Discussion Paper Series – CRC TR 224

Discussion Paper No. 203
Project B 01

Committee Search: Evaluating One or Multiple Candidates at a Time?

Christina Luxen *
Tobias Rachidi **

August 2020

*Bonn Graduate School of Economics, E-Mail: christina.luxen@uni-bonn.de
** Bonn Graduate School of Economics, E-Mail: tobias.rachidi@uni-bonn.de

Funding by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) through CRC TR 224 is gratefully acknowledged.

Committee Search: Evaluating One or Multiple Candidates at a Time?*

Christina Luxen† Tobias Rachidi‡

August 17, 2020

Abstract

This paper studies committee search where members either assess candidates "one at a time", i.e., on a rolling basis, or they simultaneously review a set of candidates of fixed size in each time period. We compare both search procedures in terms of acceptance standards and welfare. There is a trade-off between the expected value of a candidate conditional on stopping and the expected search costs. The resolution of this trade-off depends on the voting rule and the specification of search costs associated with the simultaneous evaluation of multiple candidates. The adoption of a qualified majority rule changes the evaluation of search procedures compared to the unanimity rule, revealing that the presence of a search committee alters the search design problem in comparison with the single decision-maker case. This is the main qualitative insight of this paper and we discuss its implications for committee search in practice.

Keywords: Committee search, sequential search, multiple options

JEL Classification: D71, D83

1 Introduction

Academic hiring is mostly conducted by search committees. Often several candidates are reviewed simultaneously after the application deadline has been reached, and the committee either selects one suitable candidate or the hiring process starts over if neither of the candidates satisfied the committee's acceptance standards. So far, the literature on committee search has mainly focused on a search process where candidates are reviewed "one at a time", i.e., hiring is conducted on a rolling basis. Define this search procedure as *single-option sequential search*.[1] In this paper, we consider a search technology in which committees evaluate several candidates simultaneously in each time period, which we denote by *multi-option sequential search*. Our aim is to explore whether single- or multi-option sequential search yields higher acceptance standards and a higher ex ante utilitarian welfare for the search committee.[2] Under multi-option sequential search, committee members can directly compare candidates. This has two implications: On the one hand, the expected value of a candidate conditional on hiring increases; on the other hand, the probability of hiring a particular candidate decreases, and, thus, the expected search costs are altered. Generally, there is a trade-off between these two objects that determine the committee's welfare. The resolution of this trade-off depends on the voting rule and the specification of search costs associated with

*We are grateful to our advisors Stephan Lauermann and Benny Moldovanu for continued guidance and support. We thank Alessandra Casella, Olivier Compte, Philippe Jehiel, Jean-François Laslier, Antonin Macé, Ran Spiegler, Asher Wolinsky as well as participants of the "KIT ECON Brown Bag Seminar" (Karlsruhe), the "4th CRC TR 224 Workshop for Young Researchers", the "BGSE Micro Workshop" (Bonn) and the "CES Economic Theory Seminar" (Paris 1) for helpful comments and discussions. Rachidi thanks the Paris School of Economics, where parts of this research were conducted, for its hospitality. This work was supported by the German Research Foundation (DFG) under Germany's Excellence Strategy EXC 2126/1 390838866 (Excellence Cluster "ECONtribute: Markets and Public Policy") (Luxen), through the Hausdorff Center for Mathematics (Rachidi), through CRC TR 224 (Project B01), by a grant from the European Research Council (ERC 638115, awarded to Stephan Lauermann), the Studienstiftung des deutschen Volkes (Rachidi), and the Deutsche Akademische Austauschdienst (Rachidi).

†Bonn Graduate School of Economics, E-Mail: christina.luxen@uni-bonn.de

‡Bonn Graduate School of Economics, E-Mail: tobias.rachidi@uni-bonn.de

[1] In the search literature, this is mostly denoted as *sequential search*.

[2] A second application is a family searching for a house. The decision to purchase can be made after each showing or after a certain number of houses have been seen. Compte and Jehiel (2010) suggest an application to project selection: Suppose that a firm has scarce resources and needs to decide on a new project to fund, where project ideas arrive randomly.

the simultaneous evaluation of multiple candidates. We find that under unanimity voting, the ranking of the two search procedures depends on how the search costs vary with the number of candidates simultaneously evaluated in each period. In contrast, under qualified majority voting distinct from unanimity, this sensitivity to the shape of the cost function partly disappears. Consequently, the problem of the design of search technologies for committees is different from the search design problem for a single decision-maker, noting that the latter is a special case of a search committee operating under the unanimity voting rule. This insight constitutes the main contribution of this paper.

In our model, a search committee consisting of at least one member seeks to hire one candidate, and we consider two search technologies: Under single-option sequential search, exactly one candidate arrives per period, and under multi-option sequential search, the committee reviews in each time period a fixed number $K > 1$ of candidates simultaneously. The time horizon is infinite, and rejected candidates cannot be recalled. Note that multi-option sequential search can also be interpreted as delayed voting: Suppose that one candidate per period arrives. Then, simultaneously evaluating K candidates in some round of the dynamic search procedure can be viewed as taking voting decisions only every K periods instead of every single period. In other words, choosing the number of candidates to be evaluated simultaneously can be viewed as selecting voting times.[3]

The committee members' preferences feature independent private values. For every member, the value of a candidate is a random variable, which is distributed independently and identically across time, members, and candidates. Each committee member observes his or her own value realization for every candidate and has distributional knowledge about the other members' values.

We consider a class of voting rules where each member may either vote for one of the available candidates or may opt to continue search. A candidate is then hired if and only if the number of votes he or she receives exceeds a qualified majority threshold ranging from simple majority to unanimity. This class of voting rules is frequently used in practice, for example in certain resolutions of the German Caritas (cf. Deutscher Caritasverband e.V. (2018)), in the election of the President

[3] We thank Olivier Compte for suggesting this interpretation.

of Germany (cf. Bundesrepublik Deutschland (2019)),[4], or in the papal conclave (cf. Benedict XVI (2013)).[5] In the latter circumstances, it is common that more than two candidates are in contention.

If a candidate is hired, search stops; otherwise, search continues, and each committee member bears an additive search cost $c \cdot h(K) > 0$. We restrict the committee members' voting strategies to symmetric and neutral[6] stationary Markov strategies. Then, a member votes in favor of some candidate if and only if the candidate's value is the highest among all observed K values and it exceeds some cutoff representing the member's acceptance standard. Acceptance standards coincide with welfare because values are private.[7]

We first prove the existence and uniqueness of a symmetric and neutral stationary Markov equilibrium in the single- and multi-option sequential search setting for all qualified majority voting rules including unanimity voting. The uniqueness of equilibrium is shown for value distributions that admit a log-concave density. In the subsequent comparison of the two search procedures, we maintain this distributional assumption.

Then, we study the case of unanimity voting in detail. We find that if the cost function h is superadditive or linear in the number of evaluated candidates, single-option sequential search yields higher acceptance standards and higher welfare than multi-option sequential search. Intuitively, given some acceptance standard, the expected value of a candidate conditional on stopping is higher if $K > 1$ than if $K = 1$. However, at the same time, expected search costs are also higher because the probability of hiring a particular candidate is lower and costs are superadditive or linear. We show that the increase in the expected value conditional on stopping is limited and that the overall trade-off is resolved in favor of single-option sequential search. In contrast, if the cost function h is strictly subadditive in the number of candidates, multi-option sequential search yields higher welfare if the magnitude of search costs quantified by the parameter c is sufficiently small. Here, if c

[4] In these cases, abstaining is equivalent to voting in favor of continuing search

[5] Abstention is not allowed in the papal conclave. However, since any male Catholic is a potential candidate for papacy, voting for a person without a chance is equivalent to voting to continue search.

[6] A strategy is *neutral* if it does not condition on the identity of the candidate.

[7] To be precise, this holds if and only if the equilibrium cutoff is interior.

is small, acceptance standards are close to the upper bound of the support of the value distribution. Hence, while the probability of hiring a particular candidate is higher under single-option sequential search, it is low for both search protocols. Therefore, if c is sufficiently small, expected search costs are actually lower under multi-option sequential search because h is assumed to be subadditive. In addition, as before, the expected value conditional on stopping for $K > 1$ is not lower than the respective value for $K = 1$. Extensions to interdependent values and correlated values show the robustness of these results.

Next, we consider qualified majority voting rules that do not require full unanimity. We find that multi-option sequential search yields a higher welfare than single-option sequential search for all cost functions h as long as c is sufficiently small. Thus, the sensitivity to the shape of the cost function h that we find for the unanimity rule partly disappears. To prove this result, we first establish that the ranking of the expected values conditional on stopping from the unanimity voting case carries over to qualified majority, meaning, the respective expected value is higher if $K > 1$ compared to $K = 1$. Then, we show that if c is sufficiently small, this increase in the expected value conditional on stopping outweighs the potential rise in expected costs.[8] Consequently, as alluded to above, the comparison of single- to multi-option sequential search differs considerably if the search committee operates under qualified majority voting instead of unanimity voting. Thus, our results imply in particular that the conclusions for the single decision-maker case do not carry over to committee search with qualified majority voting.

We are aware of only one other paper analyzing the differences between the committee search setting and the single-searcher case with respect to the search technology and the implications for its design. In independent work, Cao and Zhu (2019) compare single-option sequential search to fixed-sample-size search, where the committee first determines the total number of candidates to be reviewed, then reviews the candidates sequentially, and finally selects one of these candidates. The latter is conceptually different to multi-option sequential search. Cao and Zhu (2019) show that previous results from the single-searcher setup do not

[8]Depending on the shape of the cost function h, expected search costs might also decrease. Of course, this only reinforces our reasoning.

carry over to the committee search setting. We will discuss further details and differences in the next section.

The paper is organized as follows: Section 2 reviews the related literature, Section 3 introduces the model, and Section 4 proves the existence and uniqueness of the equilibrium. Section 5 treats the unanimity voting case, Section 6 contains the results for qualified majority voting rules, and Section 7 concludes while discussing the implications of our results for committee search in practice. Appendix A contains the proofs, and Appendix B derives expressions for the probability of approving a particular candidate and the expected value conditional on stopping.

2 Related Literature

Our paper contributes to the growing literature on committee search where a committee conducts search dynamically over time.[9] Albrecht et al. (2010), Compte and Jehiel (2010), and Moldovanu and Shi (2013) assume that the committee employs single-option sequential search, where, in each time period, the committee draws exactly one alternative from a known distribution and decides by voting whether to accept the current alternative or to continue costly search by drawing a new alternative. The time horizon is infinite, and there is no recall.

In Albrecht et al. (2010) and Compte and Jehiel (2010), preferences feature private values, and search is costly because of multiplicative discounting. Albrecht et al. (2010) show that there exists a unique equilibrium if the density of the value distribution is log-concave.[10] Further, they compare the committee search problem and the single-agent search problem in terms of acceptance standards and expected search duration. More generally, they study the effect of increasing either the committee size or the majority requirement on acceptance standards and the expected search duration. Finally, they show that the welfare-maximizing majority requirement increases in the members' patience. Our paper focuses on the effect of different search procedures on acceptance standards and welfare given

[9] The static case of committee decision-making has also been analyzed in depth, cf. the survey by Li and Suen (2009).

[10] Conceptually, the proof strategy of our uniqueness result follows Albrecht et al. (2010), but as outlined below, the presence of more than one candidate per period requires a substantial amount of supplementary arguments.

the voting rule, whereas Albrecht et al. (2010) study the implications of different voting rules or committee sizes while holding the search technology, i.e., single-option sequential search, fixed. In Compte and Jehiel (2010), in each period, one candidate or proposal is drawn from a potentially multi-dimensional proposal space. The members' values of some proposal are given by utility functions mapping proposals into values. Compte and Jehiel (2010) show how different aspects shape the final outcome under single-option sequential search. If the proposal space is multi-dimensional, they find a systematic difference between unanimity voting and qualified majority voting. In the former case, the size of the agreement set, meaning, the set of proposals that are approved by at least as many members as the majority threshold requires for acceptance, becomes small, while, in the latter case, the size of the agreement set does not vanish as members become arbitrarily patient. When restricting attention to single-option sequential search, in the framework of Compte and Jehiel (2010), our model essentially corresponds to the case of a multi-dimensional proposal space with linear utility. The proposal space is a hypercube whose dimension is equal to the committee size, each member is associated with one distinct dimension of the proposal space, and the members' values are given by the characteristic of the proposal they are linked to. Consequently, this systematic difference between unanimity and qualified majority voting arises in our setting as well, and it turns out to be important for our results concerning the comparison of different search technologies.

