BLAME IT ON THE RAIN? VOTER RATIONALITY AND EXOGENOUS ECONOMIC SHOCKS

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ABSTRACT. In standard political agency models, elections have socially beneficial incentive and screening effects. However, several recent papers have cast doubt on the ability of voters to play the role cast for them in public choice models. In this paper, I present evidence from India that voters are responsive to exogenous rainfall shocks, and argue that this is an important (and heretofore unexamined) feature of Indian politics. My estimates show that the effect of transitory rainfall on support for incumbents in post-monsoon elections is large and statistically significant. A one standard deviation increase in rainfall in the year before the election causes a 5.2 percentage point increase in an incumbent's vote margin. However, I show that in a rational political agency model based on that of Banks and Sundaram (1998), voter rationality alone does not rule out a correlation between observable exogenous economic shocks and support for the incumbent. My analysis clarifies the assumptions that are necessary for such a correlation to serve as evidence against voter rationality.

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1. INTRODUCTION

From a narrow consequentialist perspective, the normative appeal of democracy rests principally on the belief that voters can improve the performance of governments by removing poorly performing political leaders at the polls. Rational choice models offer support for this belief by showing how the choices of rational self-interested voters can result in better selection of and incentives for public officials. These models rest on the assumption that voters do indeed rationally evaluate the performance of the incumbent and vote for the candidate who offers the greatest expected payoff. While in general such an assessment may be quite complex, with an appropriate model setup, rational voters will use a relatively simple retrospective voting rule that conditions support for the incumbent on the state of the economy during the incumbent's term.

Consistent with these models, there is substantial systematic evidence that voters engage in economic voting, conditioning their support for the incumbent on the performance of the economy during the incumbent's term in office. Lewis-Beck and Stegmaier (2000) review such evidence and conclude that the phenomenon is robust, appearing across the world's democracies. In one of the few developing country economic voting studies, Pacek and Radcliff (1995) look at elections from eight developing countries and find that negative GDP growth reduces the vote share of the incumbent. They also find a negative relationship between GDP growth and turnout, suggesting that in recessions voters mobilize to express their discontent.

However, the extent of voter rationality has been questioned. One strand of this literature focuses on voter myopia. For example, Achen and Bartels (2004) analyze U.S. data and conclude that voters respond mostly to the economy's performance over the preceding six months rather than its performance over the incumbent's full four year term. Given the volatility of the economy, such voting behavior is unlikely to select competent political leaders, and rather than providing incentives for leaders to choose and implement good policies, it may create perverse incentives for the incumbent to goose the economy in the months leading up to the election.

Another strand tests whether voters respond to factors deemed by the analyst to be irrelevant to a rational evaluation of the likely performance of alternative candidates. Wolfers (2007) analyzes

U.S. gubernatorial elections and concludes that voters irrationally attribute the effects of oil price movements to the incumbent. His empirical approach follows that of Bertrand and Mullainathan (2001)[1] and examines whether voters filter out observable exogenous shocks to states' economies. Wolfers uses movements in oil prices as an exogenous source of variation in employment, which affect oil producing states and rust belt states differentially. Wolfers finds large and statistically significant estimates of an effect of the deviation of log unemployment from trend level, instrumented by oil price shocks, on incumbent vote shares. He argues that this is evidence of bounded rationality by voters, who fail to filter out the component of state economic performance attributable to factors outside the governor's control. Similarly, Patty and Weber (2006) present experimental evidence that subjects are unable to fully filter out noise when assessing the quality of the incumbent. If voters engage in simple rule-of-thumb pocketbook voting, as suggested by these findings, then the beneficial screening and incentive effects of elections would be attenuated. The consequent "noisiness" of the implicit contract facing politicians would reduce their incentive to exert effort, as the connection between their effort and their electoral fortunes would be less strong. Furthermore, this noisiness would result in more low quality incumbents retained (by being lucky), and more high quality incumbents dismissed (by being unlucky), resulting in worse screening.

The goal of this paper is to provide further evidence that observable exogenous economic shocks affect voter behavior, and to clarify the assumptions necessary for such a correlation to serve as evidence against voter rationality. First, I present evidence from India that voters are responsive to exogenous rainfall shocks, and argue that this is an important (and heretofore unexamined) feature of Indian politics.[2] My estimates show that the impact of transitory rainfall on support for incumbents in post-monsoon elections is large and statistically significant. A one standard deviation increase in rainfall in the year prior to the election causes a 5.2 percentage point increase

[1]Bertrand and Mullainathan (2001) develop the methodology to examine whether corporations reward CEOs for profits that are properly attributed to random exogenous factors.

[2]In independent contemporaneous work, Afzal (2007) documents a correlation between rainfall and voting behavior using election data from India and Pakistan. She argues that, by increasing voters' income, rainfall can change a corrupt politician's incentives to steal. As an alternative explanation, she argues that rainfall can affect the income generated by a politician's own land, and thereby reduce his incentives to exert effort in office. My theoretical argument is more fundamental, and clarifies the assumptions necessary for a correlation between exogenous economic shocks and voter behavior to provide evidence against voter rationality.

in an incumbent's percentage vote margin. Importantly, the effect of rainfall shocks in rural India on voters' pocketbooks is presumably much easier for voters to understand than are the effects of oil price movements on the US economy. Interpreted using Wolfers (2007)'s model, my findings seem to provide even more striking evidence against voter rationality.

However, I show that in a rational political agency model based on that of Banks and Sundaram (1998), voter rationality alone does not rule out a correlation between observable exogenous economic shocks and support for the incumbent. Different realizations of the exogenous shock induce different games between the voters and the incumbent. If the exogenous economic shock is simply an additive disturbance in voter's income, then there is no correlation between rational voters' retention decision and the economic shock. If, however, there is some interaction effect between the realization of the economic shock and incumbent's action in the economy's production function, then it is possible for rational voter behavior to correlate with the economic shock. It may well be that when positive observable economic shocks are realized, actions by the government have little effect on voter's incomes and consequently few bad incumbents are revealed, whereas when negative economic shocks are realized, the difference between good incumbents and bad incumbents becomes stark as good incumbents' effort is more likely to separate them from bad incumbents. For example, it may be that the quality of irrigation infrastructure set up by the government is revealed in low rainfall periods, resulting in greater dismissals of incumbents.

The plan of the paper is as follows. Section 2 presents evidence that rainfall has a causal effect on support for the incumbent in Indian parliamentary elections; Section 3 presents a political agency model with observable exogenous shocks; Section 4 concludes.

2. The Effect of Rainfall on Support for the Incumbent in India

Rainfall is an important determinant of household incomes in rural India. It is also, as I show below, an important determinant of the electoral fortunes of members of Parliament, despite the fact that it is an easily observable, and presumably well-understood, exogenous economic shock that is outside the control of the government.

2.1. **Data.** I analyze voting data from eight elections for the Parliament of India, the Lok Sabha, between 1977 and 1999. Members of the Lok Sabha are elected from 543 single member parliamentary constituencies (PCs), the boundaries of which were fixed between 1973 and 2001, under a first past the post voting rule. Figure 1 depicts the PC boundaries. The unit of analysis is an incumbent in a given election.

