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A preferential attachment model of campaign contributions in state legislative elections

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Abstract In state legislative elections some candidates attract contributions from many donors whereas other candidates have much smaller donor pools. Why? What are the origins of these disparities? This paper conceptualizes contributions as a type of attachment between the donor and the state legislative candidate. To model the formation of these attachments, this paper proposes a variant of the Barabasi-Albert preferential attachment model. The theoretical model is tested with data on over one million contributions to state legislative candidates in 2008. The paper also derives implications for macro-level inequities across candidates which are tested by comparing the observed inequities to simulations of the preferential attachment model. The results provide strong support for the hypotheses and show that the preferential attachment model provides a parsimonious representation of contributions to state legislative candidates.

Keywords State legislatures · Campaign finance · Polya process · Preferential attachment

1 Introduction

Numerous studies have documented the rising costs of state legislative campaigns, and total contributions amounted to over one billion dollars for the first time in the 2007–2008 election cycle (Barber 2010). Underlying the average costs of campaigns is a substantial amount of variation as most candidates have relatively little campaign money while a small proportion of candidates have much more. In 2008, the Gini coefficient for candidates' campaign money was 0.722.[1] In comparison, income inequality in the United States was 0.408, and in Zimbabwe was 0.501 (United Nations Development Programme 2010). Most studies

[1] As discussed below, the pattern of large inequities in found in nearly every state, although some of the inequity is due to between-state differences (e.g., candidates in California have more money than candidates in Wyoming).

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attribute this variation to a mixture of state, district, or candidate characteristics. These factors and their effects are typically held constant throughout the duration of a campaign. In this study, we take a different approach and consider whether donors influence the choices of subsequent donors as the campaign progresses. The model is a variant of the Barabasi-Albert (BA) preferential attachment model (Barabasi and Albert 1999) and posits that donors will bandwagon with candidates who have attracted many previous donors. As shown below, the model provides a parsimonious account of how large inequalities in candidates' donor pools arise from the sequential decisions of contributors.

The theoretical propositions from the preferential attachment model are tested using data on over one million contributions to candidates for state legislative offices in 2008, aggregate distributions from over 75 chambers, and more than 100,000 simulations. This is one of the most extensive data analyses of state legislative campaign finance to appear in a single study. The findings are consistent with the preferential attachment model, controlling for common factors such as population size, chamber size, legislative professionalism, incumbency, majority party status, open seat elections, committee positions, legislative leaders, opponent's campaign finance, and prior vote share. The preferential attachment model also provides a compelling account of the origins of the large inequalities in the number of contributors to candidates at the state level. The final section of the paper summarizes the main findings, discusses how they can recast existing findings in a new light, and suggests new directions for research on state legislative campaign finance.

2 Literature review

Existing studies find that there is a substantial amount of variation in campaign money in state legislative elections. This variation is attributed to a variety of state, chamber, district, and candidate characteristics. A predominant theoretical approach is the investment model of contributions. This model posits that there is a marketplace for policies, and donors contribute resources to candidates in exchange for the candidate's effort to pass (or insulate) certain policies (Denzau and Munger 1986). One implication of this model is that contributors will support incumbents (Moncrief 1992; Thompson et al. 1994; Hogan 2000) and candidates with compatible policy preferences (Box-Steffensmeier and Dow 1992; Cassie and Thompson 1998; Hogan et al. 2006).

Many studies examine other candidate-specific factors thought to be related to legislative influence. Candidates who have greater influence over the policy process are relatively more valuable for donors and thus should attract more contributions. Candidates who have held leadership positions in the chamber are expected to be particularly influential and more attractive to donors (Hogan 2000). Candidates can also have influence over specific policy domains, such as those with experience on particular committees (e.g., natural resources, finance, and insurance). These members have been found to attract contributions from corresponding economic interests (Box-Steffensmeier and Dow 1992; Dow et al. 1998).

Another line of research has examined campaign finance from a comparative state perspective. Chamber characteristics such as majority party control (Thompson et al. 1994; Hogan 2000) and legislative professionalism (Hogan 2000) are positively related to contributions. Parties with unified control of the executive and legislative branches receive larger contributions (Engstrom and Ewell 2010), as do candidates in more populous districts (Gierzynski and Breaux 1991; Hogan and Hamm 1998), in states with fewer campaign finance regulations (Hogan and Hamm 1998), and without term limits (Apollonio and La

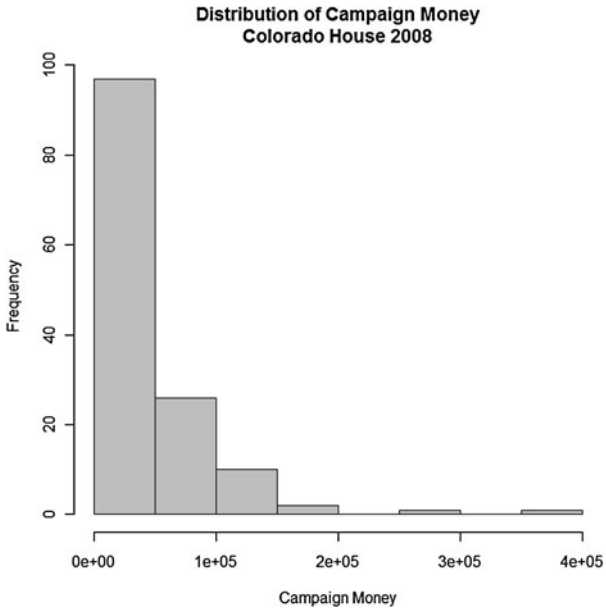

Fig. 1 Candidates for the Colorado House of representatives in 2008

Raja 2006). Campaign finance laws can also impact candidate competition for state legislative offices (Hamm and Hogan 2008; Malhotra 2008).