Moldovanu and Shi (2013) assume that committee members have interdependent preferences, and they focus on the unanimity voting rule. Committee members face additive search costs. Each member is linked to a signal about the candidate arriving in some period, and a member's value of this candidate amounts to a weighted average of this member's own signal and the signals associated with the other members. The weight attached to a member's own signal is interpreted as the level of partisanship in the committee. If members only observe their own signals, they are called specialists, whereas, if members observe all signals, they are termed generalists. Moldovanu and Shi (2013) analyze how acceptance standards and welfare react to varying degrees of partisanship and compare the decisions of committees composed of either generalists or specialists. For the case of unanimity voting, our results concerning acceptance standards and partly welfare extend when committee members have interdependent preferences.

We know of only one other contribution that is concerned with the comparison of different search technologies in the committee search environment.[11] In independent work, Cao and Zhu (2019) compare single-option sequential search with simple majority voting to a fixed-sample-size search technology that can be described as follows: First, the committee determines the total sample size via the random proposer mechanism. Then, in each period, one alternative is drawn until the predetermined sample size is reached. Finally, the committee selects an alternative according to plurality voting. There is no discounting, but members bear additive search costs that are linear in the number of alternatives. Moreover, their main model focuses on committees with two members and uniformly distributed values.[12] Cao and Zhu (2019)'s main insight is that the finding from the single decision-maker setting that single-option sequential search always dominates fixed-sample-size search, as for example established in Rothschild (1974), does not extend to the committee search setting. In contrast, fixed-sample-size search dominates sequential search if the per-observation search cost is very small or large enough. These results are driven by the trade-off of the flexibility advantage of single-option sequential search, which captures that search can be stopped as soon as an appropriate alternative is drawn, against the commitment advantage of fixed-sample-size search, which captures that the number of observations is ex ante optimal. While Cao and Zhu (2019) independently ask a similar research question to ours, they study a conceptually different search technology, inducing different results driven by different effects. Therefore, we view our paper to be complementary to their work.

In the literature on search conducted by a single decision-maker, not only single-option sequential search due to McCall (1970) but also other search technologies

[11] In the literature on auctions, the comparison between different selling technologies has been studied before. Wang (1993) compares auctions to posted-price selling in terms of revenue and prices and finds that the ranking of the two technologies depends on the seller's auctioning costs and on the steepness of the marginal revenue curve.

[12] Cao and Zhu (2019) show that their results extend to values that are drawn from the exponential distribution. Further, they establish via numerical simulations that their findings also partly carry over to larger committees.

such as fixed-sample-size search have been discussed and contrasted, see for instance Stigler (1961), Rothschild (1974), and Burdett and Judd (1983). In Morgan (1983) as well as Manning and Morgan (1985), search is conducted by a single decision-maker, and they consider general classes of search procedures, where, in each period, the single agent decides how many alternatives to draw in the following period if search continues and whether to stop search in the current period. Therefore, multi-option sequential search conducted by a single decision-maker is part of the search technologies studied in Morgan (1983) as well as Manning and Morgan (1985). Morgan (1983) derives properties of the optimal sample size in each time period depending on the searcher's recall, time horizon, and outside option, but he does not analytically identify conditions on the primitives of the model under which single-option sequential search is optimal. However, he mentions numerical simulations indicating in particular that single-option sequential search might not be optimal if there is no recall and there are intraperiodic economies of scale in the simultaneous evaluation of multiple alternatives. To some extent, our analytical result for committee search with unanimity voting and subadditive costs specialized to the single-agent case addresses this point. Manning and Morgan (1985) show analytically that single-option sequential search conducted by a single agent is optimal if the time horizon is infinite, there is full recall, and the searcher bears additive search costs that are non-decreasing and strictly convex in the number of alternatives per period. This result resembles our finding for committee search with unanimity voting and superadditive or linear search costs when specializing to the single-searcher case. Note that Manning and Morgan (1985) assume full recall, whereas, we assume that rejected alternatives cannot be recalled. Yet, as long as the sample size per period does not depend on calendar time (as it is the case under single-option as well as multi-option sequential search), in the single-agent case, the no recall assumption is without loss.[13] Therefore, our finding for committee search with unanimity voting and superadditive or linear search costs specialized to the single-agent case can be derived from Manning and

[13]For single-option sequential search and a single decision-maker, this point has been made previously by Albrecht et al. (2010).

Morgan (1985)'s result.[14]

3 Model

A committee consisting of members $\mathcal{N} := \{1, ..., N\}$ with $N \geq 1$, who are indexed by i, seeks to hire one candidate. In each discrete period of time t, a set of candidates $\mathcal{K} := \{1, ..., K\}$ with $1 \leq K < \infty$ arrives. If $K = 1$, we call the resulting search procedure single-option sequential search, whereas, if $K > 1$, the search technology is termed multi-option sequential search.

Preferences feature private values. For each committee member $i \in \mathcal{N}$, the value of hiring candidate $k \in \mathcal{K}$ is governed by the random variable X_i^k, where X_i^k is distributed independently and identically across time periods, candidates, and members according to the cumulative distribution function F with density f. We assume that the distribution of X_i^k has full support on the bounded interval $[0, \bar{x}]$ with $\bar{x} > 0$. Let μ denote the mean of the random variable X_i^k. For all candidates $k \in \mathcal{K}$, committee member $i \in \mathcal{N}$ observes the realization of X_i^k perfectly and has only distributional knowledge about the value X_j^k that any committee member j other than i assigns to candidate k.

The timing is as follows: In every time period, member i observes a realization of the vector of random variables $(X_i^1, \ldots, X_i^K)$, that is, K values. Then, members simultaneously cast a vote, voting either for one candidate k (action k) or for the option to continue search (action 0). Candidate k is hired and search is stopped if and only if the number of votes in favor of k is larger than or equal to the (qualified) majority threshold $M \in \{1, \ldots, N\}$, with $M > \frac{N}{2}$.[15] This class of voting rules encompasses, for instance, unanimity voting corresponding to the case where $M = N$ or simple majority voting with an odd number of members, that is, $M = \frac{N+1}{2}$. If search is continued, each committee member incurs a per period cost of $c \cdot h(K) > 0$, where $h(K)$ is the value of some function $h : \mathbb{N}_+ \rightarrow \mathbb{R}_{>0}$ evaluated at K, and $c > 0$ represents a scaling parameter. Finally, we assume that

[14] However, note that our assumption on the shape of the cost function is slightly more general because non-decreasing and strictly convex costs are also superadditive or linear.

[15] The assumption $M > \frac{N}{2}$ ensures that no two distinct candidates meet the (qualified) majority requirement at the same time.

the search horizon is infinite, and that rejected candidates cannot be recalled.

4 Equilibrium Analysis

Committee member i's strategy is a sequence of functions $\sigma_i = \{\sigma_i(H_t)\}_t$, mapping from any history H_t until period t to $\Delta(\{0\} \cup \mathcal{K})$, i.e., all probability distributions over the set of actions $\{0\} \cup \mathcal{K}$ that are available in each period. As is common in the literature on committee search, we restrict strategies to be (1) Markovian, meaning, the action that member i's strategy prescribes in period t does not depend on the entire history up to period t, but only on the evaluation of the most recent K candidates, and we focus on (2) stationary and (3) symmetric equilibria, that is, the equilibrium strategies are neither sensitive to calendar time nor to the identity of the committee member. In addition, we assume strategies to be (4) neutral, that is, they have to be invariant with respect to permutations of the candidates' labels.[16] Essentially, neutrality rules out stationary and symmetric equilibria in Markov strategies in which voters coordinate on ignoring one or more candidates. Apart from conditions (1) - (4), we also impose that search terminates in finite time, excluding dominated equilibria in which all members always vote to continue search, independently of the value realizations. Subsequently, we simply write equilibrium when referring to a stationary and symmetric Markov equilibrium in neutral strategies.

Strategies that satisfy these refinements are characterized by cutoffs $z \in [0, \bar{x})$. More specifically, in any time period, upon observing the value realizations $(x_i^1, ..., x_i^K) \in [0, \bar{x}]^K$, member $i \in \mathcal{N}$ votes in favor of candidate $k \in \mathcal{K}$ if and only if

$$x_i^k \geq \max_{l \neq k} x_i^l \text{ and } x_i^k \geq z.$$

We call these strategies *maximum-strategies with cutoff*. In words, every member chooses the best among the K available candidates and approves this candidate

[16] Any stationary Markov strategy can be described by a mapping $s : [0, \overline{x}]^K \to \Delta(\{0\} \cup \mathcal{K})$. A strategy s satisfies neutrality if, for all $(x^1, \ldots, x^K) \in [0, \overline{x}]^K$, it holds that $s(x^{\rho(1)}, \ldots, x^{\rho(K)}) = (s^0(x^1, \ldots, x^K), s^{\rho(1)}(x^1, \ldots, x^K), \ldots, s^{\rho(K)}(x^1, \ldots, x^K))$ for any permutation ρ of the set $\mathcal{K}$.

if and only if the respective value exceeds the cutoff, or acceptance standard, z. Intuitively, since candidates are identical ex ante and because members treat candidates in a neutral way, all candidates have the same chance to be elected from the perspective of an individual member. Consequently, no member has an incentive to vote in favor of any candidate but the best.[17]

Interior equilibrium cutoffs $z \in (0, \bar{x})$ solve $z = v$, where v is the continuation value implied by this strategy profile.[18] The continuation value which coincides with the ex ante utilitarian welfare per committee member is given by

$$v = -\frac{c \cdot h(K)}{K \cdot \Pr(\text{candidate } k \text{ hired})} + \mathbb{E}[X_i^k|\text{candidate } k \text{ hired}].$$

The continuation value amounts to the difference between the expected value conditional on stopping $\mathbb{E}[X_i^k|\text{candidate } k \text{ hired}]$ and the expected search costs $\frac{c \cdot h(K)}{K \cdot \Pr(\text{candidate } k \text{ hired})}$. Let $Q^K(z, N, M)$ be the cumulative distribution function of the Binomial distribution with parameters N and $\Pr(X_i^k \geq z \text{ and } X_i^k \geq \max_{l \neq k} X_i^l)$ evaluated at $M-1$. Also, for any $b \in \mathbb{N}_0$ with $b \leq N$, $q^K(z, N, b)$ denotes the corresponding probability mass function evaluated at b. Further, we argue in Appendix B.2 that

$$\Pr(X_i^k \geq z \text{ and } X_i^k \geq \max_{l \neq k} X_i^l) = \frac{1}{K}[1 - F(z)^K].$$

Then, the equilibrium equation can be written as

$$z = -\frac{c \cdot h(K)}{K \cdot [1 - Q^K(z, N, M)]} + \mathbb{E}[X_i^k|\text{candidate } k \text{ hired}]. \tag{1}$$

Intuitively, acceptance standards z arising in equilibrium are calibrated in a way such that a member is indifferent between stopping and continuing search whenever the value of some candidate coincides with the cutoff z. A derivation of the equilibrium strategies and the equation characterizing the equilibrium cutoffs can be found in Appendix A.1.

[17] Note that mixed strategies do not arise in equilibrium.

[18] Boundary solutions, i.e., equilibria involving some maximum strategy with cutoff $z = 0$, may arise if the search costs $c \cdot h(K)$ are large. Subsequently, we take care of this issue.

4.1 Equilibrium Existence

We claim that there exists an equilibrium. The reasoning in the previous part implies that there exists an equilibrium if and only if there either exists $0 \leq z < \overline{x}$ that solves equation (1), or there is a boundary equilibrium, in which the maximum-strategy with cutoff $z = 0$ forms an equilibrium.

Proposition 1. *There exists an equilibrium.*

We prove the existence of an equilibrium while making use of the intermediate value theorem. Similar existence arguments appear in Albrecht et al. (2010), Compte and Jehiel (2010), and Moldovanu and Shi (2013).[19]

4.2 Equilibrium Uniqueness

We turn to the problem of equilibrium uniqueness. Apart from being of interest in itself, the uniqueness of equilibrium is important for a transparent comparison between single-option sequential search and multi-option sequential search. It turns out that the equilibrium is unique if we impose the assumption that the density f is log-concave.[20]

Proposition 2. *If the density f is log-concave, the equilibrium is unique.*

Many well-known distributions including, for instance, the uniform distribution or the truncated normal distribution meet this requirement.[21]
Conceptually, the proof strategy follows Albrecht et al. (2010), but, as discussed below, the presence of more than one candidate per period requires a substantial amount of supplementary steps that are not needed if $K = 1$. The arguments from the previous parts imply that there is a unique equilibrium if and only if either equation (1) admits exactly one solution and there is no supplementary boundary equilibrium or there is a boundary equilibrium and the equilibrium equation has

[19] In particular, Moldovanu and Shi (2013) show the existence of an equilibrium for the case of single-option sequential search with unanimity voting, i.e., $K = 1$ and $M = N$.