2.1.1. *Identifying incumbents.* The voting data come from the Election Commission of India (ECI) and include the name, gender, party, and votes received of each candidate running for Parliament. Unfortunately, the names of candidates are not consistently recorded across elections. For example, one politician was recorded as "Vyrichorla Kishore Chandra Suryanarayana Deo" when he successfully ran for office in 1977, but as "K.C.Suryanarayana Deo Vyricherla" when he ran for reelection in 1980. The procedure used to match names is the following: First all exact name matches between winners of the previous election and candidates in the current election in the same PC are made and removed. Then a preliminary match is made between the winner of the previous election and the candidate from the same party as the winner in each remaining PC-election, adjusting the party codes so that related parties are considered the same party. These lists of preliminary matches were then manually scanned for matches like the example above. The manual matching algorithm used was to match names that are clear mispellings or alternative transliterations, and to match names composed of more than one word if and only if at least two words in the names matched. So if the last names were the same but the first names were different, the names were *not* matched. This procedure yielded 2,526 incumbents out of a total of 7 * 543 = 3,801 PC-election observations in seven elections (incumbents cannot be identified in the 1977 election). I verified this procedure by taking random samples of the remaining unmatched PC-elections and found no false negatives. It remains possible that some incumbents were not identified, in particular those who switched to an unrelated party between elections. A small subset of the matched incumbent names is provided in Table 1 in the Appendix.

2.1.2. *Rainfall data.* The rainfall data are from the Center for Climatic Research at the University of Delaware and consist of monthly rainfall sampled on a 0.5° by 0.5° latitude-longitude grid from

1950 to 1999. A typical PC contains about four of these grid nodes. To generate an estimate of the rainfall in each month in each PC, I first created an interpolated surface using ArcGIS's "spatial analyst tool" and from that surface created a new raster dataset on a 0.2° by 0.2° latitude-longitude grid. The interpolated rainfall values that fall within each PC were then averaged to generate a measurement of average rainfall in each PC for each month in the data.

To create an exogenous rainfall variable, I transform these PC-level data into fractional deviations from mean rainfall in each PC. So for a rainfall data point in January, say, the mean used is the average January rainfall in that PC between 1950 and 1999.

2.1.3. *Yield data.* The yield data are from Duflo and Pande (2005) and are based on the World Bank India Agriculture and Climate dataset. The data cover 271 Indian districts across 13 of the main agricultural states of India — comprising 80% of India's land area — from 1956 - 1999. Districts are a basic administrative subunit, the boundaries of which do not coincide with the boundaries of PCs. Figure 2 depicts the 1991 district boundaries. Figure 3 depicts both the 1991 district boundaries and PC boundaries over parts of the states of Uttar Pradesh, Madhya Pradesh and Rajasthan. Many PCs are composed of parts of several districts. To map the district-level yield data into PCs, I use the following formula:

$$y_{pt} = \sum_{d \in D} \alpha_{dp} y_{dt} \tag{1}$$

where y_{pt} is the yield data in PC p in year t, D is the set of all districts, α_{dp} is the fraction of the area of PC p that is composed of district d, and y_{dt} is the yield data in district d in year t.

I used data on PC boundaries from ECI and data on 1991 district boundaries from GfK MACON. I merged the two boundary datasets to create the partition based on all of the intersections in the two datasets and calculated the area of each element of that partition using ArcGIS. The agricultural data are based on *1961* district boundaries. Most of the boundary changes between 1961 and 1991 involve districts splitting in two. I used a list of district divisions between 1961 and 1991 from the University of Maryland Indian District Database (http://www.bsos.umd.edu/socy/vanneman/districts/) to create a 1961 district boundary-based partition. From this partition I calculated the α_{dp}'s, and

calculated PC-level yield data from the district-level data using those weightings. Of the 2,526 incumbent-election observations I am able to impute yield data for 1,340.[3]

Yield is measured in rupees per hectare and is based on six major crops: wheat, rice, sorghum, sugarcane, pearl millet and maize. Production and cultivated area data are from Indian government publications. However, the prices used to calculate yield are the average crop price across 1960-64 and are deflated by state-specific Consumer Price Indices with 1973-74 as the base year. Importantly, then, the yield data do not account for changes in prices. They thus likely overstate the variance in revenue yield, since price generally would negatively correlate with supply shocks.

2.2. **Results.**

2.2.1. *The effect of rainfall on crop yields.* Table 3 reports estimates of the relationship between crop yields and transitory rainfall in years and PCs in which an incumbent is running. Unsurprisingly, transitory rainfall in the same year and in the prior year has a statistically significant positive effect on yields that is robust to the inclusion of year and PC fixed effects. My preferred specification includes these fixed effects and is reported in column (4). Using these estimates, a one standard deviation increase in rainfall causes a 3.7% increase in crop yields, while a one standard deviation increase in rainfall in the prior year causes a 3.3% increase in crop yields. Presumably, one reason that rainfall in the prior year affects crop yields is that some portion of the harvests that are used to calculate crop yields in a year are in the ground in the prior year and benefit from the prior year rainfall. Another possibility is that high prior year rainfall relieves credit constraints of poor farmers, resulting in more efficient input use in the following year.

2.2.2. *The effect of rainfall on support for the incumbent.* Table 4 reports estimates of the effect of transitory rainfall on the incumbent's fractional margin of victory / defeat. I include only

[3]Unfortunately, I do not have the underlying cultivable area data used to calculate the yield data. Given heterogeneity across districts in area under cultivation, it would be better to generate PC-level yields by first creating PC-level crop production and cultivable area data from the district-level data, and then calculating yield from those PC-level datasets. Instead I simply calculated PC-level yield directly from the district-level yield data. My procedure essentially assumes that the density of cultivable area is the same across districts, since the weights given to the district-level yields is solely based on the area of the PC composed by that district and does not account for area under cultivation.

incumbent-elections for which I have yield data, both to make these estimates comparable to estimates of the relationship between transitory rainfall and crop yields above, and because crop yield data are available for major agricultural states, which are the states for which it is more likely that rain would have an effect on voting.[4] The basic OLS estimates suggest that in election years in which rainfall in a PC is high, the incumbent MP fares slightly better at the polls. However, when PC and year fixed effects are included (reported in column (4)), the size of the coefficient falls.

A potential difficulty with these estimates is that voting in four of the seven elections occurred prior to June, when the summer monsoon begins in India. Voters in these elections would not vote in response to the quality of the monsoon in that year. To investigate this, Table 5 adds interactions between an indicator for whether the election occurred in June or later, after the monsoon, and the rainfall variables.[5] Somewhat surprisingly, in the preferred specification with year and PC fixed effects reported in column (4), we find that post-monsoon elections are significantly more sensitive to rainfall in the year before the election than are pre-monsoon elections. Using these estimates, a one standard deviation increase in rainfall in the year before the election increases the incumbent's vote margin by 5.2 percentage points for post-monsoon elections. 148 of the 625 incumbents in the post-monsoon elections won or lost by less than this amount. For pre-monsoon elections, a one standard deviation increase in rainfall in the year of the election results in a 1.7 percentage point increase in the incumbent's vote margin.

It seems then that the effect of transitory rainfall on support for the incumbent is substantial. These data provide strong evidence that voters respond to exogenous economic shocks at the polls by offering greater support to the incumbent when rainfall is high.

Interpreting this effect is challenging, however. Wolfers (2007) interprets his analogous results showing that voters respond to oil price shocks as evidence of voters' inability to filter out the component of their incomes that is due to observable random factors and not properly attributable to the incumbent. One weakness of Wolfers' test of the rational model is that it puts a rather heroic burden on voters. His first stage regression shows that oil price movements do indeed

[4]The results are similar using the entire sample of incumbent-elections (unreported).

