suggested that those differences reflect economic inequality:

> "The old and cheap, outdated machinery is usually found in areas with populations that are of lower income, minorities, seniors on fixed incomes."(Gore, 2000)

The view that older machinery is used in poorer counties is intuitively appealing, and has been widely reported in the media. For example, according to *The*

Economist (June 9, 2001, p. 32) "everybody knows that the worst voting machinery is concentrated in poor areas." Somewhat surprisingly, such widespread belief does not seem to be consistent with the data on the distribution of voting equipment types across counties. In Section 3 we show that, on average, machines of older types are not used in relatively poorer counties. When data on voting equipment from Election Data Services (EDS) are matched with the most recent census data, one finds that the median household income in counties using lever and punchcard machines (the older machinery) is higher than in counties using optical scanners or electronic machines (the newer machinery). Also, summary statistics do not provide *prima facie* evidence that machines of older types are disproportionately used in counties with larger minorities or older population.

In Section 3 we also present logit regressions with different types of equipment as dependent variables. This more formal analysis is consistent with the patterns suggested by the summary statistics. Specifically, we find evidence against the hypothesis that lower income increases the probability of using lever or punchcard machines rather than optical scanners or electronic machines, controlling for other potential determinants of voting equipment choice. If anything, richer counties seem to be more likely to use machines of older type.

Is there a "paradox of chads"? Should we be surprised to find out that many richer counties use older technology, such as punchcard machines, while a large number of relatively poorer ones have switched to more advanced machinery?

We think the apparent paradox has a simple economic explanation. Our explanation hinges on two points:

1) all other things equal, a richer county is more likely to adopt a more advanced technology, but

2) among all things that must be equal we should include the county's current technology.

If the richer county has already adopted a more advanced technology in the past, it will benefit less from adopting and even more advanced technology in the future, while the adoption of the newest technology will have the highest benefits in counties that are still using much older technology. As a consequence, richer counties may be leapfrogged by poorer counties.

Section 4 presents a simple model which is consistent with these ideas. The model is consistent with a positive relationship between current income and use of older machinery. However, the model predicts that, once past income has been controlled for, the relationship between current income and use of older machinery should be negative.

Section 5 examines whether the available empirical evidence is consistent with our hypotheses. First, we show that between 1980 and 2000 the share of counties that used optical or electronic machines went from 1 percent to 49.1 percent. The transition took place through reductions in the number of counties that used paper ballots (from 40.4 percent to 12.5 percent) or lever machines (from 36.4 percent to 14.7 percent). By contrast, the share of counties that used punchcard machines barely moved (19.1 versus 19.2). This pattern is consistent with our story.

In order to provide a more direct and formal test of our hypothesis, in Section 5 we also present logit estimates using past values for income. The results provide support for our model. We find that:

1) Income in 1969 has a positive effect on the probability of using older equipment in 1999. In the case of punchcards, such effect is one order of magnitude larger than the effect of 1989 income when one does not control for 1969 income.

2) When income in 1969 is included in the regression, the effect of income in 1989 becomes *negative (*for punchcard machines) or insignificant (for lever plus punchcard).

In other words, the positive correlation between most recent income and use of older equipment is explained by the positive correlation between most recent income and past income. When past income is explicitly taken into account, the effect of current income - as predicted by our model - becomes negative or insignificant.

Hence our analysis provides a consistent explanation for the "paradox of chads." "Chads" are found in counties that used to be richer in the 1960s, when punchcard machines were adopted - and, therefore, on average, are still likely to be richer today. When past income is controlled for, a "nonparadoxical" negative relationship between present income and use of older, outdated equipment emerges.

In Section 6 we extend the analysis to explicitly include another important variable along with income: population size. We argue that, all other things equal, a larger population increases the probability of adopting more advanced voting technology. The aggregate cost of adopting a new technology includes a significant fixed component, which is independent of size. Henceforth, cost per capita is decreasing in the size of a county. Moreover, benefits from adopting more advanced technology may be positively related to total size (for example, the benefits from speedy vote-tallying may be higher in larger counties). Does this imply that larger counties - controlling for income - will be more likely to use more advanced technology? No, for the same reasons why a higher income does not guarantee a better technology. Section 6 contains an empirical analysis of the relationship between historical levels of population and current usage of voting equipment. The results are consistent with our general point. The probability of using lever machines in 1999 is *positively* related to population in 1930 (when larger counties were more likely to adopt state-of-the-art lever machines), but negatively related to population in 1990, when larger counties were more likely to adopt more advanced electronic machines, other things being equal. By the same token, the probability of using punchcard machines is negatively related to population in 1930, but positively related to population in 1970, when punchcard machines were being adopted.

Finally, a word of caveat about the purpose and limits of our analysis. Our paper does not intend to assess whether the distribution of voting equipment in the 2000 election has resulted in the undercount of the votes cast by specific groups (democrats, minorities, etc). Such analysis is beyond our goals and our data. Even further from our objectives is to join the legal and political controversy on the Florida recount, for which we are clearly unqualified. Our study intends to contribute to the ongoing debate on voting equipment choice by making a separate point: cross-county differences in types of voting equipment - *whatever implications* they may have had for different groups of voters in past elections - do not reflect current economic inequality across U.S. counties. Rather, they are the complex result of a series of historical decisions affected by past values of income and population.

In summary, the strikingly heterogeneous distribution of voting equipment in the U.S. can be best understood as reflecting an intriguing "archeology" of historical decisions and trends. In a way, voting equipment is like a time machine. New York and Connecticut's antique lever machines mirrors the past economic and demographic preeminence of the Northeast. Punchcard machines in Atlanta, Los Angeles, and Miami witness the expansion of those regions after Second World

War. The electronic machines of New Mexico speak about today's economic and demographic realities.

2 Types of voting equipment in the United States

As reported by Election Data System, as of April 1, 1999, the 3141 U.S. counties used five different systems to count votes:

1) Paper ballots: 407 counties.

2) Lever machines: 476 counties.

3) Punchcard machines: 625 counties.

4) Optical scanners: 1231 counties.

5) Electronic machines: 261 counties

The remaining 141 counties used mixed systems.[5]

The paper ballot system is the oldest method.[6] It was first adopted in Australia in 1856, and introduced in the U.S. in the second half of the 19th century. In its current form, the paper ballot system employs uniform official ballots on which the names of all candidates are printed. Voters privately record their choices by marking the boxes next to the candidate they select and drop the voted ballot

[5] Mixed systems are mainly found in those states, such as Massachusetts and Michigan, in which decisions over vote equipment are not taken by counties but by towns.

