COALIZER

A Coalition Tool Combining Office and Policy Motivations of Political Parties

Robin Graichen	graro@hrz.tu-chemnitz.de
Hanns-Seidel-Foundation Scholarship Holder	Chemnitz University of Technology, Germany
Eric Linhart	eric.linhart@phil.tu-chemnitz.de
Faculty of Humanities, Department of Political Science	Chemnitz University of Technology, Germany
Christopher Schuster	cschuste@ucsc.edu
Jack Baskin School of Engineering	University of California, Santa Cruz, USA
Udo Heller	udoheller@gmx.de
Faculty of Computer Science	Chemnitz University of Technology, Germany
Andreas Müller	anmu@cs.tu-chemnitz.de
Faculty of Computer Science, Faculty Computing Center	Chemnitz University of Technology, Germany

Paper prepared for the 2018 Annual Conference of the European Consortium for Political Research, August 22-25, 2018 Hamburg.

Coalizer is available online at

www.mytuc.org/mcbz

1 Introduction

"Coalition formation is a problem of great interest in artificial intelligence, allowing groups of autonomous, rational agents to form stable teams" (Chalkiadakis et al. 2007). While coalition formation processes can be found in many disciplines in the broader sense, it is in particular an important aspect in the field of politics and political science: Between 1945 and 2009, 337 elections in European democracies were held. Single-party majorities were reached in only 47 cases (Döring/Hellström 2013). Hence, formation of governmental coalitions between two or more political parties is a typical procedure in multiparty systems following an election (Saalfeld 2007). There are often several different coalition options that can be formed by parties. Since coalition building processes are delaying the adjuration of governments, knowledge of coalition formation is exceedingly relevant.

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. von Neumann/Morgenstern 1944; Riker 1962) or on policy motivations (e.g. Leiserson 1966; DeSwaan 1973) of parties, more recent theories combine both types of motivation (e.g. Austen-Smith/Banks 1988; Sened 1995, 1996; Baron/Diermeier 2001; Schofield/Sened 2006). They are therefore more appropriate for explaining coalition formation but, at the same time, they are also more complicated. As a consequence, they are difficult to use for non-experts in formal coalition theory. Political scientists who have no specialized knowledge in formal coalition building as well as interested members of the public should be provided an opportunity to use those models since they represent the state of the art and can explain coalition building outcomes. Furthermore, more recent coalition theories aim for showing utility maximizing strategies for parties and equilibria. Thus, conclusions regarding possibly stable coalition governments can be drawn even in the absence of coalition statements by parties.

One approach for making formal coalition theories more broadly applicable are coalition tools. With applications that facilitate recent coalition theories, results can be analyzed by a wide range of users such as academics, politicians, journalists, and the general public. Existing tools available for coalition building do not incorporate advances from more recent theories and are often confined to the identification of winning or minimal winning coalitions such as tools provided by online versions of newspapers, e.g. Spiegel online and FAZ.net in Germany. Other tools are often part 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 more recent, empirically tested and approved coalition theories and adopt either an office- or a policy orientated approach (e.g. Becker 2005; Shikano/Becker 2009; Rohn et al. 2016).[1] To summarize, existing tools either fail to accurately model 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. Coalizer is explicitly targeted at multi-issue data as it is provided by Voting Advice Applications (VAAs) for many recent elections. The proliferation of VAAs provides a new alternative for obtaining party position data. Multi-issue data used by such VAAs has several advantages: it is generated close to elections, it is proclaimed to include the relevant topics of an election, and often publicly available. Our coalition tool considers the complexity of recent office and policy orientated 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 recent 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 analysis, we argue that there is need for a new, more elaborate tool that supports the ad-hoc use of multi-issue data as provided by VAAs 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 at the example of the German federal elections in 2017. Finally, section 5 concludes the paper with a brief summary and an outlook.

2 Overview of Coalition Theories

According to Müller/Strøm (1999), parties seek three primary objectives. First, they aim to be successful in elections (vote motivation). Second, they aim 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 (Laver/Schofield 1990; Saalfeld 2007; Linhart 2013).

The most basic coalition theories[2] 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 (Leiserson 1968) since there are fewer parties to share offices with. In particular, parties which are not needed for a coalition's majority in parliament are not

[1] A more detailed review of existing coalition tools is given in section 3.

[2] A detailed survey of all published coalition theories is beyond the scope of this paper. We rather sketch the general development of coalition research and outline the current state of the art.

expected to be members in coalitions (von Neumann/Morgenstern 1944). Formally, the respective concept of minimal winning coalitions (MWC) is defined as

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

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 so-called 'Gamson's Law' has widely been confirmed empirically (Warwick/Druckman 2006; Carroll/Cox 2007). 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 coalition theories has been developed which include policy motivations. Generally, these theories are based on policy positions y_p of parties p on a left/right scale and expect coalitions to be more likely if party positions 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 et al. (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: 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 offices motivations. As both office and policy facets are important for parties, 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

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

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):

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

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; Baron/Diermeier 2001; Bandyopadhyay/Oak 2008; Morelli 1999; Sened 1995, 1996). Despite the usage of similar utility functions, these 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. For simplicity reasons, these models are often limited to three-party-systems or one-dimensional policy spaces.