[20] For the case of single-option sequential search with unanimity voting, i.e. $K = 1$ and $M = N$, the uniqueness of equilibrium has been established in Moldovanu and Shi (2013).

[21] For a comprehensive list of distributions that admit a log-concave density, we refer to Bagnoli and Bergstrom (2005).

no solution. Rearrange equation (1):

$$\frac{c \cdot h(K)}{K \cdot [1 - Q^K(z, N, M)]} = \mathbb{E}[X_i^k | \text{candidate } k \text{ hired}] - z.$$

The essential part of the proof is to establish that the left-hand side of this equation is increasing in z, whereas the right-hand side is decreasing in z. Then, the uniqueness result follows from the opposite monotonicities of the discussed functions.

First, it is straightforward to derive that the left-hand side is increasing in z. Intuitively, if the acceptance standard z increases, the probability of voting in favor of some candidate k decreases, and, hence, the probability of hiring this candidate k and the overall probability of stopping decrease as well. Thus, the expected search costs increase. Consequently, it remains to show that $\mathbb{E}[X_i^k|\text{candidate } k \text{ hired}] - z$ is decreasing in z. This claim is stated as Lemma 1.[22] Define $S^K(z, N, M) := \mathbb{E}[X_i^k|\text{candidate } k \text{ hired}]$ to emphasize that the expected value conditional on hiring depends on K and M.

Lemma 1. *Consider any $K \geq 1$. If the density f is log-concave, the function*

$$S^K(z, N, M) - z$$

is decreasing in z.

Subsequently, we discuss the proof of Lemma 1. Introduce the following two objects:

$$\mu_a^K(z) := \mathbb{E}[X_i^k | X_i^k \geq z \text{ and } X_i^k \geq \max_{l \neq k} X_i^l], \text{ and}$$
$$\mu_r^K(z) := \mathbb{E}[X_i^k | X_i^k < z \text{ or } X_i^k < \max_{l \neq k} X_i^l].$$

These conditional expectations capture the expected value of an arbitrary candidate $k \in \mathcal{K}$ for an arbitrary member $i \in \mathcal{N}$ conditional on approving or rejecting

[22]For single-option sequential search, i.e., $K = 1$, this property has been shown in Albrecht et al. (2010).

this candidate, respectively. We argue in Appendix B.1 that

$$\mathbb{E}[X_i^k|\text{candidate } k \text{ hired}] = w^K(z)\mu_a^K(z) + [1 - w^K(z)]\mu_r^K(z), \tag{2}$$

with $w^K(z)$ being defined as

$$w^K(z) := \sum_{l=M}^{N} \frac{q^K(z,N,l)}{1 - Q^K(z,N,M)} \frac{l}{N}.$$[23]

Intuitively, conditional on stopping, the accepted candidate k might be supported or rejected by an arbitrary member. Therefore, the expected value of k conditional on stopping amounts to an average of the expected values conditional on supporting as well as rejecting candidate k. The weight $w^K(z)$ represents the expected share of members supporting k conditional on k meeting the majority requirement. Note that under unanimity voting, hired candidates must be accepted by every member. Thus, in this case, the expected value conditional on hiring simplifies to $\mathbb{E}[X_i^k|\text{candidate } k \text{ hired}] = \mu_a^K(z)$.

After some intermediate steps that are similar to those in the proof of Albrecht et al. (2010) we obtain that, for $z \in (0, \bar{x})$,

$$\frac{d\mathbb{E}[X_i^k|\text{candidate } k \text{ hired}]}{dz} < w^K(z)\frac{d\mu_a^K(z)}{dz} + [1 - w^K(z)]\frac{d\mu_r^K(z)}{dz}.$$

Hence, the key proof step is to show that $\frac{d\mu_a^K(z)}{dz} \leq 1$ and $\frac{d\mu_r^K(z)}{dz} \leq 1$. Notice that if $K = 1$, these conditional expected values are truncated means:

$$\mu_a^1(z) = \mathbb{E}[X_i^k|X_i^k \geq z], \text{ and } \mu_r^1(z) = \mathbb{E}[X_i^k|X_i^k < z].$$

It is well-known that log-concavity of f implies the desired Lipschitz conditions on the truncated means, i.e., $\frac{d\mu_a^1(z)}{dz} \leq 1$ and $\frac{d\mu_r^1(z)}{dz} \leq 1$ (see e.g. Bagnoli and Bergstrom (2005)). However, for $K > 1$, the discussed implications are not standard because the involved expected values conditional on rejecting or supporting a candidate do no longer constitute truncated means. To obtain that $\frac{d\mu_a^K(z)}{dz} \leq 1$, we establish that

[23] This kind of representation of the expected value conditional on stopping is due to Albrecht et al. (2010).

the conditional density $\Pr(X_i^k = x | X_i^k \geq \max_{l \neq k} X_i^l)$ is log-concave by employing the fact that log-concavity is preserved under integration, which has been shown in Prékopa (1973). Then, like in the case of $K = 1$, log-concavity implies the desired Lipschitz condition on $\mu_a^K(z)$. Next, we show that $\frac{d\mu_r^K(z)}{dz} \leq 1$ by directly invoking the log-concavity of f as well as its implications. Again, the preservation of log-concavity under integration due to Prékopa (1973) is important. Taking both aspects together, Lemma 1 follows, and we obtain that the right-hand side of the equation above is decreasing in z. When comparing the welfare induced by single-option sequential search and multi-option sequential search, we repeatedly make use of Lemma 1. We believe that the technical property established in Lemma 1 might be useful beyond its application in this paper.

5 Unanimity Voting

Having established equilibrium existence and uniqueness, in this section we assume that the committee employs unanimity voting, i.e., we set $M = N$. We contrast the unique equilibria under single-option and multi-option sequential search in terms of acceptance standards and welfare and show how the superiority of one or the other search technology depends on the structure of the search costs.

5.1 Superadditive or Linear Costs

In this part, we study cost functions h that satisfy

$$\frac{h(K)}{K} \geq h(1) \tag{3}$$

for all $K > 1$. In a slight abuse of wording, we say that condition (3) gives rise to *superadditive or linear* costs.[24] Intuitively, the restriction on the function h means that the search costs per candidate under multi-option sequential search are at least as high as under single-option sequential search. For instance, if $h(K) = K^\alpha$ for some $\alpha \geq 1$, costs are superadditive or linear.

Denote the ex ante utilitarian welfare per committee member in the game with

[24]Note that the condition is actually weaker than (strict) superadditivity or linearity.

$K \geq 1$ candidates per period by v_K. Proposition 3 establishes that the welfare under multi-option sequential search with arbitrarily many candidates $K > 1$ is strictly lower than the welfare under single-option sequential search.

Proposition 3. *Suppose that the voting rule is unanimity, i.e., $M = N$, and assume that the density f is log-concave.*
If the search costs are superadditive or linear in the number of candidates, i.e., satisfy (3), the committee's ex ante utilitarian welfare is higher under single-option sequential search relative to multi-option sequential search, i.e., $v_1 > v_K$ for all $K > 1$.

The basic trade-off when moving from $K = 1$ to $K > 1$ is that, on the one hand, the expected value conditional on stopping rises, but on the other hand, expected search costs rise, too. The former effect arises because unanimity voting means that, conditional on stopping, all members vote in favor of the hired candidate, and, when there are multiple candidates, members only approve some candidate if the associated value is the maximum out of the K values they observe. The latter effect is due to two aspects: First, the probability of hiring an arbitrary candidate k is smaller if $K > 1$, and, second, since costs are superadditive or linear, the search costs per candidate are weakly higher if $K > 1$ compared to $K = 1$. Thus, a priori, the ranking of the two search procedures in terms of welfare is ambiguous. The key proof step is to show that the increase in the expected value conditional on stopping is limited when moving from single-option sequential search to multi-option sequential search. Concretely, for any $K > 1$ and any fixed cutoff z, we derive an upper bound for the ratio

$$\frac{\mu_a^K(z) - z}{\mu_a^1(z) - z} = \frac{\mathbb{E}[X_i^k | X_i^k \geq \max_{l \neq k} X_i^l, X_i^k \geq z] - z}{\mathbb{E}[X_i^k | X_i^k \geq z] - z}.$$

Lemma 2. *Consider any $K > 1$. For all $z \in [0, \overline{x})$,*

$$\frac{\mu_a^K(z) - z}{\mu_a^1(z) - z} < \frac{1 - F(z)}{\frac{1}{K}[1 - F(z)^K]}.$$

Note that it is easy to see that a lower bound of this ratio is 1 because in the numerator, the maximum over $K > 1$ values is considered. Lemma 2 reveals that an upper bound of the ratio is given by the ratio of the probability that an individual member votes in favor of candidate k if there is only one candidate to this probability if there are $K > 1$ candidates. We believe that this technical property might be useful beyond its application in this paper.

Now, let us sketch the proof of Proposition 3 for interior cutoffs. In this case, acceptance standards coincide with welfare.[25] Consider the ratio of the expected value conditional on stopping net of the cutoff when $K > 1$ compared to the net value when $K = 1$, that is,

$$\frac{\mathbb{E}[X^k | X^k \geq \max_{l \neq k} X^l, X^k \geq z_K] - z_K}{\mathbb{E}[X^k | X^k \geq z_1] - z_1},$$

where z_K denotes the cutoff when there are $K \geq 1$ candidates. Towards a contradiction, assume that $z_1 \leq z_K$. By the equilibrium equation, i.e., equation (1), the considered ratio is equal to the ratio of the expected search costs when $K > 1$ versus when $K = 1$. Then, the superadditive or linear cost assumption yields a lower bound on this ratio of expected search costs. Moreover, recall that Lemma 1 reveals that the log-concavity of f implies the Lipschitz condition $\frac{d\mu_a^K(z)}{dz} \leq 1$. While invoking $\frac{d\mu_a^K(z)}{dz} \leq 1$ and making use of Lemma 2, we obtain an upper bound on the discussed ratio of expected values conditional on stopping. It turns out that the derived lower bound is larger than the upper bound, which constitutes the desired contradiction.

5.2 Subadditive Costs

Next, we consider cost functions h that satisfy

$$\frac{h(K)}{K} < h(1) \tag{4}$$

for all $K > 1$. We say, again in a slight abuse of wording, that condition (4) gives rise to *subadditive* costs.[26] This assumption is reasonable if there are fixed costs associated with the hiring process or if there are cost savings when multiple

[25] We emphasize that the result also holds if some equilibria constitute boundary solutions.

[26] Note that the distinction between superadditive or linear costs and subadditive costs is not exhaustive.

candidates can be considered. For example, if $h(K) = K^\beta$ for some $\beta < 1$, costs are subadditive. Proposition 4 reveals that under the assumption of subadditive costs, the conclusion of the previous part of this section is partly reversed: If the magnitude of the search costs as quantified by the parameter c is sufficiently small, evaluating multiple candidates at a time improves welfare.

Proposition 4. *Suppose that the voting rule is unanimity, i.e., $M = N$, assume that the density f is log-concave, and consider any function h giving rise to subadditive costs, i.e., satisfying (4). Then, for all $K > 1$, there exists $\bar{c}_K > 0$ such that for all $c < \bar{c}_K$, the committee's ex ante utilitarian welfare is higher under multi-option sequential search with K candidates per period relative to single-option sequential search, i.e., $v_K > v_1$.*

Intuitively, again, the expected value conditional on stopping is not lower for $K > 1$ relative to $K = 1$. However, in contrast to the previous cost regime, for subadditive costs and sufficiently small magnitudes of search costs c, the expected search costs are actually lower if $K > 1$ compared to $K = 1$, yielding a higher welfare for the committee if multi-option sequential search is employed.
Let us sketch the proof of Proposition 4 in more detail. Assume, by contradiction, that there exists $K > 1$, such that for all $\bar{c}_K > 0$, there exists $c < \bar{c}_K$ such that $v_1 \geq v_K$. Without loss of generality, suppose that both cutoffs are interior. Then, they coincide with welfare and, thus, we have that $z_1 \geq z_K$. First, we show that given $z_1 \geq z_K$, the expected value conditional on stopping is increasing when moving from $K = 1$ to $K > 1$. This is a consequence of the log-concavity of f and, more precisely, the Lipschitz condition $\frac{d\mu_a^K(z)}{dz} \leq 1$ we derived in Lemma 1. The equilibrium condition (1) then implies that the expected search costs should also be higher if $K > 1$ compared to $K = 1$. However, if c becomes small, under both search procedures, the equilibrium acceptance standards are close to the upper bound of the value distribution, $\bar{x}$. This conclusion crucially relies on the fact that the voting rule is unanimity and fails in the case of qualified majority rules distinct from unanimity. Then, even though the probability of hiring an arbitrary candidate k is higher for $K = 1$, this probability is small for $K = 1$ as well as for $K > 1$. In fact, if c is small enough, the difference is low enough such that, given

subadditive costs, the expected search costs are overall actually smaller for $K > 1$ than for $K = 1$. This is the desired contradiction.

