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# Coalizer: A coalition tool combining office and policy motivations of political parties

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**ABSTRACT**
While prior work on coalition theories focuses either solely on office or on policy motivations of parties, more elaborate theories combine both types of motivation. Said combination makes them much more appropriate for explaining coalition formation but also more complex. One possibility to make these models broadly applicable are coalition tools. Since existing tools do not incorporate advances from such theories, we present a new coalition tool called Coalizer which takes both office and policy motivations into account and reflects the state of coalition theory. Among others, Coalizer includes features like the computation of policy utility values basing on party positions (supporting different estimation modes), the combination of office and policy utility values, and the indication of utility maximizing strategies for parties. In this paper, we present our coalition tool and illustrate its functionality with the example of the German federal elections in 2017. Coalizer is available online at www.mytuc.org/mcbz

**KEYWORDS**
Coalition theory; formal models; online tool; decision support system

## Introduction

The formation of coalition governments is a fundamental and widely observed process in the field of political science: Between 1945 and 2017, 468 elections in European democracies were held in which single-party majorities were reached in only 80 cases (Döring & Manow, 2018). Hence, the formation of governmental coalitions between two or more political parties is a typical procedure in multiparty systems after elections (Saalfeld, 2007). Since in coalition building processes parties decide who will and who will not govern the people and this decision heavily influences policy outcomes, knowledge of coalition formation is exceedingly relevant (cf. DeWinter & Dumont, 2006).

The process of coalition formation has been thoroughly studied both theoretically and empirically. While prior work on coalition theories focuses either solely on office allocations (e.g. Riker, 1962; von Neumann & Morgenstern, 1944) or on policy motivations of parties (e.g. DeSwaan, 1973; Leiserson, 1966), subsequent theories combine both types of motivation (e.g. Austen-Smith & Banks, 1988; Baron & Diermeier, 2001; Schofield & Sened, 2006; Sened, 1995, 1996). These combined theories are therefore more appropriate to explain the formation of majority coalitions but, at the same time, they are also more complex as they integrate and combine two different motivation types. As a consequence, such theories are difficult to apply for non-experts. However, also political scientists without specialized knowledge in formal coalition theory as well as political science students should be provided an opportunity to apply those models in order to understand coalition building. Furthermore, these younger coalition theories can be helpful for parties in bargaining situations to explore promises and challenges of different government alternatives.

One approach for making formal coalition theories more broadly applicable are coalition tools. With applications that facilitate coalition theories, results can be analyzed by a wider range of users such as academics, ambitious politicians and journalists, and – with some reservations – parts of the general public. These tools also afford students of political science better understanding of formal coalition theories as they can be overstrained by their levels of abstraction (Boyer, 1999). However, existing tools available for coalition building do not incorporate advances from younger theories. They do not consider both kinds of motivation but often are confined to the identification of winning or minimal winning coalitions like tools provided by online versions of newspapers, e.g. Spiegel Online and FAZ.net in Germany. Other tools are often part

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of complex software packages and not available as stand-alone applications. The intended audience of these tools are experts. As mentioned above, these coalition tools do not incorporate younger, empirically tested and approved coalition theories and adopt either an office- or a policy-oriented approach (e.g. Becker, 2005; Rohn, Kalech, & Diskin, 2016; Shikano & Becker, 2009). To summarize, existing tools either fail to accurately capture the complexity of coalition building models, neglect usability aspects, or omit information on party positions. For this reason, we develop and present a new coalition tool called Coalizer. Our coalition tool considers the complexity of office- and policy-oriented coalition theories and is implemented as a user-friendly web application.

The remainder of this paper is organized as follows. In the next section, we briefly present the coalition theories that coalition tools should be able to handle. In section 3, we give a short survey of existing coalition tools. Based on this review, we argue that there is need for a new, more elaborate tool that supports the ad-hoc use of complex data and that implements both office- and policy-oriented aspects of coalition formation processes. In section 4, which forms the core of the paper, we describe the functionality of our coalition tool and illustrate its benefits using the example of the German federal elections in 2017. Finally, section 5 concludes the paper with a brief summary and an outlook.

## Overview of coalition theories

According to Müller and Strøm (1999), parties seek three primary objectives. First, they aim to be successful in elections (vote motivation). Second, they want to staff public offices with their own personnel (office motivation). And third, they press for the implementation of policies (policy motivation). Since negotiations about coalitions take place after elections and their results can therefore not effect parties' electoral outcomes, (nearly) all coalition theories focus on the latter two factors, parties' office and policy motivations (DeWinter & Dumont, 2006; Laver & Schofield, 1990; Linhart, 2013; Saalfeld, 2007, 2011).

The most basic coalition theories model parties as purely office-oriented. In the view of these theories, parties' only aim is to maximize staffing. As a consequence, parties prefer coalitions with fewer partners since there are fewer parties to share offices with (Leiserson, 1968). In particular, parties which are not needed for a coalition's majority in parliament are not expected to be members in coalitions (von Neumann & Morgenstern, 1944). Formally, the respective concept of minimal winning coalitions (MWC) is defined as

$$\mathrm{MWC} = \{C \epsilon 2^{N} \mid s_C > 50\% \text{ and } s_C - s_p \leq 50\% \text{ for all } p \epsilon C\}$$

where $N$ denotes the set of all parties, $2^N$ the set of all coalitions, $s_p$ the seat share of a party $p$ and $s_C$ the seat share of all parties of coalition $C$.

Gamson (1961) assumed that coalition parties typically distribute offices according to their relative strengths in parliaments. This expectation ('Gamson's Law') has widely been confirmed empirically (Carroll & Cox, 2007; Warwick & Druckman, 2006). Consequently, the expected share of offices *off* for a party $p$ in a coalition $C$ can be approximated as

$$off_p(C) = s_p / s_C.$$

With $s_p$ being constant after elections, parties aiming to maximize their offices have to minimize $s_C$ what means that they should join the smallest winning coalition called smallest size coalition or minimum winning coalition (Gamson, 1961; Riker, 1962).

These and similar theories have been legitimately criticized for completely ignoring parties' policy gains. Consequently, a second generation of policy-oriented coalition theories has been developed. Generally, these theories are based on policy positions $y_p$ of parties $p$ and expect coalitions to be more likely if party positions within coalitions are closer. DeSwaan (1973), for example, proposes using the distance between the leftmost and the rightmost party in a coalition as a coalition's range. The larger this range, the more heterogeneous is the respective coalition and the less likely is its formation, since parties have to compromise more widely on policy.

Peleg (1981) and Van Roozendaal (1992) take the motives of single parties into account. While policy positions of other parties in a coalition might be rather disparate, this would only pose a minor problem for the central party, if the fringe parties neutralize each other so that an expected policy compromise would be close to the central party's ideal position.

Bringing both thoughts together, parties should evaluate coalitions with regard to how close expected coalition policies come to their own position (cf. Morgan, 1976). This argument has later been formalized in the term

$||y_C - y_p||$

where $y_C$ denotes the expected policy of a coalition $C$.

A newer policy-oriented model of coalition formation has been developed by Rusinowska, de Swart, and van der Rijt (2005). On the basis "of a government which is defined as a certain policy and a majority coalition supporting this policy" (Rusinowska et al., 2005, p. 153), Rusinowska et al.'s coalition theory aims for identifying a stable government with respect to policy preferences of all parties.