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 are estimated as (weighted) means of the governing parties' positions. Thus, the utility functions can be specified as

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

We discuss minor modifications of this function in section 4.

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: 303-304). Our coalition tool is able to handle both options.

Third, the model of Sened (1995, 1996) includes party-specific weighting parameters, α_p and β_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, for the specified form, as

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

3 Review of Existing Coalition Tools

In this section, we investigate how existing coalition tools reflect the state of the art of coalition formation theories. Non-scientific 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 online 2018; FAZ.net 2016). 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.

Conversely, the tool koal-o-mat (Bolte 2017) considers solely policy factors. It accesses data from the VAA Wahl-O-Mat for – currently – 43 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. Künsebeck (2018) recently presented a similar application with similar issues.

A more complex and sophisticated coalition tool – KOALA – was introduced by Becker (2005) and Shikano/Becker (2009). KOALA is designed as 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 R-package, KOALA does not include a graphical user interface, cannot be executed as stand-alone-application and is difficult to use for non-experts. Furthermore, more recent coalition theories such as third-generation theories are not currently supported by KOALA. Besides KOALA, several other R packages that solve similarly simple coalition games can be downloaded via the CRAN project website.[3]

The Rusinowska et al. model can be computed with various software tools such as Macbeth and Relview (Roubens et al. 2006; Berghammer et al. 2007). 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 et al. 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 neglected.

Finally, Rohn et a. (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 Appendix 2).

To summarize, existing coalition tools do not adequately reflect the current state of the art in recent office- and policy-orientated coalition theories and are often not designed as stand-alone applications that can be used both by lay users and experts.

4 Coalizer

As outlined in the previous section, there is a considerable discrepancy between the current state of coalition theory and existing coalition tools. In particular, none of the tools support the most elaborate third-generation coalition theories. Our paper aims to reduce this gap by introducing the new coalition tool called Coalizer. In contrast to existing tools, 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. We first describe the functionality of Coalizer and then demonstrate its practical usability for analyzing coalition formation after the German federal elections in 2017.

[3] Comprehensive R Archive Network, https://cran.r-project.org. For example, Package ‚GameTheory', Cano-Berlanga et al. (2015); Package ‚GameTheoryAllocation', Saavedra-Nieves (2016).

4.1 Functionality

Coalizer is available online at www.mytuc.org/mcbz.[4]

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 modelling which is used by the *Analysis* part. The contents of the *Theory* page 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 past elections. These are listed at the subpage *Elections*. Most of the provided examples refer to German federal and state level elections and contain party positions from the Wahl-O-Mat, the most widely used VAA in Germany.[5] By navigating to the subpage *Analysis* and selecting the respective data, the user can study one of the provided coalition formation processes directly. 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.[6] 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. The latter can be of any dimension. Positions on a unidimensional left/right scale are possible as well as vectors in n-spaces. While there are no further formal prerequisites, we strongly recommend to normalize the data to $[0; 1]^n$ spaces. 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 Appendix 1.

The *Analysis* subpage 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 datasets that was

[4] The link is the shortened URL for https://www.informatik.tu-chemnitz.de/coalizer/web/start_en

[5] Positions are coded within the [0; 1] interval with 1 standing for agreement with a VAA question, 0 represents disagreement, and 0.5 refers to indifference.

[6] Coalizer can process both .txt and .csv file formats.

uploaded, entered, or provided. Below, the user selects whether she wants to see results including all winning coalitions or minimal winning coalition only.[7] 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). They can either be computed as Euclidean distances

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

or according to a Cityblock metric

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

Both measures are normalized with regard to the dimension of the policy space. Coalition policies y_C are estimated as (unweighted) policy means of all parties that are members of a coalition.

In addition, the coalition tool also determines the pairwise distances between all parties and depicts them as a two-dimensional 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.

In the next step 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. All modes consider the weighting parameters α_p and β_p which must be entered at the page's bottom manually.[8] By default, all parameters are set to 0.5 leading to a uniform/balanced weighting like if no parameters were included.

