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OUTCOMES OF COLLECTIVE DECISIONS WITH EXTERNALITIES PREDICTED

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ABSTRACT

In collective decision making bilateral deals can increase or decrease the likelihood of finding compromises, depending on whether such deals have externalities. Positive externalities mean third actors profit from bilateral deals, whereas negative externalities mean bilateral deals hurt third actors. We develop the first model of collective decision making that takes externalities into account. The model computes the expected outcomes of the issues to be decided and construes four coalitions of actors on each pair of issues. Then it searches for a set of alternative expected outcomes, such that no coalition can further increase the payoffs of one of its members, either (i) without decreasing the payoffs of one of its members, or (ii) without decreasing the payoffs of any actor. The Generalized Nash Bargaining Solution is used to pick a single outcome. The model is tested on data from decisions in the European Union.

KEY WORDS • collective decision making • European Union • externalities of exchange • Nash bargaining solution

Introduction

In collective decision making situations a group of actors have to accommodate their different positions on the issues that have to be decided in order to reach a final decision. Bilateral deals between (subgroups of) actors can increase or decrease the likelihood of finding compromises that are acceptable to all actors in the group, depending on whether such deals have positive or negative externalities for actors not involved in the bilateral deal. In the case of positive externalities, bilateral deals cause decision outcomes to become better for other actors not involved in the deal, whereas in the case of negative externalities, decision outcomes become worse for actors not involved in the deal. We develop a model where exchange partners explicitly try to avoid negative externalities for other actors to promote decision making by agreement. We test the model in the context of the European Union where a strong norm for unanimity has been observed repeatedly, even under qualified majority voting rules (Mattila and Lane, 2001; Thomson et al., 2006).

We model collective decision making as decision making about controversial issues with single peaked preference functions, as most well-known models do (Black, 1958; Bueno de Mesquita et al., 1985; Bueno de Mesquita and Stokman, 1994; Steunenberg, 1994; Tsebelis and Garrett, 1996, and many others). Decision making may well require simultaneous decisions on several issues. Different issues should represent rather independent controversial elements of the decision-making situation and as a set should cover the full range of possible outcomes.

The dynamics in the decision-making process result from actors, with different intensity and potential, trying to realize their preferred outcome on an issue (their initial position), whereas per issue only one outcome that is binding for all actors can be chosen. In a complex situation, possibly involving many actors, actors will try to build a coalition as large as possible behind their initial positions or behind a position that is as close as possible to theirs. This informal bargaining process can be seen to precede formal decision making and to affect the final positions of the actors in the decision making, aiming at a collective outcome that reflects their interests as much as possible.

The dynamics of bargaining processes in decision making are therefore primarily based on processes to induce or force other actors to change their positions. Three fundamental processes can result in such shifts in positions: *persuasion*, *logrolling*, and *enforcement*.[1] Through persuasion, actors aim at changing each other's initial positions as well as the salience of these positions (Stokman et al., 2000). This is achieved through providing convincing information. Persuasion is particularly a dominant process in settings where common interests are stronger than diversity of interests. In such settings, unanimous cooperative solutions prevail even if formal institutions permit (qualified) majority decisions or final decision making by one or more, but not all, individuals.

Logrolling and enforcement typically do not affect initial positions and saliences. Logrolling can be seen as a process of negotiated exchanges between two (subgroups of) actors. The result is that actors are willing to support another position on an issue that is of relatively less importance to them in exchange for support of other actors on the issue that is relatively more important to them. Such bilateral deals between (subgroups of) actors create cooperative win–win solutions for the exchanging partners, but not necessarily for all actors. In a similar vein, actors can feel *enforced* to support another position under the pressure of power. The two processes, logrolling and enforcement, are primarily likely if actors' initial positions fundamentally differ because of the different weighing of ultimate goals. In such situations, arguments do not help to bring initial positions closer to one another, so coalitions can be built only through processes that affect the final or voting positions of actors.

1. In his sociological critique of economic models of politics, Udehn (1996) derives the same three fundamental processes from the literature.

In the social sciences, models have been developed to predict final outcomes of decision making on the basis of the formal decision-making procedure, the so-called procedural models, and for each of the aforementioned bargaining processes. In the present article we compare the predictions of our newly developed model with predictions of models in all these classes.

For persuasion processes that are oriented to encompass the full set of all actors, the Nash Bargaining Solution is applicable if certain conditions are fulfilled. Achen (2006) shows that the weighted mean of the positions of the actors can be used as a first approximation of the Nash Bargaining Solution if the reversal point of no-agreement is very unattractive and the actors are risk averse. Each of the positions is then weighted by the product of the power and the salience of the actor. That solution was earlier known as the Compromise Model (CM) (Van den Bos, 1991; Stokman and Van den Bos, 1994). In the present article the CM is the baseline model to which all other models' performances are compared.

Procedural models are based on a careful analysis of the formal decision-making procedures. Given the complexity of European Union decision-making procedures, it is not surprising that scholars have different views on them. We compare the predictions of our newly developed model with two different well-known interpretations, namely the *Procedural Model* of Steunenberg and Selck (2006) on the one hand and the *Tsebelis Model* (1996) on the other.

The best-known bargaining model assuming decision making is characterized by a process of enforcement is the model of Bueno de Mesquita (Bueno de Mesquita and Stokman, 1994; Bueno de Mesquita et al., 1985). In this model actors try to strengthen the coalition surrounding their position by compelling or persuading other actors to change their positions. In the model, each actor decides whether or not to challenge the position of each other actor on an issue. The outcome of this decision is determined by the expected outcome of the challenge, which is in turn evaluated according to its expected effect on the decision outcome of the issue. In the present article the predictions of Bueno de Mesquita's model are compared with predictions of our newly developed exchange model and with the outcomes of EU decision making.

A prominent model of logrolling processes or exchange was developed by Coleman (1972, 1990). He devised an exchange model for social exchange that has been adapted for and applied to collective decision making as well (Marsden and Laumann, 1977; Laumann et al., 1987; König, 1997; Pappi and Henning, 1998). Coleman assumed that actors have interest in some events and control over other events. By exchanging control over events, mutually beneficial outcomes can be achieved. The solution is an analytic solution, based on the competitive equilibrium approach assuming that actors are price-takers. The model does not give insight into which actors exchange with which other actors at the micro level. Moreover, the major mechanism in this model is that of a market of private goods and the necessary adaptations to collective goods (binding outcomes for all) are not straightforward (see Stokman and Van Oosten, 1994).

In addition to the Coleman model, we investigated two other models of exchange applied to EU decision making. One of them, the *Procedural Exchange* model proposed by König and Proksch (2006), is an extension of the Coleman model in which informal bargaining and procedural voting elements are combined. The second model is the voting *Position Exchange Model* (PEM) model of Stokman and Van Oosten (1994). This model assumes collective decision making is based on the micro process of bilateral exchanges of voting positions. As a consequence, positive and negative externalities of such exchanges for other actors can be assessed (Van Assen et al., 2003).

In their standard textbook of microeconomics, Mas-Colell et al. (1995) define an *externality* to be present whenever the well being of an actor is *directly* affected by the actions of another actor. If an actor or a group of actors shifts its position on one or more issues, it will affect the outcome of the decision(s). As the outcome of a decision is binding for all actors, this implies that such a shift has *externalities* for all other actors. If the outcome moves away from the position of another actor, the externality is *negative*; if it moves towards the position of another actor, the externality is *positive*. We may assume that bilateral exchanges with negative externalities for others do not serve an overall consensus of all actors. If such bilateral exchanges have only positive externalities for other actors, the parochial interests of the exchanging partners coalesce with those of the whole group and we can assume that such exchanges facilitate an outcome that is acceptable for all. Within a setting where the formal or informal decision rules are based on overall consensus, we therefore assume that actors attempt to avoid bilateral exchanges with negative externalities.