[6] The historical information in this section has been obtained from the Federal Election Commission (www.fec.gov/elections.html).

in a sealed ballot box. Many industrial democracies, including Canada and Italy, use paper ballots as their exclusive voting system.

Lever machines were first employed in Lockport, New York in 1892, and were adopted statewide a few years later. According to the Federal Election Committee (2001) "by 1930, lever machines had been installed in virtually every major city in the United States, and by the 1960s well over half of the Nation's votes were being cast on these machines." On lever machines, each candidate is assigned a lever identified by a printed strip. Voters pull down selected levers to indicate choice. When the voter exits the booth, the voted levers are automatically returned to their original position, causing a connected counter wheel to turn. The position of each counter at the close of the polls indicates the number of votes cast on the lever that drives it. Lever machines are no longer made. According to the Federal Election Commission, "the trend is to replace them with computer-based marksense or direct recording electronic systems."

Punchcard voting systems were first used in 1964 by Fulton and De Kalb Counties (Georgia), Lane County (Oregon) and San Joaquin and Monterey Counties (California). Voters punch holes in the card with a supplied pin. The resulting leftover piece of paper is referred to as a chad (a term of unknown origin).[7] With votomatic cards, the locations at which holes may be punched are assigned

[7]Imperfectly punched chads include "hanging chads" (one corner of the chad is hanging on the punchcard), "swinging chads" (two corners are attached to the card), and "pregnant chads" (a hole is punched through a fully attached chad).

numbers. With datavote cards the name of the candidate is printed on the ballot next to the hole to be punched.[8] After voters have punched their cards, ballots are fed into a computer vote-tabulating device.

Optical scanners recognize marks on paper through optical reading techniques. Voters record their choices by filling in a rectangle, circle or oval. The tabulating device reads the votes using 'dark mark logic' (i.e., by selecting the darkest mark within a given set). Optical scanned ballots have been adopted in the U.S. since the 1970s. Optical scanners (also known as 'marksense optical scan systems') are currently considered "state-of-the-art" voting technology, and directly compete with the last type of voting system, electronic machines. With electronic machines (also known as "direct recording electronic" systems, or DRE), the voter directly enters choice with the use of a touch-screen or similar device. The voter's choice are electronically stored via a memory cartridge, diskette or smart card.

Until the early 1970s there existed no national standards on voting equipment. In 1975 the General Accounting Office's Office of Federal Elections sponsored an influential report (*Effective Use of Computing Technology in Vote-Tallying)* which called for more computerization. In 1984 the federal government issued a report on the *Feasibility of Developing Voluntary Standards for Voting Equipment* (Federal Election Commission and National Institute of Standards and Technology,

[8]Votomatic systems were used by 18.4 % of the counties in 1999. Datavote systems were used by 1.8 % of counties. Since the two systems are basically identical, we aggregate them as "punchcard systems." Our results would not change if we were to consider them as separate systems.

1984). In a subsequent report, also sponsored by Federal Election Commission and the National Institute of Standards and Technology, Roy Saltman (1988) recommended to phase out punchcard machines in favor of optical scanners and electronic machines. In 1990, the Federal Election Commission proposed the first national performance and test standards for punchcard, optical and electronic voting systems. Decisions on whether to follow the Commission's guidelines and on the actual choice of voting equipment were left to local officials. The recent events in Florida have highlighted one of the technical problems with punchcard machines, that is, the possibility of "undercount" because of imperfectly displaced chads. The relative merits of optical scanners and electronic systems are currently debated by experts and politicians.[9] Both systems are currently purchased by U.S. local officials. A recent study by Ansolabehere et al. (2001), issued as part of the Caltech/MIT Voting Technology Project, has used "residual votes" (i.e., ballots cast for which no presidential preference was counted) as yardstick for "reliability," and has concluded that paper ballots, lever machines and optical scanners are more "reliable" (i.e., less likely to produce uncounted ballots) than punchcard machines and electronic machines. In fact, the oldest system of all, paper ballots, seems to be the most reliable. We will return on these issues in Section 4, when we model the adoption of voting equipment by county officials.

[9] A related controversy has involved the different consequences of precint counting versus central counting of optically scanned ballots (e.g. see Commission on Civil Rights, 2001). Our data does not contain details on different uses of machines of the same type.

3 Determinants of voting equipment use: a preliminary analysis

As a first step towards understanding the determinants of voting equipment choice, we consider the following county characteristics:

1) Median household income (1989).

2) Population (1990).

3) % Population 65 years or older (1990).

4) % Population classified as minorities (1990).

5) % Population 25 percent or older with Bachelor's degree or higher (1990).

6) Local government revenues per capita (1986-97).

The summary statistics for these variables are reported in Table 1.

Average median household income in 1989 was \$28,817 in counties with lever machines, \$30,584 in counties with punchcard machines, \$28,124 in counties with optical scanners; and \$27,992 in counties with electronic machines. That is, lever and punchcard systems are used in counties with incomes above the average median income for all counties. By contrast, median income in counties that use optical or electronic is (slightly) below average. The lowest income is found in counties that use paper ballots (\$24,799).

The summary statistics also show that punchcard counties, on average, have a substantially larger population (140007 inhabitants versus an average for all counties equal to 79182 inhabitants). Counties that use lever and electronic machines also have populations larger than average, although the difference is not as large as in punchcard counties. By contrast, counties that use optical scanners are smaller (54601 inhabitants) than average.

The percentage of minorities is higher (19.8 %) in counties that use levers, and lower in counties that used punchcard machines (12.5%), when compared to optical and electronic (17.7% and 16.7% respectively). The percentage is also lower for paper ballots (11.4%). The percentage of seniors is 18% in counties with paper ballots, 14% in counties with levers and optical, 15% in counties with optical, and 13% in counties with electronic.

