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What is needed to change the result of an election: an analysis with agent-based models

Quanto é preciso para mudar o resultado de uma eleição: uma análise com modelos baseados em agentes

Diogo Signor[1]
Elder Mauricio Silva[2]
Ronivaldo Steingraber[3]

Abstract: How does the result of elections in non-ideal situations behave? When, e.g., there is vote buying strategy occurring into the election process. This article investigates this point using a virtual election through an agent-based model environment. Building

1 Mestre em Economia pelo Programa de Pós-Graduação em Economia da Universidade Federal de Santa Catarina (2015) e doutorando em economia desde 2015 pela mesma instituição. Possui Curso avançado de Avaliação de Políticas Públicas. Fundacão Itau Social, ITAU SOCIAL, Brasil.

2 Mestre em Economia (Conceito CAPES 5). Universidade Federal de Santa Catarina, UFSC. Doutorado em andamento em Economia (Conceito CAPES 5). Universidade Federal de Santa Catarina, UFSC, Brasil. Possui curso avançado em Individual and Agent-based Modelling, T.U. Dresden, Germany

3 Mestre em Desenvolvimento Econômico pela Universidade Federal do Paraná(2002) e doutorado em Desenvolvimento Econômico pela Universidade Federal do Paraná(2009). Atualmente é 40 DE da Universidade Federal de Santa Catarina.

a tool for policymakers to test possible scenarios in a virtual environment before to apply in real world. In our model candidates have a limited campaign period to convince the residents to vote for them. They visit the houses of the residents to explain their campaign promises and sometimes offer a bribe. We have found that the existence of bribes can change the election results only if some other factors are also present. The result of an election can be modified when the values are given to voters as bribes are high, or the voters have no kind of memory. Also, the period of the electoral campaign can facilitate changes in the result, the bigger the period, easy to change an electoral result.

Keywords: vote; parliamentary mandate; buying votes.

Resumo: Como se comporta o resultado das eleições em situações não ideais? Quando, por exemplo, existe uma estratégia de compra de votos durante o processo de eleição. Este artigo investiga este ponto usando uma eleição virtual através de um modelo baseado em agente, pode servir como uma ferramenta para os formadores de política, apto a testar cenários possíveis em um ambiente virtual antes de aplicar na prática. Em nosso modelo os candidatos têm um período de campanha limitado para convencer os eleitores a votar neles. Os candidatos visitam as residências para explicar suas promessas de campanha, e às vezes oferecem um suborno. Como resultados vimos que a existência de subornos pode alterar os resultados das eleições, mas somente se outros fatores também estiverem presentes. O resultado de uma eleição pode ser modificado quando os valores ofertados aos eleitores como subornos são elevados, ou se os eleitores não

têm nenhum tipo de memória. Além disso, o período de campanha eleitoral pode facilitar mudanças no resultado, quanto maior o período, mais fácil de mudar um resultado eleitoral.

Palavras chave: voto; mandato parlamentar; compra de votos.

1 Introduction

Although in the theory of representative democracy elections are summed up in the contest between the candidates, fighting for votes of the voters, in practice it is not so simple. This interaction between the different actors involves considerable resources, as pointed by Speck (2003, p. 148). However, campaign money is not only used lawfully. Several studies have shown that there are illicit ways of persuading the voter to vote for a candidate, a practice commonly known as "buying votes" (e.g., Abramo, 2007, p. 8; Speck, 2003, p. 160; Brusco et al., 2004, p. 70; Gonzalez-Ocantos et al., 2012, p. 210). In Brusco et al. (2004, p. 66) the purchase of votes is defined as the offer of money or other consumer goods by political parties or candidates in exchange for the promise of their vote. This is what we also use here as the purchase of votes.

Several papers highlight the importance of financial resources for an electoral campaign (Cox, Thies, 2000, p. 40; Jacobson, 1985, p. 183; Green, Krasno, 1988, p. 900; and Speck, Mancuso, 2014, p. 34, among others). In this sense, studies show that the resources expended with electoral campaigns also depend on different factors, such as whether the candidate seeks re-election (Jacobson, 1985, p. 55; Jacobson, 1990, p. 334), or the sex of the candidates (Samuels, 2000, p. 490).