[5]These elections were in Dec. 1984, Nov. 1989 and Sept. - Oct. 1999.

affect employment differentially across states. The mechanism by which they do this is complex, involving general equilibrium effects that ripple across sectors of the economy, causing economic pain to be felt by individuals seemingly far removed from the petroleum industry. Voters must not only know that oil prices have changed, but also be able to correctly calculate the component of their transitory income that is attributable to this price movement. A worker laid off by K-Mart who would have kept his job had oil prices not gone up, and whose job could not have been saved by better management of the economy by the governor, must correctly make this inference and not attribute his misfortune to the incumbent governor or party. While an economist armed with Stata® and a good dataset may be up to this challenging problem of statistical inference, it seems somewhat fanciful to expect the median voter to do so. Note that, interpreted using Wolfer's logic, the effect of rainfall on voting behavior in India provides even stronger evidence against voter rationality, as rainfall is more easily observed than are oil prices, and the relationship between rainfall and voters' incomes is surely much easier for voters to understand than is the relationship between oil prices and voters' incomes in the U.S..

Following Wolfers (2007)'s procedure, a natural estimation procedure to run next would be an instrumental variables estimate of the effect of crop yields on the incumbent's vote margin, but for this to be valid, an exclusion restriction must hold — rainfall must affect voting behavior only through its effect on crop yields.

However, as the next Section demonstrates, this exclusion restriction is unlikely to hold. The signal extraction problem facing voters is different following high rainfall realizations than it is following low rainfall realizations. The result is that rational voting behavior may well correlate with observable random economic shocks. Interpreting these correlations as evidence against voter rationality requires strong assumptions about the relationship between the economic shock and the signal extraction problem faced by voters.

3. MODEL

This model is based on that of Banks and Sundaram (1998). There is one representative voter, and infinitely many politicians. Each politician is either Good or Bad, with his type denoted

$\omega \in \Omega \equiv \{\omega^G, \omega^B\} \subset \mathbb{R}$, unobserved by the voter, with $\omega^G > \omega^B$. Politicians' types are drawn i.i.d. with $\Pr(\omega = \omega^G) = \lambda$.

There are two periods, $t = 1, 2$. The timing of events in each period is as follows.

(1) The voter chooses a politician to serve in office.

(2) A publicly observable shock $r_t \in R \equiv [\underline{r}, \bar{r}]$ is realized from a distribution with pdf $g(r)$.

(3) The office-holder makes a costly effort choice $a_t \in A \equiv [\underline{a}, \bar{a}]$, not observed by the voter.

(4) Output $y_t \in Y \equiv [\underline{y}, \bar{y}]$ is realized from a continous distribution with the strictly increasing conditional cdf $F(y|a_t, r_t)$, with corresponding pdf $f(y|a_t, r_t)$, and the voter and politician receive their payoff for the period.

Assume that $f(y|a_t, r_t)$ satisfies the monotone likelihood ratio property:

$$\forall\, r, y > y', a > a', \text{ we have } \frac{f(y|a,r)}{f(y|a',r)} > \frac{f(y'|a,r)}{f(y'|a',r)} \tag{2}$$

Note that (2) implies that $F(y|a, r)$ is decreasing in a for fixed y and r (see Milgrom, 1981).

3.1. **Preferences.** Politicians not in office for a period receive a payoff normalized to 0 for the period. Office-holders receive a period payoff of $u(a_t; \omega)$, which satisfies the following assumptions:

$$\forall\, a \in A, u(a; \omega^G) \geq u(a, \omega^B) \tag{3}$$

$$\forall\, \omega \in \Omega, u(\cdot; \omega) \text{ is continuous and strictly concave.} \tag{4}$$

$$\text{Supermodularity: } \forall\, a > \hat{a}, \text{ we have } u(a; \omega^G) - u(\hat{a}; \omega^G) > u(a; \omega^B) - u(\hat{a}; \omega^B) \tag{5}$$

The purpose of (5) is to guarantee that Good incumbents prefer taking strictly higher actions than Bad incumbents.

The voter receives a per-period payoff of $v(y_t)$ with $v'(\cdot) > 0$.

3.2. **Strategy Sets.** Each politician i's strategy is a pair of functions, (μ_i, γ_i) where $\mu_i : \Omega \times R \to A$ specifies the first period action as a function of the politician's type and r_1 and $\gamma_i : \Omega \times Y \times$

$\{0,1\} \times R^2 \rightarrow A$ specifies the second period action as a function of the politician's type, y_1, an indicator k for whether the politician was an incumbent in the first period, r_1, and r_2.[6]

Assume that the voter simply chooses a random politician to hold office in the first period since the voter's prior belief about the type of each politician is identical. Similarly, I assume that if the voter does not choose to retain the incumbent for the second period, he simply chooses a new politician at random. The voter's strategy is then just a single function $\sigma : Y \times R \rightarrow \{0,1\}$ that specifies whether to return the incumbent for a second term as a function of y_1 and r_1.

3.3. **Analysis of the Model.** I now characterize perfect Bayesian equilibria (PBE) of the model with the property that all politicians use the same strategy (and I therefore drop the subscript i on the μ's and γ's). In particular, in the first proposition I show that there exist equilibria such that politicians' strategies are *type monotone* in the sense that Good politicians choose higher actions in both the first and second periods than Bad politicians, and the voter employs a cut-off rule such that first term office holders are retained if and only if first period output is sufficiently high, given the realization of r_1. In the proof of the following proposition, I show that, in equilibrium, politicians' second period actions are a function only of their type; hence I denote these strategies as simply $\gamma^*(\omega)$.

Proposition 1. *There exists a PBE with strategy profile* $(\sigma^*(y_1, r_1), \mu^*(\omega, r_1), \gamma^*(\omega))$ *such that,* $\forall\, r_1 \in R$, $\sigma^*(y_1, r_1) = 1 \Leftrightarrow y_1 \geq \hat{y}(r_1)$ *for some* $\hat{y} : R \rightarrow Y$, $\mu^*(\omega^G, r_1) > \mu^*(\omega^B, r_1)$, *and* $\gamma^*(\omega^G) > \gamma^*(\omega^B)$.

Proof is in the Appendix.

In equilbrium, the realization of output in the first period provides information to the voter about the first period office holder's type and first period action choice, and the voter's strategy has both incentive effects for the politician's first period action and screening effects in that it increases the likelihood of having a Good politician in office in the second period.

In special cases, the model predicts that the voter's retention decision is independent of the first period publicly observed shock.

[6]To simplify, I restrict attention to pure strategies.

Proposition 2. *Let $y_t = r_t + a_t + \epsilon_t$ where $\epsilon_t \sim N(0, \sigma^2)$. Then there exist parameters such that there exists a PBE such that $Cov(r_1, \sigma^*(y_1, r_1) = 0$; that is, the voter's retention decision is uncorrelated with the first period publicly observed shock.*

Proof. Let $\phi_{0,\sigma^2}(\epsilon)$ and $\Phi_{0,\sigma^2}(\epsilon)$ denote the pdf and cdf of ϵ_t, respectively. Note that $f(y_t|a_t, r_t) = \phi_{r_t+a_t,\sigma^2}(y_t) = \phi_{0,\sigma^2}(y_t - a_t - r_t)$ and $F(y_t|a_t, r_t) = \Phi_{0,\sigma^2}(y_t - a_t - r_t)$, and that $f(y_t|a_t, r_t)$ satisfies the monotone likelihood ratio property (2).