While the second-generation theories overcome the criticism of policy-indifference, they conversely ignore office motivations. As both office and policy facets are important for parties (cf. Bäck & Dumont, 2007; Martin & Stevenson, 2001), newer theories of a third generation include both components. Axelrod's (1970) concept of minimal connected winning coalitions can be interpreted as the oldest coalition theory including both office and policy motivations of parties. According to Axelrod, a coalition is connected, if a coalition which includes two parties $p_1$ and $p_2$ with positions $y_1$ and $y_2$ also includes all parties with positions between $y_1$ and $y_2$. Formally, the set of connected coalitions CON is defined as

$\text{CON} = \{C \epsilon 2^N \mid p \epsilon C \text{ for all } p \text{ with } y_p \epsilon (\min_{p \epsilon C}(y_p), \max_{p \epsilon C}(y_p))\}$.

Based on this definition, a minimal connected winning coalition MCWC is a connected winning coalition in which every party is necessary for either the winning or the connected criterion (or both):

$\text{MCWC} = \{C \epsilon \text{CON} \mid s_C > 50\% \text{ and } (s_C - s_p \leq 50\% \text{ or } C \backslash \{p\} \notin \text{CON}) \text{ for all } p \epsilon C\}$.

Newer theories typically model parties' utility $u_p(C)$ as a combination of their office ($u_p^{off}(C)$) and policy motivations ($u_p^{pol}(C)$):

$u_p(C) = u_p^{off}(C) + u_p^{pol}(C)$

(Austen-Smith & Banks, 1988; Bandyopadhyay & Oak, 2008; Baron & Diermeier, 2001; Morelli, 1999; Sened, 1995, 1996). Despite the usage of similar utility functions, these third-generation theories vary in many central questions (for an overview, see Linhart, 2013). Some of them embed the utility functions into sequential formateur games, whereas others search for equilibria in freestyle bargaining games. If formateur games are constructed, the fallback solutions vary. And for simplicity reasons, these models are often limited to three-party-systems or one-dimensional policy spaces. The freestyle bargaining games, on the other hand, are based on games in which one coalition requires a majority of the votes. These models, thus, are limited to (legislative) majority coalitions[1].

Furthermore, we want to point out three important aspects for the programming of a coalition tool: First, some theories allow arbitrary office distributions and policy compromises, while others specify these. If specified, offices are distributed proportionally (according to Gamson's Law, see above), and coalition policies typically are estimated as (weighted) means of the governing parties' positions. Thus, the utility functions can be specified as

$u_p(C) = s_p/s_C - ||y_C - y_p||$.

Second, some theories assume such utility functions for all parties, while others consider opposition parties' utility to be zero. The latter implies that parties are purely extrinsically motivated by policy whereas the first assumes purely intrinsically policy-motivated parties (Linhart, 2013, pp. 303–304). Our coalition tool is able to handle both options.

Third, the model of Sened (1995, 1996)) includes party-specific weighting parameters, $\alpha_p$ and $\beta_p$, in order to take into account that different parties can be motivated by offices or policy to different degrees. Since the inclusion of those parameters is the more general approach, we will also integrate them into our coalition tool. The respective utility function reads as

$u_p(C) = \alpha_p u_p^{off}(C) + \beta_p u_p^{pol}(C)$

or, in the specified form, as

$u_p(C) = \alpha_p s_p/s_C - \beta_p ||y_C - y_p||$.

We conclude this section with the hint that the here referred to third-generation theories are highly sophisticated and comprehensive, but still cannot include any facets of coalition formation that might be important. For example, modeling the office utility as the pure share of offices which $p$ can expect in $C$, this approach does not take into account that different offices are of different value for different parties (cf. Bäck et al., 2011; Ecker, Meyer, & Müller, 2015; Raabe & Linhart, 2015).

Likewise, leading a coalition might give a party an additional benefit what is neglected, if the prime minister's post is counted like any other minister. Further, Leiserson's (1968) 'bargaining proposition' says that parties should prefer coalitions with a smaller number of parties because of lower bargaining costs. Although the bargaining proposition has been corroborated empirically, third-generation theories do not account for it.

## Review of existing coalition tools

In this section, we investigate how existing coalition tools reflect the state of the art of coalition formation theories. Nonscientific coalition tools are often provided by online versions of newspapers in the course of parliamentary elections – in Germany, for example, by Spiegel Online and FAZ.net. These tools typically show seat distributions of parties after elections and allow users to select single parties in order to see which hypothetical coalitions would constitute a majority (Spiegel FAZ.net, 2019; Online, 2018). Those applications are therefore helpful to identify winning coalitions. In order to identify minimal winning coalitions, the user has to remove each party of a winning coalition individually and test whether the coalition is still winning. However, these tools lack options to consider policy motivations and analyze office motivations.

A more elaborate tool has been developed by Bauer, Bender, Aßenmacher, Klima, and Küchenhoff (2019). This tool's aim is to estimate the likeliness of different coalitions' winning or minimal winning status based on current polls. Thus, like the nonscientific tools, this application does not allow the inclusion of policy factors and is limited to data provided by the developers.

Conversely, the tool koal-o-mat (Bolte, 2017) considers solely policy factors. It accesses data from the voting advice application (VAA) Wahl-O-Mat for – currently – 51 German elections on different levels. Koal-o-mat lists a plethora of two- and/or three-party coalitions sorted by the level of agreement. As a practical issue, a vast number of irrelevant party combinations are presented to the user, and it is not possible to upload further data. In terms of theoretical background, the tool does not include office considerations and is limited to three parties per coalition.

A more complex and sophisticated coalition tool – KOALA – was introduced by Becker (2005) and Shikano and Becker (2009). KOALA is designed as an R-package and supports the models of winning, minimal winning, smallest size and minimal connected winning coalitions. By default, KOALA displays a coalition matrix that represents all possible governments. Since it is implemented as an R-package, KOALA does not include a graphical user interface, cannot be executed as a stand-alone-application and is difficult to use for non-experts. Furthermore, the third-generation theories currently are not supported by KOALA. Besides KOALA, several other R packages that solve similarly simple coalition games can be downloaded via the CRAN project website (https://cran.r-project.org), for example the package ‚GameTheory' (Cano-Berlanga, Gimenez-Gomez, & Vilella, 2015) or the package ‚GameTheoryAllocation' (Saavedra-Nieves, 2016).

The Rusinowska et al. (2005) model can be computed with various software tools such as Macbeth and Relview (Berghammer, Rusinowska, & de Swart, 2007; Roubens, Rusinowska, & de Swart, 2006). To make this coalition theory more applicable, it was later combined with notions from different fields including relation algebra, graph theory and social choice theory (Berghammer, Rusinowska, & de Swart, 2009). This coalition theory can be applied with the help of other software (Macbeth, Relview) but has not been implemented in a coalition tool in a narrower definition. Furthermore, the coalition theory is behind the state of the art, since parties' office motivations are ignored.

Finally, Rohn et al. (2016) recently developed the "Coalition Formation Decision Support System" (CFDSS). The CFDSS web application searches for a government that is expected to be durable and stable based on seat distributions, party positions, and policy weights, according to a coalition theory developed in the respective paper. However, the theoretic foundations of coalition formation in CFDSS are disputable (see Linhart & Graichen, 2020).