Yet, we have seen in Brazil that the political parties play a decisive role in the election, as pointed out by De Souza and Mezzaroba (2015, p. 302).

In order to have an idea of the effect of this practice on electoral campaigns Samuels (2001, p. 580) have shown that the offer of certain lottery tickets, and even a small tangible reward as coffee, have a small, but significant impact on increasing voter turnout. However, the literature indicates that the proportion of voters receiving vote-buying offers varies per various characteristics, such as the region and unit of the federation where the electoral campaign occurs; whether the city is capital or interior; age; income; and educational level of the voters; etc. (Speck, 2003, p. 155; Abramo, 2007, p. 2).

Since the purchase of votes exists, there is no simple way to analyze how financial resources can affect an election, since the numbers resulting from this practice may be sufficient to change the outcome of a dispute (Abramo et al., 2007, p. 5). So, a question arises: can a candidate's financial resources even change the outcome of an election? Based on the use of an agent-based model, this paper seeks to analyze the impact of financial resources on election campaigns; estimating how much it would take for the outcome of an election to be changed and to test cases where voters have some kind of memory.

The research is justified because the distortions caused by the candidates' financial resources may oppose the democratic character of the elections, which allow politicians to come to power and deal with private interests rather than their constituencies. That generate inefficiencies, that is since the candidate elected uses the unidentified money to buy votes he will need to take it back. For example, Khemani (2013, p. 90), using data from Philippines elections, shows evidence that buying votes in poor economies is associated with the lower provision of public services.

This article is structured as follows: this section presented the contextualization of our theme, problem, and objective of the research; next section presents the model used to estimate our results; followed by a section which presents the results obtained; and, a brief conclusion with our final considerations.

2 Model[4]

To simulate an electoral campaign, we used a virtual city with 10,000 residents. It is assumed that all the residents will vote, and they are distributed into 2,500 residences. The sick the reality we attribute an age properties to our agents. We divide the population into groups. Which one is divided into four bands with the following proportions showed in Table 1. These proportions were chosen to mimic the real Brazilian age distribution taken from TSE data for 2016.

Table 1 - Proportion of voters by age group.

Age group (years)	Percentage of total voters (%)
16 – 24	15
25 – 34	22
35 – 60	46
61 or more	17

Source: Prepared by the authors, based on TSE data (2016).

4 The code was write an opensource platform, it is available at: http://modelingcommons.org/account/models/712

Two candidates here called Candidates *A* and Candidate *B*, are in a run for the city mayor. We will assume that the Candidate *A* has as main campaign promises: greater investments in health and education. Candidate *B* has its main campaign promises: job creation and tax reduction.

Each candidate visits several homes per day during the electoral period. In the corrupt case, the candidate makes an *M* (value of the bribe) offer of money to buy the votes. The election campaign period is composed of 100 days. Therefore, candidates may not be able to visit all the houses of the municipality and offer a bribe to all voters of the city.

Voters respect a utility function, depending on their interests, which will vary per age; and give different weights for each of those promises. Based on that they make their voting decisions (Table 2). In other words, a head of the family, who is more concerned with the health and education of his children, would vote for Candidate *A*; instead, a young person, who tends to be starting his professional career, would like Candidate *B* to choose, because, e.g., it must be worried about finding or maintain a good job.

Table 2 - Weights assigned to each campaign promise per age range of the voters.

Promise	Weight attributed by age group (%)			
	16 – 24	25 – 34	35 – 60	61 or more
(1) Health	10	10	25	40
(2) Education	25	10	25	25
(3) Employment	40	40	25	25
(4) Tax reduction	25	40	25	10

Source: Prepared by the authors.

Two models are proposed: one honest and other corrupt. In the honest system, the candidates and the voters are honest, so voting decisions and the campaign promises will be fulfilled as announced. It is assumed that every 1% that the voter attributes to the candidate's main campaign promise is equivalent to one more unity in his utility function.