Existing studies demonstrate the relationship between candidate, chamber, and state characteristics and state legislative campaign finance. However, the distribution of campaign money reveals an unexpected pattern as a small proportion of candidates bring in huge revenues. Figure 1 shows a histogram of campaign money for candidates to the Colorado House in 2008. This is not unique to the Colorado House, as the same pattern occurs across states and chambers.[1]

Does this distribution simply reflect the logic of the political marketplace? Are some candidates so much more influential than others that this pattern is a simple reflection of skewed legislative influence? This seems unlikely, as previous studies examine categorical indicators of influence (e.g., committee seats or members of the majority party) which would suggest that candidates cluster together to create a multimodal distribution. While marketplace arguments are important for our understanding of contributions, they do not appear to explain observed disparities in candidate's campaign revenues.

One aspect of campaign finance that warrants much closer examination is the timing of contributions, and whether donors influence the choices of other donors. The following section develops a variant of the preferential attachment model (Barabasi and Albert 1999) to examine campaign contributions to state legislative candidates. The model is shown to be consistent with both individual-level contribution data and the aggregate patterns shown in Fig. 1.

[1] Histograms for the other chambers are shown in the supporting information available online at http://v.web.umkc.edu/vonnahmeg/papers/puchSI_prefAtt.pdf. One notable exception to this pattern was Connecticut, where a system of publicly financed campaign spending was used statewide in 2008.

3 Theory

This study conceptualizes contributions as a type of attachment between the donor and candidate, as the donor transfers resources to the candidate. A key characteristic of this approach is that attachments are formed sequentially. Contributions are made at different points in the campaign such that early contributors could alter the decision calculus of later contributors. Why? Is there a logical justification for expecting donors to influence the decisions of subsequent donors? There are three mechanisms that suggest a link between the decisions of current and previous donors, and imply that donors will bandwagon with candidates that have many existing attachments.

The first mechanism extends the logic of marketplace arguments beyond static candidate characteristics. It is an *electoral mechanism* which anticipates that donors will improve a candidate's chance of being elected and thus attract additional donors. Donors who are intent on shaping policy must foremost find candidates who can win, since supporting a candidate who ultimately loses the election will not advance the donor's policy objectives (Jacobson 2009; Masket 2009). While donors seek candidates who can win, contributing to a candidate itself increases the candidate's chance of winning in two ways: deterring challengers and by helping the candidate win when challenged. Prior studies show that contributions deter challenger entry in congressional elections (Box-Steffensmeier 1996; Stone et al. 2004; Carson 2005; although Goodliffe 2001 does not find a deterrent effect). Deterrent effects have also been found in state legislative elections (Hogan 2001) suggesting that contributions are potentially an effective way to preempt challenges and thereby assure that the recipient will be elected.

If deterrence fails and a candidate is challenged, contributions also help to finance the campaign. Contributions assist campaigns by providing them resources to recruit professional staff, produce and broadcast campaign ads, host events, and contact voters through direct mail, phone banks, and canvassing (Erikson and Palfrey 1998; Goldstein and Freedman 2000; Stratmann 2009). Contributions thus indirectly help candidates by deterring opposition and directly help them by enabling greater campaign activity. For these reasons, candidates who have many existing donors are more likely to win the election, and thus more likely to attract additional donors, and even more likely to win the election, and so on.

Studies of congressional elections are somewhat less sanguine about the effectiveness of incumbent spending, as a high level of incumbent spending is often a result of vulnerability (e.g., Jacobson 2006). Even for incumbents, however, the association between spending and lower vote shares is likely due to external factors rather than an instance of campaign spending driving away supporters. Studies of state legislative elections similarly show a positive association between contributions and electoral success, particularly for challengers (Gierzynski and Breaux 1991; Breaux and Gierzynski 1991; Abbe and Herrnson 2003).

A second justification for the preferential attachment process is a *signaling mechanism*. Previous research argues that voters want to identify the best possible candidates, but lack complete information about the candidates. In lieu of having complete information about the candidates, voters rely (in part) on contributions as a costly signal of candidate quality (Prat 2002; Coate 2004). According to this argument, having many donors is a sign of a high quality candidate while having a meager donor pool indicates a low quality candidate (Prat 2002; Coate 2004). While the signaling mechanism has been applied to voters, the logic of the argument is not inherently limited to just the voting population and could readily be extended to include other donors. In this way, donors could use the decisions of previous donors as a guide for identifying the best candidates. As a larger donor pool sends a stronger signal of support, donors are likely to follow the decisions of previous donors (Masket 2009).