As shown in the proof of Proposition 1, the voter's cut-off rule $\hat{y}(r_1)$ is defined by

$$f(\hat{y}(r_1)|\mu^*(\omega^G, r_1), r_1) = f(\hat{y}(r_1)|\mu^*(\omega^B, r_1), r_1) \tag{6}$$

or

$$\phi_{0,\sigma^2}[\hat{y}(r_1) - \mu^*(\omega^G, r_1) - r_1] = \phi_{0,\sigma^2}[\hat{y}(r_1) - \mu^*(\omega^B, r_1) - r_1] \tag{7}$$

The politicians' first period strategy is defined by

$$\mu^*(\omega, r_1) = \underset{a\in[0,1]}{\operatorname{argmax}}\{u(a;\omega) + [1 - \Phi_{0,\sigma^2}(\hat{y}(r_1) - a - r_1)]u(\gamma^*(\omega);\omega)\} \tag{8}$$

Assuming an interior solution, $\mu^*(\omega, r_1)$ is defined by

$$\frac{\partial u(a;\omega)}{\partial a}\Big|_{a=\mu^*(\omega,r_1)} = \phi_{0,\sigma^2}[\hat{y}(r_1) - \mu^*(\omega, r_1) - r_1]u(\gamma^*(\omega);\omega) \tag{9}$$

Suppose the voter's cutoff rule is $\hat{y}(r_1) = k + r_1$ for some fixed k. Subbing this into (7) and (9) we have

$$\phi_{0,\sigma^2}(k - \mu^*(\omega^G, r_1)) = \phi_{0,\sigma^2}(k - \mu^*(\omega^B, r_1)) \tag{10}$$

$$\frac{\partial u(a;\omega)}{\partial a}\Big|_{a=\mu^*(\omega,r_1)} = \phi_{0,\sigma^2}[k - \mu^*(\omega, r_1)]u(\gamma^*(\omega);\omega) \tag{11}$$

By (11) we see that given the voter's cutoff rule, the politicians' first period action is not a function of r_1. Therefore, there exists a single k that satisfies (10) for all r_1. Thus there exists a PBE with $\hat{y}(r_1) = k + r_1$ for some fixed k.

We can now calculate $Cov(\sigma^*(y_1, r_1), r_1)$ as

$$
\begin{aligned}
&Cov(\sigma^*(y_1, r_1), r_1) = E[r_1\sigma^*(y_1, r_1)] - E[r_1]E[\sigma^*(y_1, r_1)] \\
&= E[E[r_1\sigma^*(y_1, r_1)|r_1]] - E[r_1]E[E[\sigma^*(y_1, r_1)|r_1]] \\
&= \int_R r\Big[\lambda[1 - F(k + r|\mu^*(\omega^G), r)] + (1 - \lambda)[1 - F(k + r|\mu^*(\omega^B), r)]\Big]g(r)dr - \\
&E[r] * \int_R \Big[\lambda[1 - F(k + r|\mu^*(\omega^G), r)] + (1 - \lambda)[1 - F(k + r|\mu^*(\omega^B), r)]\Big]g(r)dr = \\
&= \int_R r\Big[\lambda[1 - \Phi_{0,\sigma^2}(k - \mu^*(\omega^G))] + (1 - \lambda)[1 - \Phi_{0,\sigma^2}(k - \mu^*(\omega^B)))]\Big]g(r)dr - \\
&E[r] * \int_R \Big[\lambda[1 - \Phi_{0,\sigma^2}(k - \mu^*(\omega^G))] + (1 - \lambda)[1 - \Phi_{0,\sigma^2}(k - \mu^*(\omega^B))]\Big]g(r)dr = \\
&\Big[\lambda[1 - \Phi_{0,\sigma^2}(k - \mu^*(\omega^G))] + (1 - \lambda)[1 - \Phi_{0,\sigma^2}(k - \mu^*(\omega^B))]\Big]\Big[E[r] - E[r]\Big] = 0
\end{aligned}
\tag{12}
$$

□

The intuition for the result that the voter's retention decision is uncorrelated with the first period economic shock is that the voter filters out the shock when forming beliefs about the quality of the first period office-holder based on the realized output. When a favorable shock is realized the voter raises the bar by exactly the amount of the shock, so that the first period office-holder faces the exact same incentives regardless of the realization of the shock. The result is that the first period office-holder's action is independent of the shock, and so is the voter's retention decision. Under the assumptions of Proposition 2, then, Wolfers (2007)'s test of voter rationality is sound. Importantly, however, this result is in no way general but rather is specific to the simple additive production function assumed. The main result of this section is stated in the next proposition — for certain parameters, rational economic voting by the voter results in a correlation between the voter's retention decision and the observable random first period shock.

Proposition 3. *Let* $A = [0,1]$, $R = [0,1]$, $Y = [-1,1]$, $f(y|a,r) = \theta(a,r)y + 1/2$ *where* $\theta(a,r) = \frac{1}{2}[-1+a+r]$, $g(r) = 1$, *and* $u(a;\omega) = a - \frac{a^2}{\omega}$. *Then there exist parameters such that there exist PBE such that* $Cov(r_1, \sigma^*(r_1, y_1)) \neq 0$.

Proof. Note that $F(y|a,r) = \frac{1}{2}[\theta(a,r)y^2 + y - \theta(a,r) + 1]$ and that $f(y|a,r)$ satisfies the monotone likelihood ratio property (2). By Proposition 1 we know that there exists a PBE with type-monotone strategies of politicians and with the voter employing a cutoff rule defined by $\hat{y}(r_1)$.

The politicians' second period strategy is

$$\gamma^*(\omega) = \underset{a\in[0,1]}{\operatorname{argmax}}\{a - \frac{a^2}{\omega}\} \tag{13}$$

Assume Ω is such that the solution to this problem is always interior and we have

$$\gamma^*(\omega) = \frac{\omega}{2} \tag{14}$$

and the second period value function given by

$$U(\omega) = \frac{\omega}{4} \tag{15}$$

$\hat{y}(r_1)$ is defined by

$$\theta(\mu^*(\omega^G, r_1), r_1)\hat{y}(r_1) - \frac{1}{2} = \theta(\mu^*(\omega^B, r_1), r_1)\hat{y}(r_1) - \frac{1}{2} \tag{16}$$

which gives us a constant cutoff rule:

$$\hat{y}(r_1) = 0 \tag{17}$$

The politicians' first period strategy is defined by

$$\mu^*(\omega, r_1) = \underset{a\in[0,1]}{\operatorname{argmax}}\{a - \frac{a^2}{\omega} + [1 - F(0|r_1, a)]\frac{\omega}{4}\} \tag{18}$$

Assume Ω is such that the solution to this problem is always interior and we have

$$\mu^*(\omega, r) = \frac{\omega}{2}(1 + \frac{\omega}{16}) \tag{19}$$

With the equilibrium now characterized, we can calculate the covariance between the voter's retention decision and the first period shock as

$$
\begin{aligned}
&Cov(\sigma^*(\omega, r_1), r_1) = E[r_1\sigma^*(y_1, r_1)] - E[r_1]E[\sigma^*(y_1, r_1)] \\
&= E[E[r_1\sigma^*(y_1, r_1)|r_1]] - E[r_1]E[E[\sigma^*(y_1, r_1)|r_1]] \\
&= \int_R r\Big[\lambda[1 - F(\hat{y}(r)|\mu^*(\omega^G, r), r)] + (1-\lambda)[1 - F(\hat{y}(r)|\mu^*(\omega^B, r), r)]\Big]g(r)dr - \\
&E[r] * \int_R \Big[\lambda[1 - F(\hat{y}(r)|\mu^*(\omega^G, r), r)] + (1-\lambda)[1 - F(\hat{y}(r)|\mu^*(\omega^B, r), r)]\Big]g(r)dr \\
&= \int_0^1 r\Big[\lambda[\frac{1}{2} + \frac{\theta(\mu^*(\omega^G, r), r)}{2}] + (1-\lambda)[\frac{1}{2} + \frac{\theta(\mu^*(\omega^B, r), r)}{2}]\Big]dr - \\
&\frac{1}{2} * \int_0^1 \Big[\lambda[\frac{1}{2} + \frac{\theta(\mu^*(\omega^G, r), r)}{2}] + (1-\lambda)[\frac{1}{2} + \frac{\theta(\mu^*(\omega^B, r), r)}{2}]\Big]dr
\end{aligned} \tag{20}
$$