For example, a voter who is in the first age group, who assigns importance of 10% for health, 25% for education, 40% for employment and 25% for tax reduction. It will have a utility of 35 if Candidate *A* is elected and 65 if the Candidate *B* is elected. This can be summarized as:

$$U(x_t)=U(x_{At})+U(x_{Bt}), \qquad (1)$$

in which $U(x_t)$ is the utility of the voter x in period t and $U(x_{At})$ and $U(x_{Bt})$ are the utilities of the voter attributed to the victory of candidates' *A* and *B*, respectively. That is, if candidate *A* wins the elections, $U(x_t)=U(x_{At})$, because $U(x_{Bt})$ = 0. And the utility which is perceived from each candidate will depends of theirs promises, like this:

$$U(x_{At})=\sum_{(i=1)}^{n} D_i \rho_i, \ \ and \ \ U(x_{Bt})=\sum_{(i=1)} D_i \rho_i \qquad (2)$$

where D_i is a dummy which assigns value 1 if the candidate makes the campaign promise *i*, check Table 2 (can be health, education, employment, or tax reduction), or zero if the candidate did not offer that promise. And ρ_i is the weight assigned to each of the campaign promises by the voter. In the honest dispute, the candidates in the electoral race get votes and will be elected the one whose majority of the population gives more weight to their campaign promises.

In the corrupt system, both voters and politicians are corrupt. In this case, voters accept the bribe offered by the

candidate who requests their vote and ends up changing their utility; generated a new utility mixed by their promises plus the monetary value receives:

$$U(x_{At})=\sum_{(i=1)}^{n} D_i \rho_i + M_t \ \ and \ \ U(x_{Bt})=\sum_{(i=1)}^{n} D_i \rho_i + M_t, \qquad (3)$$

where M_t is the monetary value given by the candidate to the voter to vote for him in period t.

The utility was used as proxies to know in whom the voters have the intention to vote. In this case, when $M \rightarrow \infty$ the probability of the voter voting for the candidate who offered a bribe will tend to 1, thus reducing the likelihood of voting on the competitor to zero. Therefore, the odds assigned by voters to campaign promises were suppressed by the bribe.

It should be noted that all voters vote, that is, voting is mandatory. And, to put it simply, without loss of generality, it is assumed that the 10,000 voters of that municipality reside in it and that the null votes are not possible. The next section presents the procedures adopted and the results obtained.

3 Procedure and results

Case: Honest Election

The way we settled the model in a fair election the Candidate *B* must win. That happens because we create a city that represents the age distribution of a typic Brazilian city, and the combinations of the utilities will give the Candidate *B* the victory, as shown in Table 3. Just as an example, we run the model with the data of the Japanese demography. Everything being equal, and just change the demography data for one like the Japanese one, the results of an election would be different, with the Candidate *A* being elected.

Table 3: Results of an honest election.

Demography	Votes for Candidate A	Votes for Candidate B	Winner
Brazilian	4,355	5,645	Candidate B
Japanese	5,240	4,760	Candidate A

Source: Prepared by the authors.

Case: Voters without memory

In this first cycle of simulations voters' preferences are permanently altered by the bribe, this means that the voter does not return to their original preferences in the next election. It leads the adjacent election the result of their preference modified by the bribe if it was received one. We simulated 50,000 elections. On fair terms Candidate *B* would win all those elections, however, the introduction of bribes, even at the lowest simulated value, modified this conclusion and brought victories to Candidate A (see Table 4).

Table 4 – Elections with voters without memory, deferent value of bribes. Even the lowest value of bribe is enough to change the elections results when the voters have no memory.