A third justification for the preferential attachment process is a *solicitation mechanism*. Contributions crucially provide resources to a campaign, part of which can be spent soliciting other donors (Jacobson 2009). Previous studies of campaign solicitations show that they have a significant effect on donors, finding that donors are much more likely to contribute to a campaign when asked (Brady et al. 1999; Grant and Rudolph 2002; Joe et al. 2008). Yet solicitation activities require an initial investment to host fundraisers, send out direct mail, develop an online presence, or organize phone banks. As contributions transfer resources to the campaign, they enable further solicitation of other prospective donors, which should bring in more resources enabling more solicitation, and so on (Wilcox 1988; Biersack et al. 1993). These arguments also suggest that early contributions should be especially valuable as they allow the campaign to establish itself and initiate the preferential attachment process (Wilcox 1988; Biersack et al. 1993; Jacobson 2009; Masket 2009). [2]

There are thus three mechanisms that imply the operation of a preferential attachment process in contributions to state legislative candidates.[3] The three mechanisms are not mutually exclusive, and empirically this paper focuses on testing the preferential attachment process itself rather than trying to isolate the specific underlying mechanism(s), a point that is further discussed in the conclusion. As applied to contributions, the preferential attachment process in this paper asserts that the probability that a new donor (d) contributes to a candidate (c) is

$$\text{Prob}(d, c) = \frac{n_c}{\sum_C n_c} \tag{1}$$

where the numerator is the number of existing attachments for candidate c and the denominator is the sum of the existing attachments over all of the candidates.[4] Simply put, the probability that a new donor contributes to the candidate is equal to the candidate's share of the existing donor pool. If a candidate has 2 % of the existing donor pool, there is a 2 % chance that a donor will contribute to the candidate. As the candidate's share of the existing donor pool changes so does her ability to attract subsequent donors.[5] The model leads to the following hypothesis.

H1: A candidate's share of the existing donor pool affects her probability of gaining additional donors. As the candidate's share of the existing donor pool increases, she is more likely to attract future donors.

If the first hypothesis is correct, then the model further implies that a "rich-get-richer" process unfolds over time. A candidate with many donors is disproportionately likely to add

[2]For example, EMILY's List is an organization that supports female candidates and particularly assists with raising early money (EMILY is an acronym for "early money is like yeast"—it raises the dough).

[3]A counter-argument is that contributions might be reinforcing to a point, but once a candidate has a sufficient number of donors, then subsequent donors might direct their resources towards other candidates. This raises the possibility that prior contributions might be unrelated or possibly negatively related to later contributions.

[4]The denominator includes all candidates to the chamber rather than a particular district, as most contributions come from beyond the district's borders. This is not unanticipated as previous research finds that contributions to Congressional candidates are a form of monetary surrogacy in which a person who supports a candidate but lives outside her district contributes to the campaign as the voter cannot cast a ballot for the candidate (Gimpel et al. 2008). We found a similar pattern in the states by geocoding 250 randomly chosen donors from each chamber in 2008. We found that a clear majority of contributions came from out-of-district sources (74.1 % for lower chambers and 66.8 % for upper chambers—which have larger districts).

[5]The online supporting information includes an extensive discussion of the relationship between contribution amounts and the number of donors.

future donors, which would magnify her advantage and make her even more likely to add subsequent donors, thereby widening her advantage even further, and so on (Barabasi and Albert 1999; Newman 2010). This suggests that the preferential attachment model could also describe the origins of large disparities in contributions since a candidate could amass larger and larger leads as the campaign unfolds over time.[6]

According to Eq. (1), the probability that a donor contributes to a candidate is equal to the candidate's share of the existing donor pool. If we consider a candidate (A) who is one candidate among Z other candidates, then we can determine the probability distribution that candidate A has x donors of n total donors. If $1 \leq i_1 < i_2 < i_3 < \cdots < i_x \leq n$ are the indices of contributions to A, then the probability of a particular series of contributions in which A receives x of n donors is:

$$\frac{Z_0}{\tau_0} \times \frac{Z_0+1}{\tau_1} \times \frac{Z_0+2}{\tau_2} \times \cdots \times \frac{Z_0+(i_1-2)}{\tau_{i_1-2}} \times \frac{A_0}{\tau_{i_1-1}} \times \frac{Z_0+(i_1-1)}{\tau_{i_1}} \times \cdots$$
$$\times \frac{Z_0+(i_2-3)}{\tau_{i_2-2}} \times \frac{A_0+1}{\tau_{i_2-1}} \times \frac{Z_0+(i_2-2)}{\tau_{i_2}} \times \cdots \times \frac{A_0+(x-1)}{\tau_{i_x-1}} \times \cdots$$
$$\times \frac{Z_0+(n-x-1)}{\tau_{n-1}},$$

where A_0 is the number of initial donors to candidate A, Z_0 is the number of initial donors to the Z other candidates, and τ_i is the total number of donors (i.e., $Z_i + A_i$) up to that time (Mahmoud 2009). There are $\binom{n}{x}$ sequences in which A has x of n donors so the probability is:

$$\text{Prob}(X = x) = \binom{n}{x} \frac{(A_0)_x (Z_0)_{n-x}}{(A_0 + Z_0)_n},$$

where $(k)_n$ is the Pochhammer symbol:

$$(k)_n = k(k+1)(k+2)\cdots(k+n-1).$$

This is the Polya-Eggenberger distribution (Mahmoud 2009). The Polya-Eggenberger distribution is motivated by the Polya urn scheme (Johnson et al. 2005; Mahmoud 2009). The Polya urn is posited initially to contain a certain number of white balls (w) and a certain number of red balls (r). A ball is drawn from the urn and then replaced with itself and another ball of the same color (i.e., the process is contagious). This process is repeated n times. In this example the Polya-Eggenberger distribution provides the probability that there are x red balls in the urn following n draws.

The Polya urn scheme is analogous to the model of contributions. We could consider a Polya urn in which each red ball represents a contribution to a particular candidate. If a donor draws a red ball, then she puts that ball back into the urn along with another red ball representing her contribution. A candidate who received 100 contributions of 1000 total donors would thus have 100 balls in an urn of 1000 and there would be a 1/10 chance that the next donor would draw a red ball. As each donor chooses a candidate in sequence, they alter the candidate's share of the total number of donors (i.e., number of balls in the urn). In the case of more than two candidates and more donors than candidates the probabilities will be decreasing, such that the probability that a candidate has x donors is declining for higher values of x (i.e., the distribution is right-skewed).[7] This leads to the second hypothesis.