To summarize, existing coalition tools do not adequately reflect the current state of the art in office- and policy-oriented coalition theories and are often not designed as stand-alone applications

that can be used both by lay users and experts. In order to overcome this shortcoming, we introduce a new coalition tool called Coalizer.

## Coalizer

Coalizer takes both office and policy motivations into account and thus reflects the current state of coalition theories. As an online web application, coalition formation processes can be analyzed in common web browsers without prior installation. In this section, we first describe the functionality of Coalizer and then illustrate its practical usability using the example of coalition formation after the German federal elections in 2017.

### *Functionality*

Coalizer is available online at www.mytuc.org/mcbz. The welcome page includes a menu with the items *Data, Analysis*, and *Theory* in the left. *Data* allows the user to access data from elections which we have already provided. Users can also upload or manually enter new data. At *Analysis*, several analyses regarding coalition formation processes can be operated. Finally, the *Theory* page provides information about the modeling which is used in the *Analysis* part. The contents of the *Theory* page largely correspond to this paper's theory section, we therefore focus on *Data* and *Analysis* in the following.

The *Data* page includes the second-level subpages *Elections, Parties*, and *Upload*. As mentioned above, Coalizer already includes data about several elections. These are listed at the subpage *Elections*. Party positions and seat numbers have been verified and cannot be altered by the user. The user can also create a new dataset by clicking the 'new election' button. Before doing so, relevant parties have to be added with real names, synonyms, and colors on the *Parties* subpage. At the *Elections* page, the user can then select parties and enter these parties' seat numbers and policy positions. Alternatively, and more conveniently, datasets can also be uploaded at the *Upload* subpage. Similar to manual entry, all party names and synonyms have to be listed at the *Parties* subpage before the upload. Independent of whether the data is uploaded or entered manually, both the number of seats and the policy positions have to be provided for every party.

Importantly, Coalizer is able to handle policy positions of any dimension. Positions can refer to a unidimensional left/right scale (as provided, for example, by the manifesto project; cf. Volkens et al., 2017, see Dinas & Gemenis, 2010 for a possible method), a policy space with few dimensions (e.g. a two-dimensional policy space consisting of a socio-economic and a socio-cultural dimension as it can be taken from the Chapel Hill expert survey; see Bakker et al., 2015), or vectors in $n$-spaces (if a battery of specific questions constitutes the policy space as this is the case in VAAs; see Garzia & Marschall, 2014; Gemenis & van Ham, 2014).[2] While there are no further formal prerequisites, we strongly recommend to normalize the data to [0; 1] for each dimension. Since office utilities refer to expected shares of cabinet posts and therefore are normalized between 0 and 1, analyses might lead to non-meaningful results, if policy data deviated too strongly from this normalization. Technical hints on how upload files must be organized can be found in the Appendix.

The *Analysis* subpage *Expert Mode* allows options for the evaluation to be specified (cf. figure 1 which shows a screenshot of this page). On the top, the user can select one of the uploaded, entered, or provided datasets. Below, the user selects whether she wants to see results including all winning coalitions or minimal winning coalitions only. While the first option might depict a more complete picture, the analysis can get very lengthy and difficult to interpret for party systems with numerous coalition options. Additionally, Coalizer enables the choice between two ways of calculating the policy distances $||y_C - y_p||$ (and the respective policy utilities that correspond to negated distance values). They can either be computed as Euclidean distances

$$||y_C - y_p|| = \sqrt{\sum_{j=1}^{n} \left(y_{Cj} - y_{pj}\right)^2}$$

or according to a City Block metric

$$||y_C - y_p|| = \sum_{j=1}^{n} \left|y_{Cj} - y_{pj}\right|.$$

Both measures are normalized with regard to the dimension of the policy space, i.e. values are divided by $\sqrt{n}$ (Euclidean) or $n$ (City Block), respectively.

Coalition policies $y_C$ are estimated as means of all parties' policy positions that are members of

a coalition. Here, the user can choose whether or not party strengths play a role. If a value of 0 is chosen, party strengths are ignored and all governing parties influence coalition policies to the same degree. Formally, this means that

$$y_C^0 = \sum_{\substack{p=1 \\ p \in C}}^{m} y_p / m_C,$$

where $m_C$ denotes the number of parties in $C$.

A degree of 1, on the other hand, stands for a fully proportional impact of parties' sizes on coalition policies. Formally, then

$$y_C^1 = \sum_{\substack{p=1 \\ p \in C}}^{m} \left(s_p / s_C\right) y_p.$$

Depending on whether the user finds the first or the latter assumption more convincing, she can set the value to 0 or 1. Further, she can gradually balance out both assumptions by choosing a value in-between. The higher this value, the stronger the parties' strength will influence the coalition policies. A degree of $x$ assumes a coalition policy of

$(1\text{-}x)\ y_C^0 + x\ y_C^1$.

In the next step, the user can optionally mark one of the parties as a party with an outstanding role in the coalition formation process. The institutional contexts for government formation can considerably differ. For example, incumbent governments, largest parties or appointed formateurs can hold outstanding positions, since institutional settings can give them advantages in government formation process