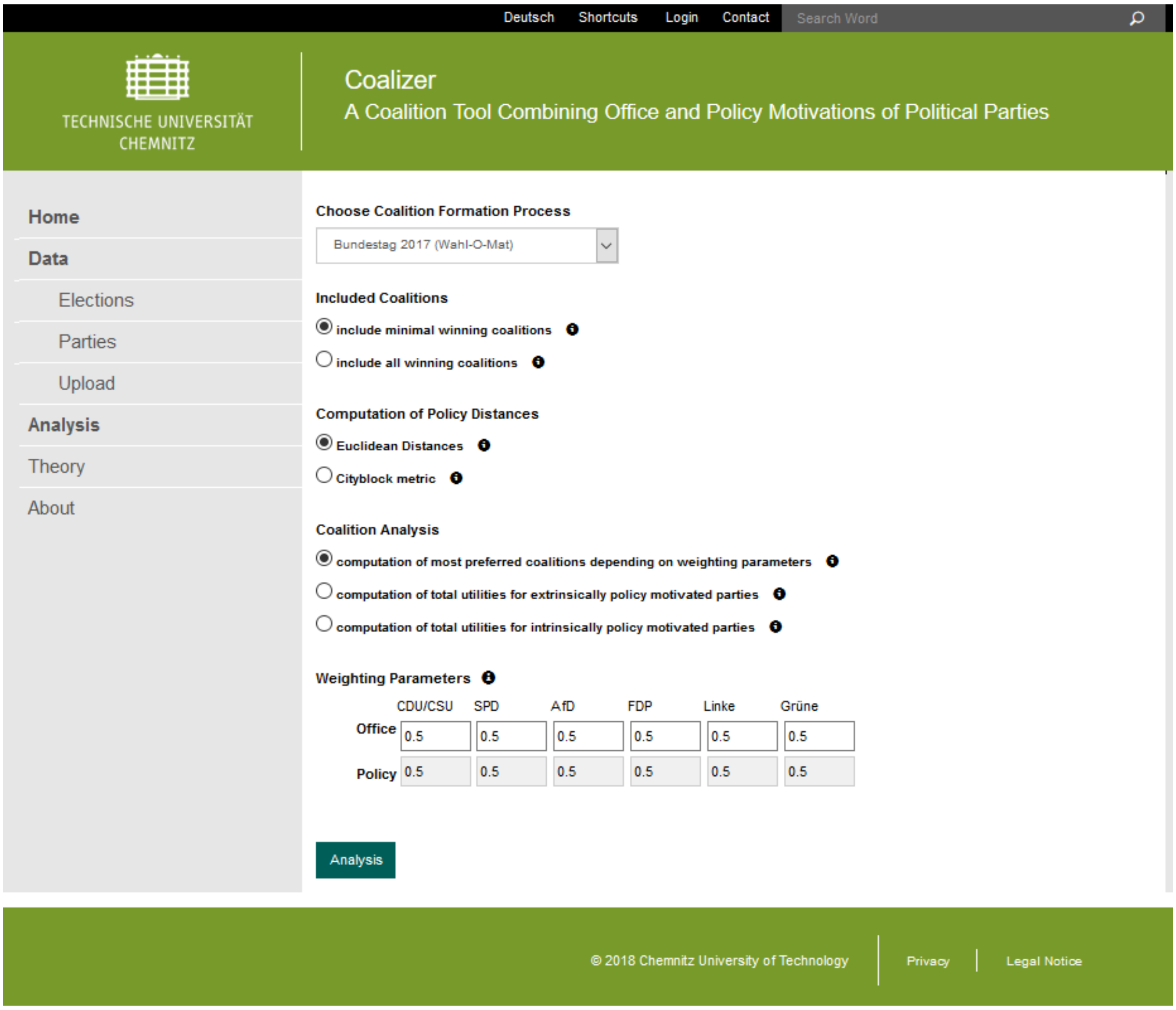
All options show the same basic information on the top: a visualization of the seat distribution and distances between the parties, a table with basic details about the (minimal) winning coalitions, parties' office utilities for each (minimal) winning coalition according to Gamson's Law, and the distances between y_p and y_C according to the selected specifications.[9]

7 Minority governments will be included in a later step.

8 Since the sum of both degrees is 100% = 1, the policy weighting parameter is automatically computed by Coalizer as $\beta_p = 1 - \alpha_p$. Finding equilibria also for the second analysis option, purely intrinsically policy motivated parties, will be included in a later step.

9 A more detailed explanation will follow in subsection 4.2.

Figure 1: Analysis page



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) the entered weight parameters do not play a role, as all utility maximizing coalitions and 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 modelled 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 α_p for which $u_p(C)$ is neutral or positive, formally

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

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

Finally, when using this option, Coalizer computes the most preferred coalitions depending on the weight 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 α_p^{min} value and ending at the maximum α_p value of 1. For others, the utility maximizing coalition can depend on the exact degrees of office and policy motivation. In these cases, the upper limits of a preferred coalition correspond to the lower bounds of the coalition mentioned in the line below.

The second analysis option assumes purely extrinsically policy orientated parties, too. This option additionally shows the total utility of all parties in all selected coalitions on the basis of the formula above and the entered weighting parameters. 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 (expected coalition). This search proceeds in 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 fulfils the necessary condition, Coalizer states that no coalition government is expected. This might indicate that early elections can take place or caretaker governments will be installed.

