MCDM Application of the Third Vote

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Abstract

When choosing among alternatives, group members may have various preferences regarding the properties of a solution being sought. Since the properties partially do and partially do not meet their collective wishes, the alternatives are in fact better or worse representatives of the collective will. This idea is implemented in the so-called Third Vote election method aimed at enhancing policy representation, and we show how to use it for collective multi-criteria decision making. To be specific, we consider an example of a committee charged with naming a campus library when neither plurality vote nor Condorcet method nor Borda count gives a unique solution. The committee members have differing opinions, such as whether the library should reflect the national affiliation, be named after a great man, relate to sciences, and so forth. Balancing opinion on these issues, the proposed library names are evaluated and the optimal compromise is found.

> *The only way to rectify our reasonings is to make them as tangible as those of the Mathematicians, so that we can find our error at a glance, and when there are disputes among persons, we can simply say: Let us calculate, without further ado, to see who is right.*
> *Gottfried Wilhelm von Leibniz (1646–1716)*

Leibniz GW (1685) The art of discovery. Letter to Philipp Spener. In: Wiener PP (1951) Leibniz Selections. Charles Scribners Sons, New York, p. 51.

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1 Introduction: Library Names as Representatives of Collective Opinions

From the formal viewpoint, 'representatives' need not be individuals. In Tangian (2017a), they are not persons but political parties. Now we take it one step further, requiring of representatives no human nature at all, only a capability to stand for the interests of a group of people. More specifically, when choosing among an assortment of alternatives, the group members may have various preferences regarding the properties of a solution being sought. Since the properties partially do and partially do not meet collective wishes, the alternatives can be considered better or worse representatives of the collective wills.

This idea is reflected in the Third Vote election method (Tangian 2017b).[1] It was designed to implement the relatively recent concept of policy representation—how the party system and the government represent the policy preferences of the electorate (Budge et al. 2001; Budge and McDonald 2007; Volkens et al. 2013), which is not supported by conventional voting by candidate name. Correspondingly, under the Third Vote, the individuals cast no votes for candidates but are asked about their preferences on policy issues raised in the candidates' manifestos: Domestic deployment of federal armed forces?—Yes/No; Increase taxes for passenger diesel cars?—Yes/No, etc., just like in voting advice applications (VAA) (Garzia and Marschall 2014; Vote Match Europe 2020; You vote EU 2020) but without advising how to vote. Instead, the answers are processed to reveal the policy profile for the electorate that indicates the balance of public opinion for each question. The degree to which the candidates' policy profiles match with it is expressed by the candidates' indices of *popularity* (the average percentage of electors represented on all the questions) and *universality* (the percentage of questions when a majority is represented). These indices are analogous to preference proximity measures in the Condorcet method in its rigorous version (Young 1988) with the difference that (a) they are applied not to preference matrices but vectors of policy profiles and (b) they enable weighting of policy issues according to their importance, whereas weighting of elements of preference matrices makes little sense. If the candidates are political parties, the parliament seats are distributed among them in proportion to their indices.

The necessity for such a sophistication is caused by two reasons. The first one is the irrationality of the voters who, disregarding electoral manifestos, may vote contrary to their own political preferences for the 'wrong' candidates (Manin 1997; Adams et al. 2011). One explanation is the 'paradox of the platform' Brams (1976)—voters rate candidates 'in general', in particular because of the understanding of the political spectrum as a left-right ideological axis that is too simplistic (Tangian 2019b, 2020, Chapters 9 and 14) and results in the so-called 'blind corner

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[1] The name 'Third Vote' was given to oppose the method to the German two-vote system, within which it has been tested (Tangian 2017c; Third Vote 2020; World Forum for Democracy 2016, 2019). The two-vote system is used also in Bolivia, Ethiopia, Lesotho, New Zealand, Thailand, South Africa, South Korea, United Kingdom (Scotland, Wales, and the London assembly) (Mixed-member 2020). In fact, the Third Vote can be used alone or combined with any conventional voting method (Tangian 2019a).

of political representation' (Thomassen 2012). The Third Vote surmounts this phenomenon by redirecting the voters' attention from the charisma of candidates, communication skills and ideological labels to subject matters.