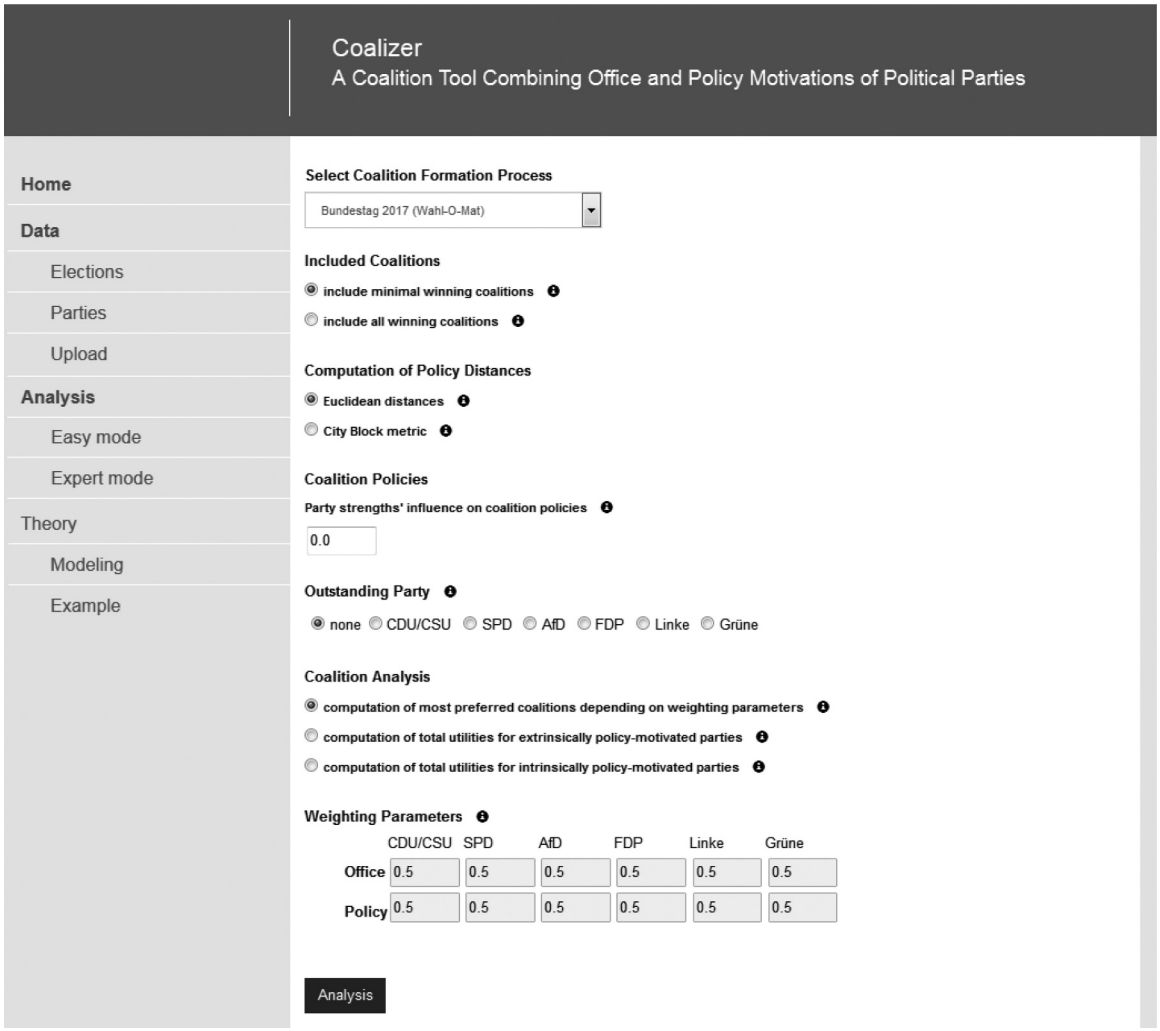



**Figure 1.** Analysis page.

es. If the users marks a party as outstanding, she will get the information whether or not this party is part of a coalition.[3]

Finally, the user can select three modes of computing total utilities. These different modes account for the various options as discussed at the end of section 2. Modes 2 and 3 consider the weighting parameters $\alpha_p$ and $\beta_p$ which can be entered at the page's bottom manually. Since the sum of both degrees is 100% = 1, the policy weighting parameter is automatically computed by Coalizer as $\beta_p = 1 - \alpha_p$. By default, all parameters are set to 0.5 leading to a uniform/balanced weighting like if no parameters were included.

All options show the same basic information on the top: information about the parliament's size and the minimum number of seats for a majority, a visualiza tion of the seat distribution, distances between the parties, a table with basic details about the (minimal) winning coalitions,[4] parties' office utilities for each (minimal) winning coalition according to Gamson's Law, and the distances between $y_p$ and $y_C$ according to the selected specifications. The pairwise distances between the parties are depicted as a two-dimensio nal ad-hoc visualization in the form of an edge-weighted graph, whose nodes correspond to political parties and whose edges represent the distances between each two parties (Kamada & Kawai, 1989). The lengths of the edges may not perfectly represent the true distance between parties due to multidimensional scaling to a two-dimensional plane. However, the Neato technique (North, 2004) approximates an optimal layout and thereby enables visualizing party policy differences and potential coalitions.

Further down the page, the results rely on the selected mode of analysis. For the first analysis option (computation of most preferred coalitions depending on weighting parameters), all utility maximizing coalitions for all possible combinations of office and policy orientations are displayed. This mode is closely related to Sened's (1995, 1996)) theory in which the policy motivation is modeled as purely extrinsic. This means that opposition parties are not seen as responsible for a government's policy output and therefore hold a fix utility value of 0 – they do not staff any cabinet posts ($u_p^{off}(C) = 0$) and are not punished for policy compromises ($u_p^{pol}(C) = 0$). As for government parties, the overall utility can be both positive (if $|u_p^{off}(C)| > |u_p^{pol}(C)|$) or negative (if $|u_p^{pol}(C)| > |u_p^{off}(C)|$), the question is whether the party's office utility term is large enough to prefer membership in a coalition over the opposition role. Technically, we search for the minimum $\alpha_p$ for which $u_p(C)$ is zero or positive, formally

$$\alpha_p^{min} = u_p^{pol}(C)/(u_p^{pol}(C) - u_p^{off}(C)).$$

The $\alpha_p^{min}$ values are shown in the table below the policy distances. The higher these values, the less likely is the participation of a party in the respective coalition.

Finally, when using this option, Coalizer computes the most preferred coalitions depending on the weighting parameters, searching for the coalition with the highest utility value for each party and each combination of weighting parameters between 0 and 1 in steps of .01. For some parties, there might be only one single best option, starting at the respective $\alpha_p^{min}$ value and ending at the maximum $\alpha_p$ value of 1. For others, the utility maximizing coalition can depend on the exact degrees of office and policy motivation. The respective table shows all coalitions which are utility maximizing options for at least one party and one combination of weighting parameters.

The second analysis option assumes purely extrinsically policy-oriented parties, too. This option, however, computes utility values only according to the weighting parameters as chosen by the user. There fore, detailed information regarding concrete utility values is shown in this mode. Moreover, the coalition with the highest utility value is indicated. If a party's utility values in all coalitions are negative, 'opposition' is indicated as the best choice.

Basing on these values, Coalizer further searches for stable solutions (referred to as 'expected coalition'). This search proceeds in a sequence of steps. If a coalition exists which provides the maximum utility for all its members, this equilibrium should be expected as the coalition formation process' outcome (sufficient condition). If no such coalition exists, Coalizer seeks for coalitions in which at least all member parties achieve positive utilities (necessary condition). Unlike the sufficient condition, this criterion may lead to a set of possible outcomes. If none of the coalitions fulfills the necessary condition, Coalizer states that no coalition government is expected according to the given specification. This might indicate that early elections can take place or caretaker governments will

be installed – or the user could test whether different, maybe more realistic choices at the *Analyses* page lead to other results.

In contrast to the second option, the third analysis option assumes purely intrinsically policy-oriented parties. This means that a government's policy output is an important factor also for opposition parties, so that their utility functions do not differ from those of government parties. The respective table with total utility values is shown when users chose this option. In this mode coalitions with negative utility can be optimal solutions (if all coalitions of this party are evaluated negatively). Thus, the criteria for the search of expected coalitions as mentioned above cannot be applied here, and the respective analysis ends with an indication of the utility maximizing coalition for each party.

While one of Coalizer's aims is the provision of a tool which allows the users to analyze coalition formation processes with the help of state-of-the-art coalition theories, the tool also should be applicable for a broader userbase. The model specifications, however, require some expertise, since the users have to know what exactly they specify. For the broader audience, we have therefore additionally included an 'easy mode' as a 'one click' solution. This mode also allows lay users without knowledge of coalition theory to get a sense of parties' possible motives and potential outcomes of the game. Using the 'easy mode', the analysis displays minimal winning coalitions only, depicts a visualization of the parties' policy distances, assumes that all coalition parties influence policy outcomes to the same degree (party strengths' influence on coalition policies is set to 0), measures distances between party positions and expected coalition policies based on Euclidean distances, shows the parties' utility maximizing coalitions assuming extrinsically policy-motivated parties, and identifies an expected coalition. By default, the office and policy weighting parameters are set to the value 0.5 each. No party is considered as outstanding.