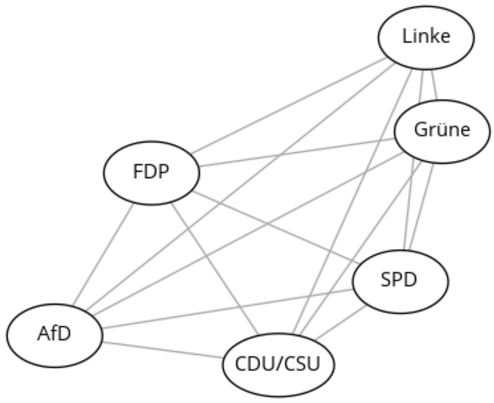
The third analysis option assumes purely intrinsically policy orientated parties. This means that a government's policy output is an important factor even for opposition parties, so their utility functions do not differ from those of government parties. The respective table with total utility values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

4.2 Application: the German Federal Elections in 2017

For a deeper understanding of Coalizer, we demonstrate its functionality at the example of the latest German federal elections which were held on 24 September 2017. Seven parties (six, if we treat CDU and CSU as a unity) made it into the parliament. Screenshots of party distances and seat distributions of possible coalitions are shown on Figure 2. Coalizer also depicts the distribution of seats in a pie chart to illustrate the absolute majority (not shown in Figure 2).

We limit the example to the set of all possible minimal winning coalitions. Column (k) indicates the total number of seats of each coalition. The number of parties carrying a coalition is given in column (n).[10] The difference (d) results from the number of seats (k) and the absolute majority. Additionally, all minimal winning coalitions are marked in column (m) to differentiate these coalitions from other winning coalitions.

Figure 2: Visualization of policy distances and distribution of seats



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

10 CDU and CSU are treated as one fraction.

Two of these 11 minimal winning coalitions are of particular importance: The so-called grand coalition between CDU/CSU and SPD formed the incumbent government. According to pre-ballot 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.

Policy distances plotted in Figure 2 result from the parties' positions given in the German VAA Wahl-O-Mat. The exact positions can be found in Appendix 1. According to the policy distances graph, the largest pairwise difference exists between the Left and the Alternative for Germany (AfD). Their policies differ to a great extent whereas the Greens have the most similarity with the Left.

A screenshot of the 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 office positions, CDU/CSU could achieve its highest office 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).

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.

Coalizer computes and indicates policy distances both for governing and opposition parties in each coalition. A screenshot of the Euclidean policy distances is given in Figure 4. Only one of the possible coalitions fulfills the criterion of being most preferred by all involved parties: the grand coalition would be aspired by a purely policy motivated CDU/CSU as well as by a purely policy motivated SPD. The policy distances of both parties are the lowest in their joint coalition (0.243) compared to any other coalition option. Assuming to be purely policy motivated, AfD and FDP as well as the Left and the Greens would prefer to form a coalition government with CDU/CSU. Here, the Green party (0.245) positions closer than the Left (0.399) and the FDP (0.290) positions closer than the AfD (0.355) to their ideal policies. Hence, the Jamaica coalition is not the most preferred coalition of any of its members. Since

CDU/CSU as well as SPD would achieve minimum policy distances by forming the grand coalition, this coalition is an equilibrium solution regarding policy motivations solely. Same conclusions can be drawn using Cityblock distances (cf. Figure 5).

Figure 3: Office utilities

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 4: Euclidean policy distances

Euclidean Policy Distances	CDU/CSU	SPD	AfD	FDP	Linke	Grüne
CDU/CSU SPD	0.243	0.243	0.612	0.5	0.623	0.493
CDU/CSU AfD Grüne	0.322	0.406	0.409	0.448	0.549	0.425
CDU/CSU AfD Linke	0.368	0.428	0.399	0.448	0.477	0.456
CDU/CSU AfD FDP	0.312	0.522	0.355	0.29	0.698	0.627
CDU/CSU FDP Linke	0.34	0.405	0.537	0.34	0.474	0.443
CDU/CSU FDP Grüne	0.295	0.385	0.547	0.343	0.549	0.415
CDU/CSU Linke Grüne	0.445	0.364	0.638	0.555	0.339	0.245
SPD AfD Linke Grüne	0.49	0.329	0.532	0.538	0.358	0.292
SPD AfD FDP Grüne	0.391	0.342	0.446	0.378	0.515	0.408
SPD AfD FDP Linke	0.423	0.364	0.442	0.382	0.46	0.434
SPD FDP Linke Grüne	0.477	0.31	0.618	0.477	0.359	0.282

Figure 5: Cityblock policy distances

Cityblock 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 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
CDU/CSU FDP Linke	0.263	0.333	0.461	0.281	0.412	0.373
CDU/CSU FDP Grüne	0.215	0.303	0.465	0.276	0.469	0.333
CDU/CSU Linke Grüne	0.364	0.276	0.553	0.461	0.268	0.202
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
SPD FDP Linke Grüne	0.378	0.24	0.536	0.378	0.286	0.227

