Chapter 37
Social Choice and Voting

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Abstract When individuals in a society have different preferences over the options available to the society, how should social decisions be taken so as to achieve a reasonable compromise? What are the principles that one should use in one's ethical evaluation of different states of the society? These ethical issues are at the centre of the theory of social choice and welfare. While they have been discussed and debated for centuries, what the modern theory of social choice and welfare has done is to bring to bear formal reasoning in exploring them. The literature that has developed in this area over the last 70 years or so is vast and it is not possible to give in this short review even a list of the major developments. What I seek to do here is to focus on a few of the most conspicuous landmarks in this literature.

37.1 Introduction

When individuals in a society have different preferences over the options available to the society, how should social decisions be taken so as to achieve a reasonable compromise? What are the principles that one should use in one's ethical evaluation of different states of the society? These ethical issues are at the centre of the theory of social choice and welfare. While they have been discussed and debated for centuries, what the modern theory of social choice and welfare has done is to bring to bear formal reasoning in exploring them. The literature that has developed in this area over the last 70 years or so is vast and it is not possible to give in this short review even a list of the major developments. What I seek to do here is to focus on a few of the most conspicuous landmarks in this literature.

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37.2 Two Aspects of Social Choice: Aggregation of Individual Preferences to Achieve Compromise vs. Social Welfare Judgments of an Ethical Observer

Consider the following exchange between two persons, i and j (where j is an Indian):

i: "Should India abolish death penalty altogether?"
j: "No, since 90 % of Indians believe that death penalty should be retained for very serious crimes such as premeditated murder."
i: "But what do *you* think India should do? Should India abolish death penalty?
j: "Yes, definitely. In my opinion, death penalty has no place in any civilized society because ..."

This exchange illustrates the two very different senses in which one can interpret the ethical problem of social choice or evaluation of social options. Implicit in j's answer to i's first question is the interpretation of the problem of social choice or evaluation of social options as a problem of aggregating the (possibly conflicting) opinions or preferences of the individuals in a given society so as to arrive at a reasonable compromise. Under this interpretation, typically the individuals' opinions or preferences are taken as given and the problem is simply one of aggregating these given opinions. In this context, an appeal to the fact that 90% of the population shares a particular preference can be a convincing reason for the society to do or not to do something. The second interpretation implicit in i's second question and j's answer to it is the interpretation of the social evaluation of options or the prescription for social choice as reflecting an individual's own ethical beliefs. An appeal to the shared opinion of an overwhelming majority of the society does not seem to be particularly relevant here; the individual evaluating the social options needs to provide independent justifications for her ethical beliefs.

The modern theory of social choice and welfare explores problems of social choice and social evaluation in both the senses mentioned above. In assessing the intuitive significance of many of the contributions to this theory, however, it is important to keep in mind the distinction, introduced by Little [8], Bergson [2], and Sen [15], between the two interpretations. In this essay, I concentrate on the literature that is concerned primarily with the first intuitive problem mentioned above, namely, the problem of arriving at a compromise in the presence of conflicting individual preferences or opinions.

37.3 Some Basic Notation and Definitions

Let $N = \{1, 2, \ldots, n\}$ denote a society. 1, 2, ..., and n ($\infty > n > 1$) denote the individuals in the society. I use the society in the usual sense of the term, though, for many purposes, the society can be interpreted in a flexible fashion to indicate any group of individuals (e.g., a committee). Let X denote the set of all

conceivable social alternatives or options. X can be interpreted in different ways depending on the context. In welfare economics, the elements of X are often taken to be alternative complete description of the affairs in the society, though there is sometimes ambiguity about what exactly constitutes such a complete description. The elements of X are denoted by x, y, z, etc. Let $\mathcal{T}$ be the set of all binary weak preference relations ("at least as good as") R^* defined over X, such that R^* satisfies reflexivity over X (i.e., for all $x \in X$, xR^*x). Given x, $y \in X$ and $R^* \in \mathcal{T}$, xR^*y denotes that x is at least as good as y in terms of the binary weak preference relation R^*. For all $R^* \in \mathcal{T}$ and all x, $y \in X$, [xP^*y iff (xR^*y and not yR^*x)] and [xI^*y iff (xR^*y and yR^*x)]. P^* and I^* are to be interpreted, respectively, as the strict preference relation ("preferred to") and indifference relation ("indifferent to") corresponding to R^*.