Bribes value	Average votes for candidate A	Average votes for candidate B	Total wins of candidate A	Total wins of candidate B
5	4,859 ± 451	5,141 ± 442	3,000	7,000
10	4,884 ± 440	5,116 ± 456	4,000	6,000
15	5,013 ± 654	4,987 ± 650	4,000	6,000
20	4,881 ± 470	5,119 ± 491	4,700	5,300
25	4,819 ± 858	5,181 ± 821	5,000	5,000
Total	4,891	5,109	20,700	29,300

Source: Prepared by the authors.

This configuration has brought us interesting results, but we do not need to maintain the restriction of only one candidate offers bribes per electoral cycle, so we relax this assumption. The results for this new case - both candidates offer bribes - are compiled in Table 5. There is a reduction in the standard deviation, the variation of votes received between one election and another is smaller than that observed in the previous case. Nevertheless, in some elections, the Candidate *A* can win. This does not occur in the first two levels of bribes; but after 50,000 simulated elections, Candidate *A* received 8,900 victories, compared to 20,700 in the previous scenario, that is, Candidate *A* has his victories reduced.

Table 5 - Elections with voters without memory, a different value of bribes, both candidates offer bribes. The situation when both candidates offer bribes turns more difficult to change the election results.

Bribes value	Average votes for candidate A	Average votes for candidate B	Total wins of candidate A	Total wins of candidate B
5	4,584 ± 208	5,415 ± 217	0	10,000
10	4,720 ± 188	5,279 ± 199	0	10,000
15	4,899 ± 162	5,100 ± 170	3,500	6,500
20	4,906 ± 147	5,093 ± 152	2,400	7,600
25	4,931 ± 135	5,068 ± 140	3,000	7,000
Total	4,808	5,109	8,900	41,100

Source: Prepared by the authors.

Case: Voters with memory

Now we will analyze the simulations where the voters have memory, after the electoral cycle the voter returns to his original preferences, that is, he remembers his original preferences without the interference of the bribe. In the previous studies, voters carried to the next electoral cycle their ultimate utility of the previous electoral cycle.

Table 6 - Voters with memory, different values of bribes, only one candidate buys votes. The memory makes more difficult to change the elections results, even with only one candidate offering bribe the results are changed only for high values of bribes.

Bribes value	Average votes for candidate A	Average votes for candidate B	Total wins of candidate A	Total wins of candidate B
5	4,536 ± 60	5,464 ± 88	0	10,000
10	4,697 ± 58	5,303 ± 114	0	10,000
15	4,858 ± 69	5,142 ± 143	0	10,000
20	4,469 ± 653	5,531 ± 587	4,200	5,800
25	4,396 ± 135	5,604 ± 798	5,000	5,000
Total	4,591	5,409	9,200	40,800

Source: Prepared by the authors.

We also analyzed the scenario where both candidates offer bribes and when only the candidate behind offers. For the case where both candidates offer bribes, Table 7, the result is the scenario of a fair election, without buying votes. In the ideal case the Candidate *B* would win the election with

5,645 votes; for no amount of bribe, this total of votes was surpassed. Although Candidate *B* had won all the 50,000 elections, it finished with an average of votes inferior to the fair model.

When only one candidate makes a bribe offer, Table 6, the result of the elections is changed with the increase of the amount of the bribe, that is, Candidate *A* can elect even if the voters have memory, but for this it is necessary that the value of the bribe is high and that only one candidate offers bribes per electoral cycle.

Table 7 - Voters with memory, different values of bribes, both candidates buy votes. There is no change at the results of elections.

Bribes value	Average votes for candidate A	Average votes for candidate B	Total wins of candidate A	Total wins of candidate B
5	4.373 ± 45	5.627 ± 55	0	10.000
10	4.361 ± 26	5.639 ± 31	0	10.000
15	4.365 ± 46	5.635 ± 52	0	10.000
20	4.377 ± 53	5.623 ± 70	0	10.000
25	4.402 ± 59	5.598 ± 66	0	10.000
Total	4.376	5.624	0	50.000

Source: Prepared by the authors.