Figure 6: Minimum office weighting parameters

Minimal Office Weighting Parameter for Positive Total Utilities						
	CDU/CSU	**SPD**	**AfD**	**FDP**	**Linke**	**Grüne**
CDU/CSU SPD	0.29	0.39	.	.	.	.
CDU/CSU AfD Grüne	0.35	.	0.64	.	.	0.73
CDU/CSU AfD Linke	0.38	.	0.64	.	0.74	.
CDU/CSU AfD FDP	0.35	.	0.62	0.61	.	.
CDU/CSU FDP Linke	0.36	.	.	0.63	0.74	.
CDU/CSU FDP Grüne	0.33	.	.	0.63	.	0.71
CDU/CSU Linke Grüne	0.41	.	.	.	0.66	0.59
SPD AfD Linke Grüne	.	0.46	0.69	.	0.67	0.63
SPD AfD FDP Grüne	.	0.47	0.66	0.66	.	0.71
SPD AfD FDP Linke	.	0.49	0.66	0.66	0.73	.
SPD FDP Linke Grüne	.	0.43	.	0.69	0.66	0.61

After having computed office and policy utilities, Coalizer then evaluates both components in order to determine the minimum office weighting parameters (first analysis option). A screenshot of the outcomes is given in Figure 6. With respect to CDU/CSU and SPD, the formation of the grand coalition seems particularly favorable. Both parties achieve positive utilities with least possible office motivations (CDU/CSU: 0.29, SPD: 0.39). On the other hand, there is no coalition option for AfD, FDP, the Left, or the Greens, in which one of the parties could be assumed to have a lower office than policy motivation. Regarding the Jamaica coalition, especially the Greens would need to be extremely office motivated in order to gain positive utility.

Depending on all possible combinations of office and policy orientations, Coalizer finally determines those coalitions in which parties can expect maximum utilities compared to all coalition options. A screenshot of the outcomes for our example is shown in Figure 7.

Figure 7: Most preferred coalitions depending on weighting parameters

Most Preferred Minimal Winning Coalitions Depending on Weighting Parameters
CDU/CSU: Preferred Coalition of "CDU/CSU SPD " starting at a office weighting parameter of 0.29
CDU/CSU: Preferred Coalition of "CDU/CSU FDP Grüne " starting at a office weighting parameter of 0.86
CDU/CSU: Preferred Coalition of "CDU/CSU Linke Grüne " starting at a office weighting parameter of 0.9
SPD: Preferred Coalition of "CDU/CSU SPD " starting at a office weighting parameter of 0.39
SPD: Preferred Coalition of "SPD FDP Linke Grüne " starting at a office weighting parameter of 0.68
AfD: Preferred Coalition of "CDU/CSU AfD FDP " starting at a office weighting parameter of 0.62
AfD: Preferred Coalition of "SPD AfD FDP Grüne " starting at a office weighting parameter of 0.86
AfD: Preferred Coalition of "SPD AfD Linke Grüne " starting at a office weighting parameter of 0.94
FDP: Preferred Coalition of "CDU/CSU AfD FDP " starting at a office weighting parameter of 0.61
FDP: Preferred Coalition of "CDU/CSU FDP Grüne " starting at a office weighting parameter of 0.8
FDP: Preferred Coalition of "SPD FDP Linke Grüne " starting at a office weighting parameter of 0.92
Linke: Preferred Coalition of "CDU/CSU Linke Grüne " starting at a office weighting parameter of 0.66
Linke: Preferred Coalition of "SPD FDP Linke Grüne " starting at a office weighting parameter of 0.77
Grüne: Preferred Coalition of "CDU/CSU Linke Grüne " starting at a office weighting parameter of 0.59
Grüne: Preferred Coalition of "SPD FDP Linke Grüne " starting at a office weighting parameter of 0.85

Coalizer lists all preferred coalitions for each party and indicates the minimum office weighting parameter for each coalition. With respect to CDU/CSU, the coalition with the Social Democrats (SPD) is most preferred in a wide range of office motivation (0.29 to 0.85), followed by the Jamaica Coalition (0.86 to 0.89). An extremely office motivated CDU/CSU (0.90 to 1.00) would even find its maximum utility in a coalition with the Left and the Greens. The SPD prioritizes the grand coalition within a wide range of office motivations as well

(0.39 to 0.67). With an office motivation starting at a value of 0.68 the SPD prefers the coalition with FDP, the Left, and the Greens.

With respect to the Jamaica coalition, the FDP would prefer this coalition option within an office motivation of 0.80 to 0.91, but an alliance with CDU/CSU and FDP is not preferred by the Greens with any combination of office and policy motivation. Thus, the Jamaica coalition is – in contrast to the grand coalition – no equilibrium solution. Furthermore, there are two other equilibria depending on weighting parameters: coalition between CDU/CSU, the Left, and the Greens as well as a coalition between SPD, FDP, the Left, and the Greens would be an equilibrium solution only if the involved parties would be extremely office motivated. However, both coalition options can be interpreted as very unrealistic. Thus, the grand coalition is more likely than the other equilibria and can be expected as solution to the coalition formation process.