The PEM enables one to investigate positive and negative externalities for others, but does not include assumptions about possible effects of positive or negative externalities for the exchange rates and/or choice of exchange partners. Application of the model in the context of the European Union, for example, showed that the negative externalities of model-predicted bilateral exchanges were about twice the size of the positive externalities (Arregui et al., 2006). The authors used this finding as their main argument why the PEM did not improve on the predictions of the CM in this study, whereas it did in many other studies (e.g. Achterkamp, 1999; Bueno de Mesquita and Stokman, 1994; Rojer, 1996). Given the fact that the European Union is a setting with a strong norm of decision making by consensus, we expect that actors adapt their exchange behavior to avoid such negative externalities. That's why we develop the *Externalities Exchange Model* (EEM) in this article; the first formal exchange model that takes externalities into account. The central idea of the EEM is to restrict the set of possible outcomes of collective decision making by avoiding negative externalities. If actors avoid negative externalities this restriction might induce equilibrium in decision making, which places the EEM in the context of the literature on structure-induced equilibrium (e.g. Shepsle and Weingast, 1981). The EEM is based upon the game theoretic Generalized Nash Bargaining Solution (GNBS) of Chae and Heidhues (2004), and takes the CM and the PEM, both of which do not take externalities into account, as its starting points.

The EEM is a model of *group* exchange that incorporates externalities, in contrast to the PEM. Since the EEM is strongly related to the PEM, a separate section is devoted to the PEM later in the text. Apart from the models mentioned above, we evaluate the performance of three other models of collective decision making. These models were all applied by Thomson et al. (2006) in their study of European Union decision making. The *Domestic Constraints Model* of Bailer and Schneider (Thomson et al., 2006, Chapter 6) models the influence of domestic politics in the member states on decision making at the European level. The *Coalition Model* of Boekhoorn et al. (Thomson et al., 2006, Chapter 7) examines the dynamics of coalition formation, both within the Council and between the Commission, the EP and the Council. Finally, Widgén and Pajala (Thomson et al., 2006, Chapter 9) present their *Issue Line Model*, in which the multi-issue decision situation is reduced to a single dimension, before being decided upon. For details on these models we once more refer to Thomson et al. (2006).

The next section discusses the general structure of collective decision making and the CM. Thereafter, the PEM and externalities in collective decision making are discussed. In the subsequent section the EEM is introduced. In the section after that, we briefly discuss the design of the study. The next section shows the results of our analysis and the article is concluded with a discussion.

The Structure of Collective Decision Making and the CM

The models referred to in the introduction all assume the same structure of collective decision making. It is assumed that there exists a finite set M of controversial issues, which can each be represented by a one-dimensional interval scale. These issues are *mutually exclusive* and *exhaustive*, i.e. an actor can take a position on one issue, irrespective of his position on another issue (mutual exclusiveness), and the issues together cover the entire collective decision problem (exhaustiveness).

It is assumed that each actor n, from the finite set of actors N, takes a position, x_{nm}, on the scale of each issue m, representing n's most preferred outcome of m. Furthermore, each actor n is assumed to have a *salience*, s_{nm}, for each issue m, expressing the relative importance of issue m to the actor n. Finally, each actor n has a *capability*, c_n, reflecting n's potential to affect the final outcome of each of the issues in M. The actors' positions, saliences and capabilities are assumed to be common knowledge. Based on this common knowledge, all actors are supposed to have a common *expected outcome*, O_m, of each issue m. In the CM, the PEM and the EEM, O_m is assumed to be the weighted average of the actors' positions, with weights equal to the actors' capabilities times their saliences:

$$O_m = \frac{\sum_n c_n s_{nm} x_{nm}}{\sum_n c_n s_{nm}} \tag{1}$$

The CM predicts that the outcome of issue m is equal to O_m as defined in (1). Both the PEM and the EEM use Equation (1) as the commonly expected outcome of an issue, before a possible exchange.

The Position Exchange Model and Externalities

The basic idea of the PEM is that pairs of actors can mutually increase their utilities compared with their utilities of the expected outcome in (1) by exchanging their positions on pairs of issues. The PEM assumes that actors have single-peaked preferences: an actor's initial position on an issue represents his preferred outcome, and any deviation of the final outcome from it, is evaluated as strictly worse. The utility of actor n (U_n) over the outcomes of all the issues in M is assumed to be:

$$U_n = -\sum_{m \in M} s_{nm} |x_{nm} - O_m|. \tag{2}$$

Equation (2) shows that an actor's utility is assumed to be (i) additive over all issues, and (ii) decreasing linearly in the absolute distance of the outcome from the actor's position, with the salience of the issue determining the rate of decrease.[2]

In the PEM, two actors are assumed to be able to exchange on a pair of issues only if they have positions on opposing sides of the expected outcomes on both issues.[3] With two issues, and their expected outcomes, we can partition the set of actors into four groups, A, B, C, and D, as is shown in Figure 1. Members of group A are on the left-hand side of the expected outcomes on the interval scales of both issues, those of group D are on the right side of both issues. Members of group B are on the left-hand side of the expected outcome on issue 1, and on the right-hand side on issue 2, with members of C having opposite positions. From this it immediately follows that members of A can only potentially exchange with members of D, and members of B can only potentially exchange with members of C.

2. Equation (2) does not imply that we impose the condition that each actor's utility is negative. Adding an arbitrary constant to (2) does not change the predictions of all the models.

3. If both actors are on the same side of the expected outcome, a shift of the position of the actor closest to the expected outcome in the direction of the position of the actor farthest from the outcome is profitable for both actors. Since it is profitable for both, exchange is not necessary.

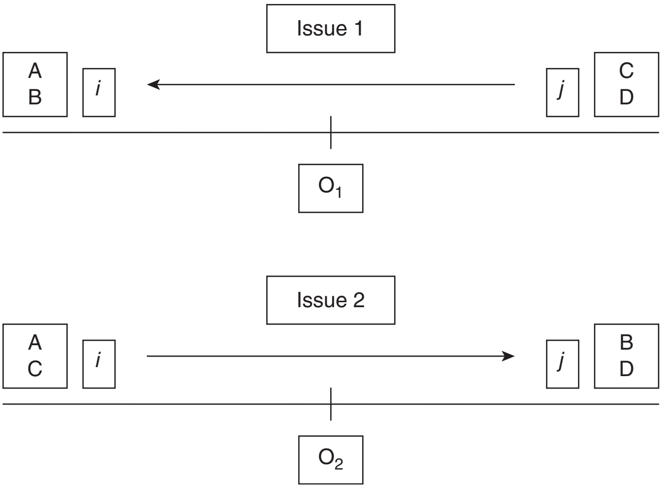

Figure 1. Exchange Between Actors $i \in A$ and $j \in D$ on Issues 1 and 2. O_1 and O_2 Indicate the Expected Outcomes on Issues 1 and 2, Respectively, before the Exchange. *A*, *B*, *C*, and *D* Indicate Groups of Actors.

Exchange between two actors is profitable only if the actors have different relative saliences for the two relevant issues. Without loss of generality, assume two actors, *i* and *j*, and two issues, 1 and 2. Assume *i* and *j* are on opposite sides of the expected outcomes of issues 1 and 2. Denote the changes in the expected outcomes on issues 1 and 2, caused by position shifts of actors *i* and *j*, as δ_1 and δ_2, respectively. Then *i* and *j* can only exchange profitably if either (3) or (4) is true.

$$\frac{s_{i1}}{s_{i2}} \leq \frac{\delta_2}{\delta_1} \leq \frac{s_{j1}}{s_{j2}} \tag{3}$$

$$\frac{s_{i1}}{s_{i2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{j1}}{s_{j2}} \tag{4}$$

Equations (3) and (4) show that exchange is only mutually profitable if the *exchange ratio* (δ_2/δ_1) is in between the relative saliences. See Appendix A for a proof of why this is true. If (3) holds, *i* shifts his position on issue 1 in the direction of *j*, whereas *j* shifts his position on issue 2 in the direction of *i*. Issue 1 is then called the *supply issue* of *i* and the *demand issue* of *j*, whereas issue 2 is the demand issue of *i* and the supply issue of *j*. If (4) holds, issue 2 is the supply issue of *i* and issue 1 is the supply issue of *j*. The latter situation is depicted in Figure 1.