5.3 Extensions

For the unanimity voting rule, we explore the robustness of our results via two extensions: Allowing for interdependent values instead of private values, and allowing for correlated values instead of independent values.[27]

For the case of interdependent values, we follow the approach in Moldovanu and Shi (2013), assuming that the value a member derives from hiring some candidate is a weighted average of his own observed signal and the signals of all other members. We find that our results regarding acceptance standards carry over from the analysis under private values. As far as welfare is concerned, note that under the assumption of interdependent values, acceptance standards and welfare no longer coincide even if the equilibrium cutoff is interior (cf. Moldovanu and Shi (2013)). If costs are subadditive, the ranking of single-option and multi-option sequential search in terms of welfare from the private-values case extends to interdependent values. Overall, this suggests that our results concerning unanimity voting are not driven by the private-values assumption on preferences.

To relax the assumption that candidates' values are distributed independently across committee members, we introduce an unknown state of the world s_k for each candidate $k \in \mathcal{K}$, which we assume to be independently and identically distributed across time and candidates. Conditional on the state realization s_k, the values associated with candidate k are then independently and identically distributed across committee members. The state-dependent value distributions are assumed to be stochastically ranked according to the likelihood-ratio ordering. While relaxing the independence of values across members, we maintain the assumption that committee members have private values. Thus, acceptance standards and welfare again coincide whenever the equilibrium is interior. We find that both results for the unanimity voting rule carry over from the private-values case to correlated values. Therefore, we conclude that, while the assumption of independently distributed values is admittedly strong, it does not drive our results

[27] The arguments for these extensions are available on request from the authors.

for the unanimity voting rule.

6 Qualified Majority Voting

Having studied the case of unanimity voting, in this section, we turn to qualified majority voting, considering a majority requirement M such that $M < N$. As before, we compare the unique equilibria of multi-option sequential search and single-option sequential search in terms of acceptance standards and welfare. Again, let v_K be the ex ante utilitarian welfare per committee member if there are $K \geq 1$ candidates per period. As already stated, the welfare induced by a search procedure is determined by two ingredients: the expected value conditional on hiring and the expected search costs. To start, we compare in Lemma 3 the expected values conditional on stopping when there are $K > 1$ versus $K = 1$ candidates per period. Recall that $S^K(z, N, M) = \mathbb{E}[X_i^k | \text{candidate } k \text{ hired}]$.

Lemma 3. *Consider any $K > 1$. For all $z \in [0, \bar{x})$,*

$$S^1(z, N, M) < S^K(z, N, M).$$

Lemma 3 reveals that, when fixing a cutoff value z, the expected value conditional on stopping when $K > 1$ is higher than the corresponding expected value when $K = 1$. If the voting rule is unanimity, this conclusion is immediate because, in this case, for any $K > 1$,

$$S^1(z, N, N) = \mathbb{E}[X_i^k | X_i^k \geq z] < \mathbb{E}[X_i^k | X_i^k \geq z \text{ and } X_i^k \geq \max_{l \neq k} X_i^l] = S^K(z, N, N).$$

Yet, if the voting rule is qualified majority, the conclusion is not obvious because there are two forces pulling in opposite directions. Consider the average representation of the expected value conditional on hiring as introduced in equation (2):

$$S^K(z, N, N) = w^K(z)\mu_a^K(z) + [1 - w^K(z)]\mu_r^K(z).$$

Note that for $M < N$, in contrast to unanimity, it does not hold that $w^K(z) = 1$ for all $K \geq 1$, but $w^K(z)$ depends non-trivially on K. Now, take any $K > 1$, and fix a cutoff value z. Observe that $\mu_a^K(z) > \mu_a^1(z)$ as well as $\mu_r^K(z) > \mu_r^1(z)$, that is, both the expected value conditional on approving as well as conditional on rejecting an arbitrary candidate is higher under multi-option sequential search compared to single-option sequential search. Similar to the case of unanimity voting, $\mu_a^K(z)$ increases since a member approves a candidate only if the candidate's value is the highest among the K values that this member observes. Furthermore, in intuitive terms, the reason why $\mu_r^K(z)$ increases is as follows: if $K = 1$, rejecting some candidate means that this candidate's value is below the cutoff z. In contrast, if $K > 1$, a member might also reject some candidate with a value above the cutoff z in case another candidate has an even higher value. However, at the same time, we have that $w^K(z) < w^1(z)$. Conditional on stopping, the expected share of members who approve some candidate k decreases when moving from single-option to multi-option sequential search. This holds because the probability that a single member approves some candidate k decreases, since the candidate's value has to be the maximum out of K values in addition to being above the cutoff z. Finally, since $\mu_a^K(z) > \mu_r^K(z)$ as well as $\mu_a^1(z) > \mu_r^1(z)$, the overall effect on the expected value conditional on stopping is a priori ambiguous. We prove Lemma 3 by employing a technical result from Albrecht et al. (2010) related to the expected share of members who approve some candidate k conditional on stopping.

In Proposition 5, we claim that multi-option sequential search dominates single-option sequential search independently of the shape of the cost function (superadditive or linear, subadditive, or none of the two) as long as the magnitude of the search costs is sufficiently small.

Proposition 5. *Suppose that the density f is log-concave, take any qualified majority voting rule distinct from unanimity, i.e., $M < N$, and consider any function h.*

Then, for all $K > 1$, there exists $\bar{c}_K > 0$ such that for all $c < \bar{c}_K$, the committee's ex ante utilitarian welfare is higher under multi-option sequential search with K candidates per period relative to single-option sequential search, i.e., $v_K > v_1$.

Intuitively, the increase in the expected value conditional on hiring when moving from single-option sequential search to multi-option sequential search as revealed by Lemma 3 outweighs the potential rise of expected search costs[28] if the magnitude of costs c is sufficiently small. We emphasize once again that this result does not depend on the type of the cost function. For any function h, and for any $K > 1$, there are cost levels c such that single-option sequential search is dominated by multi-option sequential search.[29]

Let us discuss the proof of Proposition 5. To the contrary, suppose that there exists $K > 1$, such that for all $\bar{c}_K > 0$, there exists $c < \bar{c}_K$ such that $v_1 \geq v_K$. Again, without loss of generality, focus on interior cutoffs. Thus, we have that $z_1 \geq z_K$ where, again, z_K denotes the equilibrium cutoff if there are $K \geq 1$ candidates per period. Recall that Lemma 1 implies that the log-concavity of f is sufficient for $\frac{dS^1(z,N,M)}{dz} \leq 1$. When employing this Lipschitz condition, we obtain that the difference $S^K(z_K, N, M) - S^1(z_K, N, M)$ is bounded above by the difference in expected search costs between $K > 1$ and $K = 1$. Now, in contrast to unanimity voting, if $M < N$, the equilibrium cutoffs arising under single-option as well as under multi-option sequential search do not converge to the upper bound of the value distribution as the magnitude of search costs c becomes small, but they remain bounded away from $\bar{x}$.[30] The intuition for this result is as follows: Under qualified majority voting, conditional on stopping, a candidate might be hired even though some particular member has rejected this candidate. Taking that scenario—which does not arise under unanimity voting—into account, members do not become arbitrarily picky if search costs become small. Consequently, if c goes to 0, the difference in expected search costs discussed above vanishes. However, due to Lemma 3, the difference $S^K(z_K, N, M) - S^1(z_K, N, M)$ remains strictly positive.[31] This is the desired contradiction.

Our analysis reveals that the ranking of the two types of search technologies for the single-searcher case does not generally extend to the committee search case.

[28]We write potential rise of expected search costs because depending on the shape of the function h the expected search costs might also be lower under multi-option sequential search compared to single-option sequential search. Of course, this only reinforces our reasoning.

[29]However, as emphasized in Proposition 5, the threshold $\bar{c}_K$ depends on the number of candidates $K > 1$ that are simultaneously evaluated in each time period.

[30]For the case of single-option sequential search, this observation has been made previously in Albrecht et al. (2010) as well as Compte and Jehiel (2010).

[31]This step fails if the voting rule is unanimity because, in this case, if c goes to 0, z_K converges to $\bar{x}$ and, thus, $S^K(z_K, N, N) - S^1(z_K, N, N)$ would vanish as well.

Again, note that the single decision-maker case is equivalent to the case of a committee with size $N = 1$ operating under the unanimity voting rule. Thus, our results from section 5 apply. For the committee search case, we have shown that, if costs are superadditive or linear and the magnitude of search costs c is small, single-option sequential search is superior if the voting rule is unanimity, whereas multi-option sequential search yields a higher welfare under qualified majority voting. What drives this difference? If the voting rule is unanimity, there is a race between the difference in the expected value conditional on stopping and the difference in the expected search costs between $K > 1$ and $K = 1$: if c becomes small, the difference in expected search costs between $K > 1$ and $K = 1$ vanishes, and, in addition, the difference in the expected value conditional on hiring also goes to 0. In contrast, under qualified majority voting, if c becomes small, as in the unanimity voting case, the difference in the expected search costs goes to 0. However, in contrast to the unanimity voting case, the difference in the expected value conditional on stopping does not vanish because equilibrium cutoffs do not converge to $\bar{x}$, but they stay bounded away from it. This discrepancy explains why the ranking of the two types of search procedures is different when the voting rule is qualified majority instead of unanimity. Therefore, when comparing the single-searcher case with the committee search case, the choice of the voting rule crucially matters.

7 Conclusion

In this paper, we contrast two committee search procedures: the well-known sequential search procedure, in which candidates are evaluated "one at a time", and multi-option sequential search, in which, in each period, committees simultaneously evaluate a set of candidates of fixed size. We study the equilibrium behavior under these search procedures and show equilibrium existence as well as uniqueness within some reasonably restricted class of equilibria. Based on the equilibrium analysis, we compare single-option and multi-option sequential search in terms of acceptance standards and welfare. We identify circumstances under which the "one at a time" policy commonly studied in the committee search literature is not optimal. Generally, the superiority of one or the other search technology depends on two important ingredients of the search problem: the voting rule and the specification of the search costs associated with the simultaneous evaluation of multiple candidates.

If the committee operates under the unanimity rule, single-option sequential search outperforms any multi-option sequential search procedure if the search costs increase at least linearly in the number of candidates evaluated in each period. In contrast, if the search costs are strictly below the linear benchmark, even if they are only slightly below it, multi-option sequential search improves welfare if the magnitude of costs is sufficiently small. Therefore, in the case of unanimity voting, the conclusion is sensitive to the shape of the cost function. Allowing for correlation among the committee members' values does not alter these findings. Similarly, our results concerning acceptance standards and partly welfare also carry over to the case of interdependent-value preferences. Thus, these findings appear to be robust.

This dependence on the form of the cost function partly vanishes when committees employ a qualified majority rule different from unanimity. In this case, evaluating multiple candidates in each time period improves welfare compared to single-option sequential search for any type of cost function as long as the magnitude of the search costs is sufficiently small. Consequently, the assessment of single-option and multi-option sequential search considerably changes when moving from the unanimity rule to qualified majority rules. This is the main qualitative insight of this paper. Again, note that the search conducted by a single agent is a special case of committee search with unanimity voting. Consequently, our analysis reveals that the results for the single decision-maker case (cf. section 2 for references) do not carry over to the committee setting, but the presence of a committee alters the search design problem and implies different rankings of search procedures.

Finally, let us discuss the implications of our results for committee search in practice. First, consider the application to academic hiring and suppose that a university seeks to hire a full professor. It seems reasonable to assume that search costs are rather negligible in view of the importance of the hiring decision. Therefore, in this case, if the hiring committee employs a qualified majority rule distinct from unanimity, our results suggest that the committee should not hire on a rolling basis, but rather evaluate multiple candidates at a time. In reality, we indeed observe that hiring committees often employ some kind of multi-option sequential search procedure, making their choice of the search procedure consistent with our results.[32] Second, go back to the example of a family searching for a house. Here, it seems natural that the voting rule is unanimity. Now, the family might search for a house in their current area of residence or they might be planning to move to an ulterior region. The former situation might correspond to the case of linear costs whereas the latter circumstances give rise to subadditive costs because the family has to travel to the region where they search for a house. Thus, our findings suggest that the family should employ single-option sequential search in the first case and multi-option sequential search in the second case. Third, consider the application of project search conducted by a committee in a firm. If the project choice is of high importance for the firm, the situation appears to be similar to academic hiring, and, hence, as long as the voting rule is not unanimity, our results suggest relying on multi-option sequential search instead of single-option sequential search. In contrast, if the required search effort is substantial relative to the importance of the value of the projects, search should rather be conducted according to the "one at at time" policy. The above discussion demonstrates that our findings have practically relevant implications which appear to be intuitive.