In order to investigate systematically the relationship between voting methods and county characteristics, we have performed logit estimations. Logit estimates with each type of counting method as dependant variable are reported in Tables 2a-2d. In each table, column (i) shows estimates when only income and population are used as independent variables. In column (ii) we add additional controls (seniors, minorities, population with bachelor's population, all as percentages of the population, plus local government revenues per capita).[10] Column (iii) and (iv) reports logit estimations results using Huber/White/sandwich estimators of

[10]We also performed estimations with additional variables (population density and percentage of votes for the democratic candidate in presidential elections). The variables turned out insignificant and did not change the results.

variance with clustering by state. In Table 2e we show logit estimates when we aggregate lever and punchcard machines. In Table 2f we show logit estimates when we ask what is the probability of using lever and punchcard machines versus optical and electronic (that tis, we drop paper ballots from the sample).

Overall, the logit estimates tend to confirm the regularities one can detect from the summary statistics:

a) paper ballots are used in poorer and smaller counties.

b) we can reject the hypothesis that a lower income increases the probability of using older machines (levers and punchcards) rather than newer machines (optical and electronic). If anything, there seem to be some evidence for the opposite correlation.

c) analogously, one can reject that a larger percentage of minorities or seniors in the population is associated with a higher probability of using lever machines and/or punchcard machines.

d) higher population is associated with the use of older machines.

Does the lack of a negative correlation between income and older equipment mean that economic considerations are not relevant for the choice of voting equipment? Not at all. In the following section we develop an economic model that can help shed some light on the relationship between income and voting equipment choice.

4 A model of voting equipment choice

In this section we present a stylized model of voting equipment choice. In order to present the main insights in the simplest possible way, we assume only two periods and three types of equipment. Extensions to allow for a larger (infinite) number of periods and a larger (infinite) number of equipment types are available from the authors. Also, we will assume a deterministic environment. Extensions that allow for uncertainty are also available from the authors.

In words, our model works as follows. Suppose that two counties - identical in everything except for income - are using technology A, when a better technology B becomes available.[11] Then, the richer county is more likely to adopt B, because its opportunity cost of adopting the innovation is lower (as long as utility is concave in income, the marginal benefits from alternative uses of income are lower in a richer counties). Now suppose that, after a while, a new technology C, better than B, becomes available. Which county will be more likely to adopt it? The richer county, which is now using B, or the poorer county, which is still using A? It depends. While the opportunity cost of adopting C is lower in the richer county, the benefits from adopting C are also lower. By assumption, switching from B to C will not give as high a gain as the more dramatic switch from A to

[11]As discussed below, terms such as "better," "costs," and "benefits" refer to the objective function of the relevant decision maker, the county's local official. More idealistically, one may interpret the utility of the county as equal to the utility of the county's median voter or representative citizen.

C. In other words, the net benefits from adopting the new technology C depend on a county's current technology. All other things equal, the less advanced is the county's current technology, the higher are the benefits from switching to the most advanced technology C. If the difference between "benefit effect" (larger in poorer county) and "cost effect" (larger in richer counties) is high enough, we may see a large number of richer counties "leapfrogged" by relatively poorer counties.[12] Nonetheless, our framework implies that, when controlling for past income levels, a higher income today is associated with a lower probability of using older equipment.

More formally, consider a two-period model. In each period, counties can use "type 0" equipment (paper ballots) at no cost. In period 1, a county can adopt "type 1" equipment ("old machines"). In period 2, a county can adopt "type 2" equipment ("new machines"). The quality of period t equipment is denoted by x_t (with $x_2 > x_2 > x_0$, where x_0 is the quality of paper ballots). The utility of county i's decision-maker in period t is given by

$$U_t^i = S(q_t^i) + V(y_t^i - c_t^i) \tag{1}$$

where q_t^i denotes the quality of voting machines in county i at time t, y_t^i is county

[12]The possibility of leapfrogging in the adoption of innovation is familiar to students of industrial organization, economic development, and international economics. For example, see Aghion and Howitt (2000) and Brezis et al. (1993).

i's income per capita at time t, and c_t^i denotes voting equipment costs per capita at time t. $S(q_t^i)$ is the utility from voting equipment, and is increasing in q_t^i. $V(y_t^i - c_t)$ is the utility from "consumption" (i.e., from all other uses of income, other than purchasing voting equipment), and is increasing and concave in $y_t^i - c_t$. If at time t the county adopts machines of type t we have $q_t^i = x_t$ and $c_t^i = k_t$, where k_t is the cost of type-t machines.[13] Otherwise, $q_t^i = q_{t-1}^i$ and $c_t^i = 0$.[14]

Implicit assumptions in our model are that:

a) Voting machines do not depreciate from one period to the next. This is a good approximation of reality. Actual machines are very durable, especially since they are used less than a few days a year.

b) Voting machines cannot be resold in a secondary market. This is also consistent with reality - the only major exception being the recent move by Palm Beach County to sell its infamous punchcard machines on eBay in order to finance a state-mandated overhaul of its voting equipment (Associated Press, May 5, 2001)

County i's decision maker maximizes

$$U_1^i(q_1^i,\ y_1^i - c_1^i) + \beta U_2^i(q_2^i,\ y_2^i - c_2^i) \tag{2}$$

[13] For simplicity, we assume that the costs of adopting type-t equipment are the same for all counties. The model can be easily extended to allow for different costs per capita across counties of different size. We will return to this extension later.

[14] We abstract from "running costs," which could be easily added without much gain of insights.

where $0 < \beta < 1$ is the subjective discount factor.

A brief discussion of the objective function is in order. Our interpretation is that, historically, decisions have been taken by local officials who have maximized their own utility function. What objectives have been pursued by such agents? Certainly not maximization of accuracy. While expert evaluations of the relative performance of different voting equipment have focused mainly on "reliability" (minimization of "residual votes," "spoiled ballots," etc.), it seems unlikely that, before the Florida crisis, accuracy played a paramount role in actual decisions over voting machinery.[15] If "reliability" had been the key goal of local officials, one would be hard pressed to explain why they bothered to adopt newer machines at all, when paper ballots seem to provide the most reliable, accurate system available (Ansolabehere et al., 2001). Either local officials were systematically mistaken on the characteristics of the machines they adopted, or they were willing to trade off reliability with other benefits from more advanced machines.[16] In particular, voting machines are, above all, labor-saving devices: they make voting procedures (especially vote-counting) quicker and easier. And the labor saved tends to belong to county officials themselves and their assistants.[17]

[15] "Reliability" as low "residual vote" should not be confused with the minimization of actual machine failures, which may well be a high priority for local officials. In fact, state and federal voting equipment certifications impose tight standards for machine failure rates. As pointed out by Ansolabehere et al. (2001), human factor (interaction of voter and machine) rather than pure mechanical failure seems to drive much of "error" in voting.