Subbing in for $\theta^*(\mu^*(\omega, r), r)$ we have

$$
\begin{aligned}
&\int_0^1 r\Big[\lambda[\frac{1}{2} + \frac{\frac{1}{2} * [-1 + \frac{\omega^G}{2}(1 + \frac{\omega^G}{16}) + r]}{2}] + (1-\lambda)[\frac{1}{2} + \frac{\frac{1}{2} * [-1 + \frac{\omega^G}{2}(1 + \frac{\omega^G}{16}) + r]}{2}]\Big]dr - \\
&\frac{1}{2} * \int_0^1 \Big[\lambda[\frac{1}{2} + \frac{\frac{1}{2} * [-1 + \frac{\omega^G}{2}(1 + \frac{\omega^G}{16}) + r]}{2}] + (1-\lambda)[\frac{1}{2} + \frac{\frac{1}{2} * [-1 + \frac{\omega^G}{2}(1 + \frac{\omega^G}{16}) + r]}{2}]\Big]dr
\end{aligned} \tag{21}
$$

Integrating we get

$$
\begin{aligned}
Cov(\sigma^*(y_1, r_1), r_1) =& \frac{1}{2}\Big[1 + \frac{1}{4}[-1 + \lambda\frac{\omega^G}{2}(1 + \frac{\omega^G}{16}) + (1-\lambda)\frac{\omega^B}{2}(1 + \frac{\omega^B}{16})]\Big] + \frac{1}{12} - \\
& \frac{1}{2}\Big[1 + \frac{1}{4}[-1 + \lambda\frac{\omega^G}{2}(1 + \frac{\omega^G}{16}) + (1-\lambda)\frac{\omega^B}{2}(1 + \frac{\omega^B}{16})] + \frac{1}{8}\Big] \\
=& \frac{1}{48} \neq 0
\end{aligned} \tag{22}
$$

□

This simple model can thus yield an outcome where it appears that the voter is "punishing" the incumbent for bad luck. The intuition for this result is that, in equilibrium, the voter dismisses the incumbent following any realization of r_1 and y_1 such that the incumbent is more likely to be Bad than Good. There is no reason that the probability that this happens has to be the same for different

realizations of r_1. Each realization of r_1 induces a family of conditional probability distributions of y_1 parameterized by a_1, and some of these families can result in a greater equilibrium likelihood of dismissing the incumbent than other families.

This possibility is illustrated graphically in Figure 4, which plots the probability density function of the voter's income conditional on various realizations of the economic shock and various action choices by the incumbent. For example, the line marked "f(y, action(good), high shock)" is the density function following the first period action choice of the Good type and a relatively high realization of r_1. Since the voter's cutoff rule is constant at $\hat{y}(r_1) = 0$, it is clear that there is a higher probability of retaining the incumbent following a high realization of r_1 than following a low realization of r_1, since as r_1 increases, the density function tilts upward such that there is greater probability mass above the voter's cutoff income level.

3.4. **Discussion.** Given these results, it is clear that to interpret a correlation between incumbents' vote share and observable exogenous economic shocks as evidence against voter rationality requires an assumption about the relationship between the economic shock and the information extraction problem faced by voters. In particular, we have seen that with a simple linear production function in which the economic shock is an additive disturbance term, a rational voter's retention decision will be uncorrelated with the shock, but when the shock interacts with the incumbent's action choice, as in Proposition 3, the fate of the incumbent at the polls may be tied to the realization of the shock.

To put this in more concrete terms, consider the correlation documented in Section 2 above between rainfall and support for the incumbent MP in India. It may well be that, in times of high rainfall, actions by the government have little effect on voters' incomes and consequently few bad incumbents are revealed, whereas when rainfall is low, the difference between good incumbents and bad incumbents become stark as good incumbents' effort is more likely to separate them from bad incumbents. For example, it may be that the quality of irrigation infrastructure set up by the government is revealed in low rainfall periods, resulting in greater dismissals of incumbents at the polls. Or following low rainfall, incumbents may have a bigger role to play in providing drought

relief or using government regulation to stabilize incomes, with the result that more bad incumbents are revealed. Similarly, the signal extraction problem faced by voters in U.S. gubernatorial elections may be quite different when oil prices are high, and a correlation between oil price shocks and voter behavior provides no *prima facie* case against voter rationality.

4. Conclusion

Understanding better what drives voter behavior in the developing world is increasingly of interest as developing countries continue to move toward multi-party democracies. A clearer understanding of voter behavior would also inform models of government behavior. Evidence of naive economic voting would support models of political business cycles,[7] for example.

The results presented here document a substantial effect of rainfall on support for incumbents in India. Intuitively, it may seem that such a correlation between an observable random economic shock and voter behavior must reflect some degree of bounded rationality on the part of voters. However, zero correlation does not follow from voter rationality alone but rather requires separability between the shock and the signal extraction problem faced by the voter.

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[7]See Nordhaus (1975) for a formalization of the theory of political business cycles (PBCs) that uses rule-of-thumb voting. Rational PBC models include Rogoff (1990). Block, Ferree, and Singh (2003) find evidence for PBCs in Africa.

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APPENDIX

Proof of Proposition 1. We begin with the office-holder's second period action, and first observe that in equilibrium, Good politicians take higher second-period actions than Bad politicians, and politicians of a given type choose the same action in every second period subgame.

Lemma 1. *In any PBE strategy profile* $(\omega^*, (\mu^*, \gamma^*))$*, we must have* $\forall\, r_1, r_2, y_1, k,\ \gamma^*(\omega^G, y_1, k, r_1, r_2) = \gamma^*(\omega^G) > \gamma^*(\omega^B, y_1, k, r_1, r_2) = \gamma^*(\omega^B)$.

Proof. Consider the action choice of the office-holder in the second period. In any subgame beginning in the second period, by sequential rationality we must have

$$\gamma^*(\omega, y_1, k, r_1, r_2) = \operatorname*{argmax}_{a \in A} u(a; \omega) \tag{23}$$

For any type, the solution to this problem in every subgame must be the same. Denote the solution as a function of type as $\gamma^*(\omega)$. By definition of an optimum, then, we must have

$$u(\gamma^*(\omega^G); \omega^G) \geq u(\gamma^*(\omega^B); \omega^G) \tag{24}$$

and

$$u(\gamma^*(\omega^B); \omega^B) \geq u(\gamma^*(\omega^G); \omega^B) \tag{25}$$

Adding these we get

$$u(\gamma^*(\omega^G); \omega^G) + u(\gamma^*(\omega^B); \omega^B) \geq u(\gamma^*(\omega^B); \omega^G) + u(\gamma^*(\omega^G); \omega^B) \tag{26}$$

By supermodularity of $u(a; \omega)$, then, we have our result. □

Given Lemma 1, henceforth we will refer to the politicians' second period strategy as a function only of their type. Denote the politicians' second-period value function $u(\gamma^*(\omega); \omega)$ by $U(\omega)$ and note that by (3) we have

$$U(\omega^G) \geq U(\omega^B) \tag{27}$$

Note that retained first-period incumbents and politicians new to the office of the same type take the same second period action, so all the voter cares about is the *type* of the second period office-holder, not his tenure.