Let $\mathcal{R}$ be the set of all $R^* \in \mathcal{T}$ such that R^* is an ordering over X, i.e., R^* satisfies the following three properties: (i) *reflexivity* over X; (ii) *connectedness* over X (for all distinct x, $y \in X$, xR^*y or yR^*x; and (iii) *transitivity* over X (for all x, y, $z \in X$, if xR^*y and yR^*z, then xR^*z). Let L be the set of all R^* in $\mathcal{R}$, such that R^* is linear, i.e., for all distinct x, $y \in X$, not [xR^*y and yR^*x]. Thus, L is the set of all preference orderings which do not permit indifference between distinct options.

Much in the theory of social choice can be formulated either in terms of a social ranking of options or in terms of the society's choices from different possible sets of feasible social options. I use the former formulation here.

Definition 37.1 A *social ranking rule* is a function $f: \mathcal{S}^n \longrightarrow \mathcal{T}$, where $\varnothing \neq \mathcal{S} \subseteq \mathcal{R}$.

$\mathcal{S}$ is to be interpreted as the set of all binary weak preference relations that an individual may have. The elements of $\mathcal{S}^n$ will be denoted by $(R_1, \ldots, R_n)$, $(R'_1, \ldots, R'_n)$, etc., and will be interpreted as profiles of individual weak preference relations. R_i, R'_i, etc., denote weak preference relations of individual i ($i \in N$). Thus, a social ranking rule $f: \mathcal{S}^n \longrightarrow \mathcal{T}$ is a function, which, for every profile of individual preferences in $\mathcal{S}^n$, specifies exactly one binary weak preference relation R in $\mathcal{T}$, R being interpreted as a social weak preference relation, or ranking, over X. xRy denotes that x is at least as good as y for the society. Typically, it is assumed that $\mathcal{S} = \mathcal{R}$, i.e., the set of all admissible preferences for an individual is the set of all orderings over X.

A social ranking R over X, has intuitive, though not logical, implications for social choice. For example, it will be intuitively rather odd to say that x is better for the society than y, but, given the choice between x and y, the society should choose y and reject x. Given the social ranking R and given a non-empty subset A of X, we say that $C(A, R) \equiv \{x \in A : xRy \text{ for all } y \in A\}$ is the *choice set* generated by R for A. Intuitively, $C(A, R)$ is the set of best alternatives in A, "best" being defined in terms of R. If A is the set of all feasible options before the society, then the society can choose any option in $C(A, R)$. It is possible to have an empty $C(A, R)$. For example, if xPy and yPz and zPx, then $C(\{x, y, z\}, R)$ is empty. In this case, R does not give much guidance about what the society should choose from $\{x, y, z\}$.

37.4   Arrow's Impossibility Theorem for Social Ranking Rules

What restrictions should one postulate for social ranking rules? This is the issue that Arrow ([1], 1963) addressed. He introduced four such restrictions.

Definition 37.2 Let $f : \mathcal{S}^n \longrightarrow \mathcal{T}$ be a social ranking rule. f satisfies:

(i) *Collective Rationality* iff $\mathcal{S}=\mathcal{R}$ and, for every $(R_1, \ldots, R_n)$ in $\mathcal{S}^n$, $R = f(R_1, \ldots, R_n)$ is an ordering;

(ii) *Weak Pareto Principle* iff, for every $(R_1, \ldots, R_n)$ in $\mathcal{S}^n$ and for all $x, y \in X$, if xP_iy for all $i \in N$, then xPy.

(iii) *Independence of Irrelevant Alternatives* iff, for all $(R_1, \ldots, R_n)$, $(R'_1, \ldots, R'_n)$ $\in \mathcal{S}^n$, and for all $x, y \in X$, if for all $i \in N$, [xR_iy iff xR'_iy] and [yR_ix iff yR'_ix], then [xRy iff $xR'y$] and [yRx iff $yR'x$].