[16] A third possibility is that current analyses of voting equipment reliability do not provide correct estimates of relative accuracy.

[17] Voters may also benefit from shorter lines if voting procedures are speeded up by the machines.

When priority is given to the speed and convenience of vote counting, mechanized lever machines can be viewed as "progress" with respect to paper ballots, computerized punchcard machines as "progress" with respect to lever systems, etc.[18] More generally, one can assume that innovation in the voting equipment industry is targeted to the satisfaction of its costumers (the county officials), and that, on average, successful (i.e., adopted) innovations must have provided higher utility to such customers.[19] All things considered, it seems reasonable to assume that, from the perspective of local officials, "newer" voting equipment has been perceived as "better" equipment.

In this section we will solve tour model's simple optimization problem for the case $\beta = 0$.[20]

Since $S(.)$ is increasing and $V(.)$ is increasing and concave, it is immediate to obtain the following:

Proposition 1

In period 1, a county i will adopt voting machines of type 1 if and only if its

[18] Historically, the shift from paper ballots to lever machines might also have been motivated as an attempt by higher officials to reduce voting fraud.

[19] An explicit analysis of the supply side of the voting equipment industry is beyond the scope of this paper.

[20] $\beta = 0$ is a realistic assumption for our model: voting equipment is chosen by local officials with horizons that are unlikely to exceed their terms in office, while, as we have seen, the introduction of new types of voting equipment has taken place over long intervals. The straightforward generalization for $0 < \beta$ □ 0 is available upon request. Not surprisingly, the main effect of a nonzero β is to increase the fraction of counties that switch to type-1 machines in period 1.

income is higher than y_1^*, which is implicitly defined by the following equation:

$$S(x_1) + V(y_1^* - k_1) = S(x_0) + V(y_1^*) \tag{3}$$

That is, the richer counties in period 1 will adopt type-1 machineries, while the poorer counties will not.

For example, if $V(.) = ln(.)$, we have

$$y_1^* = \frac{k_1 e^{S(x_1)-S(x_0)}}{e^{S(x_1)-S(x_0)} - 1}$$

Since $S(.)$ is increasing, the benefits from adopting type-2 technology, *ceteris paribus*, are higher for those counties that have not adopted type-1 technology in period 1. Therefore, we have:

Proposition 2

In period 2, a county with $q_1^i = x_0$ will adopt machines of type 2 if and only if its income is above y_2^*, which is implicitly defined by the following equation:

$$S(x_2) + V(y_2^* - k_2) = S(x_0) + V(y_2^*) \tag{4}$$

while a county with $q_1^i = x_1$will adopt machines of type 2 if and only if its income *is above y_2^{**}, which is implicitly defined by the following equation:*

$$S(x_2) + V(y_2^{**} - k_2) = S(x_1) + V(y_2^{**}) \tag{5}$$

It is immediate to verify that $y_2^{**} > y_2^*$.

For example, if $V(.) = ln(.)$, we have

$$y_2^{**} = \frac{k_2 e^{S(x_2)-S(x_1)}}{e^{S(x_2)-S(x_1)} - 1} > y_2^* = \frac{k_2 e^{S(x_2)-S(x_0)}}{e^{S(x_2)-S(x_0)} - 1} \tag{6}$$

As shown in Figure 1, when income is correlated across the two periods, a high enough gap between y_2^{**} and y_2^* and a high enough correlation between first-period income and second-period income is consistent with a positive correlation between second-period income and use of *type-1* equipment in period 2. However, it is immediate to obtain the following

Corollary

A positive correlation between second-period income and use of type-1 equipment in period 2 vanishes when conditioning on past income. Specifically, when we look at conditional distributions - that is, at counties with the same income in period 1 - we have that the use of older equipment is either independent of period-2 income (for y_2^{**} large) or negatively associated with period-2 income (for

y_2^{**} *small).*

In the following section we will use our simple model's insights to investigate the relationship between present and past income and voting equipment usage.

5 History matters: the role of past income

In this section we will investigate whether the empirical evidence is consistent with our hypothesis that the current distribution of voting equipment use is the outcome of historical decisions.

Ideally, we would like to have historical data on voting equipment use of individual counties over the past few decades. Since we do not have such a panel data, we first consider aggregate data about the distribution of voting equipment in the 1980 and 2000 elections, as provided in Ansolabehere (2001). As shown in Table 3, we find that between 1980 and 2000 the share of counties that used optical or electronic machines went from 1 percent to 49.1 percent. The transition took place through reductions in the number of counties that used paper ballots (from 40.4 percent to 12.5 percent) or lever machines (from 36.4 percent to 14.7 percent). By contrast, the share of counties that used punchcard machines barely moved (19.1 versus 19.2). This pattern is consistent with our story.

In order to provide a more direct and formal test of our hypothesis, we calculate logit estimates using past values for income. The results are reported in Tables 6a-6b, and provide strong support for our model. In table 6a we aggregate lever and punchcard (as our "type-1 technology") and obtain the following results:

1) Income in 1969 has a positive effect on the probability of using lever or punchcard machines in 1999. Such effect is larger than the effect of 1989 income in our previous logit estimation (table 2f), when we did not control for 1969 income.

2) When income in 1969 is included in the regression, the effect of 1989 becomes insignificant.

When we consider the probability of using punchcard machines alone (table 7b) we obtain even stronger results, as one may expect from the fact that 1969 income is within the time frame in which punchcard machines were adopted, while lever machines were adopted in many counties before Second World War.[21] In particular, we have

1) Income in 1969 has a positive effect on the probability of using punchcards in 1999. In fact, such effect is one order of magnitude larger than the effect of 1989 income in our previous logit estimation (table 2c).

[21] Similar but slightly less strong results are obtained using 1959 income, which is the oldest data on median household income available at the county-level.

2) When income in 1969 is included in the regression, the effect of income in 1989 becomes *negative*.

In other words, the positive correlation between most recent income and use of punchcards is completely due to the positive correlation between most recent income and past income (i.e., the county's income when punchcards were actually adopted). When past income is explicitly taken into account, the effect of current income - as expected in our model - becomes negative

By taking explicitly into account the role of historical income, we can provide a factually consistent story about the relationship between income and the use of different voting equipment. Our story provides a solution for the "paradox of chads": "chads" are not found among poorer counties but among counties that used to be richer in 1969 - and, therefore, are still likely to be relatively richer in the 1980s and 1990s. But when past income is controlled for, a "nonparadoxical" negative relationship between present income and use of older punchcard equipment emerges.