[32]See for example the descriptions of the hiring processes of the Columbia University in the City of New York (2016), The University of Arizona (2019) or The University of California, Berkeley (2019).

Appendix A Proofs

A.1 Characterization

To begin with, we claim that the best response of any member $i \in \mathcal{N}$ against an arbitrary neutral stationary Markov strategy that is symmetric across all other members amounts to a maximum-strategy with cutoff, that is, member i votes in favor of candidate $k \in \mathcal{K}$ if and only if

$$x_i^k \geq \max_{l \neq k} x_i^l \text{ and } x_i^k \geq z$$

with $z \in [0, \bar{x})$ being some cutoff.

Assume that all members except for member $i \in \mathcal{N}$ in some period t behave according to a common Markovian strategy that is stationary and neutral. First of all, let v be the continuation value member i obtains when search continues. Note that v does not depend on past or current actions or value realizations since the continuation strategy adopted by all members in periods following t is Markovian. Also, it is neither sensitive to the identity i of the member nor to calendar time because continuation strategies are symmetric across members and stationary. Now, suppose that member i observes the value realizations $(x_i^1, \ldots, x_i^K)$ in period t. Member i is pivotal for candidate k if and only if exactly $M-1$ out of the other $N-1$ members choose action k in the given period, that is, approve candidate k. Let $p_k(a,b) > 0$ with $a \in \mathbb{N}$, $b \in \mathbb{N}_0$ and $b \leq a$ denote the probability that exactly b out of a members choose action k in the given period. Similarly, $P_k(a,b) > 0$ with $a, b \in \mathbb{N}$ and $b \leq a$ describes the probability that at most $b-1$ out of a members select action k. Then, the probability that member i is pivotal in favor of candidate k is given by $p_k(N-1, M-1)$.

The expected utility that member i obtains when approving candidate k can be expressed as follows:

$$[(1 - P_k(N-1, M)) + p_k(N-1, M-1)][x_i^k] + \sum_{l \in \{1,\ldots,K\}: l \neq k} [1 - P_l(N-1, m)][x_i^l]$$
$$+ [P_k(N-1, M) - p_k(N-1, M-1) - \sum_{l \in \{1,\ldots,K\}: l \neq k} (1 - P_l(N-1, M))][v].$$

The expected payoff of member i when voting in favor of continuing search, i.e., selecting action 0, amounts to

$$\sum_{l\in\{1,\dots,K\}}[1-P_l(N-1,M)][x_i^l]+[1-\sum_{l\in\{1,\dots,K\}}(1-P_l(N-1,M))][v].$$

Since the stationary Markov strategy that is commonly adopted by members distinct from i is neutral, it holds that $P_d(a,b)=P_e(a,b)$ as well as $p_d(a,b)=p_e(a,b)$ for all $d,e\in\mathcal{K}$. For simplicity, write $P(a,b)$ and $p(a,b)$ to denote these probabilities. Consequently, the expected utility of choosing action k can be reformulated in the following way:

$$\begin{aligned}p(N-1,M-1)[x_i^k]+[1-P(N-1,M)][\sum_{l\in\{1,\dots,K\}}x_i^l]\\+[1-K(1-P(N-1,M))-p(N-1,M-1)][v].\end{aligned}$$

Similarly, the expected payoff of action 0 simplifies to the expression

$$[1-P(N-1,M)][\sum_{l\in\{1,\dots,K\}}x_i^l]+[1-K(1-P(N-1,M))][v].$$

Thus, voting in favor of candidate k is optimal for member i if and only if, for all $m\in\mathcal{K}$ with $m\neq k$,

$$\begin{aligned}&p(N-1,M-1)[x_i^k]+[1-P(N-1,M)][\sum_{l\in\{1,\dots,K\}}x_i^l]\\&\qquad+[1-K(1-P(N-1,M))-p(N-1,M-1)][v]\\\geq\ &p(N-1,M-1)[x_i^m]+[1-P(N-1,M)][\sum_{l\in\{1,\dots,K\}}x_i^l]\\&\qquad+[1-K(1-P(N-1,M))-p(N-1,M-1)][v],\end{aligned}$$

and, at the same time,

$$
\begin{aligned}
&p(N-1,M-1)[x_i^k]+[1-P(N-1,M)][\sum_{l\in\{1,\ldots,K\}} x_i^l] \\
&+[1-K(1-P(N-1,M))-p(N-1,M-1)][v] \\
\geq&[1-P(N-1,M)][\sum_{l\in\{1,\ldots,K\}} x_i^l]+[1-K(1-P(N-1,M))][v].
\end{aligned}
$$

The former condition is equivalent to requiring that $x_i^k \geq \max_{l\neq j} x_i^l$. The latter condition reduces to $x_i^k \geq v$. This means that there exists a cutoff value $z_i(t) \in [0,\overline{x})$ such that this condition is met if and only if $x_i^j \geq z_i(t)$. Moreover, the cutoff value solves $z_i(t) = v$ whenever it is interior. Hence, given an arbitrary neutral stationary Markov strategy commonly adopted by all members except for member i in period t, it is optimal for member i to employ a maximum-strategy with cutoff $z_i(t)$ in this period.

In the following, we make use of this claim, and we establish the sufficiency and the necessity part separately.

With regard to necessity, it is immediate from the previous claim that any symmetric stationary Markov equilibrium in neutral strategies must involve a maximum-strategy with cutoff $z \in [0,\bar{x})$ solving $z = v$ whenever being interior, and that this strategy is commonly adopted by all members since, otherwise, at least one member has a profitable deviation. In particular, the cutoffs are neither sensitive to the members' identities nor to calendar time because, by assumption, equilibria are symmetric and stationary. Moreover, the consistency of continuation values and equilibrium strategies implies that v must satisfy

$$
\begin{aligned}
v = &-c\cdot h(K)+[1-K(1-P(N,M))]v \\
&+K\cdot[1-P(N,M)]\mathbb{E}[X_i^k|\text{candidate } k \text{ hired}].
\end{aligned}
$$

Rearranging this equation yields

$$
v = -\frac{c\cdot h(K)}{K\cdot[1-P(N,M)]}+\mathbb{E}[X_i^k|\text{candidate } k \text{ hired}].
$$

Therefore, equilibrium cutoffs solve the equation

$$z = -\frac{c \cdot h(K)}{K \cdot [1 - P(N, M)]} + \mathbb{E}[X_i^k | \text{candidate } k \text{ hired}]$$

whenever they are interior. Finally, recall that $P(N, M)$ denotes the probability that at most $M-1$ out of N members approve some candidate k. Thus, when using the notation introduced in the main text, we have that $P(N, M) = Q^K(z, N, M)$. This concludes the proof of the necessity part.

Next, we turn to sufficiency. First of all, observe that strategy profiles in which all members adopt the same maximum-strategy with cutoff $z \in [0, \overline{x})$ are symmetric, neutral, and stationary Markov. Furthermore, as argued in the necessity part of this proof, these strategy profiles give rise to continuation values satisfying

$$v = -\frac{c \cdot h(K)}{K \cdot [1 - Q^K(z, N, M)]} + \mathbb{E}[X_i^k | \text{candidate } k \text{ hired}].$$

Consequently, it remains to verify that these strategy profiles constitute equilibria. To this end, consider any strategy with cutoff $z \in [0, \overline{x})$ solving

$$z = v = -\frac{c \cdot h(K)}{K \cdot [1 - Q^K(z, N, M)]} + \mathbb{E}[X_i^k | \text{candidate } k \text{ hired}]$$

whenever the cutoff z is interior. First, by construction, the consistency of continuation values and strategies is fulfilled. Second, if all members apart from member $i \in \mathcal{N}$ in period t adopt the discussed strategy, the claim above implies that it is optimal for member i to follow the same strategy in period t, that is, the maximum-strategy with cutoff $z_i(t)$ solving $z_i(t) = v = z$ whenever it is interior. Now, the one-shot deviation principle implies that no member has a profitable deviation. Thus, the maximum-strategy with cutoff z solving

$$z = v = -\frac{c \cdot h(K)}{K \cdot [1 - Q^K(z, N, M)]} + \mathbb{E}[X_i^k | \text{candidate } k \text{ hired}]$$

whenever being interior constitutes an equilibrium. This completes the sufficiency part.

A.2 Existence and Uniqueness

Proof of Proposition 1.

Recall that $S^K(z,N,M) = \mathbb{E}[X_i^k|\text{candidate } k \text{ accepted}]$. Rewriting equation (1) which characterizes equilibrium cutoff values yields

$$\frac{c \cdot h(K)}{K \cdot [1 - Q^K(z,N,M)]} = S^K(z,N,M) - z.$$

Suppose that $z = 0$. In this case, the left-hand side amounts to $\frac{c \cdot h(K)}{K \cdot [1-Q^K(0,N,M)]} = \frac{c\frac{h(K)}{K}}{1-Q^K(0,N,M)}$ and the right-hand side reduces to $S^K(0,N,M)$. In contrast, if $z \to \bar{x}$, the left-hand side goes to ∞ whereas the right-hand side amounts to $S^K(\bar{x},N,M) - \bar{x} \leq 0$.

Depending on the magnitude of the search costs c, we perform a case distinction:

1) $\frac{c\frac{h(K)}{K}}{1-Q^K(0,N,M)} < S^K(0,N,M)$

In this case, we observe that the left-hand side is strictly smaller than the right-hand side of the equilibrium equation when evaluating both sides at $z = 0$. In contrast, if z is sufficiently close to $\overline{x}$, the left-hand side is strictly larger than the right-hand side. Moreover, note that both sides of the equation involve functions that are continuous in z. Hence, the intermediate value theorem yields the existence of a cutoff z that solves equation (1).

2) $\frac{c\frac{h(K)}{K}}{1-Q^K k(0,N,M)} = S^K(0,N,M)$

Here, the cutoff $z = 0$ solves the equilibrium equation which means that the maximum-strategy with cutoff $z = 0$ constitutes an equilibrium.

3) $\frac{c\frac{h(K)}{K}}{1-Q^K(0,N,M)} > S^K(0,N,M)$

In this case, suppose that all members apart from member $i \in \mathcal{N}$ in period t adopt the maximum-strategy with cutoff $z = 0$. In this case, the arguments in Appendix A.1 still apply, and, thus, it is optimal for member i to follow some maximum-strategy with cutoff. However, since $v = -\frac{c\frac{h(K)}{K}}{1-Q^K(0,N,M)} + S^K(0,N,M) < 0$ by assumption, the optimal cutoff for member i in the given period is $z = 0$. The reason is that member i wants to stop search as quickly as possible, and the probability of voting in favor of some candidate k is maximized at $z = 0$. Alluding to the one-deviation-principle, this shows that there exists a boundary equilibrium such that the maximum-strategy with cutoff amounting to $z = 0$ forms an equilibrium. $\square$

Proof of Lemma 1.
We establish that $S_z^K(z,N,M) \leq 1$ which implies that the function $S^K(z,N,M) - z$ is non-increasing in z. Subsequently, again, we make use of the notation

$$\mu_a^K(z) = \mathbb{E}[X_i^k | X_i^k \geq z \text{ and } X_i^k \geq \max_{l \neq k} X_i^l] \text{ and}$$
$$\mu_r^K(z) = \mathbb{E}[X_i^k | X_i^k < z \text{ or } X_i^k < \max_{l \neq k} X_i^l].$$