(iv) *Non-dictatorship* iff there does not exist $i \in N$, such that, for all $x, y \in X$ and all $(R_1, \ldots, R_n)$ in $\mathcal{S}^n$, if xP_iy, then xPy.

Collective rationality requires that, for every possible profile of individual preference orderings, the social ranking rule should specify an ordering as the social binary weak preference relation. Collective rationality can have two distinct types of justification. First, if the social weak preference relation, R, is to be used as the basis for social choice from a given set, A, of feasible social options, then R should generate a non-empty choice set for A. The restriction that R be an ordering is sufficient, though not necessary, to ensure that $C(A, R)$ will be non-empty for every finite non-empty subset A of X. A second justification for collective rationality can be that social choices from different possible sets of feasible options should be "rational", rational choices being conceived as choices that could be induced by an ordering (this is the conception of rational choice that economists typically use). The Weak Pareto Principle, embodying respect for unanimity, has been almost universally accepted in welfare economics. Independence of Irrelevant Alternatives requires that if the profile of individual orderings changes but every individual's ranking of two options, x and y, remains the same before and after the change, then the society's ranking of x and y must remain the same. This is sometimes justified by the pragmatic consideration that it leads to an economy of information needed for the social ranking over pairs of options: in the absence of this property, for the society to rank two alternatives, not only will it need information about how all individuals rank those two options, but it may also need information about the individuals' rankings with respect to other ("irrelevant") options. Another pragmatic justification for the condition is that violation of Independence of Irrelevant Alternatives gives individuals the opportunity to "misreveal" their preferences so as to change the social decision to their advantage (see Plott [12]). Finally, Non-dictatorship seems to be a reasonable condition: it simply requires that the society should not have a dictator, i.e., an individual such that whenever she strictly prefers any option x to any other option y, the society must rank x strictly above y irrespective of other individuals' preferences.

The following result due to Arrow constitutes one of the foundational results in the theory of social choice.

Theorem 37.1 (Arrow [1]): *If #X ≥ 3, then there does not exist any social ranking rule which simultaneously satisfies Collective Rationality, the Weak Pareto Principle, Independence of Irrelevant Alternatives, and Non-dictatorship.*

Given the apparent plausibility of the four conditions, the impossibility of satisfying all of them simultaneously (given the mild restriction that $\#X \geq 3$) has the flavor of a paradox. It is not, therefore, surprising that a significant part of the literature on the theory of social choice has been devoted to finding ways of escape from the dilemma posed by Arrow's result.

I would like to make two comments relating to the interpretation of Arrow's [1] theorem. First, since Arrow's framework makes the social ranking exclusively dependent on the profile of individual preference orderings, the question arises about the intuitive content of these preference orderings. One response to this question may be to say that an individual's preference ordering reflects all that the individual considers to be relevant in assessing the options, including, possibly, her ethical values (e.g., " a social state that involves excessive social and economic inequality is abhorrent" and "tigers have a right to survive and policies which will lead to their extinction are ethically unacceptable") as well as her self interest ("I shall be better off in x as compared to y"). This answer is adequate if the social choice problem is one of arriving at a compromise in the face of conflicting preferences, assumed to be given. It is not, however, adequate when one interprets the social ranking of options as reflecting an individual's judgments about social welfare. If I am giving *my* ethical assessment of alternative social options, then it is reasonable to expect that I should take into account all the individuals' personal well-being (it is possible that the survival of tigers and the extent of social inequality directly affects an individual's personal well-being), but it is not at all clear why I should take into account *their* ethical views about social and economic inequality or the survival of tigers in making *my* ethical assessment of social options (see Broome [3], p.12).