6 History matters: the role of past population size

Income per capita is an important determinant of voting equipment use. But it is not the only determinant. In this section the analysis is extended to include another key variable: population size. We argue that, all other things equal, a larger population increases the probability of adopting more advanced voting technology. The aggregate cost of adopting a new technology includes an important fixed component, which is independent of size. These fixed costs stem from numerous sources, including the indivisibility of machines and the existence of large fixed costs in initial training and "adaptation."[22] Henceforth, cost per capita is decreasing in the size of a county.[23] Formally, we can expand the model in Section 3 by assuming that the costs per capita of adopting technology of type t in a county with population equal to N_t are given by

$$k_t + \frac{f_t}{N_t} \tag{7}$$

where f_t is a fixed cost. Moreover, benefits from adopting more advanced technology may be positively related to total size (for example, the benefits from

[22] See Office of Federal Elections and National Bureau of Standards (1975).

[23] This can be viewed as an application of the standard idea that the per capita cost of public goods should be decreasing in size. For a recent discussion of this issue, see Alesina and Spolaore (2001).

speed in vote-tallying may be higher in larger counties). Hence, our previous specification can be extended to include population as an argument in the *S(.)* function, e.g.,

$$S(q_t N_t) \tag{8}$$

Does our extension to population size imply that *currently* larger counties - controlling for income - will be more likely to use more advanced technology? No, for the same reasons why a *currently* higher income does not guarantee a better technology. What matters is population size *when* the different types of equipment were introduced. Since we have data for population before Second World War (while income data is only available from 959), we can disaggregate lever machines and punchcard machines, and test whether their use today is related to past values of population as predicted by our model. Tables 7a-7b show logit estimates when *past* values of population are included as explanatory variables. The results confirm our general message. As predicted by our model, the probability of using lever machines in 1999 is *positively* related to population in 1930, but negatively related to population in 1990. Controlling for today's population size, countries that were larger in 1930, when lever machines were state-of-the-art, were more likely to have adopted them. But, *controlling* for 1930 size, a larger size in 1990 means a higher chance of having replaced lever machines with more updated equipment by 1999. By the same token, the probability of using punchcard machines is *negatively* related to population in 1930, but *positively* related to population in 1970.

The extension of the model to include population size adds realism and explanatory power to our basic framework without changing the central insights. For example, the role of population size can also help explain an additional fact, documented in Ansolabehere et al. (2001): counties that abandoned paper ballots were more likely to adopt optical scanners, while counties that abandoned lever machines were more likely to adopt electronic machines. Electronic machines have much higher fixed costs than optical scanners (which, by contrast, have higher variable costs because they require expensive special paper). Hence, we should expect that counties with larger population would adopt electronic machines rather than optical scanners. Since larger counties are also more likely to have used lever machines rather than paper ballots in the past, a pattern lever to electronic/paper to optical is soon established. [24]

Another possible extension of our basic framework entails an explicit role for human capital. The introduction of newer technology, other things being equal, is likely to bring about higher benefits and smaller costs (from learning etc.) when voters and officials have higher education. Since these effects are probably higher for the computerized technologies of the 1980s and 1990s (optical scanners and

[24]Of course, factors such as habits and learning may also have played an important role (electronic machines are conceptually similar to lever machines, while optical scanners use a 'paper' technology).

electronic machines), it is not surprising that the percentage of population with a college degree is positively related with the adoption of such equipment. The analysis of historical levels of human capital in the adoption of older technology is left for further research.

Other extensions could focus on the role of local public finance across different jurisdictions. In our specification we simply assume that the relevant decision maker obtains utility from the county (average or median) "income." In reality, the relationship between a county's income and the resources available to local officials is also mediated by institutional mechanisms and constraints that may differ across jurisdictions. At the empirical level, they are partly captured by the independent effect of current local government revenues per capita in our regressions. The analysis of the effects of these variables from a historical perspective is also matter for future inquiry.

7 Concluding remarks

In this paper we have documented the relationship between usage of different types of voting equipment and county characteristics. Contrary to widespread belief, machines of older types are not used in relatively poorer counties. We have provided a stylized model in which the adoption of new voting equipment depends on a county's income, population, and existing type of equipment at the time the new technology is introduced. We have successfully tested numerous implications of our model. In particular, as predicted by our theory, when we control for the relevant decision variables (income and population size) at the time in which the older technologies were state-of-the-art, the effects of more recent income and population become negative or insignificant.

Overall, we have found evidence that voting equipment adoption in the U.S. has been characterized by significant "leapfrogging," with the latest technology being adopted by counties that had not adopted the previous state-of-the-art equipment.

These findings may shed new light on the debate over the causes and consequences of voting equipment choice in the U.S., and correct some misconceptions that have colored such discussions.

At least as importantly from the perspective of economic analysis, we think that our study provides valuable insights on the more general issue of the adoption of new technology by decentralized public authorities. We suspect that similar mechanisms and outcomes are at work with respect to other decisions involving the upgrade of durable public goods across different jurisdictions.