### *Illustration: the German federal elections in 2017*

For a deeper understanding of how Coalizer works, we demonstrate its functionality with the example of the latest German federal election which was held on 24 September 2017. Seven parties made it into parliament in the course of the election: the Christian Democrats (CDU/CSU),[5] the Social Democrats (SPD), the right-wing populist 'Alternative für Deutschland' (Alternative for Germany, AfD), the Liberals (FDP), the Socialists (Left Party) and the Greens (cf. Faas & Klingelhöfer, 2019; for an overview of the German parties and the party system, see; Linhart, 2020, pp. 30–37). Screenshots of party distances and seat distributions of possible coalitions are shown in figure 2. Coalizer also depicts the distribution of seats in a pie chart to illustrate the absolute majority.

Policy distances plotted in figure 2 result from the parties' positions given in the Wahl-O-Mat, a German VAA based on 38 questions which played a role in the 2017 federal elections.[6] Our graphical tool merges these 38 questions into a two-dimensional graph where closeness between parties reflects the similarity of their answers. According to the policy distances graph, the largest pairwise difference exists between the Left Party and the Alternative for Germany (AfD), the smallest between the Left Party and the Greens. Figure 2 demonstrates that both the Wahl-O-Mat questions and our graphical tool make sense in this context. Both the (center-)left (Left Party, Greens, SPD) and the (center-)right parties (AfD, FDP, CDU/CSU) cluster together with the centrist parties (CDU/CSU, SPD) in the middle and the most extreme parties (Left Party, AfD) holding the largest distance (cf. Bräuninger, Debus, Müller, & Stecker, 2019).

The table below gives some basic information on possible coalitions by listing all minimal winning coalitions – to which we limited this example. Column (k) indicates the total number of seats of each coalition.[7] The number of parties carrying a coalition is given in column (n). The difference (d) results from the number of seats (k) and the absolute majority and thus indicates the surplus of a coalition. Additionally, all minimal winning coalitions are marked in column (m) to differentiate these coalitions from other winning coalitions. As Germany is a typical case for free-style bargaining, we did not mark an outstanding party in this example. If we had done so, a further column (f) would indicate whether or not this party were part of the respective coalition.

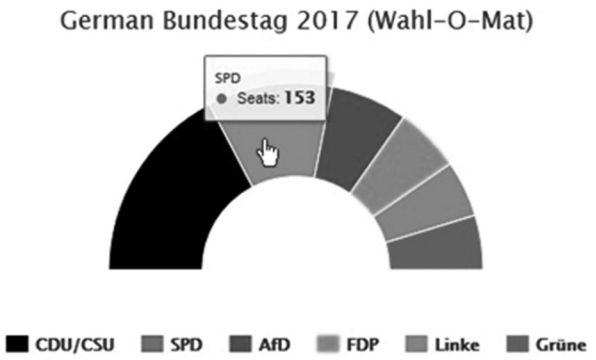
Two of these 11 minimal winning coalitions are of particular importance. The so-called grand coalition between the largest party groups, CDU/CSU

Parliamentary distribution of seats

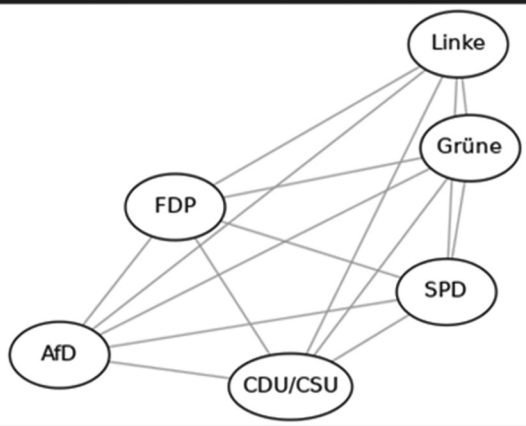
The parliament has 709 seats.

An absolute majority is achieved with 355 seats.

Seat distribution of 6 parties




Visualization of Policy Distances




Possible Coalitions and Seat Distributions

| | CDU/CSU | SPD | AfD | FDP | Linke | Grüne | k | n | d | m |
|---|---|---|---|---|---|---|---|---|---|---|
| CDU/CSU SPD | 246 | 153 | 0 | 0 | 0 | 0 | 399 | 2 | 44 | yes |
| CDU/CSU Linke Grüne | 246 | 0 | 0 | 0 | 69 | 67 | 382 | 3 | 27 | yes |
| CDU/CSU FDP Grüne | 246 | 0 | 0 | 80 | 0 | 67 | 393 | 3 | 38 | yes |
| CDU/CSU FDP Linke | 246 | 0 | 0 | 80 | 69 | 0 | 395 | 3 | 40 | yes |
| CDU/CSU AfD Grüne | 246 | 0 | 94 | 0 | 0 | 67 | 407 | 3 | 52 | yes |
| CDU/CSU AfD Linke | 246 | 0 | 94 | 0 | 69 | 0 | 409 | 3 | 54 | yes |
| CDU/CSU AfD FDP | 246 | 0 | 94 | 80 | 0 | 0 | 420 | 3 | 65 | yes |
| SPD FDP Linke Grüne | 0 | 153 | 0 | 80 | 69 | 67 | 369 | 4 | 14 | yes |
| SPD AfD Linke Grüne | 0 | 153 | 94 | 0 | 69 | 67 | 383 | 4 | 28 | yes |
| SPD AfD FDP Grüne | 0 | 153 | 94 | 80 | 0 | 67 | 394 | 4 | 39 | yes |
| SPD AfD FDP Linke | 0 | 153 | 94 | 80 | 69 | 0 | 396 | 4 | 41 | yes |

**Figure 2.** Visualization of policy distances between single parties and distribution of seats in possible minimal winning coalitions.

and SPD, formed the incumbent government. According to pre-election polls and coalition signals, only this coalition and the so-called Jamaica coalition – named after Jamaica's flag which consists of the same three colors as the party colors of CDU/CSU (black), FDP (yellow) and the Greens (green) – were likely to obtain a majority and to be politically feasible (Bräuninger et al., 2019; Faas & Klingelhöfer, 2019).

A screenshot of the expected office utilities table is shown in figure 3. The value zero indicates that a party is not a member of the respective coalition. If the parties were to merely maximize cabinet posts, CDU/CSU could achieve its highest utility in a coalition with the Left and the Greens. The Left and the Greens expect their highest office utilities in a joint coalition with SPD and FDP. The office utilities of SPD and FDP are at maximum values in this coalition option as well. With respect to CDU/CSU, the Jamaica coalition is marginally better rated than the grand coalition (CDU/CSU and SPD), since the office utility of CDU/CSU is slightly lower in the grand coalition (0.617) than in a coalition government with FDP and the Greens (0.626).

Following the logic of smallest size coalitions (Gamson, 1961; Riker, 1962), a political party avoids the influence of its partners the most by building the coalition with its highest office utility. In this respect, the possible coalition between SPD, FDP, the Left and the Greens corresponds to the conjunction of maximum office utilities and represents an equilibrium solution regarding sole office motivations. This result illustrates once more that purely office-oriented considerations are not sufficiently sophisticated to model coalition formation adequately.