Another argument for the Third Vote is overcoming the constraints imposed by conventional voting. We remind that if the choice alternatives are more than two, a simple plurality vote can cause the Borda paradox, in which the winner is actually the least desired by an absolute majority. A pairwise vote can result in cyclic orderings with no winner—the classical Condorcet paradox. Successive pairwise voting that excludes the losers at each step enables manipulation of the outcomes by tweaking the order in which the pairs are put to the vote, etc.; see Black (1958), Nurmi (1999), Gehrlein and Lepelley (2011). Unlike these voting methods, the Third Vote consists of several Yes/No votes on dichotomous policy issues which are obviously not exposed to paradoxes. The electorate's policy profile is composed of balances of public opinion on the issues, and since the electorate is considered a single body, neither paradox can emerge.

Collective decisions made by conventional voting by name are subject to all known voting paradoxes. To surmount them, the Third Vote can be used, and the given paper shows how to do this in collective multi-criteria decision making (MCDM). To be specific, we consider an example of a committee charged with naming a campus library—the problem in fact dealt with by Professor of University Paris I and President of the Condorcet Campus in Paris–Aubervilliers, Jean-Marc Bonisseau. In this context, library names represent wishes of the supervising committee whose members have differing opinions, such as whether the library should reflect the national affiliation, be named after a great man, relate to sciences, and so forth. Regarding the balances of opinion on these issues, the preselected library names are evaluated using the already mentioned indices of popularity and universality. The indices help to find the optimal compromise and bring the committee to a rational consensus.

Using these indices bridges the MCDM-techniques and some approaches from the field of social choice. As early as in the 1980–1990s, the outranking methods for MCDM have been developed (Pardalos et al. 1985; Vincke 1992; Roy 1996; Schärlig 1996). We recall that an alternative *A outranks* an alternative *B* if there exists a sufficient majority of criteria for which *A* is better classified than *B* (*concordance*) and if the unfavorable deviations for the rest of the criteria (*discordance*) are not too high (Zopounidis 1999).

The social concordance for alternative *A* versus *B* can be measured by the universality index. Then the universality of *A* is the percentage of criteria (questions, in our terminology) that indicate a social preference for *A* rather than *B*. Thereby, a 'sufficient majority of criteria' corresponds to a high universality. A low concordance, or an 'insufficient number of criteria', corresponds to a low universality. The *degree* of social discordance can be measured by the popularity index. The popularity of *A* is the mean size of the social groups satisfied with the alternative's particular qualities (criteria); thereby, *A* is judged from the viewpoint of 'public approval' of its properties, not in comparison with other alternatives. The popularity of *A* is high if it is supported by large groups regarding most criteria and opposed by small groups regarding the rest of the criteria. This is exactly the same as 'the unfavorable

deviations for the [rest of the] criteria are not too high'. Consequently, the discordance is low if the popularity is high and vice versa.

As for relevant approaches in the field of social choice, we refer to the *proposition aggregation* in multiple elections (Brams et al. 1998). Multiple election is selection from bundles of accepted/rejected propositions, e.g. (Create new jobs, Reduce student fees), (Create no new jobs, Reduce student fees), etc. Under the *proposition aggregation* each proposition is voted on separately, and the desired bundle is determined. If it is not available, the one that is closest to it is selected. In other words, electors vote for particular characteristics of the alternatives, then the combination of the most desired bundle of characteristics is taken as a reference, being analogous to the electorate's policy profile, and the closest among the available alternatives, which are analogous to candidates' profiles, is selected.

Currently, the mathematical problem of how to best satisfy a collective with a composite program is studied within a new branch of social choice theory called *judgment aggregation* (Grossi and Pigozzi 2014; Lang et al. 2017; List 2012; List and Puppe 2009). In a sense, our approach is in line with it, having relevance to some other fields as well. For instance, the voters' Yes/No answer to a question imply voting at a time for several candidates that share the same position on the issue—it will be clearly seen from both Table 1 and Fig. 1. Thereby, the operation on every question resembles *approval voting*, where electors are allowed to vote for all acceptable candidates (Brams and Fishburn 1982; Laslier and Sanver 2010).