In the PEM all possible bilateral exchanges are determined for each pair of issues from M. For each of these exchanges, position shifts are determined such that the utility gains of the exchange partners are equal and at a maximum. The exchanges are then listed in the order of the size of the utility gains. The exchange with the highest utility gains is then executed, and all other possible exchanges involving one or both of the partners of this first exchange, and in which these partners use the same supply issues as in this first exchange, are deleted from the list. This process is then repeated with the remaining exchanges on the list, until the list is empty. Then, (1) is applied to all issues with the new actor positions, and these are the outcome predictions of the PEM. See Stokman and Van Oosten (1994) for details.

Between-group and within-group externalities

That externalities occur in collective decision making is immediately apparent from (2) and the fact that position shifts affect the outcome of (1). Van Assen et al. (2003) analyzed externalities in decision making, making a distinction between *within-group* and *between-group* externalities.

Assume, without loss of generality, that actor $i \in A$ exchanges with actor $j \in D$, with issues 1 and 2 as supply issues for j and i, respectively, i.e. the situation as depicted in Figure 1. In the process of exchanging, both expected outcomes are shifted towards the positions of the members of group B, and away from the positions of the members of group C, who thus experience externalities of the exchange between i and j. Most members of B receive a windfall profit on both issues, and thus experience *positive* externalities,[4] whereas the externalities for members of C are negative. In line with Van Assen et al. (2003) we refer to this kind of externalities as *between-group* externalities: actors i and j, who are members of groups A and D, cause externalities for the members of the *other* groups B and C.

Externalities also exist for *same* group members of an exchanging actor. These externalities are referred to as *within-group* externalities. There are three possible causes of *negative* within-group externalities. If none of these causes is present, there are no or only positive within-group externalities. The three causes are: (i) the outcome shifts are in the wrong direction, (ii) the outcome shifts are in the right direction, but do not have a profitable exchange rate, and (iii) the shifts are in the right direction, have a profitable exchange rate, but at least one of the shifts is too large. Without loss of generality, consider actor $k \in A$, a fellow group member of actor i. Assume that the exchange between i and j mentioned above takes place. Thus, O_1 is shifted in the direction of x_{i1}. Since $k \in A$, O_1 is also shifted in the direction of x_{k1}.

4. A member of B can experience negative externalities if an issue shift on at least one of the issues is too far.

Case (i) occurs whenever the relative saliences of groups are 'intermixed'. This would be the case if

$$\frac{s_{i1}}{s_{i2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{j1}}{s_{j2}} \geq \frac{s_{k1}}{s_{k2}}.$$

In this case, k disagrees with i on which issue to demand and which issue to supply in exchange with j. Case (ii) occurs whenever the relative saliences of two group members are on opposite sides of the exchange ratio. This would occur if

$$\frac{s_{i1}}{s_{i2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{k1}}{s_{k2}} \geq \frac{s_{j1}}{s_{j2}}.$$

In this case, k agrees with i on the direction of exchange (demanding issue 1 and supplying issue 2), but feels that too large a shift on issue 2 has been conceded, relative to the shift on issue 1 obtained. Now consider case (iii). Even when the rate is profitable for all group members some actors in the group might still lose, when the outcome on their demand issue is shifted past their most preferred outcome.[5] All actors of group A gain from the exchange if the sum of utilities resulting from both outcome shifts is nonnegative, or, more formally,

$$s_{i1}[\delta_1 I_{1\delta} + (2|O_1 - x_{i1}| - \delta_1)(1 - I_{1\delta})] - s_{i2}\delta_2 \geq 0 \ \forall \ i \in A. \tag{5}$$

In (5) $I_{1\delta}$ is an indicator function equal to 1 if $\delta_1 < |O_1 - x_{i1}|$ on i's demand issue 1, and 0 otherwise. Hence no within-group externalities exist if (5) holds in the exchanging groups.

To summarize, in the CM no exchanges take place. In the PEM bilateral exchanges on pairs of issues occur, but cause between-group or within-group externalities that are not taken into account in the PEM. In the EEM we develop below, we account for externalities in two variants, depending on whether no negative externalities are allowed whatsoever, or only negative within-group externalities are prohibited.

The Externalities Exchange Model

The basic idea of the EEM is that all members of two groups of actors can increase their utilities compared to their utilities of the expected outcome in (1) by exchanging their positions on a pair of issues. Unlike the PEM, the EEM does not explicitly model position shifts of individual actors, but directly models the shifts

5. All actors in one group gain whenever the exchange rate is profitable and $\delta_m \leq |x_{km} - O_m|$ holds for all actors k in that group. An actor k of that group certainly loses if $\delta_m > 2|x_{km} - O_m|$, since he then loses on both his supply and demand issues. For each actor k there is a value of $y \in (1, 2]$ such that k does not profit from the exchange but is indifferent between no exchange and this exchange with a shift equal to $y|x_{km} - O_m|$.

in the expected outcomes of the pair of issues. Generally, a pair of expected outcome shifts can be caused by an infinite number of different position shifts of the individual actors. There are two variants of the EEM: the $\text{EEM}_{\text{b\&w}}$ in which both negative within-group externalities *and* negative between-group externalities are prohibited, and the EEM_{w} in which negative within-group externalities are prohibited, but negative between-group externalities are allowed for.

We argue that the EEM_{w} and $\text{EEM}_{\text{b\&w}}$ might be applicable in different decision-making situations. The $\text{EEM}_{\text{b\&w}}$ might be applicable in situations where the grand coalition of all actors in N is salient. In such a situation any negative externality, whether between-group or within-group, can be considered inadmissible. The EEM_{w} might be applicable in situations where subsets of actors tend to cluster in the same group (i.e. A, B, C, or D) across issue pairs. Here the group structure might be more salient, and the focus might be on avoiding negative within-group externalities, but not on avoiding negative between-group externalities.

The EEM assumes that two groups of actors exchange. Based on Figure 1, two such group exchanges exist: either between groups A and D, or between groups B and C. In the EEM, the predictions of the CM are taken as the initially expected outcomes of the issues. Then, for all possible pairs of issues, alternative outcomes are sought that are Pareto efficient and nonnegative for all actors involved. In the $\text{EEM}_{\text{b\&w}}$ such an outcome means that no actor in N can increase his utility without causing a utility loss to at least one other actor in N. In the EEM_{w} such an outcome means that no member of either of the two exchanging groups can increase his utility without causing a loss to at least one other actor from these two groups. Positive externalities are allowed in both variants. For both EEM variants, the set PE of exchanges yielding Pareto efficient and nonnegative outcomes, is discussed below. Thereafter, we discuss the GNBS to select one exchange of PE that yields the EEM prediction. Finally, we discuss a procedure to deal with situations involving more than two issues.

The PE set under $\textit{EEM}_{\text{w}}$

To avoid negative within-group externalities, none of the three causes mentioned earlier must occur. Without loss of generality, assume again a group exchange between A and D, such that the expected outcome of issue 1 is shifted towards A and the expected outcome of issue 2 is shifted towards D, as depicted in Figure 1. Causes (i) and (ii) of negative within-group externalities can then be avoided if and only if

$$\frac{s_{a1}}{s_{a2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{d1}}{s_{d2}}, \quad \text{for all } a \in A \text{ and } d \in D,$$

and (iii) is avoided if (5) holds.