Then, as shown in Appendix B.1, $S^K(z,N,M)$ can be expressed as

$$S^K(z,N,M) = w^K(z)\mu_a^K(z) + (1 - w^K(z))\mu_r^K(z),$$

where $w^K(z)$ is given by

$$w^K(z) = \sum_{l=M}^{N} \frac{q^K(z,N,l)}{1 - Q^K(z,N,M)} \frac{l}{N}.$$

Further, to simplify the notation, define

$$1 - R^K(z) := \Pr(X_i^k \geq \max_{l \neq k} X_i^l, X_i^k \geq z).$$

First, we obtain that $\frac{dw^K(z)}{dz} \leq 0$.[33] Observe that $w^K(z)$ constitutes the average of terms of form $\frac{l}{N}$ with weights

$$w_l^K(z) := \frac{q^K(z,N,l)}{1 - Q^K(z,N,M)}.$$

We claim that, for all $l < l'$, $\frac{w_l^K(z)}{w_{l'}^K(z)}$ is non-decreasing in z. This means that increasing z yields a stochastic decrease according to the likelihood-ratio ordering which, as is well-known, implies a stochastic decrease in terms of first-order stochastic dominance. Hence, exploiting the average structure of $w^K(z)$, when increasing z, the average $w^K(z)$ decreases. In other words, we have $\frac{dw^K(z)}{dz} \leq 0$. In order to see

[33] The argument yielding $\frac{dw^K(z)}{dz} \leq 0$ is analogous to step 2 in the proof of Lemma 1 in Albrecht et al. (2010).

that $\frac{w_l^K(z)}{w_{l'}^K(z)}$ is increasing in z, note that

$$\frac{w_l^K(z)}{w_{l'}^K(z)} = \frac{\binom{N}{l}}{\binom{N}{l'}} R^K(z)^{l'-l}(1-R^K(z))^{l-l'},$$

and, therefore, straightforward differentiation yields

$$\frac{d\frac{w_l^K(z)}{w_{l'}^K(z)}}{dz} = \frac{\binom{N}{l}}{\binom{N}{l'}} \frac{dR^K(z)}{dz}(l'-l)R^K(z)^{l'-l-1}(1-R^K(z))^{l-l'-1}.$$

The derivation in Appendix B.2 reveals that

$$1 - R^K(z) = \frac{1}{K}[1 - F(z)^K].$$

Thus, $\frac{dR^K(z)}{dz} = F(z)^{K-1}f(z) \geq 0$ and we obtain that $\frac{d\frac{w_l^K(z)}{w_{l'}^K(z)}}{dz} \geq 0$ which is the desired claim. Therefore, we conclude that $\frac{dw^K(z)}{dz} \leq 0$.
Second, we show that $\mu_a^K(z) - z$ is non-increasing or, in other words, $\frac{d\mu_a^K(z)}{dz} \leq 1$. Consider the density

$$\begin{aligned} g^K(x) :&= \Pr(X_i^k = x | X^k \geq \max_{l \neq k} X_i^l) \\ &= \frac{\Pr(X_i^k = x, X_i^k \geq \max_{l \neq k} X_i^l)}{\Pr(X_i^k \geq \max_{l \neq k} X_i^l)} \\ &= \frac{\Pr(X_i^k = x, x \geq \max_{l \neq k} X_i^l)}{\Pr(X_i^k \geq \max_{l \neq k} X_i^l)} \\ &= \frac{\Pr(X_i^k = x)\Pr(x \geq \max_{l \neq k} X_i^l)}{\Pr(X_i^k \geq \max_{l \neq k} X_i^l)} \\ &= Kf(x)[F(x)]^{K-1}. \end{aligned}$$

We know from Prékopa (1973) that the log-concavity of the density f implies that the cdf F is also log-concave. Moreover, since the product of log-concave functions must be again log-concave, we obtain that the density g^K is log-concave as well. Therefore, as is well-known, the log-concavity of g^K implies that the random variable $X_i^k | X_i^k \geq \max_{l \neq k} X_i^l$ has the decreasing mean residual life property which means that $\mu_a^K(z) - z$ is non-increasing.[34] Thus, we conclude that $\frac{d\mu_a^K(z)}{dz} \leq 1$. Third, we establish that $\frac{d\mu_r^K(z)}{dz} \leq 1$. By the law of total expectation, we obtain

$$\mu = \mathbb{E}[X_i^k] = \mu_a^K(z)[1 - R(z)] + \mu_r^K(z)R(z).$$

Again, in Appendix B.2, we derive that

$$1 - R^K(z) = \frac{1}{K}[1 - F(z)^K].$$

Thus,

$$\mu = \mu_a^K(z)[\frac{1}{K}(1 - F(z)^K)] + \mu_r^K(z)[1 - \frac{1}{K}(1 - F(z)^K)].$$

Let G^K be the cdf of the random variable $X_i^k | X_i^k \geq \max_{l \neq k} X_i^l$. Hence, rearranging yields

$$\begin{aligned}
\mu_r^K(z) &= \frac{\mu - \mu_a^K(z)[\frac{1}{K}(1 - F(z)^K)]}{1 - \frac{1}{K}(1 - F(z)^K)} \\
&= \frac{\int_0^{\bar{x}} sf(s)ds - [\frac{1}{K}(1 - F(z)^K)] \int_z^{\bar{x}} s \frac{g^K(s)}{1 - G^K(z)} ds}{1 - \frac{1}{K}(1 - F(z)^K)} \\
&= \frac{\int_0^{\bar{x}} sf(s)ds - \int_z^{\bar{x}} sf(s)F(s)^{K-1} ds}{1 - \frac{1}{K}(1 - F(z)^K)}.
\end{aligned}$$

[34] Bagnoli and Bergstrom (2005) discuss the relationship between log-concave densities and concepts from reliability theory.

Taking the derivative of $\mu_r^K(z)$ with respect to z yields

$$\begin{aligned}
&\frac{d\mu_r^K(z)}{dz}\\
&= \frac{(zf(z)F(z)^{K-1}))\cdot(1-\frac{1}{K}(1-F(z)^K))}{[1-\frac{1}{K}(1-F(z)^K)]^2}\\
&- \frac{(\int_0^{\bar{x}} sf(s)ds - \int_z^{\bar{x}} sf(s)F(s)^{K-1}ds)\cdot f(z)F(z)^{K-1}}{[1-\frac{1}{K}(1-F(z)^K)]^2}\\
&= \frac{f(z)F(z)^{K-1}}{[1-\frac{1}{K}(1-F(z)^K)]^2}\\
&\cdot [z(1-\frac{1}{K}) + z\frac{1}{K}F(z)^K - sF(s)\Big|_0^{\bar{x}} + \int_0^{\bar{x}} F(s)ds + s\frac{1}{K}F(s)^K\Big|_z^{\bar{x}} - \int_z^{\bar{x}} \frac{1}{K}F(s)^K ds]\\
&= \frac{f(z)F(z)^{K-1}}{[1-\frac{1}{K}(1-F(z)^K)]^2}\\
&\cdot [z(1-\frac{1}{K}) + z\frac{1}{K}F(z)^K - \bar{x}(1-\frac{1}{K}) - z\frac{1}{K}F(z)^K + \int_0^{\bar{x}} F(s)ds - \int_z^{\bar{x}} \frac{1}{K}F(s)^K ds]\\
&= \frac{f(z)F(z)^{K-1}[(z-\bar{x})(1-\frac{1}{K}) + \int_0^{\bar{x}} F(s)ds - \int_z^{\bar{x}} \frac{1}{K}F(s)^K ds]}{[1-\frac{1}{K}(1-F(z)^K)]^2}\\
&= \frac{f(z)F(z)^{K-1}[\int_0^{\bar{x}} F(s)ds - \int_z^{\bar{x}} [1-\frac{1}{K}(1-F(s)^K)]ds]}{[1-\frac{1}{K}(1-F(z)^K)]^2}\\
&= \frac{f(z)F(z)^{K-1}[\int_0^{z} F(s)ds + \int_z^{\bar{x}} F(s)ds - \int_z^{\bar{x}} [1-\frac{1}{K}(1-F(s)^K)]ds]}{[1-\frac{1}{K}(1-F(z)^K)]^2}\\
&= \frac{f(z)F(z)^{K-1}[\int_0^{z} F(s)ds + \int_z^{\bar{x}} F(s) - [1-\frac{1}{K}(1-F(s)^K)]ds]}{[1-\frac{1}{K}(1-F(z)^K)]^2}.
\end{aligned}$$

Since we have $\frac{d\mu_r^K(z)}{dz}\Big|_{z=0} = 0 \leq 1$, for the remainder of the proof of $\frac{d\mu_r^K(z)}{dz} \leq 1$, suppose that $z \neq 0$.

Again, due to Prékopa (1973), log-concavity is preserved under integration. Hence, since the density f is log-concave, the cdf $F(z) = \int_0^z f(s)ds$ is also log-concave and, consequently, the left-hand integral $\int_0^z F(s)ds$ must be log-concave as well. By definition of log-concavity, this means that $\int_0^z F(s)ds \leq \frac{F(z)^2}{f(z)}$.[35]

[35] Again, for a discussion of these kinds of implications, we refer to Bagnoli and Bergstrom (2005).

Moreover, note that, for all $s \in [0, \bar{x}]$,

$$\begin{aligned}\frac{1}{K}(1 - F(s)^K) = 1 - R^K(s) &= \Pr(X^k \geq \max_{l \neq k} X^l \text{ and } X^k \geq s) \\ &\leq \Pr(X^k \geq s) = 1 - F(s).\end{aligned}$$

Thus, we obtain, for all $s \in [0, \bar{x}]$, that

$$F(s) - [1 - \frac{1}{K}(1 - F(s)^K)] \leq 0,$$

and, in particular, it holds that

$$\int_z^{\bar{x}} F(s) - [1 - \frac{1}{K}(1 - F(s)^K)] ds \leq 0.$$

Also, observe that $F(z) - [1 - \frac{1}{K}(1 - F(z)^K)] \leq 0$ is equivalent to

$$\frac{1}{1 - \frac{1}{K}(1 - F(z)^K)} \leq \frac{1}{F(z)}.$$

Employing the derived inequalities yields

$$\begin{aligned}\frac{d\mu_r^K(z)}{dz} &= \frac{f(z)F(z)^{K-1}[\int_0^z F(s)ds + \int_z^{\bar{x}} F(s) - [1 - \frac{1}{K}(1 - F(s)^K)]ds]}{[1 - \frac{1}{K}(1 - F(z)^K)]^2} \\ &\leq \frac{f(z)F(z)^{K-1} \int_0^z F(s)ds}{[1 - \frac{1}{K}(1 - F(z)^K)]^2} \\ &\leq \frac{f(z)F(z)^{K-1} \frac{F(z)^2}{f(z)}}{[1 - \frac{1}{K}(1 - F(z)^K)]^2} \\ &= \frac{F(z)^{K+1}}{[1 - \frac{1}{K}(1 - F(z)^K)]^2} \\ &\leq \frac{F(z)^{K+1}}{F(z)^2} \\ &= F(z)^{K-1} \\ &\leq 1.\end{aligned}$$

Therefore, we conclude that $\frac{d\mu_r^K(z)}{dz} \leq 1$.

Further, note that $\mu_a^K(z) > \mu_r^K(z)$ or, equivalently, $\mu_a^K(z) - \mu_r^K(z) > 0$. Taking together the three ingredients $\frac{dw^K(z)}{dz} \leq 0$, $\frac{d\mu_a^K(z)}{dz} \leq 1$ and $\frac{d\mu_r^K(z)}{dz} \leq 1$, we have

$$\begin{aligned}
S_z^K(z,N,M) &= \frac{d[w^K(z)\mu_a^K(z) + (1-w^K(z))\mu_r^K(z)]}{dz} \\
&= \frac{d[w^K(z)[\mu_a^K(z) - \mu_r^K(z)] + \mu_r^K(z)]}{dz} \\
&= \frac{dw^K(z)}{dz}[\mu_a^K(z) - \mu_r^K(z)] + w^K(z)[\frac{d\mu_a^K(z)}{dz} - \frac{d\mu_r^K(z)}{dz}] + \frac{d\mu_r^K(z)}{dz} \\
&= \frac{dw^K(z)}{dz}(\mu_a^K(z) - \mu_r^K(z)) + w^K(z)\frac{d\mu_a^K(z)}{dz} + [1-w^K(z)]\frac{d\mu_r^K(z)}{dz} \\
&\leq w^K(z)\frac{d\mu_a^K(z)}{dz} + [1-w^K(z)]\frac{d\mu_r^K(z)}{dz} \\
&\leq w^K(z) + [1-w^K(z)] \\
&= 1.
\end{aligned}$$

In conclusion, as desired, we infer that $S_z^K(z,N,M) \leq 1$ which, implies that the function $S^K(z,N,M) - z$ is non-increasing in z. Additionally, the argument reveals that $S_z^K(z,N,M) < 1$ whenever $z \neq 0$ and, thus, $S^K(z,N,M) - z$ is strictly decreasing in z. □

Proof of Proposition 2.