If the user wants to compare the parties' total utilities with self-specified weighting parameters, the second and the third analysis option can be chosen. Using weighting parameters of 0.5 each, Coalizer computes total utilities that can be interpreted as if the parties were equally office and policy motivated. Screenshots of the outcomes of 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 8 and 9.

In case of purely extrinsically policy motivated parties, only the grand coalition is a solution that fulfills the criterion of being positively evaluated by all involved parties. Thus, an alliance between CDU/CSU and SPD represents an equilibrium solution satisfying the sufficient condition. However, the SPD’s utility value being only slightly positive can explain the Social Democrats’ reluctance to enter a grand coalition. On the other hand, AfD, FDP, the Left and the Greens do not achieve positive utilities in any coalition and therefore might prefer going in opposition.

Assuming parties to be purely intrinsically policy motivated, utility maximizing coalitions for AfD, FDP, the Left, and the Greens can be identified as well. AfD and FDP expect highest utilities in coalition with CDU/CSU, even the Left and the Greens achieve maximum utilities in coalition with CDU/CSU compared to all coalition options. The grand coalition is utility maximizing for CDU/CSU and SPD.

Figure 8: Total utilities for extrinsically policy orientated parties

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	0.187	0.07	0	0	0	0
CDU/CSU Linke Grüne	0.1	0	0	0	-0.079	-0.035
CDU/CSU FDP Grüne	0.166	0	0	-0.07	0	-0.123
CDU/CSU FDP Linke	0.142	0	0	-0.069	-0.15	0
CDU/CSU AfD Grüne	0.141	0	-0.089	0	0	-0.13
CDU/CSU AfD Linke	0.117	0	-0.085	0	-0.154	0
CDU/CSU AfD FDP	0.137	0	-0.066	-0.05	0	0
SPD FDP Linke Grüne	0	0.053	0	-0.13	-0.086	-0.05
SPD AfD Linke Grüne	0	0.035	-0.144	0	-0.089	-0.059
SPD AfD FDP Grüne	0	0.023	-0.104	-0.088	0	-0.119
SPD AfD FDP Linke	0	0.011	-0.103	-0.09	-0.143	0

UtotMax(CDU/CSU) = 0.187 in coalition CDU/CSU SPD
UtotMax(SPD) = 0.07 in coalition CDU/CSU SPD
UtotMax(AfD) = 0 in opposition
UtotMax(FDP) = 0 in opposition
UtotMax(Linke) = 0 in opposition
UtotMax(Grüne) = 0 in opposition

Expected Coalition(s): CDU/CSU SPD

In the aftermath of the 2017 federal elections, CDU/CSU, Greens and FDP met for exploratory talks. 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 (Focus Online 2017). Hence, this coalition lost its desirability on part of the FDP. Regarding Figure 7, this argument is comprehensible: The Greens preferred other (equilibrium) coalitions or being in the opposition depending on their office motivation. Thus, CDU/CSU could have made more policy concessions to the Greens than to the FDP. Finally, the grand coalition was formed by CDU/CSU and SPD (Die Bundesregierung 2018). With respect to the results of Coalizer, this coalition is expected to be the most closely aligned with realistic party motivations (cf. Figures 7, 8, 9).

Figure 9: Total utilities for intrinsically policy orientated parties

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	0.187	0.07	-0.306	-0.25	-0.312	-0.247
CDU/CSU Linke Grüne	0.1	-0.182	-0.319	-0.278	-0.079	-0.035
CDU/CSU FDP Grüne	0.166	-0.193	-0.274	-0.07	-0.275	-0.123
CDU/CSU FDP Linke	0.142	-0.203	-0.269	-0.069	-0.15	-0.222
CDU/CSU AfD Grüne	0.141	-0.203	-0.089	-0.224	-0.275	-0.13
CDU/CSU AfD Linke	0.117	-0.214	-0.085	-0.224	-0.154	-0.228
CDU/CSU AfD FDP	0.137	-0.261	-0.066	-0.05	-0.349	-0.314
SPD FDP Linke Grüne	-0.239	0.053	-0.309	-0.13	-0.086	-0.05
SPD AfD Linke Grüne	-0.245	0.035	-0.144	-0.269	-0.089	-0.059
SPD AfD FDP Grüne	-0.196	0.023	-0.104	-0.088	-0.258	-0.119
SPD AfD FDP Linke	-0.212	0.011	-0.103	-0.09	-0.143	-0.217

UtotMax(CDU/CSU) = 0.187 in coalition CDU/CSU SPD
UtotMax(SPD) = 0.07 in coalition CDU/CSU SPD
UtotMax(AfD) = -0.066 in coalition CDU/CSU AfD FDP
UtotMax(FDP) = -0.05 in coalition CDU/CSU AfD FDP
UtotMax(Linke) = -0.079 in coalition CDU/CSU Linke Grüne
UtotMax(Grüne) = -0.035 in coalition CDU/CSU Linke Grüne

5 Conclusion

In this paper, 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.