Assume (i) to (iii) can be met simultaneously by a non-empty set Δ of outcome shifts (δ_1, δ_2). Denote the maximum value of δ_m in Δ as δ_m^{max1}. A subset of

Δ might not be feasible, i.e. some values of δ_1 and δ_2 might not be possible because the actors in the groups are not powerful enough to affect this shift. Define δ_m^{max2} as the maximum outcome shifts that can be affected by all actors in D and A[6], and $\delta_m^{max} = min(\delta_m^{max1}, \delta_m^{max2})$. Then the set of feasible issue shifts Δ and Δ^w can be defined as:

$$\Delta = \{\delta = (\delta_1, \delta_2) : 0 \leq \delta_1 \leq \delta_1^{max},\ 0 \leq \delta_2 \leq \delta_2^{max}\}, \tag{6}$$

$$\Delta^w = \{\delta = (\delta_1, \delta_2) : 0 \leq \delta_1 \leq \delta_1^{max}, 0 \leq \delta_2 \leq \delta_2^{max},$$

$$\frac{s_{a1}}{s_{a2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{d1}}{s_{d2}} \forall a \in A \wedge d \in D\}, \tag{7}$$

where it is understood that shifts are in the appropriate direction. The set *PE* or Δ_{PE}^w is a subset of Δ^w and is described formally in Appendix B. If negative within-group externalities cannot be avoided then Δ_{PE}^w is defined to have only one element, (0, 0).

The PE set under $EEM_{b\&w}$

Denote the *PE* set under $\text{EEM}_{\text{b\&w}}$ by $\Delta_{PE}^{b\&w}$. $\Delta_{PE}^{b\&w}$ is a subset of Δ_{PE}^w. From the discussion of between-group externalities it follows immediately that negative between-group externalities can be avoided if and only if one of the groups in Figure 1 has no members while the outcomes of the issues are shifted in the direction of the possibly remaining, non-exchanging group. In terms of our example exchange between A and D, condition $C = \emptyset$ should be added to (7) to find $\Delta^{b\&w}$. A second and final condition to be added is that all actors in B should profit from the exchange, or $\sum_{m=1}^{M} (s_{im}[\delta_m I_{m,\delta} + (2|O_m - x_{im}| - \delta_m)(1 - I_{m,\delta})) \geq 0 \forall i \in B$. $I_{m,\delta}$ is an indicator function equal to 1 if $\delta_m < |O_m - x_{im}|$ and 0 otherwise. $\Delta_{PE}^{b\&w}$ is a subset of $\Delta^{b\&w}$ and is formally described in Appendix B. If negative externalities cannot be avoided then $\Delta_{PE}^{b\&w}$ is defined to have only one element, (0, 0).

Selecting one element from PE

To single out an element from the *PE* set the EEM uses the Generalized Nash Bargaining Solution (GNBS) of Chae and Heidhues (2004). Chae and Heidhues generalized the solution of Nash (1950) to situations of group bargaining,

6. The maximum outcome shift δ_1^{max2} is equal to $|\frac{\sum_{n \in D} c_n s_{n1}}{\sum_{n \in N} c_n s_{n1}} e_1 - \frac{\sum_{n \in D} c_n x_{n1} s_{n1}}{\sum_{n \in N} c_n s_{n1}}|$, with e_1 equal to the extreme of the interval scale of issue 1. Similarly, $\delta_2^{max2} = |\frac{\sum_{n \in A} c_n s_{n2}}{\sum_{n \in N} c_n s_{n2}} e_2 - \frac{\sum_{n \in A} c_n x_{n2} s_{n2}}{\sum_{n \in N} c_n s_{n2}}|$.

which has a number of desirable properties.[7] The GNBS is the value of δ that maximizes the weighted product of utility gains, or

$$\underset{\delta \in \Delta_{PE}}{Max} \prod_{n \in N^*} [U_n(\delta)]^{r_n}, \tag{8}$$

with utility gain U_n, and group of actors N^*. In the case of the EEM$_w$ $N^* = A \cup D$ or $N^* = B \cup C$, in the case of EEM$_{b\&w}$ $N^* = N$. The GNBS weighs the utility of each actor by the reciprocal of the size of the group to which he belongs. Correspondingly, the EEM takes as weights the capability of the actor relative to the total capability of the group to which he belongs. Letting G_n denote the group of which actor n is a member, the relative capability of n, r_n, is then:

$$r_n = \frac{c_n}{\sum_{i \in G_n} c_i}, \tag{9}$$

with $G_n = N$ in the case of the EEM$_{b\&w}$, and G_n equals the group to which i belongs (A, B, C, or D) in the case of the EEM$_w$. In the case of the EEM$_{b\&w}$, this yields the GNBS without group structure.

If Δ_{PE} contains only (0, 0) then the EEM identifies this as the solution, which is equal to that of the CM. If it contains more elements, a unique solution to the maximization problem of (8) exists if the utility space is compact and convex. That this is true is shown in Appendix C. Hence the EEM model always identifies a unique solution.

Two comments are warranted on the GNBS. First, note that while negative externalities within N^* are avoided, the GNBS also takes into account positive externalities through the product of the weighted utilities in (8). Second, (9) shows that actors' weights are computed *within* groups, implying that the weights within each group sum to 1. This in turn implies that each group is 'equally influential' in determining the solution to (8), regardless of its number of members or their relative capabilities compared to other groups. That is, whether a group consists of one or many members, whether these members are each individually powerful or weak, for profitable exchange to occur, the group is needed anyhow. There is an analogy to a monopolistic market: the fact that the supplier is only one actor facing a multitude of demanders doesn't imply that the supplier is weak. For profitable exchange to occur, he is simply needed. However, note that in the EEM the summed capabilities of a group *do* determine the group's power to shift the expected outcomes of the issues.

7. The GNBS is (i) Pareto efficient, (ii) invariant with respect to affine transformations of utility, (iii) independent of irrelevant alternatives and (iv) symmetric, and satisfies the 'representation of a homogeneous group' property. See Nash (1950) and Chae and Heidhues (2004) for details.

Procedure in case of more than two issues

In the case of more than two issues choices have to be made concerning which group exchanges to execute. The following procedure is suggested and employed in our application:

(i) Compute the CM prediction of (1) for all issues.
(ii) Compute the prediction of the EEM for all $M(M-1)$ exchange possibilities.
(iii) Actors vote for their most preferred exchange opportunity.
(iv) Select from the list of (remaining) issue pairs the one with the highest weighted votes.
(v) Eliminate all issue pairs from the list containing one of the two issues on which the exchange in (iv) took place.
(vi) If the list is not empty after (v), go back to step (iv).

On each of the $M(M-1)/2$ issue pairs there are two exchange opportunities, one between groups *A* and *D*, and one between groups *B* and *C*. If no exchange is possible or *PE* is empty, the solution of the EEM is identical to the solution of the CM, and $U = 0$.

We generalized the idea of voting for positions or outcomes to the voting procedure in (iii) in which actors vote for exchanges instead of positions. It is assumed that each actor votes for that exchange opportunity in the list that yields him the largest positive utility change. Hence we assume myopic actors and exclude strategic voting.[8] An actor's vote is weighted by the capability of the actor, relative to the sum of capabilities of all actors in *N*. The exchange with the highest sum of weighted votes is executed first. Actors vote only once, at the beginning of the process. If there is a tie, one issue pair is selected at random. In the data analyzed in this study, ties didn't occur.

The voting procedure is identical for the $EEM_{b\&w}$ and the EEM_w. Thus, whether both negative between-group *and* negative within-group externalities are avoided, or *only* negative within-group externalities are avoided, *all* actors get to vote for their most preferred exchange. This way, the EEM always accounts for within-group externalities in the voting procedure.

Research Design

The current article uses the data collected by Thomson et al. (2006), which they used for testing a large number of models that predicted decision outcomes of EU decision making.

8. An example where strategic voting is profitable is this. Assume there are exchange opportunities concerning issue pairs (1,2), (1,3), (3,4) that yield an actor a payoff of 10, 5, 1, respectively. Further assume that either (1,3) or (3,4) will win the competition, and that the actor's vote is decisive in this competition. If he votes for (3,4), (3,4) will win, otherwise (1,3) will win. Then, if he votes for his most preferred option (1,2) he gains 5, but if he votes for (3,4) he gains $1 + 10 = 11$.