To begin with, by Proposition 1, there exists an equilibrium. Moreover, we know from Lemma 1 that the function $S^K(z,N,M) - z$ is decreasing in z. Next, we show that the function

$$\frac{c \cdot h(K)}{K \cdot [1 - Q^K(z,N,M)]}$$

is increasing in z.

Again, to simplify the notation, define

$$1 - R^K(z) := \Pr(X_i^k \geq \max_{l \neq k} X_i^l, X_i^k \geq z).$$

Taking the derivative of the discussed function with respect to z yields

$$\frac{d}{dz}[\frac{c \cdot h(K)}{K \cdot [1 - Q^K(z,N,M)]}] = \frac{c \cdot h(K) \cdot Q_z^K(z,N,M)}{K \cdot [1 - Q^K(z,N,M)]^2}.$$

Further, using the relationship between the Binomial and the Beta distribution,[36] we have

$$Q^K(z,N,M) = \sum_{l=0}^{M-1} \binom{N}{l} (1 - R^K(z))^l \cdot R^K(z)^{N-l}$$
$$= \frac{N!}{(N-M)! \cdot (M-1)!} \int_0^{R^K(z)} s^{N-M}(1-s)^{M-1} ds.$$

Taking the derivative of $Q^K(z,N,M)$ with respect to z yields

$$Q_z^K(z,N,M) = \frac{N!}{(N-M)! \cdot (M-1)!} \frac{dR^K(z)}{dz} R^K(z)^{N-M}(1 - R^K(z))^{M-1}.$$

Again, the derivation in Appendix B.2 reveals that

$$1 - R^K(z) = \frac{1}{K}[1 - F(z)^K].$$

Thus, we have that $\frac{dR^K(z)}{dz} = F(z)^{K-1} f(z) \geq 0$. Hence, we obtain that $Q_z^K(z,N,M) \geq 0$, yielding the desired inference that

$$\frac{d}{dz}\left[\frac{c \cdot h(K)}{K \cdot [1 - Q^K(z,N,M)]}\right] = \frac{c \cdot h(K) \cdot Q_z^K(z,N,M)}{K \cdot [1 - Q^K(z,N,M)]^2} \geq 0.$$

Additionally, the argument shows that this derivative is strictly larger than 0 whenever $z \neq 0$ and, hence, $\frac{c \cdot h(K)}{K \cdot [1 - Q^K(z,N,M)]}$ is strictly increasing in z.
Consider the equation characterizing equilibrium cutoff values

$$S^K(z,N,M) - z = \frac{c \cdot h(K)}{K \cdot [1 - Q^K(z,N,M)]} = \frac{c\frac{h(K)}{K}}{1 - Q^K(z,N,M)}.$$

Depending on the magnitude of the search costs, we perform a case distinction:
1) $\frac{c\frac{h(K)}{K}}{1 - Q^K(0,N,M)} < S^K(0,N,M)$
In this case, all cutoffs associated with equilibrium strategies are interior, satisfying $z \neq 0$. In particular, these cutoffs must solve the equilibrium equation. However, due to Lemma 1, the left-hand side of the discussed equation is strictly decreasing and the right-hand side is strictly increasing. Therefore, both sides of

[36] cf. Casella and Berger (2002)

the equation have at most one intersection which establishes uniqueness of equilibrium.

2) $\frac{c\frac{h(K)}{K}}{1-Q^K(0,N,M)} \geq S^K(0,N,M)$

Here, the cutoff $z=0$ is part of an equilibrium. Either $z=0$ solves the equilibrium equation or there is a boundary equilibrium involving the cutoff $z=0$. To the contrary, suppose that there is another equilibrium with some cutoff $z'>0$. This cutoff must solve the equilibrium equation because it is interior. However, employing the monotonicity properties of the functions involved in the equilibrium equation that are partly derived in Lemma 1, we have

$$\frac{c\frac{h(K)}{K}}{1-Q^K(z',N,M)} > \frac{c\frac{h(K)}{K}}{1-Q^K(0,N,M)} \geq S^K(0,N,M) > S^K(z',N,M) - z'.$$

Hence, the cutoff $z'>0$ cannot be part of an equilibrium which constitutes the desired contradiction. □

A.3 Unanimity Voting

Proof of Lemma 2.

Consider any $K>1$. Suppose, by contradiction, that there exists some $z \in [0,\overline{x})$ such that

$$\frac{\mu_a^K(z)-z}{\mu_a^1(z)-z} = \frac{\mathbb{E}[X_i^k|X_i^k \geq \max_{l\neq k} X_i^l, X_i^k \geq z]-z}{\mathbb{E}[X_i^k|X_i^k \geq z]-z} \geq \frac{K[1-F(z)]}{1-F(z)^K}.$$

Rewriting the left-hand side of the inequality yields

$$\begin{aligned}
\frac{\mathbb{E}[X_i^k|X_i^k \geq \max_{l\neq k} X_i^l, X_i^k \geq z]-z}{\mathbb{E}[X_i^k|X_i^k \geq z]-z} &= \frac{\frac{\int_z^{\overline{x}} f(s)F(s)^{k-1}sds}{\frac{1}{K}[1-F(z)^K]}-z}{\frac{\int_z^{\overline{x}} f(s)sds}{1-F(z)}-z} \\
&= \frac{\frac{\int_z^{\overline{x}} f(s)F(s)^{k-1}sds}{\frac{1}{K}[1-F(z)^K]}[1-F(z)]-z[1-F(z)]}{\int_z^{\overline{x}} f(s)sds - z[1-F(z)]} \\
&= \frac{K[1-F(z)]}{1-F(z)^K}\frac{\int_z^{\overline{x}} f(s)F(s)^{K-1}sds - z[\frac{1-F(z)^K}{K}]}{\int_z^{\overline{x}} f(s)sds - z[1-F(z)]},
\end{aligned}$$

where the first step uses the fact that $\Pr(X_i^k \geq \max_{l\neq k} X_i^l, X_i^k \geq z) = \frac{1}{K}[1 - F(z)^K]$, which is derived in Appendix B.2.

Thus, we get

$$\frac{\int_z^{\overline{x}} f(s)F(s)^{K-1}sds - z[\frac{1-F(z)^K}{K}]}{\int_z^{\overline{x}} f(s)sds - z[1-F(z)]} \geq 1.$$

Since $\int_z^{\overline{x}} f(s)sds - z[1-F(z)] > 0$, we have

$$\int_z^{\overline{x}} f(s)F(s)^{K-1}sds - z[\frac{1-F(z)^K}{K}] \geq \int_z^{\overline{x}} f(s)sds - z[1-F(z)],$$

or, equivalently,

$$\int_z^{\overline{x}} f(s)[F(s)^{K-1} - 1]sds \geq z[\frac{1-F(z)^K}{K} - (1-F(z))].$$

Moreover, since $z < \bar{x}$,

$$\begin{aligned}\int_z^{\overline{x}} f(s)[F(s)^{K-1} - 1]sds &< z\int_z^{\overline{x}} f(s)[F(s)^{K-1} - 1]ds \\ &= z[\frac{1}{K}(1-F(z)^K) - (1-F(z))].\end{aligned}$$

Hence,

$$z[\frac{1-F(z)^K}{K} - (1-F(z))] > \int_z^{\overline{x}} f(s)[F(s)^{K-1} - 1]sds \geq z[\frac{1-F(z)^K}{K} - (1-F(z))],$$

which is the desired contradiction.

□

Proof of Proposition 3.

We begin by deriving conditions for when boundary solutions of either of the search procedures arise.

First of all, note that the proofs of Propositions 1 and 2 reveal that for $K = 1$, the unique equilibrium is a corner solution if and only if $c \geq \frac{\mu}{h(1)} =: c^1$. Similarly, if $K > 1$, a boundary equilibrium arises if and only if

$$c \geq \frac{S^K(0,N,N)[1-Q^K(0,N,N)]}{\frac{h(K)}{K}} = \frac{\mu_a^K(0)[\frac{1}{K}]^N}{\frac{h(K)}{K}} =: c^K.$$

We claim that $c^K < c^1$.

Suppose not, i.e., assume that $c^K \geq c^1$. By definition, this means that

$$\frac{\mu_a^K(0)[\frac{1}{K}]^N}{\frac{h(K)}{K}} \geq \frac{\mu}{h(1)}.$$

Applying Lemma 2 by setting $z = 0$ yields

$$\frac{\mu_a^K(0)}{\mu} < K.$$

Combining the two inequalities, we obtain

$$\frac{h(1)\mu_a^K(0)[\frac{1}{K}]^N}{\frac{h(K)}{K}} \geq \mu > \frac{\mu_a^K(0)}{K}.$$

Hence, since, by assumption, $\frac{h(K)}{K} \geq h(1)$,

$$[\frac{1}{K}]^{N-1} > 1.$$

If $N = 1$, we obtain that $1 = [\frac{1}{K}]^0 > 1$ and, in the case that $N \geq 2$, we must have that $K < 1$. Thus, in both cases, we derived the desired contradiction.

We are now ready to perform a case distinction depending on the magnitude of the scaling parameter c:

1) $c \geq c^1 > c^K$

In this case, single-option sequential search ($K = 1$) as well as multi-option sequential search ($K > 1$) give both rise to a boundary equilibrium with equilibrium cutoffs $z_1 = 0$ and $z_K = 0$ respectively. The respective welfare levels of the two search procedures amount to

$$v_1 = -c \cdot h(1) + \mu \text{ and}$$
$$v_k = \mu_a^K(0) - \frac{c \cdot h(K)}{K[\frac{1}{K}]^N} = \mu_a^K(0) - K^N c\frac{h(K)}{K}.$$

Towards a contradiction, suppose $v_K \geq v_1$. Applying Lemma 2 and using $\frac{h(K)}{K} \geq$

$h(1)$,

$$-c \cdot h(1) + \mu = v_1 \leq v_K = \mu_a^K(0) - K^N c \frac{h(K)}{K} < K\mu - K^N c \frac{h(K)}{K}$$
$$\leq K\mu - K^N c \cdot h(1).$$

Thus, we conclude that $[K^N - 1]c \cdot h(1) < [K - 1]\mu$. Since $c \geq c^1 = \frac{\mu}{h(1)}$, we have $K^N - 1 < K - 1$ or, equivalently, $K^N < K$. In the case of $N = 1$, there is a contradiction. If $N \geq 2$, we must have that $K < 1$ which also constitutes a contradiction.

2) $c^1 > c \geq c^K$

Here, single-option sequential search ($K = 1$) admits an interior equilibrium described by the cutoff value $z_1 > 0$ whereas multi-option sequential search ($K > 1$) has a boundary equilibrium with cutoff $z_K = 0$. Therefore, the resulting welfare levels of both search procedures are given by

$$v_1 = z_1 \text{ and}$$
$$v_K = \mu_a^K(0) - \frac{c \cdot h(K)}{K[\frac{1}{K}]^N} = \mu_a^K(0) - K^N c \frac{h(K)}{K}.$$

By definition of c^K and because of $c \geq c^K$, we directly obtain that $v_K \leq 0$. In contrast, it holds that $v_1 = z_1 > 0$, directly implying $v_K < v_1$.

3) $c^1 > c^K > c$

In this case, single-option sequential search ($K = 1$) as well as multi-option sequential search ($K > 1$) give both rise to an interior equilibrium. Denote the unique equilibrium cutoff values in the game with $K > 1$ candidates per period by z_K and the unique equilibrium cutoff value in the search game with $K = 1$ candidate per period by z_1. Given private value preferences, cutoff values, or acceptance standards, coincide with welfare, i.e., $v_1 = z_1$ and $v_K = z_K$.