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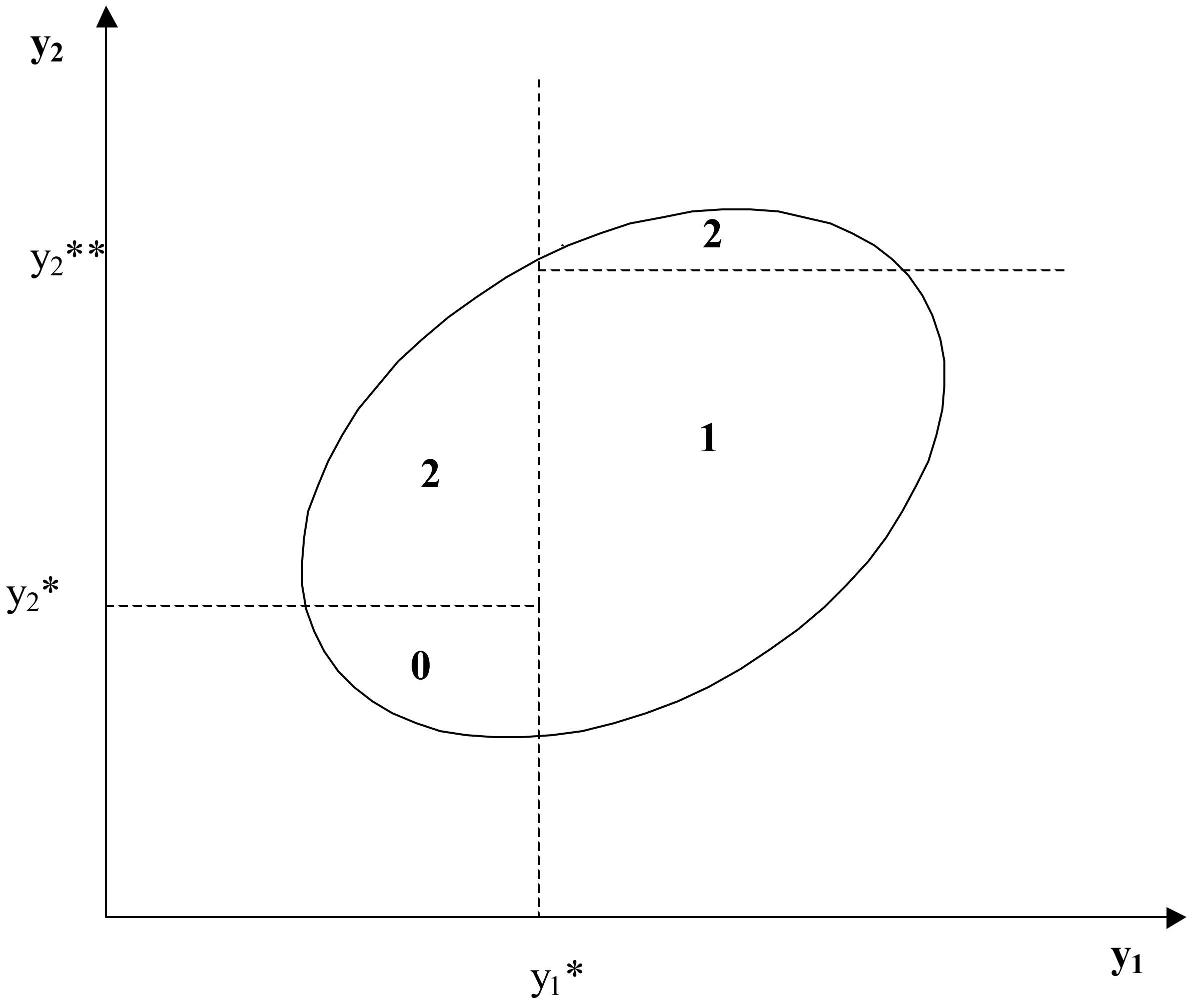

Figure 1

TABLE 1

Summary Statistics

	All counties	Paper	Lever	Punch	Optical	Elect.	Lever/ Punch	Elec/ Opt.
Median Income 89	28475	24799	28817	30584	28124	27992	29890	28088
Population 1990	79182	8869	96615	140007	54601	92282	121247	61193
% Age 65+	15	18	14	14	15	13	14	15
% Minority	15.5	11.4	19.8	12.5	17.7	16.7	15.7	17.5
% Bach.	14	12	13	14	14	13	14	14
Local Govt $/cap	1446	1707	1305	1374	1506	1144	1344	1442

Number of counties = 3141
Number of counties, paper = 407
Number of counties, lever = 476
Number of counties, punch = 625
Number of counties, optical = 1231
Number of counties, electronic = 261
Number of counties, mixed = 141

TABLE 2: Logit Estimates

All results with mixed counties dropped. Standard errors are reported in parenthesis beneath the coefficient estimates.
* denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level.

Table 2a

Paper

	(i)	**(ii)**	**(iii)**	**(iv)**
Median Income 1989	-.0000258** (.0000115)	-.0000794*** (.0000169)	-.0000258 (.0000241)	-.0000794** (.0000383)
Population 1990	-.00012 *** (8.44e-06)	-.0001035*** (8.52e-06)	-.00012*** (.0000382)	-.0001035*** (.0000369)
% Age 65+		.0486416*** (.0152558)		.0486416 (.0350578)
% Minority		-.0145374*** (.0039053)		-.0145374 (.0147063)
% Bachelors		.0752856*** (.0148393)		.0752856** (.0332496)
Local Gov. Revenues/cap.		.0000872*** (.0000352)		.0000872 (.0000574)
Log Likelihood	*-886.10886*	*-852.94436*	*-886.10886*	*-852.94436*

Number of observations = 2999
Columns (i) and (ii) report standard logit estimates. Columns (iii) and (iv) report logit estimation results using Huber/White estimator of variance with clustering by state.

Table 2b

Lever

	(i)	(ii)	(iii)	(iv)
Median Income 1989	9.85e-06 (7.10e-06)	.000047*** (.0000109)	9.85e-06 (.0000289)	.000047 (.0000329)
Population 1990	1.99e-07 (1.61e-07)	1.60e-07 (1.68e-07)	1.99e-07 (3.21e-07)	1.60e-07 (.0000369)
% Age 65+		-.0399883*** (.0144685)		-.0399883 (.0359365)
% Minority		.0134158*** (.0029389)		.0134158 (.0102091)
% Bachelors		-.0569643*** (.0118547)		-.0569643*** (.0192237)
Local Gov. Revenues/cap.		-.0003471*** (.0000901)		-.0003471 (.0003726)
Log Likelihood	*-1309.8533*	*-1268.0139*	*-1309.8533*	*-1268.0139*

Number of observations = 2999
Columns (i) and (ii) report standard logit estimates. Columns (iii) and (iv) report logit estimation results using Huber/White estimator of variance with clustering by state.