The data concern 66 proposals of the European Commission, discussed by the Council in the period January 1999 to December 2000, of which the final decision outcomes are known. These proposals contain a total of 163 controversial issues. The final decision outcome of one is missing from the data, leaving 162 issues with known decision outcomes. The Council consists of the Ministers of the member states, who deal with the relevant policy areas in their home country. The actors in the decision-making arena are the 15 member states at the time of data collection (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, Sweden and the United Kingdom), the European Parliament (EP) and the Commission. Decision making *within* the EP and the Commission is not taken into account, as they were conceived of as unitary actors in their dealings with the Council.

Data on the relevant issues within each Commission proposal and the positions, saliences and capabilities of the actors were collected by means of interviews with 125 experts. In the data, the position scales were standardized so that the extremes are 0 and 100, defined by the most extreme positions favoured by any of the actors. Position 0 mostly represented the position corresponding to the largest change. Not all actors had a position on all issues: on average 15.61 of the 17 actors took positions on each of the 162 issues. Of the 162 issues in the data set, 33 of these have only two possible positions, and are called *dichotomous*.

Actors' *capabilities* were estimated using the Shapley Shubik Index (SSI: Shapley and Shubik, 1954). To apply the SSI, all permuations of the actors in a decision-making situation are considered. For each permutation, the actor that turns a losing coalition into a winning coalition is called *pivotal*. The SSI of an actor is then the number of times an actor is pivotal divided by the number of permutations. Note that the SSI assumes that all logically possible coalitions are equally likely. This assumption severely impedes the applicability of the SSI when some actors refuse to form a coalition, for instance because of the existence of ideological differences (for an overview of the debate see, for instance, Braham and Holler, 2005a, 2005b; Garrett and Tsebelis, 1996, 1999; and Napel and Widgrén, 2005). However, as Thomson et al. (2004) show, there are no policy dimensions in the EU such that the member states can be consistently ordered across all dimensions. Thus, in the EU there appear to be no underlying ideological differences between the member states that would consistently prevent certain coalitions from forming. Moreover, the SSI is used as the power index in all the models from Thomson et al. (2006). To compare the results of the EEM to these model predictions we were required to use the SSI.

All models were applied to each proposal separately. For instance, in the EEM, only exchanges using two issues from the same proposal are analyzed. Exchanges concerning issues from different proposals were assumed not to occur since the proposals were dealt with by the EU at different points in time. The EEM was also run on issues with an unknown final decision outcome since they could, nevertheless, be used in negotiations.

Results

The predictions of the EEM were compared with those of the CM, the PEM and the other models from Thomson et al. (2006). First, we will present the descriptive statistics of the EEM and the other models, followed by a comparison of the EEM to the CM on all the issues involved. After that, we will present the results of separate analyses on dichotomous and non-dichotomous issues, comparing the EEM with the CM. Then, we will present the results of comparisons of the EEM with the other models from Thomson et al. (2006).

Thomson et al. (2006) evaluate the accuracy of models in predicting outcomes using the average distance between the predicted and actual outcomes. The performance of the EEM_w and the CM using that measure, is not significantly different (Mean Absolute Error $EEM_w = 23.35$, Mean Absolute Error $CM = 23.70$, $t = -0.50$, $df = 147$, $p = 0.62$, two-tailed). Since we are interested in what the EEM can predict both alone and in addition to what can be predicted using the other models CM, PEM, etc., our main statistical tools are sequential regression and logistic regression analysis. In each case, the observed outcome of the issues is regressed on the model predictions. Note that sequential analysis is especially suited to assess the fit of the EEM compared to that of the CM: the EEM seeks for profitable exchanges without negative externalities 'on top of' the CM prediction. Correspondingly, in sequential analysis we test for additional explained variance by the EEM, 'in top of' the variance explained by the CM and other models.

Descriptives

The data contain 162 issues. The EEM analyzes Pareto efficient outcome shifts with respect to the CM, on *pairs of issues*, within one proposal. There were 14 proposals in the data with just one issue, for which the EEM, CM, and PEM provide the same prediction. Our results only concern the 148 issues for which the three models' predictions might differ.

Of these 148 issues, the EEM_w's predictions differed from the CM's on 65, indicating that negative within-group externalities could frequently be avoided when exchanging. Of these 65 issues, the $EEM_{b\&w}$ differed from the CM on only eight, indicating that both negative between-group *and* negative within-group externalities could seldom be avoided. The upper-right triangle in Table 1 shows the correlations of all the models' predictions with each other and with the observed outcome of the decision-making process.

Of the 148 issues, 32 were dichotomous and 116 were non-dichotomous. The EEM_w's predictions differed from the CM's on 11 of the dichotomous and 54 of the non-dichotomous issues. Of these issues the $EEM_{b\&w}$'s predictions differed on two of the dichotomous and six of the non-dichotomous issues. The lower-left triangle of Table 1 shows the correlations for non-dichotomous issues only.

Table 1. Pearson Correlations between Models and Observed Outcome; Upper-right Triangle Contains All Issues, Lower-left Triangle Contains Non-dichotomous Issues Only; *N* in Parentheses

	Outcome	CM	$EEM_{b\&w}$	EEM_w	Proc	PEM	Domestic	Coalition	P.E.	Tsebelis	Coleman	I.L.	BdM
Outcome	–	0.47**	0.47**	0.51**	0.24*	0.43**	0.38**	0.44**	0.34**	0.31**	0.28**	0.26**	0.35**
		(162)	(148)	(148)	(107)	(137)	(162)	(162)	(113)	(113)	(113)	(113)	(162)
CM	0.44**	–	0.99**	0.94**	0.53**	0.76**	0.76**	0.98**	0.52**	0.46**	0.75**	0.39**	0.49**
	(129)		(148)	(148)	(107)	(137)	(162)	(162)	(113)	(113)	(113)	(113)	(162)
$EEM_{b\&w}$	0.41**	0.99**	–	0.96**	0.54**	0.78**	0.76**	0.96**	0.52**	0.46**	0.80**	0.34**	0.50**
	(116)	(116)		(148)	(96)	(137)	(148)	(148)	(101)	(101)	(101)	(101)	(148)
EEM_w	0.44**	0.93**	0.94**	–	0.54**	0.83**	0.70**	0.91**	0.50**	0.47**	0.76**	0.30**	0.48**
	(116)	(116)	(116)		(96)	(137)	(148)	(148)	(101)	(101)	(101)	(101)	(148)
Procedural	0.32**	0.60**	0.61**	0.60**	–	0.51**	0.37**	0.51**	0.71**	0.71**	0.34**	0.66**	0.23*
	(88)	(88)	(78)	(78)		(91)	(107)	(107)	(105)	(105)	(105)	(105)	(107)
PEM	0.32**	0.79**	0.81**	0.85**	0.53**	–	0.45**	0.73**	0.44**	0.47**	0.46**	0.26*	0.40**
	(114)	(114)	(114)	(114)	(77)		(137)	(137)	(96)	(96)	(96)	(96)	(137)
Domestic	0.38**	0.71**	0.69**	0.62**	0.42**	0.46**	–	0.74**	0.41**	0.36**	0.65**	0.32**	0.31**
	(129)	(129)	(116)	(116)	(88)	(114)		(162)	(113)	(113)	(113)	(113)	(162)
Coalition	0.40**	0.97**	0.95**	0.89**	0.57**	0.76**	0.70**	–	0.51**	0.45**	0.73**	0.35**	0.44**
	(129)	(129)	(116)	(116)	(88)	(114)	(129)		(113)	(113)	(113)	(113)	(162)
Procedural Exchange	0.38**	0.56**	0.57**	0.55**	0.74**	0.47**	0.47**	0.51**	–	0.85**	0.36**	0.76**	0.10
	(93)	(93)	(82)	(82)	(86)	(81)	(93)	(93)		(113)	(113)	(113)	(113)
Tsebelis	0.27**	0.50**	0.51**	0.51**	0.72**	0.50**	0.42**	0.47**	0.85**	–	0.30**	0.76**	0.14
	(93)	(93)	(82)	(82)	(86)	(81)	(93)	(93)	(93)		(113)	(113)	(113)
Coleman	0.31**	0.71**	0.76**	0.72**	0.36**	0.49**	0.58**	0.70**	0.40**	0.34**	–	0.18**	0.27**
	(93)	(93)	(82)	(82)	(86)	(81)	(93)	(93)	(93)	(93)		(113)	(113)
Issue Line	0.26*	0.38**	0.31**	0.27*	0.65**	0.23**	0.37**	0.30**	0.71**	0.71**	0.18**	–	0.07
	(93)	(93)	(82)	(82)	(86)	(81)	(93)	(93)	(93)	(93)	(93)		(113)
BdM	0.35**	0.43**	0.43**	0.42**	0.21	0.44**	0.20*	0.40**	0.12	0.13	0.24*	0.07	–
	(129)	(129)	(116)	(116)	(88)	(114)	(129)	(129)	(93)	(93)	(93)	(93)	–

* Correlation is significant at the 0.05 level (two-tailed). ** Correlation is significant at the 0.01 level (two-tailed).