Coalizer computes and indicates policy distances both for governing and opposition parties in each coalition. A screenshot of the City Block policy distances is shown in figure 4. In this example, we set the party strengths' influence on coalition policies to 0, so that all coalition parties affect coalition policies to the same degree. Coalizer indicates distances between all parties and all expected policies of the selected coalitions. A visual inspection of the table shows that distances are lowest for Christian Democrats and Social Democrats in a joint grand coalition, for AfD and FDP in a CDU/CSU-AfD-FDP coalition and for the Greens and the Left Party in a CDU/CSU-Left-Greens government. This means that the grand coalition is the most preferred option of all its members and therefore can be identified as equilibrium for purely policy-seeking parties. The analysis further gives an idea about the amount of policy compromises also for the other coalitions. The Jamaica coalition, for example, is ranked second for FDP, third for CDU/CSU and only fourth for the Greens. This result can contribute to the explanation why exploratory talks about such a coalition have failed.

Coalizer then combines both components in order to determine the minimum office weighting parameters (first analysis option). Figure 5 presents a screenshot of the outcomes. For CDU/CSU and SPD, the formation of the grand coalition seems particularly favorable. Both parties achieve positive utilities with small degrees of office motivations already (CDU/CSU: 0.21, SPD: 0.30). For the smaller parties, AfD, FDP, the Left and the Greens, on the other hand, all values lie above 0.5. This means that there is no coalition option for those parties at all, unless they are more strongly motivated by offices than by policy. Regarding the Jamaica coalition, especially the Greens would need to be highly office-motivated (at least to 67%) in order to gain positive utility from this option.

Such results are mirrored in figure 6 which lists all coalitions in which parties can expect maximum utilities for at least one combination of office/policy motivation degrees. With respect to the CDU/CSU, for example, the coalition with the Social Democrats (SPD) is the utility maximizing option for a wide range of office motivation degrees (21 through 86%), followed by the Jamaica Coalition (87 through 89%), and the CDU/CSU-Left-Greens coalition (90 through 100%). A poorly office-oriented CDU/CSU (0 through 20%) should avoid the entrance in any coalition. Results for the other parties can be interpreted in the same way.

If the user wants to compare the parties' total utilities with specific weighting parameters, she can choose the second or the third analysis option. In the here shown examples, we left the weighting

| Office Utilities | | | | | | |
|---|---|---|---|---|---|---|
| | **CDU/CSU** | **SPD** | **AfD** | **FDP** | **Linke** | **Grüne** |
| CDU/CSU SPD | 0.617 | 0.383 | 0 | 0 | 0 | 0 |
| CDU/CSU AfD FDP | 0.586 | 0 | 0.224 | 0.19 | 0 | 0 |
| CDU/CSU AfD Grüne | 0.604 | 0 | 0.231 | 0 | 0 | 0.165 |
| CDU/CSU AfD Linke | 0.601 | 0 | 0.23 | 0 | 0.169 | 0 |
| CDU/CSU FDP Grüne | 0.626 | 0 | 0 | 0.204 | 0 | 0.17 |
| CDU/CSU FDP Linke | 0.623 | 0 | 0 | 0.203 | 0.175 | 0 |
| CDU/CSU Linke Grüne | 0.644 | 0 | 0 | 0 | 0.181 | 0.175 |
| SPD AfD FDP Grüne | 0 | 0.388 | 0.239 | 0.203 | 0 | 0.17 |
| SPD AfD FDP Linke | 0 | 0.386 | 0.237 | 0.202 | 0.174 | 0 |
| SPD AfD Linke Grüne | 0 | 0.399 | 0.245 | 0 | 0.18 | 0.175 |
| SPD FDP Linke Grüne | 0 | 0.415 | 0 | 0.217 | 0.187 | 0.182 |

**Figure 3.** Office utilities for single parties in possible minimal winning coalitions.

| City Block Policy Distances | | | | | | |
|---|---|---|---|---|---|---|
| | **CDU/CSU** | **SPD** | **AfD** | **FDP** | **Linke** | **Grüne** |
| CDU/CSU SPD | 0.158 | 0.158 | 0.487 | 0.382 | 0.5 | 0.355 |
| CDU/CSU Linke Grüne | 0.364 | 0.276 | 0.553 | 0.461 | 0.268 | 0.202 |
| CDU/CSU FDP Grüne | 0.215 | 0.303 | 0.465 | 0.276 | 0.469 | 0.333 |
| CDU/CSU FDP Linke | 0.263 | 0.333 | 0.461 | 0.281 | 0.412 | 0.373 |
| CDU/CSU AfD Grüne | 0.263 | 0.342 | 0.346 | 0.386 | 0.482 | 0.364 |
| CDU/CSU AfD Linke | 0.311 | 0.373 | 0.342 | 0.39 | 0.425 | 0.404 |
| CDU/CSU AfD FDP | 0.206 | 0.434 | 0.263 | 0.215 | 0.627 | 0.544 |
| SPD FDP Linke Grüne | 0.378 | 0.24 | 0.536 | 0.378 | 0.286 | 0.227 |
| SPD AfD Linke Grüne | 0.414 | 0.27 | 0.454 | 0.454 | 0.296 | 0.25 |
| SPD AfD FDP Grüne | 0.309 | 0.296 | 0.382 | 0.322 | 0.447 | 0.349 |
| SPD AfD FDP Linke | 0.345 | 0.319 | 0.378 | 0.326 | 0.405 | 0.378 |

**Figure 4.** City Block policy distances between single parties and possible minimal winning coalitions (negatives of policy utilities).

parameters unchanged at 0.5 for all parties. Screenshots of the Coalizer's outputs for the second (total utilities for purely extrinsically policy-motivated parties) and the third analysis option (total utilities for purely intrinsically policy-motivated parties) are shown in figures 7 and figures 8.

We know from figures 5 and figures 6 already that for office orientation degrees of 0.5, the larger parties, CDU/CSU and SPD, maximize their

| Minimum Office Weighting Parameters | | | | | | |
|---|---|---|---|---|---|---|
| | CDU/CSU | SPD | AfD | FDP | Linke | Grüne |
| CDU/CSU SPD | 0.21 | 0.3 | . | . | . | . |
| CDU/CSU Linke Grüne | 0.37 | . | . | . | 0.6 | 0.54 |
| CDU/CSU FDP Grüne | 0.26 | . | . | 0.58 | . | 0.67 |
| CDU/CSU FDP Linke | 0.3 | . | . | 0.59 | 0.71 | . |
| CDU/CSU AfD Grüne | 0.31 | . | 0.6 | . | . | 0.69 |
| CDU/CSU AfD Linke | 0.35 | . | 0.6 | . | 0.72 | . |
| CDU/CSU AfD FDP | 0.27 | . | 0.55 | 0.54 | . | . |
| SPD FDP Linke Grüne | . | 0.37 | . | 0.64 | 0.61 | 0.56 |
| SPD AfD Linke Grüne | . | 0.41 | 0.65 | . | 0.63 | 0.59 |
| SPD AfD FDP Grüne | . | 0.44 | 0.62 | 0.62 | . | 0.68 |
| SPD AfD FDP Linke | . | 0.46 | 0.62 | 0.62 | 0.7 | . |

**Figure 5.** Minimum office weighting parameters for single parties to make the coalitions viable.

utilities in a grand coalition, whereas the four smaller parties' best option is opposition. This result is reflected in figure 7, as only the two larger parties hold positive utility values – the largest in the CDU/CSU-SPD option – whereas the smaller parties' utility values are negative for all options but 'opposition'. Figure 7's additional benefit is to uncover details. If the user, for example, wants to know if the grand coalition is the only positively evaluated option for the SPD at $\alpha = 0.5$, then she learns that this is not the case, but the SPD draws positive utilities from all coalitions in which it is member. Or the user learns that the Christian Democrats evaluate the Jamaica coalition ($u = 0.206$) not dramatically worse than the grand coalition ($u = 0.230$). The conclusion at figure 7's bottom, however, confirms that in this setting, the grand coalition is the most likely outcome of the coalition formation process.

