Theoretical Framework

In computational social sciences, various methodologies have emerged to study societal behavior, leveraging theories such as social choice, game theory, complexity, and chaos theory. These approaches, particularly in political science, have shed light on phenomena like voter behavior, intercultural conflicts, political integration, and ideological propagation. This study focuses on strategic voting in proportional electoral systems, aiming to model voter behavior using agent-based modeling (ABM). Unlike majoritarian systems, where strategic voting has been extensively studied, proportional systems were historically considered free of such behavior. However, recent empirical studies reveal its significance in proportional contexts. Voters consider factors like coalition possibilities, neighborhood preferences, and maximizing personal benefit to decide whether to vote strategically. The ABM approach, implemented in Python with the Mesa library and visualized using Solara, simulates voter behavior based on rational choice theory and environmental influence.

The model analyzes constituencies of varying sizes (100 to 10,000 voters) to explore the effects of district size and social interaction on voter polarization and party dominance. Hypotheses include: larger districts reduce polarization, central parties dominate in larger districts, and intensified social interactions can lead to increased polarization or radical party dominance. Challenges in developing the model stem from the rarity of ABM applications in this context and limited academic resources. Data from simulations, represented as graphs, reveal strategic voting trends, particularly in Turkey's proportional system. The findings validate the hypotheses and propose enhancements for future models. This work underscores the potential of ABM to address complexities in electoral behavior and strategic decision-making in proportional systems.

Goal of This Project

The aim of this project is to further analyse the behaviour of voters in the model with working on the raw results of an evolution carried out by the model. We will specifically be interested in the distribution of the strategic votes within the types of voters. For this, the data stored in the main `csv` file is examined. An example generation looks like:

```
data.str_out_det[10]
---
{'left_suc_strategic': {-9: 0, -7: 15, -5: 37, -3: 43, -1: 35},
 'left_unsuc_best_try': {-9: 1225, -7: 163, -5: 143, -3: 130, -1: 131},
 'right_suc_strategic': {1: 32, 3: 47, 5: 18, 7: 18, 9: 0},
 'right_unsuc_best_try': {1: 129, 3: 135, 5: 144, 7: 130, 9: 1257}}
```

Since those are Python dictionaries, we restore them in the code with evaluating them literally. For example, the 10th generation is restored with:

```
a = ast.literal_eval(data.str_out_det[10])
```

Then the first thing to do is aggregation. We want to sum these counts to one number for lefts and one number for rights. For example, generation by generation list of sums for lefts is calculated with:

```
for i in range(len(data.str_out_det)):
    a = ast.literal_eval(data.str_out_det[i])
    lefts = [a["left_suc_strategic"], a["left_unsuc_best_try"]]
    lefts_sums.append([sum(x) for x in zip(*[[i[k] for k in i] for i in lefts])])
```

Then, we also sum these aggregations to get a total for left types:

```
lefts_sums_total = [sum(x) for x in zip(*lefts_sums)]; lefts_sums_total
```

What we finally get, respectively for lefts and rights, is as follows:

```
[35812, 7778, 7754, 7987, 8045]
[7846, 7916, 7846, 7679, 35985]
```

Since, in the model, the sides are symmetric, these totals are also fairly symmetric, therefore the symmetry in the values are fairly expected.

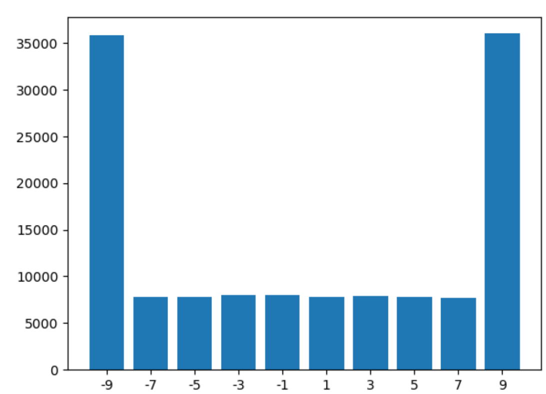
Results

The radical accumulation towards median voters are new. This is the main finding of this project. To visualize, we define an appropriately ordered list of preferences:

```
prefs = [-9, -7, -5, -3, -1, 1, 3, 5, 7, 9]
```

Then we plot the values and get:

```
plt.bar(list(map(str,prefs)), sums_total)
```



We also plot the evolution of strategic and sincere votes. This is done with classifying the vote types first, and then zipping them appropriately as follows:

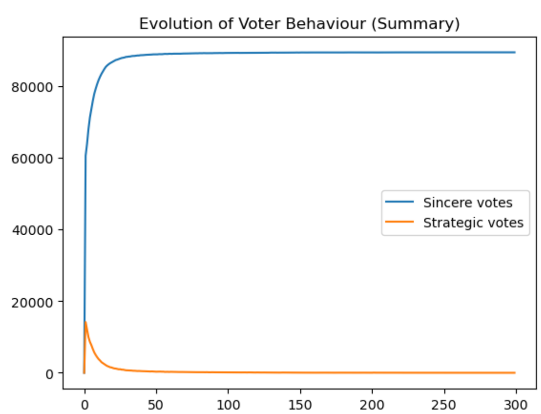
```
fig = Figure()
ax = fig.subplots()
tie = [gen["tie"] for gen in data.outcomes]
left_winning_sincere = [gen["left_winning_sincere"] for gen in data.outcomes]
left_unsuc_sincere = [gen["left_unsuc_sincere"] for gen in data.outcomes]
right_winning_sincere = [gen["right_winning_sincere"] for gen in data.outcomes]
right_unsuc_sincere = [gen["right_unsuc_sincere"] for gen in data.outcomes]
sincere_list = [tie, left_winning_sincere, left_unsuc_sincere,
                right_winning_sincere, right_unsuc_sincere]

left_suc_strategic = [gen["left_suc_strategic"] for gen in data.outcomes]
left_unsuc_best_try = [gen["left_unsuc_best_try"] for gen in data.outcomes]
right_suc_strategic = [gen["right_suc_strategic"] for gen in data.outcomes]
right_unsuc_best_try = [gen["right_unsuc_best_try"] for gen in data.outcomes]
strategic_list = [left_suc_strategic, left_unsuc_best_try,
                  right_suc_strategic, right_unsuc_best_try]

sincere = [sum(i) for i in zip(*sincere_list)]
strategic = [sum(i) for i in zip(*strategic_list)]

ax.plot(sincere, label="Sincere votes")
ax.plot(strategic, label="Strategic votes")
ax.set_title("Evolution of Voter Behaviour (Summary)")
ax.legend()
fig
```

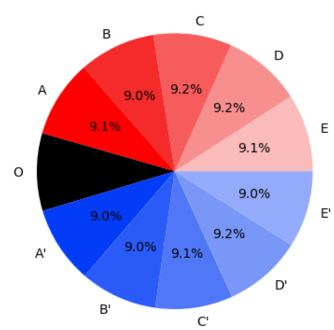
What we get is the following plot in which we can see the ultimate domination of sincere votes. This is also expected since the model goes towards an equilibrium and the initial goal was to get pattern formation and **low entropy**.



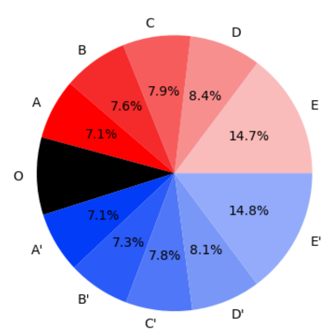
We are also interested in the evolution of the distribution of the preferences throughout the evolution. We extract the count of preferences for the first generation and plot it as follows:

```
gen1 = data.iloc[:, 1: 12].iloc[0]
fig = Figure()
ax = fig.subplots()
colors = ["#fabbbb", "#f78f8f", "#f75c5c", "#f52a2a", "#ff0000", "#000000",
          "#023cf7", "#2a5af7", "#4f77f7", "#7997f7", "#93abfa"]
ax.pie(gen1, labels=gen1.index, colors=colors, autopct='%1.1f%%')
plt.clf()
fig
```

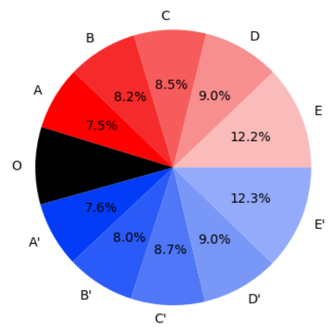
The plot is as follows:



In the model, the initial distribution of the voters are done in a uniform way, therefore we expect around the same percentage for all of the preferences. Then, when we start the evolution and calculate the next generation, a shift in preference towards the median is very well seen:



Lastly, we are interested in the equilibrium. In fact, the following is the distribution of the voters in the 300th generation:



The dominance of the median seems to have decreased, but still is present.

Conclusion

Three main visualizations on the model are done. One more advanced than the other two has given a new understanding on the model, namely the distribution of the strategic votes within the types of voters. In other words, we have found an ambient answer to the question "Which type of voters have more tendency to vote strategically: The median ones, or the radical ones?" It could just also be any of them, but it is found that median voters vote strategically, dominantly.

Starting from the simple rules of the model, this was not at all easy to suggest, or trivial. It is something that emerged from the rich structure of the model. It is also a demonstration of the advantages of using agent-based modelling and an effective computable model such as a cellular automata. In an ambient system of reasoning, we deduced that, in a community towards ideological equilibrium, median voters change their minds more than radical ones. This is not to be said in a definitive way, because the model should also take into account the *return to the original opinion* after voting strategically, but as an ambient result, it is nevertheless interesting.

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