The predictions of the EEM and the CM for the 32 dichotomous issues lie in the interval [0, 100]. Observed outcomes, however, are either 0 or 100. To evaluate the number of hits of each model in case of dichotomous issues, we set model predictions in the interval [0, 50) equal to 0 and predictions in the interval [50, 100] equal to 100. The proportions of correct predictions of the CM, the $EEM_{b\&w}$ and the EEM_w were then 0.64, 0.66 and 0.72, respectively. These proportions were all significantly larger than 0.5 ($p = 0.082$, $p = 0.056$, $p = 0.011$, one-tailed binomial test, respectively). The proportions of all other models were lower than 0.72, except for the PEM that had a proportion of 0.88.

Comparing the $EEM_{b\&w}$ with the CM

The $EEM_{b\&w}$'s predictions differed from the CM's on only eight issues. The correlations between the models' predictions and the outcome on these issues were 0.48 for the $EEM_{b\&w}$, 0.41 for the EEM_w, 0.32 for the CM, and 0.11 for the PEM, respectively. Thus, as expected, the $EEM_{b\&w}$ predicted best on this sample of nine issues. Note that no powerful statistical test could be performed because of the low number of cases.

Comparing the EEM_w with the CM

The results of sequential regression and logistic regression analyses on all cases are summarized in Table 2. In the first step of the sequential analyses the CM was entered, in the second step the EEM_w. The main result of these analyses was that adding the EEM_w prediction to the equation improved the prediction of the outcome.

If all cases were analyzed simultaneously, adding the EEM prediction increased R^2 by 0.043 ($F = 8.49$, df1 = 1, df2 = 145, $p = 0.002$, one-tailed). This corresponds to a small to intermediate effect size (Cohen, 1988). Keeping constant the CM's prediction, a unit increase in the EEM_w's prediction was associated with an average increase in the outcome equal to 0.82. If only non-dichotomous issues were analyzed, the explained variance increased by 0.016 ($F = 2.23$, df1 = 1, df2 = 113, $p = 0.069$, one-tailed), which corresponds to a small effect. Here, the coefficient of the EEM_w's prediction was 0.42. Finally, if only dichotomous issues were analyzed the EEM_w also improved the prediction of the outcome significantly ($\chi^2 = 8.42$, df = 1, $p = 0.002$, one-tailed). Controlling for the CM's prediction, a unit increase in the EEM_w's prediction on average increased the odds of outcome 100 by a factor 1.25.

It is also important to note that before adding the EEM_w's prediction the CM's prediction explained a significant part of the outcome, but that this was no longer true after entering the EEM_w's prediction. That is, the EEM_w could explain what was explained by the CM, and explained part of the outcome that could not be explained by the CM. A strange result was that the coefficient of CM was negative in the case of dichotomous issues (Wald Z = 2.23, $p = 0.932$,

Table 2. Regression Estimates; Standard Errors in Parentheses; Observed Outcome as Dependent Variable; Model I with CM only; Model II with CM and EEM_w

	All issues OLS Regression ($N = 148$)		Non-dichotomous issues OLS Regression ($N = 116$)		Dichotomous issues Logistic Regression ($N = 32$)	
	Model I	Model II	Model I	Model II	Model I	Model II
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Constant	15.63***)	15.58***	21.27***	21.43***	−2.06***	−2.70***
	(6.37)	(6.21)	(6.94)	(6.90)	(0.88)	(1.03)
CM	0.67***	−0.15	0.57***	0.15	0.04****	−0.17*
	(0.11)	(0.30)	(0.12)	(0.31)	(0.01)	(0.12)
EEM_w		0.82***		0.42*		0.22**
		(0.28)		(0.28)		(0.12)
−2LL-change						8.42***
*R*2-change	0.215***	0.043***	0.176***	0.016*		

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$, one-tailed *t*-test when OLS regression and one-tailed Wald Z-test when logistic regression, for parameters. For R^2 and −2LL significance of change was tested with one-tailed *F*-tests and one-tailed χ^2-tests, respectively.

one-tailed); controlling for the EEM_w's prediction, if CM predicted a larger probability of outcome 100, then this outcome was *less likely*. We can only attribute this strange result to sampling error.

The analyses were also performed only on those 65 issues for which the EEM_w and CM produced different predictions. Because of a lack of cases, the analysis could not be performed on dichotomous issues only. Taking all 65 issues together, adding the EEM_w to the CM significantly increased R^2 by 0.102 ($F = 9.18$, df1 = 1, df2 = 62, $p = 0.002$, one-tailed), corresponding to an intermediate to large effect size. Adding the EEM_w to the CM for non-dichotomous issues only also significantly increased R^2, by 0.031 ($F = 2.17$, df1 = 1, df2 = 51, $p = 0.044$, one-tailed), corresponding to a small to intermediate effect size.

We also tested whether the predictive success of the EEM_w and the CM differed across decision procedures (either consultation or co-decision, and either qualified majority voting or unanimity), and policy areas (internal market, agriculture and other areas). Only an effect of policy area was found; both the EEM_w and CM performed worse on non-dichotomous issues in the area of the internal market, compared with the other policy areas (R^2-change = 0.076, $p = 0.004$ and, R^2-change = 0.061, $p = 0.013$, two-tailed, respectively).

Comparing the EEM_w with the other models

There were only 14 dichotomous issues for which all the models discussed in the introduction provided a prediction, which was too low a number to reliably estimate a logistic regression model. Concerning the non-dichotomous issues, there were 75. Table 3 shows the estimates of the OLS regression including all models, on these 75 issues.

In Model II, adding the EEM_w to the model with only the CM yielded a significant increase in R^2 of 0.13 ($F = 13.21$, df1 = 1, df2 = 72, $p = 0.0005$, one-tailed). This increase corresponds to a large effect (Cohen, 1988). We note that the improvement caused by the EEM_w for these 75 issues was much larger than the improvement for all 116 non-dichotomous issues. Adding the PEM in Model III yielded an insignificant increase in R^2 of 0.003 ($F = 0.34$, df1 = 1, df2 = 71, $p = 0.281$, one-tailed). Adding all the other models in Model IV increased R^2 with 0.107, which was not significant ($F = 1.41$, df1 = 8, df2 = 63, $p = 0.105$). In Model IV, the parameters of the Procedural Exchange and the Tsebelis models were significant ($t = 2.64$, $p = 0.005$, and $t = -1.83$, $p = 0.036$, one-tailed, respectively), although the latter was negative. Models II, III and IV show that adding other models yielded a *negative* parameter for the CM, which produces a weird interpretation. The parameter of the EEM_w was significantly positive in all models.