[6] One feature of the model is that it shows how a system that is initially very egalitarian with identical donors and candidates can produce highly inegalitarian outcomes.

[7] Additional details of the Polya-Eggenberger distribution are included in the online supporting information.

H2: There are disparities in the number of donors supporting candidates such that some candidates have many donors while most candidates will receive relatively few contributions.

4 Analyses

To test the first hypothesis we analyze a large dataset on contributions to state legislative candidates in 2008 from the National Institute for Money in State Politics. We analyze data on over one million donors to over 5000 candidates in 78 chambers in 40 states.[8] The states vary widely on key characteristics such as campaign finance regulations, population size, legislative professionalization, term limits, party competition, population diversity, and region. These data were used to construct observations for donor-candidate dyads. The dependent variable used to test the first hypothesis is an indicator for whether the donor formed an attachment with the candidate (1 if the donor contributed to the candidate, 0 if not).

The main independent variable is the candidate's share of all previous donors at the time of the contribution. Since the data are time resolved, we are able to determine the date of a donor's contribution, how many donors had made contributions prior to that date, and each candidate's share of the existing attachments.[9] We also included control variables for incumbency, majority party members, candidates for open seats, legislative leaders, members of major committees, their opponent's share of the existing donors, and the party's previous vote share in that district.[10]

Conditional logit estimates were obtained for each state and chamber separately so as to hold state and chamber factors constant, such as campaign finance regulations, legislative professionalization, and term limits, among others. The conditional logit model can be used to examine categorical outcome variables, similar to the multinomial logit model, especially when there are a large number of possible outcomes such as the choice between candidates. The conditional logit model departs from the multinomial logit model in that an individual's choice depends on the characteristics of the choices themselves rather than on characteristics of the individual making the choice (Long 1997).[11] The model can thus be used to test the first hypothesis as to whether a candidate's share of the existing donor pools affects the likelihood that a donor will choose to contribute to the candidate. Estimates for the lower chambers are shown in Table 1 and estimates for upper chambers are shown in Table 2. The coefficients reported in Tables 1 and 2 are for the candidate's share of the previous donors. Due to the very large number of estimates, full tables including the control variables are available in the supporting information.

The candidate's share of the previous donors has a strong and positive relationship with the formation of attachments as hypothesized. In every chamber, the coefficient is positive and statistically significant at conventional levels. The model also suggests that the relationship will be strong. To assess the strength of the relationship we examined the predicted

[8] Michigan and Minnesota held elections for their lower chambers in 2008, but not their upper chambers.

[9] In the event that the same donor gave to the same candidate more than once, only the date of the first contribution is recorded. We also excluded self-contributions from the analysis.

[10] If the party ran no candidate in 2002, this value was set at 10 %, which makes a very conservative allowance for a core group of party supporters even if the party ran no candidate in the previous election.

[11] For example, the conditional logit model has been used to analyze the choice between different modes of transportation (e.g., car, bus, train, etc.) where the choice might depend on characteristics of the mode of transportation, such as cost (Long 1997).

Table 1 Conditional logit estimates for lower chambers. Dependent variable is the formation of an attachment in the donor-candidate dyad, independent variable is the candidate's share of the previous donors. Full results including control variables are available in the supporting information. *** denotes $p < 0.001$

State	Coef. (S.E.)	Corr.	Donors	Dyads	State	Coef. (S.E.)	Corr.	Donors	Dyads
AK	10.283*** (0.229)	0.843	9977	848045	MO	31.422*** (0.505)	0.724	24360	2484720
AR	25.818*** (0.371)	0.676	10184	1160976	MT	21.946*** (0.560)	0.810	1709	158937
AZ	20.560*** (0.310)	0.807	6812	626704	NC	33.169*** (0.531)	0.820	11542	727146
CA	36.059*** (0.366)	0.694	44913	4536213	ND	48.810*** (3.184)	0.749	584	47304
CO	39.475*** (0.399)	0.729	24990	2424030	NM	22.192*** (0.416)	0.729	7882	599032
CT	20.066*** (0.437)	0.748	17980	1690120	NV	17.255*** (0.393)	0.830	5966	542906
DE	30.081*** (0.600)	0.755	5036	352520	NY	43.640*** (0.519)	0.765	22437	1570590
FL	20.947*** (0.277)	0.732	57819	6822642	OH	45.953*** (0.379)	0.695	35267	3632501
GA	17.411*** (0.363)	0.719	11124	956664	OK	44.514*** (0.650)	0.692	13642	1255064
HI	34.525*** (0.649)	0.782	3805	331035	OR	23.753*** (0.611)	0.767	9290	947580
IA	37.738*** (0.542)	0.638	23667	2485035	PA	19.288*** (0.200)	0.850	25543	2324413
ID	27.927*** (0.772)	0.639	6274	614852	RI	6.494*** (0.173)	0.895	4860	442260
IL	47.400*** (0.722)	0.750	15571	1230109	SC	27.620*** (0.552)	0.735	12273	994113
IN	35.493*** (0.552)	0.677	12612	1261200	TN	19.624*** (0.318)	0.674	11606	1253448
KS	35.648*** (0.651)	0.693	12989	1091076	TX	42.450*** (0.467)	0.583	39424	3824128
KY	18.038*** (0.349)	0.737	7416	778680	UT	40.648*** (0.855)	0.661	7155	758430
MA	28.703*** (0.263)	0.808	36082	3391708	WA	23.321*** (0.400)	0.729	30060	2885760
ME	24.721*** (0.738)	0.881	1010	63630	WI	30.236*** (0.301)	0.650	47714	5296254
MI	41.411*** (0.407)	0.585	34270	4112400	WV	20.598*** (0.339)	0.766	8874	931770
MN	67.039*** (1.288)	0.692	4533	621012	WY	16.112*** (0.409)	0.769	2436	236292

probabilities from the conditional logit model and the observed donor shares. The correlations are shown in columns 3 and 8 in Tables 1 and 2. The average is 0.737 for the lower chambers and 0.834 for the upper chambers. The relationship between prior donor shares and the predicted probability of receiving further contributions is positive and quite strong.