Table 2c

Punch

	(i)	(ii)	(iii)	(iv)
Median Income 1989	.0000444*** (6.50e-06)	.0000475*** (.00001)	.0000444*** (.0000157)	.0000475* (.0000293)
Population 1990	6.92e-07*** (2.15e-07)	1.46e-06*** (2.65e-07)	6.92e-07* (4.28e-07)	1.46e-06*** (5.53e-07)
% Age 65+		-.0619581*** (.0133427)		-.0619581 (.0436589)
% Minority		-.0226474*** (.0035292)		-.0226474** (.0107334)
% Bachelors		-.0423815*** (.0101155)		-.0423815* (.0241772)
Local Gov. Revenues/cap.		-.0001884*** (.0000713)		-.0001884 (.0001767)
Log Likelihood	*-1488.3204*	*-1442.9768*	*-1488.3204*	*-1442.9768*

Number of observations = 2999
Columns (i) and (ii) report standard logit estimates. Columns (iii) and (iv) report logit estimation results using Huber/White estimator of variance with clustering by state.

Table 2d

Optical

	(i)	(ii)	(iii)	(iv)
Median Income 1989	6.18e-06 (5.89e-06)	. 7.59e-06 (8.58e-06)	6.18e-06 (.0000183)	7.59e-06 (.0000246)
Population 1990	-1.17e-06*** (3.01e-07)	-1.87e-06*** (3.40e-07)	-1.17e-06** (5.39e-07)	-1.87e-06*** (6.64e-07)
% Age 65+		.0439749*** (.0102525)		.0439749* (.0260792)
% Minority		.014416*** (.0023926)		.014416** (.00701)
% Bachelors		.0343289*** (.008214)		.0343289** (.0147417)
Local Gov. Revenues/cap.		.0000845 (.0000527)		.0000845 (.0001285)
Log Likelihood	*-2019.195*	*-1984.4268*	*-2019.195*	*-1984.4268*

Number of observations = 2999
Columns (i) and (ii) report standard logit estimates. Columns (iii) and (iv) report logit estimation results using Huber/White estimator of variance with clustering by state.

Table 2e

Electronic

	(i)	(ii)	(iii)	(iv)
Median Income 1989	-.000011 (9.72e-06)	-.0000373*** (.0000136)	-.000011 (.0000412)	-.0000373 (.0000515)
Population 1990	2.40e-07 (1.81e-07)	3.64e-07** (1.89e-07)	2.40e-07 (1.84e-07)	3.64e-07 (2.93e-07)
% Age 65+		-.1301422*** (.0203253)		-.1301422** (.0587795)
% Minority		-.0073817* (.0039369)		-.0073817 (.0215262)
% Bachelors		.0043609 (.0131989)		.0043609 (.0235818)
Local Gov. Revenues/cap.		-.0009965*** (.0001578)		-.0009965*** (.0003235)
Log Likelihood	*-885.44545*	*-827.82887*	*-885.44545*	*-827.82887*

Number of observations = 2999
Columns (i) and (ii) report standard logit estimates. Columns (iii) and (iv) report logit estimation results using Huber/White estimator of variance with clustering by state.

Table 2f

Lever/Punch

	(i)	(ii)	(iii)	(iv)
Median Income 1989	.0000353*** (6.04e-06)	.0000594*** (8.95e-06)	.0000353* (.0000188)	.0000594** (.0000246)
Population 1990	1.27e-06*** (2.79e-07)	1.93e-06*** (3.09e-07)	1.27e-06*** (4.41e-07)	1.93e-06*** (5.98e-07)
% Age 65+		-.0686848*** (.0112502)		-.0686848** (.0321606)
% Minority		-.0051772** (.0025467)		-.0051772 (.0103535)
% Bachelors		-.0687412*** (.0090527)		-.0687412*** (.0173012)
Local Gov. Revenues/cap.		-.0003343*** (.0000633)		-.0003343* (.0001797)
Log Likelihood	*-1916.0679*	*-1843.9015*	*-1916.0679*	*-1843.9015*

Number of observations = 2999

Columns (i) and (ii) report standard logit estimates. Columns (iii) and (iv) report logit estimation results using Huber/White estimator of variance with clustering by state.

Table 2g

Lever/Punch (with paper counties dropped)

	(i)	(ii)	(iii)	(iv)
Median Income 1989	.0000225*** (6.08e-06)	.000043*** (9.04e-06)	.0000225 (.0000181)	.000043* (.0000251)
Population 1990	9.66e-07*** (2.58e-07)	1.59e-06*** (2.94e-07)	9.66e-07** (3.99e-07)	1.59e-06*** (5.53e-07)
% Age 65+		-.0493391*** (0117387)		-.0493391 (.0328123)
% Minority		-.0077561*** (.0026036)		-.0077561 (.0099886)
% Bachelors		-.0578793*** (.0090527)		-.0578793*** (.0160235)
Local Gov. Revenues/cap.		-.0001799*** (.0000626)		-.0001799 (.0001569)
Log Likelihood	*-1739.6329*	*-1699.4657*	*-1739.6329*	*-1699.4657*

Number of observations = 2999

Columns (i) and (ii) report standard logit estimates. Columns (iii) and (iv) report logit estimation results using Huber/White estimator of variance with clustering by state.

TABLE 3

Usage of Voting Equipment in the 1980 and 2000 Elections

	% Counties 1980	**% Counties 2000**
Paper	40.4	12.5
Lever	36.4	14.7
Punch	19.1	19.2
Optical	0.8	40.2
Electronic	0.2	8.9
Mixed	3.0	4.4

Source**:** "*A Preliminary Assessment of the Reliability of Existing Voting Equipment*", The Caltech/MIT Voting Project, Version 1: February 1, 2001.

TABLE 4

AVERAGES – HISTORICAL POPULATION AND MEDIAN FAMILY INCOME

	All	Lever	Punch	Elect	Optical	Paper	Lev/Pun	Elc/Opt
MInc89	28142	28817	30574	27918	27792	24799	29814	27814
MInc79	27888	27332	30580	27517	27830	24824	29173	27774
MInc69	23322	23004	26314	22690	22770	21138	24884	22756
MInc59	16243	15361	18793	15363	15770	15317	17316	15698
Pop90	76166	96615	139259	92282	54584	8869	120806	61314
Pop80	69104	94366	121996	85300	48533	8948	110029	55076
Pop70	61636	94153	104961	75128	41501	8193	100291	47490
Pop60	54406	87565	87694	66246	37112	8591	87639	42304
Pop50	45829	79208	67676	53893	32182	9263	72624	36053
Pop40	40118	72850	54925	45618	28805	9969	62605	31805
Pop30	37380	69062	49749	41219	27081	10216	58023	29604

(Mixed Counties, the District of Columbia, Alaska and Hawaii dropped from the sample)

