Choosing k from m

Bezalel Peleg, Hans Peters

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How it started

"One year, the department was asked by the Dean to suggest two people for slots that were opening up in the Faculty of Natural Sciences and Mathematics. Four serious mathematicians were candidates; [...after the committee selection it turned out that...] not only [was] most of the department opposed to last night's decision, but there [was] even a specific pair that most of the department prefers to the one chosen [...]"

R.J. Aumann (2012) My scientific first-born. Special issue of International Journal of Game Theory in honor of Bezalel Peleg.

The central question

- There are m candidates, from which a committee of size k has to be chosen: $1 \leq k \leq m - 1$.
- There are n voters with linear preferences on the set of candidates.
- Is there a voting method such that no coalition of voters, by voting strategically, can guarantee a committee that all voters in the coalition prefer to the (or any) committee chosen by truthful voting?

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Similarly for other choices in left profile.

The same example, now with FEP

Each alternative gets weight one. We eliminate alternatives and preferences at the same time, from bottom up. For instance:

$$\begin{matrix} R^1 & R^2 & R^3 \\ a & b & c \\ b & c & a \\ c & a & b \\ d & d & d \end{matrix} \quad \text{El. } d,\ R^1 \to \quad \begin{matrix} R^2 & R^3 \\ b & c \\ c & a \\ a & b \end{matrix} \quad \text{El. } a,\ R^2 \to (b, c)$$

This way we get $\{(a,b),(b,a),(a,c),(c,a),(b,c),(c,b)\}$, say (b,a) is chosen.

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These are not all preferred to (b, a) for voters 2 and 3: these voters cannot *guarantee* something better.

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- We show how FEP can be used to choose k from m.
- We consider computation: equivalent to finding maximal matchings in bipartite graphs.
- We have an axiomatic characterization for the case $k = 1$ (not in this presentation).

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- **THEOREM** (Gibbard, 1973; Satterthwaite, 1975). Let F be non-manipulable with at least three alternatives in its range. Then F is dictatorial.

- Social choice function F is *exactly and strongly consistent* (ESC) if for every $R^N \in L^N$ there is a *strong* Nash equilibrium Q^N of (F, R^N) such that $F(Q^N) = F(R^N)$. (Peleg, 1978)

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- In other words, for an ESC social choice function there is for every profile of true preferences a strong Nash equilibrium of the voting game that results in the sincere (truthful) outcome.
- In order to obtain ESC social choice functions, *feasible elimination procedures* play a crucial role.

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Note that all this depends on the exogenously chosen weights.

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Hence c is the only R^N-maximal alternative.

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- Remark: note that $\beta(x) \geq 2$ for any β in this Theorem and any $x \in A$.
- Goes back to results by Peleg (1978), Holzman (1986), and others.

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The idea is to use FEPs to choose committees of k candidates from in total m candidates. For instance, for $k = 2$:

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- In the paper we consider mainly two preference extensions.
- **Lexicographic worst** Lexicographic comparison starting from worst alternative.

  Example: $m = 5$, $k = 3$. Preference *abcde*. Then (d, c, a) is preferred over (b, a, e) and over (b, d, c). (Order of alternatives is irrelevant.)

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- **Lexicographic from top** Lexicographic comparison starting from the right.

  Example: $m = 5$, $k = 3$. Preference *abcde*. Then (e, a, b) is preferred over (b, a, c) and over (e, c, b), but not over (e, d, a). (Order of alternatives can matter.)

Main result

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Theorem

Suppose we choose a committee of k members from a set of m alternatives according to a feasible elimination procedure ($1 \leq k \leq m-1$). Assume the lexicographic worst or lexicographic from top preference extension. Then there is no coalition who can guarantee (by reporting some preference profile) a committee that is strictly preferred by all members of the coalition to the sincere one (any committee selected from the set of sincere committees).

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- The result does not hold for (e.g.) the lexicographic best preference extension.
- The procedure cannot always be made neutral (all weights equal). But if the number of voters is relatively large then this does not matter too much, e.g., $m = 10$, $n = 1000$: take nine weights equal to 100 and one weight equal to 101.

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- LEMMA: $(a_1, \ldots, a_k)$ can result from FEP if and only if this graph has a maximal matching.
- This can be checked in polynomial time (Hopcroft and Karp, 1973). Repeating this procedure $m(m-1)\cdots(m-k+1)$ times is still polynomial.

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- In the paper we argue that methods based on pairwise majority do not have the core property and, hence, are sensitive to manipulation by coalitions.

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- There are (open) issues concerning neutrality, other preference extensions.

THE END