Section 2, 'Data Structure', explains how the model framework is adapted to the MCDM problem considered.

Section 3, 'Computing Popularity and Universality Indices', traces the computation of the library name indices of popularity and universality.

In Sect. 4, 'Choosing a Library Name by the Third Vote', the popularity and universality indices are transformed into virtual votes for library names under the Third Vote method and its combination with the conventional vote.

In Sect. 5, 'Consistency Analysis of Individual Preferences', we test the committee members' preference orderings of library names for consistency with their opinions on the particular properties of library names.

Section 6, 'Conclusion', emphasizes that the model for finding the best representatives is quite universal. It can be also used in a 'soft' form—not for making final decisions but to rationalize deliberations for finding a rational consensus.

2 Data Structure

We consider a French academic committee, which is faced with the task of choosing a name for the humanities library. The committee consists of five members A, B, C, D and E, each having one vote. After a few meetings, the following three library names (candidates) are included in the short list:

Bibliothèque des Encyclopédistes   (denoted 'Encyclopedists') after the authors of the major endeavor of the Enlightenment—the famous 35-volume *Encyclopédie* (1751–1772)

Table 1 Characteristics of the library names and wishes of the committee members

| Question	Library name characteristics			Wishes of the committee members					Balance of opinions		Question weight
q	Encyclopedists	Sartre	Weber	A	B	C	D	E	Pros %	Cons %	μ_q
1. Associated with France?	+	+	−	+	+	−	+	−	60	40	2/6
2. Name of a person?	−	+	+	−	−	+	+	+	60	40	1/6
3. Related to the Enlightenment?	+	−	−	+	+	−	−	+	60	40	1/6
4. Related to political economy?	+	−	+	+	+	−	−	+	60	40	1/6
5. Related to natural sciences?	+	−	−	+	+	+	−	+	80	20	1/6
Library name popularity P_c	60	47	43								
Library name universality U_c	83	50	33								
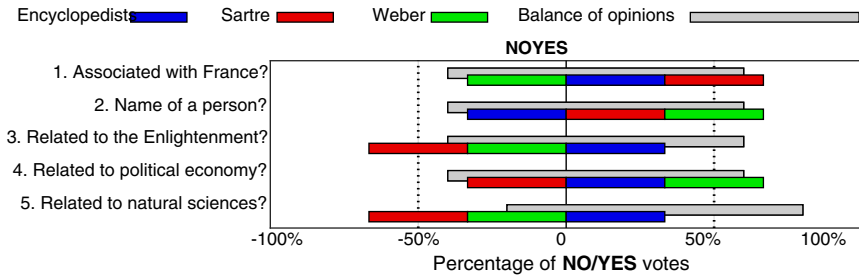
Fig. 1 Matching of the library names with the opinions of the committee

edited by Denis Diderot and Jean-Baptiste d'Alembert, which contained 71,818 articles by leading philosophers and scientists, including Voltaire, Montesquieu and Rousseau.

Bibliothèque Jean-Paul Sartre (denoted 'Sartre') after the renowned French philosopher, playwright, novelist, political activist, biographer and literary critic Jean-Paul Charles Aymard Sartre (1905–1980), a key figure of the European intellectual left of the 20th century.

Bibliothèque Max Weber (denoted 'Weber') after the German sociologist, philosopher, jurist and political economist Maximilian Carl Emil Weber (1864–1920), whose ideas, together with that of Émile Durkheim and Karl Marx, profoundly influenced social theory and social research.

Table 2 displays the preference orderings of the committee members (the VAA-indices in parentheses are explained and used in Sect. 5). Table 3 shows that neither pairwise vote, which gives a Condorcet cycle with no weakest link to cut it

$$\text{Encyclopedists} \overset{3:2}{>} \text{Sartre} \overset{3:2}{>} \text{Weber} \overset{3:2}{>} \text{Encyclopedists} \ ,$$

Table 2 Committee members' preference orderings of library names with their individual VAA-indices

Rank	A	B	C	D	E
1	Encyclopedists (6)	Encyclopedists (6)	Weber (4)	Sartre (6)	Weber (4)
2	Sartre (2)	Sartre (2)	Sartre (3)	Weber (3)	Encyclopedists (3)
3	Weber (1)	Weber (1)	Encyclopedists (1)	Encyclopedists (2)	Sartre (1)