Table 2 Conditional logit estimates for upper chambers. Dependent variable is the formation of an attachment in the donor-candidate dyad, independent variable is the candidate's share of the previous donors. Full results including control variables are available in the supporting information. *** denotes $p < 0.001$

State	Coef. (S.E.)	Corr.	Donors	Dyads	State	Coef. (S.E.)	Corr.	Donors	Dyads
AK	13.516*** (0.499)	0.917	2586	36204	MT	5.972*** (0.339)	0.948	420	10920
AR	10.288*** (0.188)	0.824	4081	93863	NC	15.910*** (0.256)	0.857	11980	539100
AZ	16.582*** (0.351)	0.899	5265	247455	ND	16.015*** (1.148)	0.855	492	21648
CA	21.796*** (0.341)	0.796	24559	957801	NM	8.772*** (0.147)	0.808	9043	515451
CO	16.021*** (0.270)	0.852	11708	444904	NV	14.494*** (0.358)	0.900	2570	79670
CT	12.307*** (0.179)	0.762	22497	1259832	NY	39.202*** (0.384)	0.695	38465	2961805
DE	10.905*** (0.241)	0.871	3113	93390	OH	20.078*** (0.322)	0.824	13507	391703
FL	7.588*** (0.065)	0.954	25856	723968	OK	29.921*** (0.458)	0.734	8337	350154
GA	16.635*** (0.402)	0.758	7261	312223	OR	17.174*** (0.526)	0.809	2716	92344
HI	18.832*** (0.555)	0.877	2788	86428	PA	26.591*** (0.400)	0.795	16784	822416
IA	14.833*** (0.302)	0.789	9602	393682	RI	11.512*** (0.302)	0.862	3126	159426
ID	14.015*** (0.455)	0.778	3665	168590	SC	19.697*** (0.229)	0.763	17916	1128708
IL	15.656*** (0.284)	0.838	14796	843372	TN	18.370*** (0.261)	0.807	8926	357040
IN	25.913*** (0.664)	0.833	4917	177012	TX	5.912*** (0.121)	0.858	14978	479296
KS	14.410*** (0.314)	0.790	11267	619685	UT	15.324*** (0.428)	0.830	2961	100674
KY	11.332*** (0.196)	0.851	6387	255480	WA	9.780*** (0.177)	0.851	12866	450310
MA	19.574*** (0.193)	0.880	28512	1254528	WI	20.571*** (0.190)	0.770	24282	752742
ME	10.723*** (0.390)	0.860	1203	74586	WV	11.795*** (0.325)	0.826	3259	78216
MO	23.404*** (0.320)	0.850	11284	372372	WY	7.064*** (0.602)	0.929	587	12327

Overall these findings provide consistent support for the first hypothesis as there is evidence of a positive relationship in all 78 separate chambers.[12]

[12] At its logical extreme, the model leads to the expectation that the prior donor shares are fully determinative of future donors' choice probabilities, such that the correlation would be 1 and all of the other factors would be entirely inconsequential. While the correlations are high they are not equal to one. The supporting information provides confidence bounds on the relationship between the predicted probabilities and prior donor shares.

In order to evaluate the second hypothesis we conducted additional tests to determine if the model is consistent with the observed inequities. We have already seen indicators of large inequities in contributions in Fig. 1, and the observed donor pools are highly unequal, but is the preferential attachment model consistent with this distribution? To test the second hypothesis we simulated the preferential attachment model to obtain the theoretical contribution patterns.

To simulate the model, every candidate and every donor were assumed to be identical. At the beginning of the simulation, every candidate was assigned one donor. The reason for this is that a candidate with zero donors would technically have a zero probability of attracting future donors. Furthermore, any candidate who does not have even a single contributor is unlikely to enter the race. According to this model, if a chamber had 129 candidates, then the first 129 donors were allocated to each candidate. Once each candidate was assigned one donor the 130th donor chose a candidate at random, as every candidate had exactly $1/129$ donors. After the 130th donor chose a candidate, the probabilities were recalculated (i.e., one candidate has $2/130$ donors and the rest have $1/130$) and the 131st donor chose a candidate. The probabilities were again recalculated and this process was repeated for all remaining donors. After all donors had chosen a candidate, we tabulated the number of donors for each candidate to produce a frequency distribution. This is a very parsimonious model and it involves no assumptions about certain candidates being more or less effective fundraisers than others. The model simply assumes that each donor (after the first 129) chooses a candidate at random with a probability equal to the proportion of previous donors who contributed to the candidate. The donors make their choices based solely on the candidates' shares of the existing donors, so these simulations allow us to assess the inequalities that result strictly from the preferential attachment model. This process was repeated 1000 times for each chamber.