Analyzing all 148 issues, we also compared the EEM_w to all models other than the CM, by starting with the other model and then adding the EEM_w. For non-dichotomous issues, this always led to a significant increase in R^2. Hence, the EEM_w could explain part of the outcome that could not be explained

Table 3. OLS Regression Estimates for Non-dichotomous Issues; Standard Errors in Parentheses; Observed Outcome as Dependent Variable; Model I with CM only; Model II with CM and EEM_w; Model III with CM, EEM_w and PEM; Model IV with all models; $N = 75$

	Model I	Model II	Model III	Model IV
	Coefficient	Coefficient	Coefficient	Coefficient
Constant	26.00***	28.50***	28.40***	34.14***
	(8.99)	(8.35)	(8.39)	(9.95)
CM	0.54***	−0.64**	−0.61**	−1.97***
	(0.15)	(0.35)	(0.36)	(0.75)
EEM_w		1.15***	1.25***	1.22***
		(0.32)	(0.36)	(0.37)
PEM			−0.13	−0.01
			(0.22)	(0.26)
Procedural				−0.02
				(0.15)
Domestic				0.12
				(0.15)
Coalition				0.82
				(0.52)
Procedural Exchange				0.42***
				(0.16)
Tsebelis				−0.29**
				(0.16)
Coleman				0.01
				(0.12)
Issue Line				0.09
				(0.18)
BdM				0.08
				(0.12)
R^2-change	0.161***	0.130***	0.294***	0.107

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$, one-tailed t-test for parameters. For R^2 significance of changes was tested with one-tailed F-tests.

by each of the other models alone. For dichotomous issues, the EEM_w did not significantly reduce −2LL when added to the PEM ($\chi^2 = 0.086$, df = 1, $p = 0.385$, one-tailed). Finally, we reversed the order of analysis, i.e. we started with the EEM_w and then added another model. For non-dichotomous issues this led to a marginally significant increase in R^2 of 0.019 ($F = 2.09$, df1 = 1, df2 = 79, $p = 0.076$, one-tailed) only when adding the Procedural Exchange Model, which corresponds to a small effect. However, this one marginal significant effect can be explained by chance alone, i.e. if the null hypothesis is true in all eight tests.[9] For dichotomous issues, −2LL *was* significantly decreased when

9. The probability that the smallest p-value of seven tests is 0.076 or larger, if the null hypothesis is true in all seven tests, is 0.469.

adding the CM to the EEM_w ($\chi^2 = 4.46$, $p = 0.015$, one-tailed). However, the parameter for the CM was then *negative* (−0.17, with S.E. = 0.12), indicating the predictive failure of the CM. The only other model that significantly decreased −2LL when added to the EEM_w, while simultaneously having a positive parameter value, was the PEM ($\chi^2 = 5.32$, $p = 0.01$, one-tailed).

Conclusions and Discussion

In decision-making contexts with a strong norm of unanimity, such as the European Union, externalities of exchanges between (subgroups of) actors play an important role in the decision-making process. Negative externalities impede the achievement of a general concensus, and will be frowned upon, whereas positive externalities promote general consensus and will be applauded. Despite the abundance of externalities in decision-making and despite the fact that field and experimental data allude to their importance for the outcomes of the decision making process, prior to this article no formal model existed that accounts for externalities. Thus, the *Externalities Exchange Model* (EEM) developed in this article is the first formal model of collective decision making that takes externalities of exchange into account.

Two variants of the EEM exist. The $EEM_{b\&w}$ prohibits both negative within-group *and* negative between-group externalities, whereas the EEM_w prohibits only negative within-group externalities. The EEM models are based on the game theoretic GNBS of Chae and Heidhues (2004). If negative externalities cannot be prevented, the EEM identifies the weighted average of all actors' voting positions as the solutions for a pair of decision issues, which equals the solution of the CM. Otherwise, the EEM prediction equals the GNBS of the set of permissible Pareto efficient group exchanges.

Although based on the principles of bilateral exchange, the EEM does not model positions shifts of individual actors, but directly models shifts in the excpected outcomes of the issues. It was proven that the EEM always identifies a unique solution. A procedure was proposed to deal with decision situations consisting of more than two issues. In this procedure all actors vote for the group exchange yielding their largest utility gain. The group exchanges are then carried out in the order of the sum of weighted votes, after deleting those issues that were already used in a previous exchange. The voting procedure thus assumes that actors' weighted votes set the 'agenda', determining the order in which the issues are dealt with. The most powerful actors, i.e. the actors with the largest weights, have the largest influence on this agenda setting. This appears to be a plausible assumption.

An additional assumption of the voting procedure is that actors are 'myopic' in the sense that they do not vote strategically. That is, they do not account for the way in which their individual votes add up with the votes of all other actors to produce the eventual order of the group exchanges. This implies that our voting procedure allows group exchanges taking place that would not have taken place, had we assumed perfectly forward-looking rational actors. Such non-myopic actors would consider all consequences of their and other players' voting behavior on the ordering of the exchanges, and subsequently choose their best replies. Since the EEM is otherwise based on assumptions of rational actor behavior, an elaboration of the EEM might therefore include strategic behavior in the voting phase, allowing only orderings of the exchanges that constitute a Nash equilibrium.

The EEM models were applied to decision making on 162 issues in the EU. Analyses were performed on 148 issues for which the predictions of the EEM, the CM, and the PEM were not identical. In group exchanges involving 65 of these issues, within-group externalities of exchange could be avoided. On only eight issues out of these 65, negative externalities of exchange could be avoided. On these eight issues the $EEM_{b\&w}$ outperformed the EEM_{w}, the CM, and the PEM, as expected, although no statistically powerful test could be performed.

Our analyses focused on comparing the EEM_{w} with the CM, a model that was said to outperform many more sophisticated models (Thomson et al., 2006). Our results were conclusive: the EEM_{w} could explain all that was explained by the CM, and additionally explained part of the outcome that could not be explained by the CM. The effect size varied across analyses from almost intermediate to large, and was largest when only the 75 non-dichotomous issues for which all models yielded a prediction were analyzed. A possible explanation for this large effect size is that on these 75 issues the outcome that would obtain when no agreement would be reached was clearly identified, which was not the case for the other issues. When this point of no agreement or reversal point is identified, it becomes easier for actors to determine the value of outcome shifts, since the reversal point provides the scale with a reference point. Consequently, exchange processes are facilitated, since it is easier for actors to negotiate about the size of the shifts. The success of the EEM compared to that of the CM is indirect evidence that groups of actors indeed exchange in order to increase their utilities.

The EEM_{w} also outperformed the PEM on non-dichotomous issues; it could explain what was explained by the PEM, and explained part of the outcome that could not be explained by the PEM. The success of the EEM_{w} compared with that of the PEM is indirect evidence supporting the hypothesis that actors, while exchanging, account for negative externalities of exchange for other actors with whom they agree on both non-dichotomous issues. Incorporating all other models as well, there was only minor evidence that the Procedural Exchange model explained part of the outcome that could not be explained by the EEM_{w} or any of the other models.

The EEM_{w} outperformed all other models on dichotomous issues, except the PEM, which outperformed the EEM_{w}. The PEM also outperforms the other models on dichotomous issues in the current article and in Thomson et al. (2006). It might be that, when dealing with dichotomous issues, exchange is easier to envision for actors than when dealing with non-dichotomous issues. With dichotomous issues, exchange simply means, 'I vote for you on this issue, if you vote for me on the other.' No 'shifting in the direction of the other' is involved. Therefore, the model of exchange underlying the PEM and the EEM might be closer to the actual decision-making process when dealing with dichotomous issues, than when dealing with non-dichotomous ones. This raises interesting research questions concerning the conditions under which exchange actually occurs in decision making and when it is a valid model of it, yielding accurate predictions. Questions like these are related to the broader issue of the scope conditions of the models we tested in this article. Bueno de Mesquita's model, for instance, was originally conceived as a model predicting outcomes in one-shot interactions, which is not characteristic of decision making in the EU context. In contrast to the Bueno de Mesquita model, EEM is expected to generate more accurate predictions in contexts where unanimity is formally or informally required and unrestricted exchanges between subgroups generate negative externalities. This is exactly the setting of the European Union. Different models may have different scope conditions, and further research must be done to find out in which decision-making contexts a model provides the best predictions.