Table 3 Pairwise vote, plurality vote and Borda scores

	Encyclopedists	Sartre	Weber
Encyclopedists		3 : 2	2 : 3
Sartre	2 : 3		3 : 2
Weber	3 : 2	2 : 3	
Plurality vote	2	1	2
Borda score (sum of ranks)	1+1+3+3+2=10	2+2+2+1+3=10	3+3+1+2+1=10

nor simple plurality vote nor Borda method of ranks result in a unique solution. It turns out that there is no consensus on five characteristics of the library name shown in Table 1.

The characteristics of the three library names, the opinions of the committee members, the balances of opinions on the issues and question weights are collected in Table 1. The first question on the national affiliation of the library name is regarded as most important and, as we assume, is double weighted. To collect data for Table 1, a special Third Vote ballots can be used, for instance, as the one in Table 4.

Figure 1 visualizes Table 1, displaying how well the library names match with the committee's wishes. For every question, the balance of committee opinions is shown by the grey bar. Its length is equal to 100%, and the prevailing committee opinion is visualized by the bar's bias from the center, as it surpasses the dotted line demarcating the 50% threshold. Every library name is depicted by a color rectangle. The 'No/Yes' conformity with a given issue is reflected by the position of the rectangle to the left or to the right of the central 0-axis, respectively.

Table 4 Third Vote ballot filled in by Committee Member A

	Yes	No	Question weight
Library name characteristics			
1. Associated with France?	×		2
2. Name of a person?		×	1
3. Related to the enlightenment?	×		1
4. Related to political economy?	×		1
5. Related to natural sciences?	×		1
Preferable library name (optional)			
1. Encyclopedists	×		
2. Sartre			
3. Weber			

3 Computing Popularity and Universality Indices

Two bottom rows of Table 4 show the popularity and universality indices of the library names. To be specific, we trace their construction for Encyclopedists. For Question 1, 'Associated with France?', it embodies the wishes of three out of five committee members, resulting in its representativeness regarding Question 1:

$$r_{\text{Encyclopedists},1} = \frac{3}{5} = 60\% .$$

For Question 2, 'Name of a person?', Encyclopedists represent the wishes of two out of five committee members, resulting in the representativeness

$$r_{\text{Encyclopedists},2} = \frac{2}{5} = 40\% .$$

For Questions 3–4, it represents $3/5 = 60\%$ of the committee, and on the last question it represents $4/5 = 80\%$.

Taking the weighted average representativeness of Encyclopedists across the five questions, we obtain Encyclopedists' popularity index

$$\mathsf{P}_{\text{Encyclopedidts}} = \sum_{q=1}^{5} \mu_q r_{\text{Encyclopedists},q} = \frac{2}{6} \times 60 + \frac{1}{6} \times 40 + \frac{1}{6} \times 60 + \frac{1}{6} \times 60 + \frac{1}{6} \times 80 = 60\% .$$

Encyclopedists' universality index is the total weight of the questions for which this library name represents the wishes of at least a non-strict majority of the committee. It is the case for all questions except Question 2, whence

$$\mathsf{U}_{\text{Encyclopedidts}} = \sum_{q:r_{\text{Encyclopedists},q} \geq 50\%} \mu_q = \frac{2}{6} + 0 + \frac{1}{6} + \frac{1}{6} + \frac{1}{6} = \frac{5}{6} \approx 83\% .$$

The indices of other library names are computed in the same way. For efficient vector formulas to compute the indices see (Tangian 2014, p. 245).