To illustrate the results, the simulated and actual frequency distributions for the Georgia House are shown in Fig. 2. The simulation results are shown as light gray lines ($n = 1000$) and the observed contribution frequencies are shown as the bold line. This provides strong support for the second hypothesis as every simulation (gray lines) produced a right-skewed distribution and the overall pattern is very consistent with the observed contribution frequencies. Similar graphs for the remaining states and chambers are included in the supporting information.

While the simulation results are visually similar to the observed distributions we also calculated Gini coefficients as a measure of inequity for both the observed chambers and the simulations. The Gini coefficient ranges from 0 to 1 with higher values indicating greater inequality. For lower chambers, the median simulated Gini (0.494) was very close to the median observed Gini (0.495). The result for upper chambers was similar, as the median simulated Gini (0.489) was very close to the median observed Gini (0.521). Not only do the observed Gini coefficients reflect a high level of inequality, but they also correspond closely to the inequities implied by the PA model.[13]

To add an additional and much more stringent test of the second hypothesis, we compared the preferential attachment model to a simulation based on traditional static variables (i.e., non-preferential attachment model). One approach to setting up the non-PA model would be to use static candidate factors, such as incumbency, open seat elections, majority party status, prior vote share, having a position on a major committee, and having a leadership

[13]Connecticut was a notable exception to this rule. Connecticut had a substantially lower Gini than the other chambers (0.181 in the House and 0.205 in the Senate), suggesting that the system of public financing that was in place in 2008 substantially reduced inequities in the number of contributions to candidates.

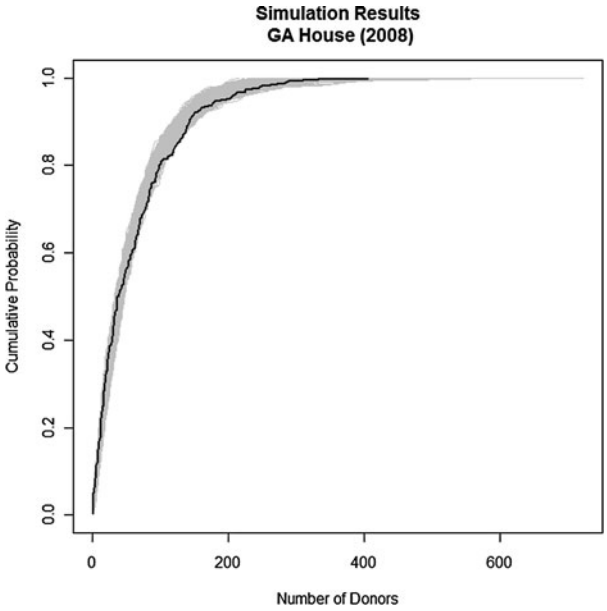

Fig. 2 Cumulative distribution for the Georgia House of representatives. Simulation results of the number of donors for the Georgia House are shown as *light gray lines*. The observed cumulative distribution is shown as a *dark bold line*

Table 3 This table shows the actual Gini coefficient, the Gini coefficient from the preferential attachment model, and the Gini coefficient from the alternative (non-preferential attachment) simulation. The values in parentheses are the differences from the actual Gini coefficient

Chamber	Observed	Preferential attachment	Non-preferential attachment
Lower	0.495	0.494 (0.001)	0.550 (0.055)
Upper	0.521	0.489 (0.032)	0.429 (0.092)

role in the chamber, to calculate the predicted probability of contributing to different candidates. In addition to this, we strengthened the non-PA model in two ways in order to set a very high bar for the preferential attachment model. First, we estimate the effects of these variables separately for each chamber so the non-PA simulation incorporates hundreds of estimated parameters. We do this so as to not constrain the effects of the static factors to be the same across chambers (e.g., effect of majority party status might vary by chamber). Second, we estimated the parameters using the 2008 data themselves, so this non-PA simulation is derived from the same data it is trying to match. This assures that the non-PA model will at least minimally match the data, even if by chance alone. Using these parameter estimates (also from a conditional logit model), we obtained predicted probabilities that the donors would contribute to each of the candidates and used these probabilities to simulate contribution patterns.

While this non-preferential attachment model is far more complex than its much simpler rival and the predicted probabilities are based on hundreds of coefficients estimated from the 2008 data itself, the preferential attachment model nevertheless outperformed it's vastly more complicated counterpart. Table 3 shows the Gini coefficients for the observed and simulated chambers. The median Gini coefficient for the lower chambers in the non-PA model was 0.550, and for upper chambers was 0.429. As shown in the table, the preferential attachment model yielded results that were closer to the actual inequalities. We also

calculated Kullback-Leibler divergences and found that they were smaller for the preferential attachment model.[14] For lower chambers the average divergence for the PA model was 0.049 compared to 0.532 for the non-PA model. For upper chambers, the divergence for the PA model was 0.055 compared to 0.218 for the non-PA model. We also compared all of the divergences across all of the simulations and found that the PA divergences were smaller in 94.5 % of state house simulations and 93.3 % of state senate simulations. The close correspondence to the Gini coefficients and lesser divergences indicate that the PA model provided a better fit for the observed data across both upper and lower chambers.

5 Summary

This paper offers a parsimonious representation of contributions and inequalities in contributions to state legislative candidates. The argument first conceptualizes contributions as a type of attachment between donors and candidates. To analyze the sequential formation of attachments throughout a campaign this paper discusses three mechanisms suggesting that donors will bandwagon with candidates who already have many donors. Empirically, these arguments suggest a preferential attachment model and this paper analyzes two hypotheses from this model. The first is that the probability of a donor contributing to a particular candidate increases with the candidate's share of the existing donors. Second, this creates a rich-get-richer effect which produces inequalities in the number of donors to the candidates. These hypotheses are examined using data on over one million contributions to candidates in 78 state legislative chambers in 2008. Both hypotheses are notably consistent with the empirical results.