The proliferation of VAAs provides a new alternative for obtaining party position data. Multi-issue data used by VAAs has several advantages: it is generated close to elections, it is proclaimed to include the relevant topics of an election, and often publicly available. For this reason, our coalition tool is explicitly targeted at multi-issue data as it is provided by VAAs for many recent elections. However, Coalizer can process any data on party positions, including estimations from experts or party manifestos. As a web application, Coalizer is online available and can simply be used with common web browsers.

Coalizer is, to the best of our knowledge, the most comprehensive coalition tool and includes, among others, the following features:

- identification of (minimal) winning coalitions,
- computation of office utility values basing on seat distributions,
- computation of policy utility values basing on party positions,
- 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.

Users can select whether only minimal winning coalitions or all majority coalitions should be included in coalition analyzes. Regarding policy utility computation, Coalizer provides two types of distance metrics: Euclidean and Cityblock. These distances can be visualized with an edge-weighted graph in two-dimensional space. Finally, our coalition tool identifies utility maximizing strategies by indicating most preferred coalitions for each party and equilibrium solutions.

Further developments will include analyzing minority coalition and seeking equilibria also for purely intrinsically policy-orientated parties.

Using the German federal election in 2017 as an example, we showed how coalition formation can be analyzed with the aforementioned features. Coalizer enables users to evaluate and interpret different alliance strategies and identifies stable teams as a first step towards artificial intelligence for coalition formation.

References

Austen-Smith, David/Banks, Jeffrey, 1988: Elections, Coalitions, and Legislative Outcomes, in: American Political Science Review, 82(2), 405-422.

Axelrod, Robert, 1970: Conflict of Interest: A Theory of Divergent Goals with Application to Politics, Chicago.

Baron, David/Diermeier, Daniel, 2001: Elections, Governments, and Parliaments in Proportional Representation Systems, in: The Quarterly Journal of Economics, 116(3), 933-967.

Becker, Axel, 2005: KOALA. Ein Programm für koalitionstheoretische Analysen unter der Statistik-Umgebung R, Mannheim.

Berghammer, Rudolf/Rusinowska, Agnieszka/de Swart, Harrie, 2007: Applying Relational Algebra and RELVIEW to Coalition Formation, in: European Journal of Operational Research, 178(2), 530-542.

Berghammer, Rudolf/Rusinowska, Agnieszka/de Swart, Harrie, 2009: An Interdisciplinary Approach to Coalition Formation, in: European Journal of Operational Research, 195(2), 487-496.

Bolte, Felix, 2017: koal-o-mat, https://rawgit.com/gockelhahn/koal-o-mat-kiss/master/index.html (access: 5 July 2018).

Cano-Berlanga, S./Gimenez-Gomez, J. M./Vilella, C., 2015: Working Paper No. 06; CREIP; Spain, March 2015. https://cran.r-project.org/web/packages/GameTheory

Carroll, Royce/Cox, Gary W., 2007: The logic of Gamson's law: Pre-electoral coalitions and portfolio allocations, in: American Journal of Political Science, 51(2), 300-313.

Chalkiadakis, Georgios/Markakis, Evangelos/Boutilier, Craig, 2007: Coalition Formation under Uncertainty. Bargaining Equilibria and the Bayesian Core Stability Concept. AAMAS 2007 Proceedings of the 6th international joint conference on Autonomous agents and multiagent systems , Article No. 64.

DeSwaan, Abram, 1973: Coalition Theories and Cabinet Formations, Amsterdam.

Die Bundesregierung, 2018. Koalitionsvertrag 2018, 14. 3. 2018, www.bundesregierung.de/Content/ DE/_Anlagen/2018/03/2018-03-14-koalitionsvertrag.pdf (access: 5 July 2018).

Döring, Holger/Hellström, Johan, 2013: Who Gets into Government? Coalition Formation in European Democracies, in: West European Politics, 36(4), 683-703.

FAZ.net, 2018. Koalitionsrechner, http://www.faz.net/op900/event/landtagswahl-in-sachsen-anhalt-2016/live/ (access: 5 July 2018).

Focus Online, 2017. Das FOCUS-Gespräch mit FDP-Chef Christian Lindner nach dem Ende der Sondierung, 25. 11. 2017, www.focus.de/politik/deutschland/politik-waere-jamaika-ins-amt-gekommen-dann-haette-die-fdp-den-nuetzlichen-idioten-fuer-eine-grosse-koalition-mit-ein-bisschen-gruen-gespielt_id_7890366.html (access: 5 July 2018).

Gamson, William A., 1961: A theory of coalition formation, in: American Sociological Review, 26(3), 373-382.