Case: Change number of residences visited

For the next two analyses, a total of 500,000 elections were simulated; we simulated the total number of residences visited between five and 25 per day, varying from five to five between each simulation. In a first part of the simulation was simulated the situation where both candidates can offer

bribes, the result, see Table 8, is that the votes received by Candidate *A* grow with the increase in the number of residences visited, at the end Candidate *A* won in 28% (70,700) of the runs.

Table 8 - Addition of residences visited, both candidates buy votes. More residence visited turn easy the job of loser candidate to change the result of an election.

Number of residences	Average votes for candidate A	Average votes for candidate B	Total wins of candidate A	Total wins of candidate B
5	4.704 ± 58	5.296 ± 58	4.200	45.800
10	4.799 ± 70	5.201 ± 70	11.900	38.100
15	4.861 ± 98	5.139 ± 98	17.500	32.500
20	4.861 ± 107	5.139 ± 107	16.800	33.200
25	4.901 ± 114	5.099 ± 114	20.300	29.700
Total	4.376	5.624	70.700	179.300

Source: Prepared by the authors.

When only one candidate offers bribes per electoral cycle, i.e., the situation where only the losing candidate attempts to buy votes in the next cycle, the number of Candidate *A* wins was higher than the first case scenario. Now it ends the simulations by winning 123,200 elections, representing 49% of the elections held. Contrary to the previous scenario, where Candidate *A* had won 28.3%, it is almost doubling the number of elections won by Candidate *A*.

Table 9 - Addition of residences visited, only one candidate buying votes. In this scenario the total of wins of Candidate A doubles.

Number of residences	Average votes for candidate A	Average votes for candidate B	Total wins of candidate A	Total wins of candidate B
5	4.989 ± 91	5.011 ± 91	24.200	25.800
10	4.998 ± 103	5.002 ± 103	24.500	25.500
15	4.979 ± 234	5.021 ± 234	24.800	25.200
20	4.987 ± 288	5.013 ± 288	24.800	25.200
25	4.960 ± 409	5.040 ± 409	24.900	25.100
Total	4.982	5.018	123.200	126.800

Source: Prepared by the authors.

Conclusion

In this work, we used an agent-based model to simulate elections and study how bribes may change this process. Despite the high stylization present in our assumptions, it was possible to verify that: (i) the results of the elections are altered through the introduction of the bribe; (ii) the existence of voter's memory influences the outcome of the elections where bribes are present; and (iii) the number of residences visited, that is, the number of attempts to buy votes, affects the result of the elections. All of this is intuitive, but we think a model could help us to study public policies in a virtual environment before applying them in the real world.

The memory of voters represents an important factor, in the presence of memory the difficulty for the corrupt candidate be elected was higher, that is, he wins a smaller amount of elections than he did when voters had no memory. We think, e.g., in real life, investment in education, or activities that bring to voters the past achievements of the candidates, that could help to increase the voter's memory.

In a real election, it is not possible to limit the number of houses visits by a candidate during the electoral campaign. One solution would be to reduce the electoral campaign period, that would have similar consequences, that is, increase the difficulty of the corrupt candidate be elected using bribes.

Yet, the value of the bribe offered by the candidates represents an important variable, in the initial cases, with low values, the behind candidate has difficulties to change the elections results. Also, when voters have memory, the corrupt candidate can only be elected if it offers much high values of bribes. Therefore, attitudes to limit the total amount dispensed in campaigns, or to equal the amount allowed for each candidate, could minimize the problem.

Finally, the ideal could be the absence of vote buying, so models like this would be unnecessary. However this article may yet be improved, still has possibilities for new extensions, such as: (i) recalculate the well-being of the voters after the election, that is, the voters have a non-static utility function; (ii) inclusion of a budget restriction for the candidate, the model does not currently have spending limits to the candidates, as if there were some inexhaustible source of resources available to the candidates; (iii) to make it possible for politicians to offer a bribe and the voters have a possibility of accepting it; among others.

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Diogo Signor
Email: diogosignor@gmail.com

Elder Mauricio Silva
Email: elder0055@gmail.com

Ronivaldo Steingraber
Email: ronivaldo.ufsc@gmail.com