What happens if we interpret Arrow's theorem as a theorem about arriving at social welfare judgments on the basis of the different individuals' well-being corresponding to different social options? In this case, the individual orderings need to be interpreted as the orderings of social options in terms of the individuals' respective well-being. But note that, in this case, the very definition of a social ranking rule will make the social ranking of options dependent exclusively on the individual well-being *orderings* and will not allow us to take into account any cardinal information about individual well-being (e.g., information that the switch from x to y increases i's well-being more than the switch from z to w). Even if we relax the definition of a social ranking rule to permit cardinal information about the well-being of individuals, Independence of Irrelevant Alternatives with its focus on the individuals' rankings over pairs of options will have the effect of making all such cardinal information irrelevant for the social ranking. When the problem is one of aggregating the judgments or opinions of individuals, there may be some plausibility in ignoring how intensely an individual feels about one option being better than

another, but ignoring cardinal information about the individuals' well-being would seem to be ethically unacceptable when the problem is one of discussing social welfare judgments. The framework of Arrow would seem to be more suitable for discussing how the society should arrive at a compromise given differing individual preferences than for discussing social welfare judgments.

37.5   The Impossibility of Paretian Liberalism

The literature inspired by Arrow [1] has given us numerous results demonstrating that a social ranking rule cannot satisfy certain apparently plausible conditions. I now take up one of these results, namely, the famous paradox of the Paretian liberal due to Sen [13, 14], which has had far-reaching influence on the theory of social choice and welfare.

Definition 37.3 Let $f : \mathcal{S}^n \longrightarrow \mathcal{T}$ be a social ranking rule. f satisfies:

(i) *Weak Collective Rationality* iff $\mathcal{S} = \mathcal{R}$ and, for every $(R_1, \ldots, R_n)$ in $\mathcal{S}^n$, R is reflexive and connected and P is acyclic, i.e., there do not exist $x_1, x_2, \ldots, x_m \in X$, such that $[x_1 P x_2$ and $x_2 P x_3$ and $\ldots$ and $x_{m-1} P x_m$ and $x_m P x_1]$;

(ii) *Minimal Liberalism* iff there exist distinct $i, j \in N$ and $x, y, z, w \in X$, such that $(x \neq y$ and $z \neq w)$, and

(5.1) for every $(R_1, \ldots, R_n)$ in $\mathcal{S}^n$, (if $x P_i y$, then $x P y$) and (if $y P_i x$, then $y P x$),

and

(5.2) for every $(R_1, \ldots, R_n)$ in $\mathcal{S}^n$, (if $z P_j w$, then $z P w$) and (if $w P_j z$, then $w P z$).

Acyclicity of P is much weaker than transitivity of R, and, hence Weak Collective Rationality is much weaker than Collective Rationality. Reflexivity and connectedness of R and acyclicity of P, together, are necessary and sufficient to ensure that $C(A, R)$ will be non-empty for every non-empty and finite subset A of X (see Sen [14], p.16). Minimal Liberalism was originally interpreted in terms of what might be called an individual's right to liberty in her "private" affairs. Under this interpretation, x and y figuring in the statement of Minimal Liberalism are visualized as two social states which are identical in all respects except for something (e.g., i's religion or the color of his shirt) that is considered to be in the personal or private sphere of individual i, and, similarly for z and w in the case of individual j. Thus, the condition stipulates that there are at least two distinct individuals in the society, each of whom enjoys decisiveness (or the "right" to decide) over some pair of distinct alternatives differing only with respect to her private life.

Theorem 37.2 (Sen [13, 14]): *There does not exist any social ranking rule which satisfies Weak Collective Rationality, Weak Pareto Principle, and Minimal Liberalism simultaneously.*

The condition of Minimal Liberalism constituted the first major departure from the dominant tradition of welfare economics, which considered information about people's preferences (or their utility) to be the only information relevant for the evaluation of social options.[1] If a social ranking rule satisfies Minimal Liberalism, then, not only do individual preferences matter for the social ranking of those two alternatives, but it also matters which two alternatives are under consideration: taking the interpretation of Minimal Liberalism in terms of an individual's decisiveness in matters relating to her private life, to invoke Minimal Liberalism one needs to know, besides the individual preferences, whether the options differ only with respect to somebody's private life.

If one accepts the interpretation of the condition in terms of individuals' rights to liberty in their private affairs, then Theorem 37.2 can be thought of as revealing a deep tension between such individual rights and the Weak Pareto Principle, which has been traditionally regarded as sacrosanct in economics. Many scholars (see, among others, Nozick [11], Gärdenfors [7], Sugden [16], and Gaertner et al. [6]) have argued that the interpretation of Minimal Liberalism in terms of individual rights is not quite compatible with our intuition about rights. Most of these scholars, however, acknowledge that Sen's intuitive insight into the tension between individual rights and the Weak Pareto Principle survives even under other formulations of individual rights suggested in the literature.