Figure 8 shows Coalizer's output for intrinsically policy-motivated parties. The results are the same like in figure 7 for coalition members but differ for opposition parties. When we assume that coalitions' policy outputs matter also for opposition parties, strategies for AfD, FDP, the Left, and the Greens should change, since now, their highest utilities can be expected in a CDU/CSU-AfD-FDP coalition (for AfD and FDP) or a CDU/CSU-Left-Greens coalition, respectively (for the Left and the Greens). Again, the detailed information for all parties and all coalition can be helpful to understand the formation process as a whole. Comparing the Greens' utility values for the grand coalition and the Jamaica coalition, for example, we detect a higher value for the latter. This means that a game in which the choice set is reduced to these two options provides incentives for the Greens to negotiate about the Jamaica option, if they are intrinsically motivated by policy, but to refuse such negotiations when extrinsically policy-motivated (cf. figure 7). The same holds true for the FDP.

Actually, the coalition formation process after the German 2017 federal elections proceeded as follows. In the beginning, CDU/CSU, Greens and FDP met for exploratory talks, after the SPD refused to participate in any government. Such talks can be explained by rather policy-motivated Social Democrats ($\alpha < 0.3$) and Christian Democrats who then tried to implement their second-best coalition option. After having abandoned the exploratory talks with CDU/CSU and Greens, the FDP reasoned their decision as follows: CDU/CSU would concede more influence on coalition policies to the Greens

than to the FDP (Faas & Klingelhöfer, 2019). Hence, this coalition lost its desirability on part of the FDP. Regarding figure 6, this argument is comprehensible: The Greens should have preferred other coalitions or being in the opposition. Thus, the CDU/CSU could have made more policy concessions to the Greens than to the FDP. In the end, the grand coalition was formed by CDU/CSU and SPD (Bräuninger et al., 2019). With respect to the results of Coalizer, this coalition is expected to be the most closely aligned with realistic party motivations (cf. figure 6 to figure 8).

## Conclusion

In our contribution, we presented a new coalition tool called Coalizer which takes both office and policy motivations of political parties into account and reflects the state of coalition theory. As data input, Coalizer needs information about party positions as well as seat distributions in the parliament. While the latter can easily come from various sources, getting accurate quantitative data on positional similarities and dissimilarities of parties can be challenging. One of Coalizer's benefits is its ability to operate with any kind of party positions. Our tool handles one- and

| Utility Maximizing Choices |
|---|
| CDU/CSU: "opposition" for an office orientation between 0 and 20 percent |
| CDU/CSU: "CDU/CSU SPD" for an office orientation between 21 and 86 percent |
| CDU/CSU: "CDU/CSU FDP Grüne" for an office orientation between 87 and 89 percent |
| CDU/CSU: "CDU/CSU Linke Grüne" for an office orientation between 90 and 100 percent |
| SPD: "opposition" for an office orientation between 0 and 29 percent |
| SPD: "CDU/CSU SPD" for an office orientation between 30 and 71 percent |
| SPD: "SPD FDP Linke Grüne" for an office orientation between 72 and 100 percent |
| AfD: "opposition" for an office orientation between 0 and 54 percent |
| AfD: "CDU/CSU AfD FDP" for an office orientation between 55 and 88 percent |
| AfD: "SPD AfD FDP Grüne" for an office orientation between 89 and 92 percent |
| AfD: "SPD AfD Linke Grüne" for an office orientation between 93 and 100 percent |
| FDP: "opposition" for an office orientation between 0 and 53 percent |
| FDP: "CDU/CSU AfD FDP" for an office orientation between 54 and 81 percent |
| FDP: "CDU/CSU FDP Grüne" for an office orientation between 82 and 88 percent |
| FDP: "SPD FDP Linke Grüne" for an office orientation between 89 and 100 percent |
| Linke: "opposition" for an office orientation between 0 and 59 percent |
| Linke: "CDU/CSU Linke Grüne" for an office orientation between 60 and 74 percent |
| Linke: "SPD FDP Linke Grüne" for an office orientation between 75 and 100 percent |
| Grüne: "opposition" for an office orientation between 0 and 53 percent |
| Grüne: "CDU/CSU Linke Grüne" for an office orientation between 54 and 78 percent |
| Grüne: "SPD FDP Linke Grüne" for an office orientation between 79 and 100 percent |

**Figure 6.** Most preferred coalitions depending on weighting parameters.

Total Utilities for Extrinsically Policy-Motivated Parties

| | CDU/CSU | SPD | AfD | FDP | Linke | Grüne |
|---|---|---|---|---|---|---|
| Office Weighting Parameter | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Policy Weighting Parameter | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| CDU/CSU SPD | 0.23 | 0.113 | 0 | 0 | 0 | 0 |
| CDU/CSU Linke Grüne | 0.14 | 0 | 0 | 0 | -0.044 | -0.014 |
| CDU/CSU FDP Grüne | 0.206 | 0 | 0 | -0.036 | 0 | -0.082 |
| CDU/CSU FDP Linke | 0.18 | 0 | 0 | -0.039 | -0.119 | 0 |
| CDU/CSU AfD Grüne | 0.171 | 0 | -0.058 | 0 | 0 | -0.1 |
| CDU/CSU AfD Linke | 0.145 | 0 | -0.056 | 0 | -0.128 | 0 |
| CDU/CSU AfD FDP | 0.19 | 0 | -0.02 | -0.013 | 0 | 0 |
| SPD FDP Linke Grüne | 0 | 0.088 | 0 | -0.081 | -0.05 | -0.023 |
| SPD AfD Linke Grüne | 0 | 0.065 | -0.105 | 0 | -0.058 | -0.038 |
| SPD AfD FDP Grüne | 0 | 0.046 | -0.072 | -0.06 | 0 | -0.09 |
| SPD AfD FDP Linke | 0 | 0.034 | -0.071 | -0.062 | -0.116 | 0 |

Utility Maximizing Coalitions

| Party | Utility Value | Coalition |
|---|---|---|
| CDU/CSU | 0.23 | CDU/CSU SPD |
| SPD | 0.113 | CDU/CSU SPD |
| AfD | 0 | in opposition |
| FDP | 0 | in opposition |
| Linke | 0 | in opposition |
| Grüne | 0 | in opposition |

Expected Coalition(s)

CDU/CSU SPD

**Figure 7.** Total utilities for extrinsically policy-motivated parties.

two-dimensional policy positions – which is typically provided by manifesto analyses or expert surveys – as well as high-dimensional policy spaces like they are generated by VAAs. As a web application, Coalizer is online available and can simply be used with common web browsers. Among others, our tool includes the following features:

- identification of (minimal) winning coalitions (but not minority coalitions),
- computation of office utility values basing on seat distributions,
- computation of policy utility values basing on party positions (supporting weightable

| Total Utilities for Intrinsically Policy-Motivated Parties | | | | | | |
|---|---|---|---|---|---|---|
| | **CDU/CSU** | **SPD** | **AfD** | **FDP** | **Linke** | **Grüne** |
| Office Weighting Parameter | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Policy Weighting Parameter | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| CDU/CSU SPD | 0.23 | 0.113 | -0.244 | -0.191 | -0.25 | -0.178 |
| CDU/CSU Linke Grüne | 0.14 | -0.138 | -0.277 | -0.231 | -0.044 | -0.014 |
| CDU/CSU FDP Grüne | 0.206 | -0.152 | -0.233 | -0.036 | -0.235 | -0.082 |
| CDU/CSU FDP Linke | 0.18 | -0.167 | -0.231 | -0.039 | -0.119 | -0.187 |
| CDU/CSU AfD Grüne | 0.171 | -0.171 | -0.058 | -0.193 | -0.241 | -0.1 |
| CDU/CSU AfD Linke | 0.145 | -0.187 | -0.056 | -0.195 | -0.128 | -0.202 |
| CDU/CSU AfD FDP | 0.19 | -0.217 | -0.02 | -0.013 | -0.314 | -0.272 |
| SPD FDP Linke Grüne | -0.189 | 0.088 | -0.268 | -0.081 | -0.05 | -0.023 |
| SPD AfD Linke Grüne | -0.207 | 0.065 | -0.105 | -0.227 | -0.058 | -0.038 |
| SPD AfD FDP Grüne | -0.155 | 0.046 | -0.072 | -0.06 | -0.224 | -0.09 |
| SPD AfD FDP Linke | -0.173 | 0.034 | -0.071 | -0.062 | -0.116 | -0.189 |

| Utility Maximizing Coalitions | | |
|---|---|---|
| Party | Utility Value | Coalition |
| CDU/CSU | 0.23 | CDU/CSU SPD |
| SPD | 0.113 | CDU/CSU SPD |
| AfD | -0.02 | CDU/CSU AfD FDP |
| FDP | -0.013 | CDU/CSU AfD FDP |
| Linke | -0.044 | CDU/CSU Linke Grüne |
| Grüne | -0.014 | CDU/CSU Linke Grüne |

**Figure 8.** Total utilities for intrinsically policy-motivated parties.

coalition policies depending on the party strengths'),
- visualization of party distances,
- a weighted combination of office and policy utility values, and
- showing utility maximizing strategies for parties and equilibria based on the combined utility values.

Our tool goes therefore beyond yet existing tools which either consider solely office (e.g. Spiegel Bauer et al., 2019; FAZ.net, 2019; Online, 2018) or policy aspects (e.g. Bolte, 2017; Rusinowska et al., 2005) of coalition formation. Further, other than most currently available coalition software, users can upload own data for analyses. Third, Coalizer is designed as a simply operable web application that can be used with common browsers also by users without knowledge in programming – in contrast to many former tools (e.g. Rusinowska et al., 2005; Shikano & Becker, 2009).

By providing an 'easy mode' and an 'expert mode', Coalizer can be applied both by specialists in formal coalition theory as well as by less experienced users.

From a party leader's point of view, our coalition tool provides support in identifying this party's utility maximizing coalition option. From the electorates' perspective, Coalizer can figure out whether a party elected by a single voter decided in her best interest after negotiating different coalition options. Academics and journalists will be able to obtain substantiated findings on coalition formation outcomes by the use of Coalizer. Thus, coalition tools foster transparency in multi-party systems, and establish new computerized approaches for the examination of political processes in general.

As regards the conceptual framework to which Coalizer refers, we could demonstrate that the utility-based concepts of the third-generation coalition theories can be helpful in order to understand parties' motives. Our illustrative example should certainly not be misinterpreted as an empirical test. But this example shows how different specifications – like the selection of intrinsically or extrinsically policy-motivated parties or the choice of weighting parameters – can change results. An investigation of which model specifications succeed in matching with real world observations – which can certainly differ between countries and change over time – can additionally deepen our understanding of coalition formation processes.

## Notes

1. A formateur is a politician who is (typically) appointed by the head of state in order to organize a coalition formation process. If she succeeds, it is usually her party leading the government and she becoming the head of government, so that coalitions against the formateur's party are unlikely in systems where formateurs are known (such as the Netherland or Israel, in contrast to Germany).
2. Recent approaches estimate policy positions based on approaches such as social media analyses (Ecker, 2017; Guerrero-Solé & Lopez-Gonzalez, 2019). Certainly, Coalizer is also able to process data from such approaches.
3. We are grateful to one of the Reviewers for this valuable hint.
4. See section 4.2. for details.
5. Formally, CDU and CSU are two different parties, but they never compete with each other in elections and always form a common party group so that it makes sense to treat them as unity in coalition-theoretic approaches.
6. The exact positions can be found in the Appendix.
7. Coalizer includes several information boxes. If a user is not sure what a certain function or abbreviation means, scrolling over the 'i'-icon reveals more information. For example, here, the user is informed about the meaning of *k*.

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## Appendix – Upload File for the 2017 German Federal Elections (Wahl-O-Mat)

Figure A1 shows the .txt-upload file for the case of German Federal Elections in 2017. Party positions originate from the German VAA "Wahl-O-Mat zur Bundestagswahl". The first row represents parties (CC = CDU/CSU, S = SPD, A = AfD, F = FDP, L = The Left, G = Alliance 90/The Greens), the second row represents the distribution of seats. From the third to the last line, policy positions in an $n$-dimensional space are indicated.

| CC | S | A | F | L | G |
|---|---|---|---|---|---|
| 246 | 153 | 94 | 80 | 69 | 67 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 1 | 1 |
| 0.5 | 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 | 1 | 1 |
| 0 | 0.5 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 0.5 | 0 | 0 |
| 0 | 0.5 | 0 | 0 | 1 | 1 |
| 0 | 0 | 0 | 0 | 1 | 1 |
| 1 | 0.5 | 1 | 1 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 | 1 |
| 0.5 | 0 | 1 | 0 | 1 | 1 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0.5 | 1 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 | 1 |
| 0.5 | 0 | 1 | 1 | 0 | 0 |
| 0.5 | 1 | 1 | 0 | 1 | 1 |
| 0.5 | 1 | 0 | 1 | 0 | 0 |
| 1 | 1 | 0.5 | 1 | 0 | 1 |
| 0.5 | 1 | 0 | 1 | 1 | 1 |
| 0 | 0 | 0.5 | 0.5 | 1 | 0 |
| 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 | 0 |
| 0.5 | 0.5 | 0 | 0 | 1 | 1 |
| 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 0 | 1 | 1 |
| 1 | 1 | 0 | 1 | 1 | 1 |
| 1 | 0 | 1 | 1 | 0 | 0 |
| 0 | 0.5 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 1 | 1 | 1 |
| 0.5 | 0 | 1 | 1 | 0 | 0.5 |
| 1 | 1 | 1 | 1 | 0 | 0.5 |
| 1 | 1 | 0 | 0.5 | 1 | 1 |
| 1 | 1 | 1 | 0.5 | 0 | 1 |
| 0 | 0.5 | 0 | 0 | 0.5 | 0.5 |
| 1 | 1 | 0 | 1 | 0.5 | 1 |

**Figure A1.** Upload file for the 2017 German federal elections (Wahl-O-Mat).