Consider now the politicians' first period action choice. Suppose the voter adopts a cut-off rule such that he retains the first-period office-holder if and only if $y_1 \geq \hat{y}(r_1)$ for some function $\hat{y} : R \to Y$. We now show that in any equilibrium when the voter adopts such a cut-off rule, politicians' first-period actions are type-monotone.

Lemma 2. *In any PBE with,* $\forall\, r_1,\ \sigma^*(r_1, y_1) = 1 \Leftrightarrow y_1 \geq \hat{y}(r_1)$ *for some* $\hat{y} : R \to Y$*, we must have* $\forall\, r_1,\ \mu^*(\omega^G, r_1) > \mu^*(\omega^B, r_1)$.

Proof. Politicians' first-period strategies must solve

$$\mu^*(\omega, r_1) = \underset{a \in A}{\operatorname{argmax}} \{u(a; \omega) + [1 - F(\hat{y}(r_1)|a, r_1)]U(\omega)\} \tag{28}$$

Recall that by (2), $1 - F(\hat{y}(r_1)|a, r_1)$ is increasing in a. Note that $[1 - F(\hat{y}(r_1)|a, r_1)]U(\omega)$, as the product of an increasing function of a and an increasing function of ω, is weakly supermodular. As the sum of a weakly supermodular function and a supermodular function, the objective function of (28) is supermodular, and therefore we have that $\forall\, r_1,\ \mu^*(\omega^G, r_1) > \mu^*(\omega^B, r_1)$. □

All that is left to show is that, given these type monotone strategies of the politicians, the voter's best response is indeed to use a cut-off rule. Denote the voter's belief at the beginning of the second period that the first-period incumbent is Good as a function of r_1 and y_1 as $\beta : Y \times R \to [0, 1]$. By Bayes' Rule, in any PBE we must have

$$\beta(y_1, r_1) = \frac{\lambda f(y_1|\mu^*(\omega^G, r_1), r_1)}{\lambda f(y_1|\mu^*(\omega^G, r_1), r_1) + (1 - \lambda) f(y_1|\mu^*(\omega^B, r_1), r_1)} \tag{29}$$

Given our assumptions, it turns out that these equilibrium beliefs are strictly increasing in y.

Lemma 3. $\forall\, r_1 \in R$ *and* $\forall\, y, y' \in Y : y > y'$ *we have* $\beta(y, r_1) > \beta(y', r_1)$.

Proof. Let $y, y' \in Y$ be such that $y > y'$. We want to show

$$\frac{\lambda f(y|\mu^*(\omega^G, r_1), r_1)}{\lambda f(y|\mu^*(\omega^G, r_1), r_1) + (1-\lambda) f(y|\mu^*(\omega^B, r_1), r_1)} > \frac{\lambda f(y'|\mu^*(\omega^G, r_1), r_1)}{\lambda f(y'|\mu^*(\omega^G, r_1), r_1) + (1-\lambda) f(y'|\mu^*(\omega^B, r_1), r_1)} \tag{30}$$

After some algebra, (30) becomes

$$\frac{f(y|\mu^*(\omega^G, r_1), r_1)}{f(y|\mu^*(\omega^B, r_1), r_1)} > \frac{f(y'|\mu^*(\omega^G, r_1), r_1)}{f(y'|\mu^*(\omega^B, r_1), r_1)} \tag{31}$$

which by (2) (MLRP) is the case. □

Given politicians' equilibrium second-period strategies, the voter prefers to have a Good type in office in the second-period to having a Bad type since Good types take higher actions, and, given (2) (MLRP), higher actions lead to higher expected payoffs for the voter. Assuming we resolve ties in favor of retaining the incumbent, in any PBE we must have

$$\beta(y_1, r_1) \geq \lambda \Leftrightarrow \sigma^*(y_1, r_1) = 1 \tag{32}$$

The cutoff function $\hat{y}(r)$ is thus defined by

$$\frac{\lambda f(\hat{y}(r_1)|\mu^*(\omega^G, r_1), r_1)}{\lambda f(\hat{y}(r_1)|\mu^*(\omega^G, r_1), r_1) + (1-\lambda) f(\hat{y}(r_1)|\mu^*(\omega^B, r_1), r_1)} = \lambda \tag{33}$$

which after some algebra becomes

$$f(\hat{y}(r_1)|\mu^*(\omega^G, r_1), r_1) = f(\hat{y}(r_1)|\mu^*(\omega^B, r_1), r_1) \tag{34}$$

By the MLRP property this $\hat{y}(r_1)$ always exists and is unique. □

TABLE 1. Examples of Non-exactly Matched Candidate Names

Name of winner in 1977	**Name of candidate in 1980**
Purna A. Sangma	Puron A. Sangma
Radha Bai Ananda Rao	B.Radhabai Ananda Rao
Rajgopalarao Boddepalli	Rajagopalarao Boddepalli
C. K. Jafar Sharif	C.K. Jaffar Sharief
G. M. Banatwala	Banatwala Gulam Mehmood
Mudaganti Ram Gopal Reddy	M. Ramgopal Reddy
Rama Chandra Rath	Ramachandra Rath
Kamakshaiah Doddavarapu	D. Kamakshaiah
H. D. Tulsidas	H.D. Tulsidasappa

TABLE 2. Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Candidate's share of votes	0.406	0.13	0	0.795	1325
Candidate's margin of victory / defeat in votes	2794.621	103590.169	-527341	418925	1325
Candidate's margin of victory / defeat as fraction of all votes	0.007	0.195	-0.88	0.682	1325
Total number of votes cast in the Parliamentary Constituency	567235.677	154035.382	168717	1275773	1325
Turnout as a fraction of all eligible voters	0.579	0.101	0.272	0.857	1325
Whether the candidate won	0.514	0.5	0	1	1325
Log of crop yield (Rupees / hectare)	4.353	0.611	0.936	6.446	1325
R_{cy}, Fractional deviation from mean rainfall in PC in year of election	-0.006	0.206	-0.678	0.841	1325
R_{cy-1}, Fractional deviation from mean rainfall in PC in year before election	0.077	0.214	-0.461	1.003	1325

Notes: Summary statistics are calculated only over incumbent-elections for which crop yield data are available. Mean rainfall in each PC is calculated over 1950-1999.