Kamada, Tomihisa/Kawai, Satoru, 1989: An algorithm for drawing general undirected graphs, in: Information Processing Letters, 31(1), 7-15.

Künsebeck, Johannes, 2018: Quantikative, http://quantikative.de/wahlomat/europawahl2014/ (access: 11 July 2018).

Laver, Michael/Schofield, Norman J., 1990: Multiparty government. The politics of coalition in Europe. Oxford.

Leiserson, Michael, 1966: Coalitions in Politics. A Theoretical and Empirical Study, Yale.

Linhart, Eric, 2013: Does an appropriate coalition theory exist for Germany? An overview of recent office- and policy-oriented coalition theories, in: German Politics 22(3), 288-313.

Neumann, John von/Morgenstern, Oskar, 1944: Theory of Games and Economic Behaviour, Princeton.

North, Stephen C., 2004: Drawing Graphs with NEATO, http://graphviz.org/pdf/neatoguide.pdf (access: 1 Aug 2018).

Riker, William H., 1962: The Theory of Political Coalitions, New Haven.

Rohn, Eli/Kalech, Meir/Diskin, Abraham, 2016: Coalition Formation Decision Support System, in: Social Science Computer review, 34 (4), 437-455.

Roubens, Marc/Rusinowska, Agnieszka/de Swart, Harrie, 2006: Using Macbeth to determine utilities of governments to parties in coalition formation, in: European Journal of Operational Research, 172(2), 588-603.

Rusinowska, Agnieszka/de Swart, Harrie/van der Rijt, Jan-Willem, 2005: A new model of coalition formation, in: Social Choice and Welfare, 24(1), 129-154.

Saalfeld, Thomas, 2007: Parteien und Wahlen, Baden-Baden.

Saavedra-Nieves, Alejandro, 2016: Tools for Calculating Allocations in Game Theory https://CRAN.R-project.org/package=GameTheoryAllocation

Schofield, Norman J./Sened, Itai, 2006: Multiparty Democracy. Elections and Legislative Politics, Cambridge.

Sened, Itai, 1995: Equilibria in Weighted Voting Games with Side Payments, in: Journal of Theoretical Politics, 7(3), 283-300.

Sened, Itai, 1996: A Model of Coalition Formation. Theory and Evidence, in: Journal of Politics, 58(2), 360-372.

Shikano, Susumu/Becker, Axel, 2009: KOALA. Ein Programm zur Datengenerierung für diskrete Entscheidungsmodelle in der Koalitionsforschung, in: Schnapp, Kai-Uwe (ed.): Datenwelten: Datenerhebung und Datenbestände in der Politikwissenschaft, Baden-Baden, 284-293.

Spiegel online, 2018. Koalitionsrechner, http://www.spiegel.de/politik/deutschland/sonntagsfrage-umfragen-zu-bundestagswahl-landtagswahl-europawahl-a-944816.html (access: 5 July 2018).

Warwick, Paul V./Druckman, James N., 2006: The portfolio allocation paradox: An investigation into the nature of a very strong but puzzling relationship, in: European Journal of Political Research, 45(4), 635-665.

Appendix 1 – Upload File for the German Federal Elections 2017 (Wahl-O-Mat)

Appendix 1 shows the 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

Appendix 2 – A short comment on Rohn et al. (2016)

The theory by Rohn et al. (2016) is based on pairwise policy distances between parties. Each party's position is reflected by a vector $y_p = (y_{p1}, \ldots, y_{pq})$ in a q-dimensional policy space.[11] $w_p = (w_{p1}, \ldots, w_{pq})$ mirrors a party's weight of the single policy dimensions, where $\sum_{j=1}^{q} w_{pj} = 1$ for all p. Further, a user who evaluates a coalition weights the importance of the policy dimensions via a vector $u = (u_1, \ldots, u_q)$. Also, $\sum_{j=1}^{q} u_j = 1$.

According to Rohn et al. (2016: 441), "[t]he distance between two parties [1 and 2], given the user's weight" is $\sum_{j=1}^{q} u_j \cdot \left| w_{1j} \cdot y_{1j} - w_{2j} \cdot y_{2j} \right|$. First of all, it does not make much sense that a distance between two parties depends on a user's weight. But even if we ignore the u term for the moment, the distance measure does not work in a meaningful way. For example, two parties A and B with exactly the same position in a two-dimensional space but different weights (see Table A1) are assumed to be 0.3 scale points away from each other, when $u = (0.5, 0.5)$. Parties C and D, whose positions obviously differ, have zero distance. Since the further modelling is based on this distance function, the whole theory does not make any sense at all.

Table A1: An example with four parties

Party p	y_p	w_p
A	(5, 5)	(0.8, 0.2)
B	(5, 5)	(0.5, 0.5)
C	(8, 2)	(0.6, 0.4)
D	(6, 4)	(0.8, 0.2)

[11] We use different notations here in order to be consistent within the paper.