4 Choosing a Library Name by the Third Vote

The popularity and universality indices enable choosing the library name by the Third Vote or by its combination with the conventional plurality vote. The computational steps are displayed in Table 5. The first two columns show the popularity (P) and universality (U) indices from Table 4. The plurality vote from Table 3 is given in absolute numbers of votes (Abs) and in normalized units (Norm)— reduced to the total of 100%. Column 'Third Vote‖Abs' is the mean of popularity and universality indices, and its Norm-version 'Third Vote‖Norm' shows their reduction to the total of 100%. The combination of the conventional plurality vote with the Third Vote is obtained by taking the mean of Columns 'Plurality vote‖

Table 5 Indices of library names by the conventional and Third Vote methods and their combinations; the highest indices (of the winners) are in frames

	Indices of repre-sentativeness		Plurality vote		Third Vote $\frac{P+U}{2}$		Plurality vote/ Third vote
	P	U	Abs	Norm	Abs	Norm	Norm
	%	%		%	%	%	%
Encyclopedists	$\boxed{60}$	$\boxed{83}$	2	$\boxed{40}$	72	$\boxed{45}$ [a]	$\boxed{43}$
Sartre	47	50	1	20	48	31	25
Weber	43	33	2	$\boxed{40}$	38	24	32

[a]The result of floating point computations rounded at the end may differ from that if rounding is made at every step. For instance, $1.4 + 1.4 = 2.8 \approx 3$, whereas $1.4 + 1.4 \approx 1 + 1 = 2$.

Norm' and 'Third Vote‖Norm'. The result is displayed in the last column of the table. If desired, this mean can be weighted in any proportion.

Every normalized index in Table 5 is the 'percentage of support' received by the library name under the corresponding election method. For each method, the frame indicates the winner. In our case, the winner is always Encyclopedists.

5 Consistency Analysis of Individual Preferences

The last point is testing the consistency of the committee members' preferences for library names as shown in Table 2 with their responses to the specific questions in Table 4. If, for instance, a committee member's most preferable library name is Encyclopedists but, at the same time, he/she rejects its relation to political economy and natural sciences, then such an inconsistency calls into question the rationality of the member's voting behavior.

To test the individual preferences on logical consistency with voter profiles, we run a kind of VAA-simulation. For the profile of every committee member and that of every library name (= the corresponding columns in Table 4), we define the matching index—the total weight of the questions for which the profiles coincide. Obviously, the higher the index, the better the individual wishes are fulfilled, indicating, if the committee member is rational, a higher position for the library name in the preference ordering.

For example, the profiles of A and Encyclopedists are identical (see Table 4), resulting in the matching index 6/6, which in Table 2 is displayed without denominator as (6). The profiles of A and Sartre coincide for Question 1 only. Due to the question's double weight, Sartre in Column A of Table 2 is indexed 2/6 denoted by (2). Finally, the profiles of A and Weber coincide for Question 4, resulting in the matching index of 1/6 denoted by (1). Since the library name matching indices in Column A of Table 2 decrease, we conclude that A's preference ordering is absolutely consistent with A's answers to Questions 1–5.

The matching indices in all other columns of Table 2 also decrease, proving that the individual preference orderings are all rational, so the model can be trusted completely.

6 Conclusion

Thus, we have shown how to apply the Third Vote to MCDM-problems. It can also be useful when voting by alternative name gives no unique solution. In particular, the Third Vote is more universal than conventional voting schemes because it is not exposed to paradoxes of conventional voting.

It should be emphasized that the Third Vote should not necessarily replace the established procedure of the committee decision making if there is some tradition or legal prescriptions. It can be regarded as an instrument of attaining a rational consensus in the sense of deliberative democracy (Fishkin 2009, 2019). One can also use the model to reduce the number of alternatives to two and then apply voting, thereby avoiding cyclic majorities.

We argue that the indices of popularity and universality used in the Third Vote evaluate the representative capability of candidates (alternatives) more adequately than the percentage of votes by name. Under conventional voting, the candidates are voted on by disjoint groups of their adherents, whereas under the Third Vote, every candidate is also supported by the adherents of other candidates who share the same position on the given question. Instead of many voter groups, there are only Yes-group and No-group on every issue (ignoring those who abstain), which are usually quite numerous. In other words, the groups of candidate adherents join (differently on each question), providing a stronger support for weak candidates. Thereby, the Third Vote reveals the full representative capability, and the candidates with common positions represent them jointly rather than exclusively, justifying minority governments as well as Downs' coalitions of minorities (Downs 1957, pp. 55–60); this is illustrated in (Tangian 2020, Chapters 8 and 13).

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