These results have the potential to recast many existing findings about state legislative campaign finance in a new light. Most studies examine static state, chamber, and candidate characteristics, and find that certain factors are related to a candidate's ability to attract contributions. This study shows that a dynamic process is at work. How do existing findings regarding static factors fit into this dynamic process? The preferential attachment model suggests that initial advantages expand over time. What the model does not explain is how those advantages first arise at the outset of a campaign. According to the model these initial differences are entirely random. We anticipate that static factors such as incumbency, open seats, committee positions, majority party status, legislative leadership positions, and district vote shares primarily explain the origins of these initial inequalities. After the very first stages of the campaign, the preferential attachment model describes how those initial advantages magnify over time.

As a preliminary test of this possibility, we used the static factors to predict candidates' donor shares among the early donors (first 20 %) and late donors (last 20 %). If static factors largely explain the origins of the inequities at the outset of the campaign then those variables should provide a better model fit for the early donors. Both a regression model of candidates' donor shares and a count model for the number of donors show that there are better model fits for the early donors. These results provide initial support for the argument that static candidate characteristics provide a source for initial differences which then expand over time through preferential attachment.[15]

[14] Kullback-Leibler divergence is a measure of the difference between two distributions. It represents the information lost by using one distribution to approximate the other, such that a smaller value represents a closer fit between the two distributions (Fox 2008).

[15] Details of these analyses are included in the supporting information.

Having found empirical support for the preferential attachment model and its relationship to the large inequalities in campaign contributions there are at least two primary directions for future research. One is to examine the inequalities in campaign money and determine whether there are any consequences for the legislatures. Are top fundraisers more influential inside the chamber? Are they more likely to show static or progressive ambition? The other is to examine the specific mechanisms underlying the preferential attachment process. Is the overall empirical pattern driven by the electoral, signaling, or solicitation mechanisms? A combination of all three? Do the underlying mechanisms vary from state to state or election to election?

There are a number of ways that this type of study could be conducted. The electoral mechanism is consistent with either a deterrent or a campaign resource effect. The time-resolved nature of the contribution data could be very useful in adjudicating between these two processes. For example, donors might bandwagon with an incumbent early on to deter challengers, but might abandon the incumbent once a quality challenger emerges, or do the opposite if donors focus instead on assisting candidates in competitive races. The signaling mechanism could be tested with surveys of donors to assess their impressions of candidates at different points in the campaign. Future research could also potentially compare incumbents and challengers as a way of evaluating the signaling mechanism. If challengers are generally less well known than incumbents, contributors to challengers might be especially responsive to the challenger's prior donor share. This might be less true of incumbents as donors might have more direct knowledge of them and thus be less reliant on signals from other donors. The type of donor might also matter as PACs might have more information about candidates, and thus be less reliant than individuals on signals from other donors.

The solicitation mechanism could examine campaign expenditures, and whether certain campaigns devote larger shares of their resources to further solicitation of donors, and thus prior donors would be especially good predictors of future contributors to those candidates. Comparisons could also be made across elections as a way of testing the solicitation mechanism against the other two. Elections that have many more candidates on the ballot (e.g., president, senate or governor) would be characterized by a higher level of general donor solicitation such that state legislative candidates would be competing with larger campaigns in their pursuit of donors. This might limit the effectiveness of their campaign solicitations such that we might expect a weaker preferential attachment pattern in those elections. Identifying the underlying mechanism would not just be of great scientific interest but could also affect candidates' financial strategies as well as campaign finance policies that seek to level the playing field across candidates.

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References

Abbe, O. G., & Herrnson, P. S. (2003). Campaign professionalism in state legislative elections. *State Politics & Policy Quarterly*, *3*(3), 223–245.

Apollonio, D. E., & La Raja, R. J. (2006). Term limits, campaign contributions, and the distribution of power in state legislatures. *Legislative Studies Quarterly*, *31*(2), 259–281.

Barber, D. R. (2010). An overview of state campaigns, 2007–2008. National Institute on Money in State Politics. http://www.followthemoney.org/press/ReportView.phtml?r=420&em=87. Accessed 2/24/2011.

Barabasi, A. L., & Albert, R. (1999). Emergence of scaling in random networks. *Science*, *286*, 509–512.