TABLE 5: Correlations

Table 5a: Correlation Matrix, Median Family Income 1989, 1979, 1969, 1959

	Income 1989	*Income 1979*	*Income 1969*	*Income 1959*
Income 1989	1			
Income 1979	0.87913	1		
Income 1969	0.848535	0.89219	1	
Income 1959	0.694591	0.775071	0.882233	1

Table 5b: Correlation Matrix, Population 1990-1930

	Pop 1990	*Pop 1980*	*Pop 1970*	*Pop 1960*	*Pop 1950*	*Pop 1940*	*Pop 1930*
Pop 1990	1						
Pop 1980	0.992317	1					
Pop 1970	0.968427	0.989966	1				
Pop 1960	0.936523	0.967696	0.992117	1			
Pop 1950	0.865697	0.910339	0.953434	0.981121	1		
Pop 1940	0.79904	0.85327	0.907774	0.946395	0.989416	1	
Pop 1930	0.760713	0.819639	0.878988	0.922386	0.97626	0.996553	1

TABLE 6: Historical Income Logit Estimates

All results with mixed counties dropped. Standard errors are reported in parenthesis beneath the coefficient estimates.
* denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level.

Table 6a

Lever/Punch

	(i)	**(ii)**	**(iii)**	**(iv)**
Median Income 1969	.0000578*** (.0000126)	.000091*** (.000014)	.0000578 (.0000465)	.000091*** (.0000368)
Median Income 1989	5.28e-06 (.0000105)	.0000197 (.0000124)	5.28e-06 (.0000257)	.0000197 (.000027)
Population 1990	9.42e-07*** (2.69e-07)	1.36e-06*** (3.10e-07)	9.42e-07** (4.36e-07)	1.36e-06** (6.05e-07)
% Age 65+		-.0677762*** (.011929)		-.0677762** (.0324112)
% Minority		.0021351 (.002754)		.0021351 (.0103593)
% Bachelors		-.0788039*** (.0093558)		-.0788039*** (.0169909)
Local Gov. Revenues/cap.		-.0004337*** (.0000746)		-.0004337** (.0002167)
Log Likelihood	*-1879.9487*	*-1793.974*	*-1879.9487*	-1793.974

Number of observations = 2962
Columns (i) and (ii) report standard logit estimates. Columns (iii) and (iv) report logit estimation results using Huber/White estimator of variance with clustering by state.

Table 6b

Punch

	(i)	(ii)	(iii)	(iv)
Median Income 1969	.0001732*** (.0000161)	.000193*** (.0000175)	.0001732*** (.0000396)	.000193*** (.0000408)
Median Income 1989	-.0000599*** (.0000126)	-.0000569*** (.000015)	-.0000599** (.0000264)	-.0000569** (.0000267)
Population 1990	2.62e-07 (1.83e-07)	7.60e-07*** (2.58e-07)	2.62e-07 (3.28e-07)	7.60e-07 (4.80e-07)
% Age 65+		-.0591836*** (.0147482)		-.0591836 (.0490966)
% Minority		-.0122754*** (.0037583)		-.0122754 (.0099833)
% Bachelors		-.0536086*** (.01071)		-.0536086** (.0233077)
Local Gov. Revenues/cap.		-.0004545*** (.000097)		-.0004545* (.0002718)
Log Likelihood	*-1407.5589*	*-1360.5877*	*-1407.5589*	*-1360.5877*

Number of observations = 2962

Columns (i) and (ii) report standard logit estimates. Columns (iii) and (iv) report logit estimation results using Huber/White estimator of variance with clustering by state.

TABLE 7: Historical Population Logit Estimates

All results with mixed counties dropped. Standard errors are reported in parenthesis beneath the coefficient estimates.
* denotes significance at the 10% level, ** denotes significance at the 5% level, and *** denotes significance at the 1% level.

Table 7a

Lever

	(i)	**(ii)**	**(iii)**	**(iv)**
Population 1930	4.33e-06*** (1.01e-06)	5.07e-06*** (1.07e-06)	4.33e-06** (2.18e-06)	5.07e-06** (2.09e-06)
Population 1990	-1.74e-06*** (6.52e-07)	-2.15e-06*** (7.35e-07)	-1.74e-06* (1.06e-06)	-2.15e-06* (1.28e-06)
Median Income 1989	.0000161** (8.54e-06)	.0000579*** (.0000122)	.0000161 (.0000334)	0000579* (.0000359)
% Age 65+		-.0619088*** (.0161329)		-.0619088* (.0354578)
% Minority		.0151031*** (.0032171)		.0151031 (.0116579)
% Bachelors		-.0665901*** (.0128679)		-.0665901*** (.0203334)
Local Gov. Revenues/cap.		-.0003978*** (.0000985)		-.0003978 (.0003725)
Log Likelihood	*-1263.0142*	*-1208.7098*	*-1263.0142*	*-1208.7098*

Number of observations = 2946
Columns (i) and (ii) report standard logit estimates. Columns (iii) and (iv) report logit estimation results using Huber/White estimator of variance with clustering by state.

Table 7b

Punch

	(i)	(ii)	(iii)	(iv)
Population 1930	-1.80e-06** (8.22e-07)	-2.47e-06*** (9.30e-07)	-1.80e-06 (1.46e-06)	-2.47e-06* (1.33e-06)
Population 1970	9.38e-07** (4.78e-07)	1.75e-06*** (6.03e-07)	9.38e-07 (8.02e-07)	1.75e-06** (8.84e-07)
Median Income 1969	.0001774*** (.0000162)	.0001982*** (.0000178)	.0001774*** (.0000393)	.0001982*** (.0000399)
Median Income 1989	-.0000604*** (.0000128)	-.0000581*** (.0000151)	-.0000604** (.0000267)	-.0000581** (.0000274)
% Age 65+		-.0517037*** (.0148848)		-.0517037 (.0490287)
% Minority		-.0105686*** (.0037785)		-.0105686 (.0101945)
% Bachelors		-.0515015*** (.0108287)		-.0515015** (.02371)
Local Gov. Revenues/cap.		-.0004759*** (.0000987)		-.0004759* (.0002789)
Log Likelihood	*-1394.5174*	-1352.0327	*-1394.5174*	*-1352.0327*

Number of observations = 2944

Columns (i) and (ii) report standard logit estimates. Columns (iii) and (iv) report logit estimation results using Huber/White estimator of variance with clustering by state.