Note that we have presented no data, and thus have performed no tests, concerning the actual decision *process*. Therefore, we cannot be sure whether the conception of decision making as 'group exchanges without negative externalities', as assumed by the EEM, is ecologically valid. Nevertheless, the good overall performance of the EEM_w relative to the other models points to the determining influence externalities have on the outcomes of decision making, and the necessity of accounting for them in any model of decision making.

The fact that the solutions resulting from the EEM are Pareto efficient under the relevant coalition structure, doesn't imply that there exist no actors that could improve on the solution for themselves. More specifically, as the PEM shows, pairs of actors will generally have exchange opportunities that are profitable for both partners, but cause negative externalities for others, possibly including their fellow group members. Hence, abstaining from these exchanges is an indication of solidarity, resembling making contributions to a collective good or cooperating in a resource dilemma (see, for instance, Hardin, 1968). This raises questions concerning the conditions under which such contributions occur. One would expect that in decision-making contexts in which the composition of the groups from Figure 1 differs markedly across issue pairs, negative between-group externalities are unacceptable, rendering the $EEM_{b\&w}$ the appropriate model. In more polarized contexts, however, where the same groups of actors frequently agree on pairs of issues, negative between-group externalities might be acceptable, but negative within-group externalities are prohibited. We explored this hypothesis for the data analyzed in the current article. Within the 148 proposals containing two or more issues, there were 179 issue pairs. For each pair of actors, we analyzed whether the observed proportion of times they were in the same group, differed significantly from the proportion expected, if actors were randomly distributed over the four groups on each issue pair, given the marginal distributions observed in the data. We indeed found significant clustering in the data. By and large there were two groups of countries distinguishable: countries mostly from northern Europe clustered together on pairs of issues (Austria, Denmark, Finland, Germany, The Netherlands, Sweden and the UK), as did southern member states (France, Greece, Italy, Portugal and Spain). Other actors were either isolated (the Commission and the EP) or hard to place in a single cluster (Belgium, Ireland and Luxembourg). According to our hypothesis, this would indicate that negative between-group externalities were acceptable, possibly explaining the predictive success of the EEM_w compared to the CM.

Investigating the conditions under which negative between-group or within-group externalities are accepted, and the consequences this has for the predictive power of the $EEM_{b\&w}$ and the EEM_w compared with other models, appears a fruitful alley for future research. Especially the clustering found in the data, based on actors' positions on the issues, seems a promising lead. The EEM should be applied to a variety of data sets together with an analysis of the clustering, to see whether our hypothesis from the previous paragraph is corroborated. Another approach would be to design experiments with induced positions, saliences and capabilities to investigate the predictive power of the EEM and the effects of clustering.

Finally, interesting questions arise concerning how the structure of actor positions on issues and the clustering into groups resulting from this, interacts with formal and informal decision rules, such as (the pressure for) unanimity, qualified majority and simple majority, or the urge to compensate losing minorities on future decisions.

Appendix

A. Conditions for mutually profitable bilateral exchange

Assume i and j are on opposite sides of the expected outcomes of issues 1 and 2. Using (2), their utilities are $U_i = -s_{i1}|x_{i1} - O_1| - s_{i2}|x_{i2} - O_2|$ and $U_j = -s_{j1}|x_{j1} - O_1| - s_{j2}|x_{j2} - O_2|$, respectively. If δ_1 is in the direction of x_{i1}, then both actors' utility changes are $s_{i1}\delta_1 - s_{i2}\delta_2$ and $-s_{j1}\delta_1 + S_{j2}\delta_2$. Since both utility changes must be nonnegative, we obtain $\frac{s_{i1}}{s_{i2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{j1}}{s_{j2}}$. If δ_1 is in the direction of x_{ji1}, then we obtain similarly $\frac{s_{j1}}{s_{j2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{i1}}{s_{i2}}$.

B. Deriving Δ^{w}_{PE} and $\Delta^{b\&w}_{PE}$

First some notation. Assume a group exchange between A and D, such that the expected outcome of issue 1 is shifted towards A and the expected outcome of issue 2 is shifted towards D. Let $x^{farthest}_{jm}$ *and* $x^{closest}_{jm}$ be the positions of the members of group j farthest and closest from O_m on j's demand issue m, respectively. Moreover, let a' and d' be the members of A and D that are closest in terms of *relative salience*, hence $\frac{s_{a'1}}{s_{a'2}} \geq \frac{\delta_2}{\delta_1} \geq \frac{s_{d'1}}{s_{d'2}}$. Denote the utility change for actor n, as $U_n : \Delta \to \Re$, and define a utility space $S = \{u \in \Re^{N^*} : u = (U_1(\delta), U_2(\delta), \ldots, U_N(\delta)), \ \delta \in \Delta\}$, with $N^* = A \cup D$ or $N^* = B \cup C$ in the EEM_w and $N^* = N$ in the $\text{EEM}_{\text{b\&w}}$.

Three conditions need to be added to Δ^w to specify Δ^w_{PE}. First, all members of both A and D prefer a shift that results in an outcome somewhere between $x^{closest}_{jm}$ and $x^{farthest}_{jm}$, over a shift beyond $x^{farthest}_{jm}$. Hence δ's upper bound becomes $min\{|x^{farthest}_{jm} - O_m|, \delta^{max}_m\}$. Second, at least one of the groups must shift at least $min\{|x^{closest}_{jm} - O_m|, \delta^{max}_2\}$, because otherwise a further shift with the same exchange ratio is a Pareto efficient improvement. Third, of course, $U_n \geq 0$ for all actors in A and D. Combining the three conditions yields:

$$\begin{aligned}\Delta^w_{PE} = \{\delta = (\delta_1, \delta_2) : (&min\{|x^{farthest}_{A1} - O_1|, \delta^{max}_1\} \geq \delta_1 \geq min\{|x^{closest}_{A1} - O_1|, \delta^{max}_1\},\\ &min\{|x^{farthest}_{D2} - O_2|, \delta^{max}_2\} \geq \delta_2 \geq \frac{s_{d'1}}{s_{d'2}}\delta_1, U_i \geq 0 \forall i \in N^*) \cup\\ &(min\{|x^{farthest}_{A1} - O_1|, \delta^{max}_1\} \geq \delta_1 \geq \frac{s_{a'2}}{s_{a'1}}\delta_2,\\ &min\{|x^{farthest}_{D2} - O_2|, \delta^{max}_2\} \geq \delta_2 \geq min\{|x^{closest}_{D2} - O_1|, \delta^{max}_2\}, U_i \geq 0 \forall i \in N^*))\end{aligned}$$

Two additional conditions of $\Delta^{b\&w}_{PE}$ are that $C = \{\varnothing\}$ and all actors' utilities should be nonnegative.

C. S *is compact and convex*

Utility space S is defined above on $\Delta = \{\delta = (\delta_1, \delta_2) : 0 \leq \delta_1 \leq \delta^{max}_1, 0 \leq \delta_2 \leq \delta^{max}_2\}$. Note that Δ is compact and convex. Because Δ is compact, S is compact as well. S is also convex because all U_n are linear.

Proof. Assume we have $\delta, \delta' \in \Delta$, $u = (U_1(\delta), U_2(\delta), \ldots, U_N(\delta))$, and $v = (U_1(\delta'), U_2(\delta'), \ldots, U_N(\delta'))$. Now consider $\lambda u + (1-\lambda)v$, with $\lambda \in [0, 1]$. For each actor n, this yields $\lambda u_n + (1-\lambda)v_n = U_n(\lambda\delta + (1-\lambda)\delta')$. Since Δ is convex, $\lambda\delta + (1-\lambda)\delta' \in \Delta$. Thus $\lambda u + (1-\lambda) \quad v = (U_1(\lambda\delta + (1-\lambda)\delta'), U_2(\lambda\delta + (1-\lambda)\delta'), \ldots, U_N(\lambda\delta + (1-\lambda)\delta')) \in S$, and S is convex. Hence the GNBS identifies only one solution from S. This solution must be in Δ_{PE} because the GNBS satisfies Pareto efficiency.

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