TABLE 3. Effect of Rainfall on Crop Yields

	Dependent variable: log of crop yield			
	(1)	(2)	(3)	(4)
R_{cy}	0.446***	0.648***	0.209***	0.183***
	(0.087)	(0.10)	(0.054)	(0.042)
R^2_{cy}	-0.845***	-1.081***	-0.167	-0.0378
	(0.25)	(0.38)	(0.18)	(0.12)
R_{cy-1}	0.298***	0.239*	0.234***	0.170***
	(0.097)	(0.12)	(0.043)	(0.047)
R^2_{cy-1}	-0.992***	-0.730**	-0.476***	-0.0912
	(0.25)	(0.36)	(0.11)	(0.10)
Constant	4.419***	4.262***	4.367***	4.082***
	(0.021)	(0.052)	(0.0095)	(0.021)
Year fixed effects?	No	Yes	No	Yes
PC fixed effects?	No	No	Yes	Yes
Observations	1325	1325	1325	1325
R^2	0.03	0.12	0.03	0.44

Notes: R_{cy} is fractional deviation from mean rainfall in election year y in Parliamentary Constituency c. Crop yields are measured in rupees per hectare. Standard errors are in parentheses and allow for clustering within Parliamentary Constituencies. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

TABLE 4. Effect of Rainfall on Vote Margin

Dependent variable: Incumbent's fractional margin of victory / defeat				
	(1)	(2)	(3)	(4)
R_{cy}	0.0700***	0.0578**	0.0531*	0.0579*
	(0.025)	(0.027)	(0.030)	(0.033)
R^2_{cy}	-0.204***	-0.201***	-0.159*	-0.192**
	(0.076)	(0.077)	(0.091)	(0.093)
R_{cy-1}	0.101***	0.0352	0.0778**	-0.000110
	(0.030)	(0.035)	(0.034)	(0.039)
R^2_{cy-1}	-0.0431	-0.00376	0.00580	0.0132
	(0.075)	(0.073)	(0.095)	(0.090)
Constant	0.0104	-0.0220	0.00762	-0.0255
	(0.0073)	(0.022)	(0.0057)	(0.023)
Year fixed effects?	No	Yes	No	Yes
PC fixed effects?	No	No	Yes	Yes
Observations	1325	1325	1325	1325
R^2	0.02	0.07	0.01	0.07

Notes: R_{cy} is fractional deviation from mean rainfall in election year y in Parliamentary Constituency c. Standard errors are in parentheses and allow for clustering within Parliamentary Constituencies. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

TABLE 5. Effect of Rainfall on Vote Margin: Pre-Monsoon vs. Post-Monsoon

Dependent variable: Incumbent's fractional margin of victory / defeat				
	(1)	(2)	(3)	(4)
R_{cy}	0.0521	0.0934**	0.0743*	0.112**
	(0.043)	(0.047)	(0.045)	(0.050)
R^2_{cy}	-0.155	-0.177*	-0.0799	-0.142
	(0.094)	(0.099)	(0.11)	(0.11)
R_{cy-1}	0.0678**	0.00892	0.0107	-0.0411
	(0.034)	(0.041)	(0.038)	(0.044)
R^2_{cy-1}	-0.295***	-0.287***	-0.297***	-0.305***
	(0.097)	(0.10)	(0.10)	(0.11)
PostMonsoon	-0.00457	-0.0332	-0.0140	0.0166
	(0.013)	(0.027)	(0.014)	(0.029)
PostMonsoon*R_{cy}	0.0899	-0.0417	0.0415	-0.0776
	(0.065)	(0.070)	(0.080)	(0.084)
PostMonsoon*R^2_{cy}	0.0979	-0.0259	0.117	0.00990
	(0.18)	(0.19)	(0.22)	(0.22)
PostMonsoon*R_{cy-1}	0.0289	0.0626	0.205**	0.199**
	(0.080)	(0.080)	(0.095)	(0.095)
PostMonsoon*R^2_{cy-1}	0.432***	0.406**	0.316*	0.318*
	(0.16)	(0.16)	(0.18)	(0.18)
Constant	0.0140	-0.0139	0.00964	-0.0211
	(0.0094)	(0.023)	(0.0077)	(0.024)
Year fixed effects?	No	Yes	No	Yes
PC fixed effects?	No	No	Yes	Yes
Observations	1325	1325	1325	1325
R^2	0.03	0.08	0.04	0.09

Notes: R_{cy} is fractional deviation from mean rainfall in election year y. PostMonsoon is an indicator for whether the election took place in June or a later month. Standard errors are in parentheses and allow for clustering within Parliamentary Constituencies. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

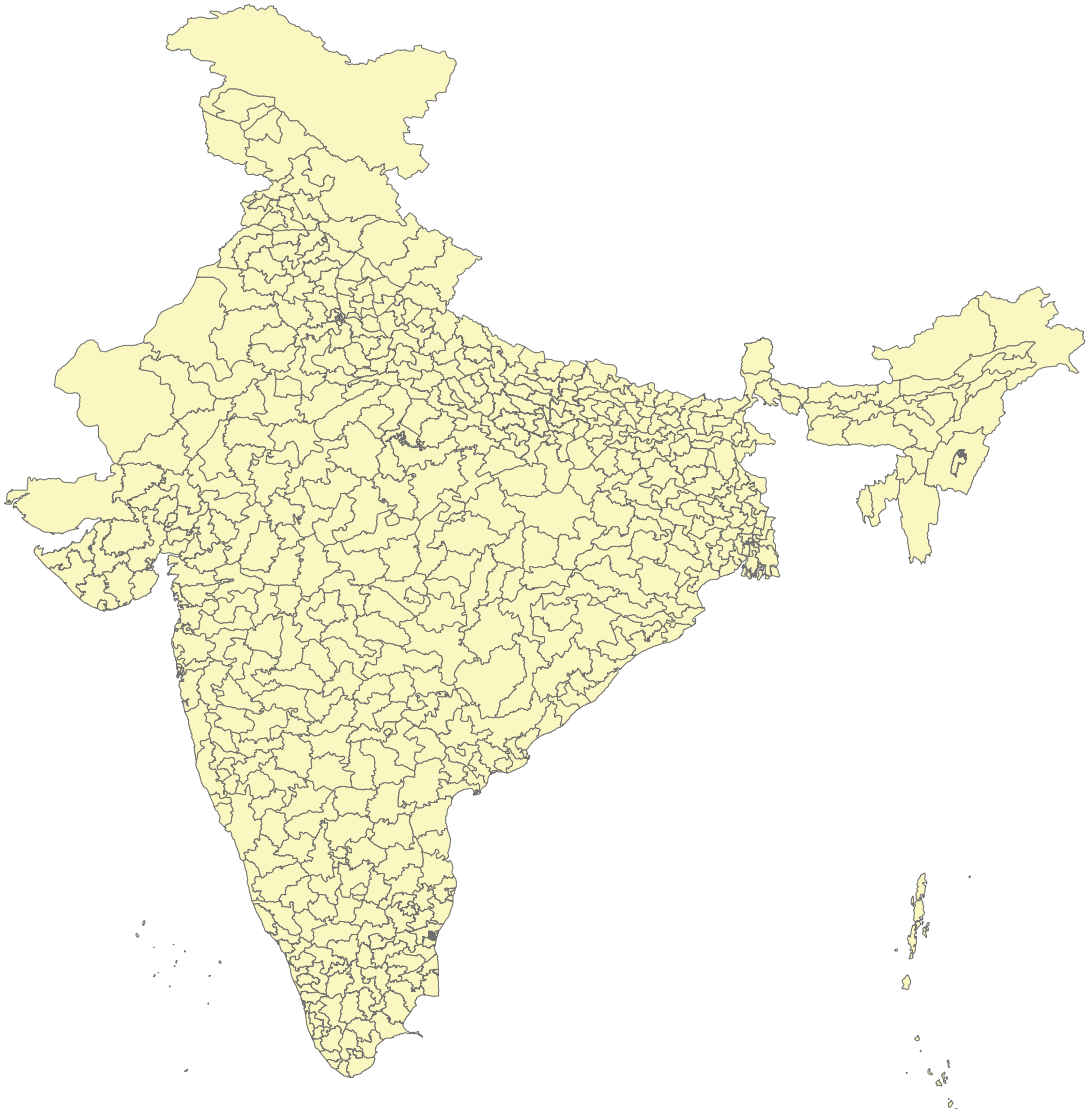

FIGURE 1. Indian Parliamentary Constituency boundaries.