Biersack, R., Herrnson, P. S., & Wilcox, C. (1993). Seeds for success: early money in congressional elections. *Legislative Studies Quarterly*, *18*(4), 535–551.
Breaux, D. A., & Gierzynski, A. (1991). "It's money that matters": campaign expenditures and state legislative primaries. *Legislative Studies Quarterly*, *16*(3), 429–443.
Box-Steffensmeier, J. M. (1996). A dynamic analysis of the role of war chests in campaign strategy. *American Journal of Political Science*, *40*(2), 352–371.
Box-Steffensmeier, J. M., & Dow, J. K. (1992). Campaign contributions in an unregulated setting: an analysis of the 1984 and 1986 California Assembly elections. *The Western Political Quarterly*, *45*(3), 609–628.
Brady, H. E., Verba, S., & Schlozman, K. L. (1999). Prospecting for participants: rational expectations and the recruitment of political activists. *American Political Science Review*, *93*(1), 153–168.
Carson, J. L. (2005). Strategy, selection, and candidate competition in U.S. House and Senate elections. *The Journal of Politics*, *67*(1), 1–28.
Cassie, W., & Thompson, J. A. (1998). Patterns of PAC contributions to state legislative candidates. In J. A. Thompson & G. F. Moncrief (Eds.), *Campaign finance in state legislative elections*. Washington: Congressional Quarterly Press.
Coate, S. (2004). Pareto-improving campaign finance policy. *American Economic Review*, *94*(3), 628–655.
Denzau, A. T., & Munger, M. C. (1986). Legislators and interest groups: how unorganized interests get represented. *American Political Science Review*, *80*, 89–106.
Dow, J. K., Endersby, J. W., & Menifield, C. E. (1998). The industrial structure of the California Assembly: committee assignments, economic interests, and campaign contributions. *Public Choice*, *94*(1–2), 67–83.
Engstrom, E. J., & Ewell, W. (2010). The impact of unified party government on campaign contributions. *Legislative Studies Quarterly*, *35*(4), 543–569.
Erikson, R. S., & Palfrey, T. R. (1998). Campaign spending and incumbency: an alternative simultaneous equations approach. *The Journal of Politics*, *60*(2), 355–373.
Fox, J. (2008). *Applied regression analysis and generalized linear models*. Thousand Oaks: Sage Publications.
Gierzynski, A., & Breaux, D. A. (1991). Money and votes in state legislative elections. *Legislative Studies Quarterly*, *16*(2), 203–217.
Gimpel, J. G., Lee, F. E., & Pearson-Merkowitz, S. (2008). The check is in the mail: interdistrict funding flows in congressional elections. *American Journal of Political Science*, *52*(2), 373–394.
Goldstein, K., & Freedman, P. (2000). New evidence for new arguments: money and advertising in the 1996 Senate elections. *The Journal of Politics*, *62*(4), 1087–1108.
Goodliffe, J. (2001). The effect of war chests on challenger entry in U.S. House elections. *American Journal of Political Science*, *45*(4), 830–844.
Grant, J. T., & Rudolph, T. J. (2002). To give or not to give: modeling individuals' contribution decisions. *Political Behavior*, *24*(1), 31–54.
Hamm, K. E., & Hogan, R. E. (2008). Campaign finance laws and candidacy decisions in state legislative elections. *Political Research Quarterly*, *61*(3), 458–467.
Hogan, R. E. (2000). The costs of representation in state legislatures: explaining variations in campaign spending. *Social Science Quarterly*, *81*, 941–956.
Hogan, R. E. (2001). Campaign war chests and challenger emergence in state legislative elections. *Political Research Quarterly*, *54*(4), 815–830.
Hogan, R. E., & Hamm, K. E. (1998). Variations in district-level campaign spending in state legislatures. In J. A. Thompson & G. F. Moncrief (Eds.), *Campaign finance in state legislative elections*. Washington: Congressional Quarterly Press.
Hogan, R. E., Hamm, K. E., & Wrzenski, R. L. (2006). *Factors affecting interest group contributions to candidates in state legislative elections*. Paper prepared for the 2006 Annual Meeting of the Midwest Political Science Association Meeting, April 20–23rd, Chicago, IL.
Jacobson, G. C. (2006). Campaign spending effects in U.S. Senate elections: evidence from the National Annenberg Election Survey. *Electoral Studies*, *25*(2), 195–226.
Jacobson, G. C. (2009). *Politics of congressional elections*. New York: Pearson.
Joe, W. Y., Malbin, M. J., Wilcox, C., Brusoe, P. W., & Pimlott, J. P. (2008). *Do small donors improve representation? Some answers from recent gubernatorial and state legislative elections*. Paper presented at the 2008 Annual Meeting of the American Political Science Association, Boston, MA, August 28–31.
Johnson, N. L., Kemp, A. W., & Kotz, S. (2005). *Univariate discrete distributions*. Hoboken: Wiley.
Long, J. S. (1997). *Regression models for categorical and limited dependent variables*. Thousand Oaks: Sage Publications.
Mahmoud, H. M. (2009). *Polya urn models*. Boca Raton: Chapman & Hall/CRC.
Malhotra, N. (2008). The impact of public financing on electoral competition: evidence from Arizona and Maine. *State Politics & Policy Quarterly*, *8*(3), 263–281.

Masket, S. E. (2009). *No middle ground: how informal party organizations control nominations and polarize legislatures*. Ann Arbor: University of Michigan Press.

Moncrief, G. F. (1992). The increase in campaign expenditures in state legislative elections: a comparison of four northwestern states. *The Western Political Quarterly*, *45*(2), 549–558.

Newman, M. E. J. (2010). *Networks: an introduction*. Oxford: Oxford University Press.

Prat, A. (2002). Campaign spending with office-seeking politicians, rational voters, and multiple lobbies. *Journal of Economic Theory*, *103*(1), 162–189.

Stone, W. J., Maisel, L. S., & Maestas, C. D. (2004). Quality counts: extending the strategic politician model of incumbent deterrence. *American Journal of Political Science*, *48*(3), 479–495.

Stratmann, T. (2009). How prices matter in politics: the returns to campaign advertising. *Public Choice*, *140*, 357–377.

Thompson, J. A., Cassie, W., & Jewell, M. E. (1994). A sacred cow or just a lot of bull? Party and PAC money in state legislative elections. *Political Research Quarterly*, *47*(1), 223–237.

United Nations Development Programme (2010). *Human development report 2010*. New York: Palgrave Macmillan. Retrieved from: http://hdr.undp.org/en/media/HDR_2010_EN_Complete_reprint.pdf.

Wilcox, C. (1988). I owe it all to me: candidates' investments in their own campaigns. *American Political Research*, *16*(3), 266–279.