# Computational Analysis of Applied Weighted Voting Games
## *... who governs and why?*

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With numerous parties in the parliament it is not easy to assess the power of each one of them. Typically, a party with more than a half of all seats obviously has all the power as it can pass any bill. Losing the majority even by a single vote changes the situation diametrically – decisions have to be made by coalitions, and the power becomes a complex function of the number of seats held by each party.

But mathematicians have a special tool designed exactly for such analysis – *weighted voting games*. In this very simple model each player (in our example representing a political party) has a number of votes and a decision is made if the number of players' votes in support of it exceeds a certain threshold. From the model, there is only one step to calculate the power – to this end, power indices has been proposed, that consider how often each player could provide the swing votes that would convert the losing side into the winning side.

As most theoretical models, weighted voting games are based on various simplifying assumptions. The model assumes that any player is always ready to cooperate with all others. In reality, however, this is usually not the case, due to sympathies and antipathies between political parties. In other words, many coalitions considered in by standard weighted voting games will never form. Moreover, in the standard model, it is impossible to consider political alliances that may have a crucial impact on the distribution of power in the parliament (this is, for instance, the case with a political alliance that has the majority). Furthermore, the standard model does not allow for multiple quotas, such as the double majority, which often occur in decision processes leading to the change of the constitution.

Another problem of weighted voting games are the computational properties. Interestingly, over twenty years ago it has been shown that checking whether a given party has any impact on the parliament is NP-hard, which means it is practically impossible for a large number of parties.

Unfortunately, existing extensions of the classical model neither can address the above problems nor their computational properties have been studied extensively enough. This means that it is difficult to apply existing models of weighted voting games in practice.

*The key objective of our project is to propose a more realistic model of weighted voting games which addresses the aforementioned problems and to develop as efficient as possible techniques to calculate power indices within this model.*

One of the main motivation of our research is the question: which aspects have a decisive effect on the power of a political party? Without a doubt the number of votes is an important factor, but the party without the majority can still be in an opposition (regardless of the number of votes) if other parties form an alliance. Another interesting question is analysis how double majority affects the strength of the political parties. We hope our research will help to answer a wide variety of such questions.

Important aspect of our work is also popularization of our results. One of our main goals is to create a dedicated website, which will allow for an advanced analysis of voting systems. The website will be designed for non-specialist. A user will have an opportunity to observe an effect of even a small change in the model, such as a minor change in the number of votes, an existence of a relation (sympathy or antipathy) between political parties, or forming an alliance. We believe that our website will not only be used by academics but it will also contribute to the understanding of the existing voting systems by the society.