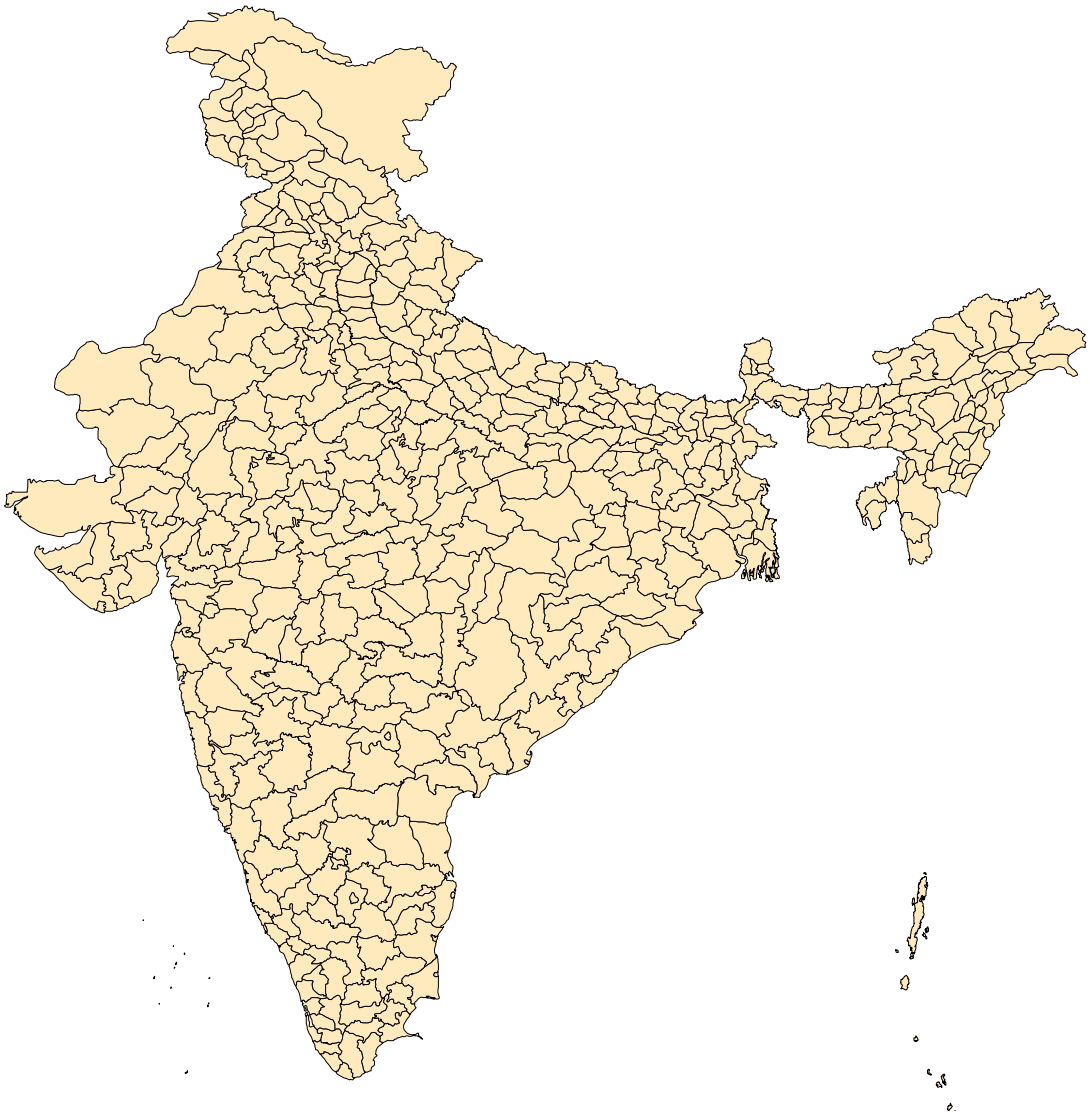

FIGURE 2. Indian district boundaries as of 1991.

FIGURE 3. Parliamentary Constituency boundaries are thick with names in bold; 1991 district boundaries are thin with names in italics.

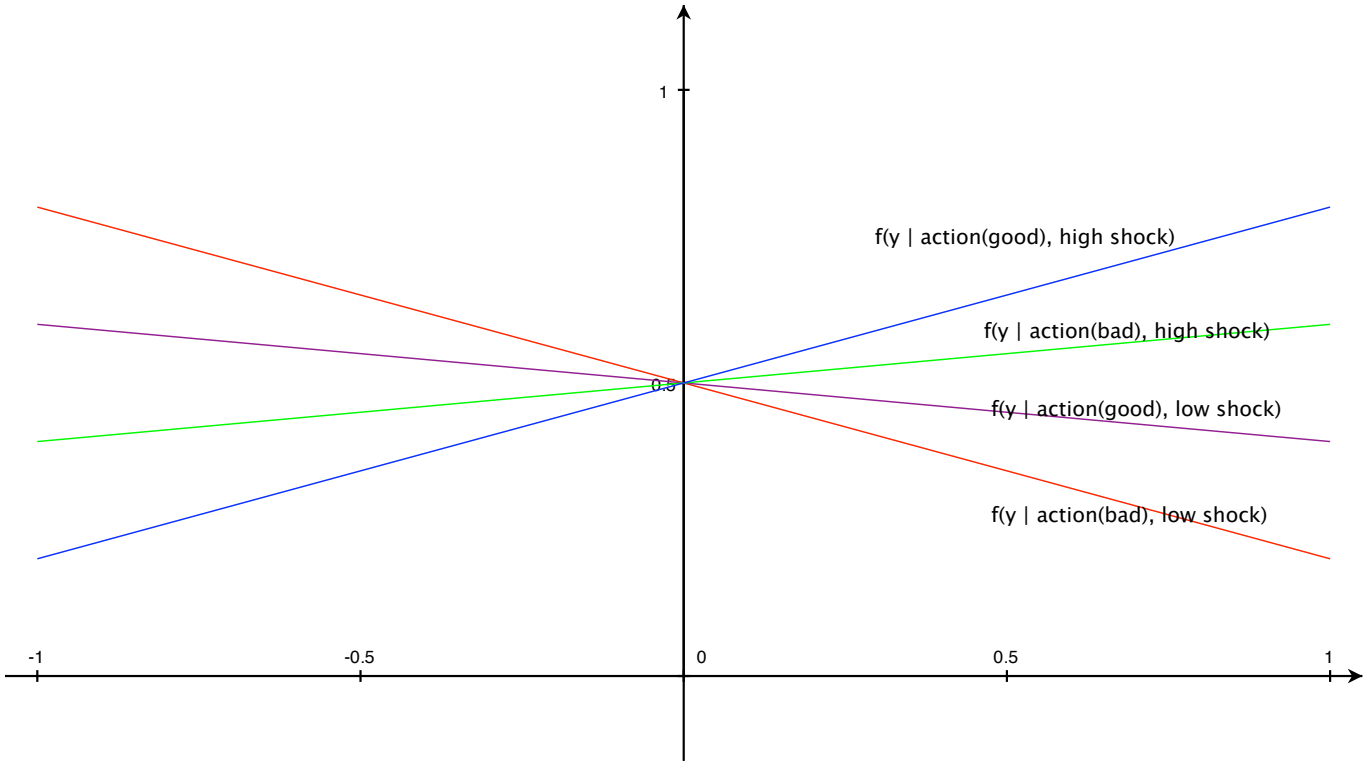

FIGURE 4. $f(y|a,r) = \theta(a,r)y + b$