37.6 Two Voting Rules

In addition to exploring the implications of axioms regarding social choice/ social evaluation, which have a priori ethical appeal, the literature on the formal theory of social choice has also analyzed the structure of a large number of voting rules, which are basically different methods of reaching a compromise in the presence of differing preferences of individuals and many of which are often used in practice. Two of these voting rules, which have been studied over more than two centuries, stand out. The first is the majority voting rule, the formal structure of which was analyzed in detail by M. de Condorcet [5]. The second is Borda's rule advocated by J.-C. de Borda [4].

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[1]This ethical position has been called "welfarism", which may not be an entirely felicitous term. Note that one can define welfarism more formally, but it is not necessary for my purpose here.

The Majority Ranking Rule

The first voting rule that I consider is the well-known majority ranking rule.

Definition 37.4 The *majority ranking rule* (MRR) is the social ranking rule f with domain $\mathcal{R}^n$, such that, for all $x, y \in X$ and all $(R_1, \ldots, R_n)$ in $\mathcal{R}^n$, xRy if and only if $\#\{i \in N : xP_iy\} \geq \#\{i \in N : yP_ix\}$.

It is easy to see that the MRR satisfies the Weak Pareto Principle, Independence of Irrelevant Alternatives, and Non-dictatorship, and that, under it, the social weak preference relation R is reflexive and connected for all $(R_1, \ldots, R_n)$ in $\mathcal{R}^n$. It is, however, well-known that, not only can the social weak preference relation R yielded by the MRR violate transitivity for some profiles of individual preference orderings, but even P can violate acyclicity under the MRR so that the choice set generated by R can be empty for some finite set of options and some profile of individual orderings. An example of this is the well-known voting paradox, where we have $N = \{1, 2, 3\}$ and $(R_1, R_2, R_3) \in \mathcal{R}^n$ is such that xP_1yP_1z, yP_2zP_2x, and zP_3xP_3y, so that the MRR yields xPy and yPz and zPx and $C(\{x, y, z\}, R)$ is empty. This is a major problem with the MRR. But how appealing is it to say that, if, at all, a majority winner exists in a set options, then the society should choose it from that set of options? To see this, it is helpful to see the properties of the MRR. One of the earliest studies of the properties of the MRR in the modern literature on social choice is to be found in May [9], who provided a characterization of the MRR in terms of a set of quite appealing properties.

While May's theorem clarifies the structure of the MRR and, in the process, demonstrates its several highly attractive properties, a very different justification for the MRR came from Condorcet [5] himself (for a lucid exposition of this perspective, see Young [19]). Suppose the number of individuals in the society is odd, we have a profile of linear individual orderings, and we have exactly two options, x and y, which have to be socially ranked and the society's ranking has to be either xPy or yPx. Further, suppose one of these two strict rankings is the "true" or "correct" ranking but it is not known which of them is the correct ranking and, a priori, the two rankings are equally likely to be correct. It does seem a little strange to characterize the ranking of options arrived at by aggregating individual preferences as "correct" or "incorrect". In some situations, however, it makes sense to talk about the correct ranking of x and y for the group. Consider the case of a trial by a jury, which Condorcet [5] discussed. A person is accused of a particular crime and the jury has to decide whether to convict him or not to convict him. All members of the jury share the same objective, namely, that the person should be convicted if and only if he is guilty. Let x denote that the person is convicted and let y denote that the person is not convicted. Given that all members of the jury have the shared objective of convicting the person if and only if he is guilty, and given that the person is either guilty or not guilty, in a very plausible sense exactly one of the two alternative strict rankings, xPy and yPx, is the correct ranking for the group, but it is not known which of them is correct. One can think of many other examples, where the two options are alternative policies for achieving a shared objective, and it seems plausible to talk about the "correct" group ranking of the

two policies though it may not be known what exactly the correct ranking may be. Assume that n is odd and each individual's strict ranking of x and y has the same probability, q $\left(1 > q > \frac{1}{2}\right)$, of being the correct ranking. Condorcet [5] showed that, given the assumptions stated above, the probability that the social ranking of x and y under the MRR will be correct is

$$p = \sum_{k=\frac{n+1}{2}}^{n} q^k (1 - q)^{n-k} \left[\frac{n!}{k! \, (n - k)!} \right]$$

and that p approaches 1 as n becomes indefinitely large. Condorcet's remarkable result provides a strong justification for the MRR when there are exactly two alternatives. For an extension of Condorcet's probabilistic reasoning to the case of more than two alternatives, the reader may refer to Young [18, 19].

Borda's Ranking Rule

Our second voting rule is due to Borda [4], who was a contemporary of Condorcet and his intellectual rival.

Let R^* be a linear ordering over X. For all $x \in X$, let $s(x, R^*)$ denote #$\{a \in X : xP^*a\} + 1$. Thus, if $X = \{x, y, z, w)$ and we have $xP^*yP^*zP^*w$, then $s(x, R^*) = 4$, $s(w, R^*) = 1$, and so on.

Definition 37.5 *Borda's ranking rule* (BRR) *is* the social ranking rule with domain L^n, such that, for all $(R_1, \ldots, R_n) \in L^n$ and all $x, y \in X$, xRy if and only if $\sum_{i \in N} s\,(x, R_i) \geq \sum_{i \in N} s\,(y, R_i)$.

Note that, to avoid some details not important for our purpose, I have defined Borda's ranking rule only for the case where the individual orderings are constrained to be linear. Given a profile of linear individual orderings, BRR proceeds as follows. For each option x and each individual ordering R_i, it specifies for x its "R_i − based score" denoted by $s(x, R_i)$. If x occupies the first position in the ordering R_i over X, then the R_i-based score of x is #X; if x occupies the second position in the ordering, then its R_i-based score is #X-1, and so on. Next, for every option in X, it sums up the R_i-based scores for x over all individuals i to get the "total score" of x. Finally, it ranks all the options on the basis of their respective total scores.

Several points may be noted here. First, for every profile of linear individual orderings, BRR yields a social ordering, and BRR satisfies the Weak Pareto Principle and non-dictatorship. But it can be easily shown that it violates Independence of Irrelevant Alternatives. Second, if X has exactly two alternatives, then it is clear that, for every profile of linear individual orderings[2] over X, BRR will yield the same social ranking as the MRR. Third, it is possible that, for some profile of linear orderings and some non-empty subset A of X, the social ranking yielded by MRR can define a unique best alternative in A, which is different from the

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[2]Recall that in defining BRR, we have assumed that only linear individual orderings are permissible.

unique best alternative in A defined by the social ranking under BRR. To see this, let $N = \{1, 2, \ldots, 9\}$ and $X = \{x, y, z, w\}$, and let $(R_1, \ldots, R_9)$ be as follows (the options in a column are in a descending order of preference)

R_1, R_2, R_3, R_4	R_5, R_6, R_7	R_8	R_9
x	y	w	x
y	z	x	y
z	w	y	w
w	x	z	z

It can be checked that, given this profile, the choice set defined for X by the social ranking under MRR is $\{x\}$ while the choice set specified for X by the social ranking under BRR is $\{y\}$.

Like MRR, BRR has also been characterized in terms of highly plausible properties (see Nitzan and Rubinstein [10][3]; see also Young's [17] characterization of Borda's rule formulated in terms of social choice rather than in terms of a social ranking). Also, for Borda's rule formulated in terms of social choice (rather than in terms of a social ranking), Young [18, 19] provides a striking justification based on probabilistic reasoning analogous to, but different from, the probabilistic reasoning that Condorcet [5] used to justify the MRR.

37.7 Concluding Remarks

This essay has considered only a few contributions to the formal theory of social choice and welfare, which has emerged as an exceptionally rich and diverse area of study. These contributions, however, illustrate how the application of formal reasoning has yielded fresh insights into some very old issues in political and social philosophy.

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