Assume, by contradiction, that that $v_1 = z_1 \leq z_K = v_K$. The equilibrium cutoff values satisfy the following equations:

$$S^K(z_K, N, N) - z_K = \frac{c \cdot h(K)}{K \cdot [1 - Q^K(z_K, N, N)]}$$
$$S^1(z_1, N, N) - z_1 = \frac{c \cdot h(1)}{1 - Q^1(z_1, N, N)}.$$

In the following, we derive bounds on the ratio

$$\frac{S^K(z_K, N, N) - z_K}{S^1(z_1, N, N) - z_1} = \frac{\mathbb{E}[X_i^k | X_i^k \geq \max_{l \neq k} X_i^l, X_i^k \geq z_K] - z_K}{\mathbb{E}[X_i^k | X_i^k \geq z_1] - z_1}.$$

First, Lemma 1 yields that the log-concavity of f and the assumption $z_1 \leq z_K$ imply the inequality

$$\frac{\mathbb{E}[X_i^k | X_i^k \geq \max_{l \neq k} X_i^l, X_i^k \geq z_K] - z_K}{\mathbb{E}[X_i^k | X_i^k \geq z_1] - z_1} \leq \frac{\mathbb{E}[X_i^k | X_i^k \geq \max_{l \neq k} X_i^l, X_i^k \geq z_1] - z_1}{\mathbb{E}[X_i^k | X_i^k \geq z_1] - z_1}.$$

Lemma 2 then yields

$$\frac{\mathbb{E}[X^k | X^k \geq \max_{l \neq k} X^l, X^k \geq z_K] - z_K}{\mathbb{E}[X^k | X^k \geq z_1] - z_1} < \frac{K(1 - F(z_1))}{1 - F(z_1)^K}.$$

Second, by the equilibrium conditions,

$$\frac{\mathbb{E}[X^k | X^k \geq \max_{l \neq k} X^l, X^k \geq z_K] - z_K}{\mathbb{E}[X^k | X^k \geq z_1] - z_1} = \frac{\frac{c \frac{h(K)}{K}}{1 - Q^K(z_K, N, N)}}{\frac{c \cdot h(1)}{1 - Q^1(z_1, N, N)}}$$
$$= \frac{\frac{c \frac{h(K)}{K}}{[\Pr(X^k \geq \max_{l \neq k} X^l, X^k \geq z_K)]^N}}{\frac{c \cdot h(1)}{[\Pr(X^k \geq z_1)]^N}}$$
$$= \frac{h(K)}{K} \frac{1}{h(1)} \frac{[\Pr(X^k \geq z_1)]^N}{[\Pr(X^k \geq \max_{l \neq k} X^l, X^k \geq z_K)]^N}.$$

Since $\frac{h(K)}{K} \geq h(1)$ and, by assumption, $z_1 \leq z_K$, we obtain

$$\frac{h(K)}{K}\frac{1}{h(1)}\frac{[\Pr(X^k \geq z_1)]^N}{[\Pr(X^k \geq \max_{l\neq k} X^l, X^k \geq z_K)]^N} \geq \frac{[\Pr(X^k \geq z_1)]^N}{[\Pr(X^k \geq \max_{l\neq k} X^l, X^k \geq z_1)]^N}$$
$$= \frac{[1-F(z_1)]^N}{[\frac{1}{K}(1-F(z_1)^K)]^N}$$
$$= [\frac{K(1-F(z_1))}{1-F(z_1)^K}]^N.$$

Therefore, we get

$$\frac{\mathbb{E}[X^k|X^k \geq \max_{l\neq k} X^l, X^k \geq z_K] - z_K}{\mathbb{E}[X^k|X^k \geq z_1] - z_1} \geq [\frac{K(1-F(z_1))}{1-F(z_1)^K}]^N.$$

Putting both bounds on $\frac{S^K(z_K,N,N)-z_K}{S^1(z_1,N,N)-z_1}$ together, we conclude

$$\frac{K(1-F(z_1))}{1-F(z_1)^K} > [\frac{K(1-F(z_1))}{1-F(z_1)^K}]^N. \tag{5}$$

If $N = 1$, inequality (5) cannot be met. If $N \geq 2$, observe that $\frac{K(1-F(z_1))}{1-F(z_1)^K} = \frac{1-F(z_1)}{\frac{1}{K}(1-F(z_1)^K)} = \frac{1-R^1(z_1)}{1-R^K(z_1)}$ is the ratio of the acceptance probabilities for $K = 1$ candidate compared to $K > 1$ candidates for a fixed cutoff z_1. Since the acceptance probability is smaller for $K > 1$ than for $K = 1$, this ratio must be strictly larger than 1. Hence, in the case of $N \geq 2$, inequality (5) yields also the desired contradiction.

Thus, it must be true that $v_1 = z_1 > z_K = v_K$. □

Proof of Proposition 4.

To begin with, denote the unique equilibrium cutoff value in the game with $K > 1$ candidates per period by z_K and the unique equilibrium cutoff value in the search game with $K = 1$ candidate per period by z_1. Suppose to the contrary that there exists some $K > 1$ such that for all $\bar{c}_K > 0$ there exists $c < \bar{c}_K$ such that $v_1 \geq v_K$. Without loss of generality, restrict attention to sufficiently small values of c such that the equilibria under both procedures are interior. Then, cutoff values coincide with welfare, i.e., $v_1 = z_1$ and $v_K = z_K$.

The respective equilibrium thresholds satisfy the following equations:

$$S^K(z_K,N,N)-z_K=\frac{c\cdot h(K)}{K\cdot[1-Q^K(z_K,N,N)]}$$
$$S^1(z_1,N,N)-z_1=\frac{c\cdot h(1)}{1-Q^1(z_1,N,N)}.$$

Lemma 1 implies that

$$S^K(z_K,N,N)-z_K=\mathbb{E}[X_i^k|X_i^k\geq\max_{l\neq k}X^l,X_i^k\geq z_K]-z_K$$

is non-increasing.

Therefore, the assumption $z_1\geq z_K$ yields the inequality

$$\mathbb{E}[X_i^k|X_i^k\geq\max_{l\neq k}X_i^l,X_i^k\geq z_1]-z_1\leq\mathbb{E}[X_i^k|X_i^k\geq\max_{l\neq k}X_i^l,X_i^k\geq z_K]-z_K.$$

Moreover, since

$$\mathbb{E}[X_i^k|X_i^k\geq z_1]\leq\mathbb{E}[X_i^k|X_i^k\geq\max_{l\neq k}X_i^l,X_i^k\geq z_1],$$

we obtain that

$$\mathbb{E}[X_i^k|X_i^k\geq z_1]-z_1\leq\mathbb{E}[X_i^k|X_i^k\geq\max_{l\neq k}X_i^l,X_i^k\geq z_K]-z_K$$
$$\Leftrightarrow\ S^1(z_1,N,N)-z_1\leq S^K(z_K,N,N)-z_K.$$

Exploiting the equilibrium equations, we get

$$\frac{c\cdot h(1)}{1-Q^1(z_1,N,N)}\leq\frac{c\frac{h(K)}{K}}{1-Q^K(z_K,N,N)}$$
$$\Leftrightarrow\ \frac{c\cdot h(1)}{[\Pr(X_i^k\geq z_1)]^N}\leq\frac{c\frac{h(K)}{K}}{[\Pr(X_i^k\geq\max_{l\neq k}X_i^l,X_i^k\geq z_K)]^N}$$
$$\Leftrightarrow\ [\Pr(X_i^k\geq\max_{l\neq k}X_i^l,X_i^k\geq z_K)]^N\leq\frac{h(K)}{K}\frac{1}{h(1)}[\Pr(X_i^k\geq z_1)]^N.$$

Furthermore, again because of $z_1\geq z_K$, we have $[\Pr(X_i^k\geq z_1)]\leq[\Pr(X_i^k\geq z_K)]$.

Thus, we obtain

$$[\Pr(X_i^k \geq \max_{l \neq k} X_i^l, X_i^k \geq z_K)]^N \leq \frac{h(K)}{K}\frac{1}{h(1)}[\Pr(X_i^k \geq z_K)]^N.$$

Using the expressions for these probabilities derived in Appendix B.2, we obtain

$$\Pr(X_i^k \geq \max_{l \neq k} X_i^l, X_i^k \geq z_K) = \frac{1}{K}[1 - F(z_K)^K]$$
$$\Pr(X_i^k \geq z_K) = 1 - F(z_K).$$

Finally, plugging these terms into the inequality yields

$$[\frac{1}{K} \cdot \frac{1 - F(z_K)^K}{1 - F(z_K)}]^N \leq \frac{h(K)}{K}\frac{1}{h(1)}.$$

Since, by assumption, $\frac{h(K)}{K} < h(1)$, we have that the right-hand side of this inequality is strictly smaller than 1. We claim that, no matter the fixed value of $0 < \frac{h(K)}{K}\frac{1}{h(1)} < 1$, as long as the cost parameter c is sufficiently small, the left-hand side of the inequality is below 1, but arbitrarily close to it. The first part of this statement follows from the proof of Proposition 3. To see the second part, note that as $c \to 0$, $z \to \bar{x}$, implying that $F(z_K) \to 1$. Using L'Hôpital's rule then yields that as $c \to 0$, the left-hand side of the inequality tends to 1. Therefore, eventually, for small c, the left-hand side of the inequality exceeds the right-hand side because $\frac{h(K)}{K}\frac{1}{h(1)} < 1$. This is the desired contradiction. □

A.4 Qualified Majority Voting

Proof of Lemma 3.

To begin with, take any $K > 1$ and fix any value $z \in (0, \bar{x})$. In order to improve readability, we often drop the dependence of the involved functions on z. We tackle the case of $z = 0$ at the end of this proof.

First, we derive an expression for $S^1(z, N, M)$ in terms of $w^1(z)$, $\mu_a^1(z)$, $F(z)$ and μ. By the law of total expectation, we have

$$\mu_r^1 = \frac{\mu - (1 - F)\mu_a^1}{F}$$

and, consequently, we obtain

$$\mu_a^1 - \mu_r^1 = \mu_a^1 - \frac{\mu - (1-F)\mu_a^1}{F} = \frac{\mu_a^1 - \mu}{F}.$$

Therefore, $S^1(z, N, M)$ can be written as

$$\begin{aligned} S^1(z, N, M) &= w^1\mu_a^1 + [1 - w^1]\mu_r^1 \\ &= \mu_r^1 + w^1[\mu_a^1 - \mu_r^1] \\ &= \frac{\mu - (1-F)\mu_a^1}{F} + w^1\frac{\mu_a^1 - \mu}{F} \\ &= \mu[\frac{1 - w^1}{F}] + \mu_a^1[\frac{w^1 - 1 + F}{F}] \\ &= \mu + [\frac{w^1 - 1 + F}{F}][\mu_a^1 - \mu]. \end{aligned}$$

Further, the law of total expectation yields

$$S^1(z, N, M) = [\frac{w^1 - 1 + F}{F}][\mu_a^1 - \mu] + [\frac{1}{K}(1 - F^K)]\mu_a^K + [1 - \frac{1}{K}(1 - F^K)]\mu_r^K.$$

Second, we develop an expression for $\mu_a^K - \mu_r^K$ as well as a lower bound on this term. The law of total expectation implies

$$\mu_r^K = \frac{\mu - \frac{1}{K}(1 - F^K)\mu_a^K}{1 - \frac{1}{K}(1 - F^K)}.$$

Thus, we obtain

$$\begin{aligned} \mu_a^K - \mu_r^K &= \mu_a^K - \frac{\mu - \frac{1}{K}(1 - F^K)\mu_a^K}{1 - \frac{1}{K}(1 - F^K)} \\ &= \frac{\mu_a^K - \mu}{1 - \frac{1}{K}(1 - F^K)} \\ &\geq \frac{\mu_a^1 - \mu}{1 - \frac{1}{K}(1 - F^K)}, \end{aligned}$$

where the inequality follows from $\mu_a^K \geq \mu_a^1$.

Now, suppose to the contrary that $S^1(z,N,M) \geq S^K(z,N,M)$. This means that

$$\begin{aligned} S^1(z,N,M) &= [\frac{w^1-1+F}{F}][\mu_a^1-\mu] + [\frac{1}{K}(1-F^K)]\mu_a^K + [1-\frac{1}{K}(1-F^K)]\mu_r^K \\ &\geq \mu_a^K w^K + \mu_r^K[1-w^K] = S^K(z,N,M). \end{aligned}$$

Rearranging this inequality yields

$$\begin{aligned} & [\frac{w^1-1+F}{F}][\mu_a^1-\mu] + \mu_r^K[1-\frac{1}{K}(1-F^K)-1+w^K] \\ & \geq \mu_a^K[w^K-\frac{1}{K}(1-F^K)] \\ \Leftrightarrow \qquad & [\frac{w^1-1+F}{F}][\mu_a^1-\mu] \geq [\mu_a^K-\mu_r^K][w^K-\frac{1}{K}(1-F^K)]. \end{aligned}$$

Employing the lower bound on $\mu_a^K - \mu_r^K$, we have

$$[\frac{w^1-1+F}{F}][\mu_a^1-\mu] \geq [\frac{\mu_a^1-\mu}{1-\frac{1}{K}(1-F^K)}][w^K-\frac{1}{K}(1-F^K)],$$

because $w^K - \frac{1}{K}(1-F^K) > 0$. To see the latter point, observe that

$$\begin{aligned} w^K &= \sum_{l=M}^{N} \frac{q^K(z,N,l)}{1-Q^K(z,N,M)}\frac{l}{N} \\ &\geq \frac{M}{N}\sum_{l=M}^{N} \frac{q^K(z,N,l)}{1-Q^K(z,N,M)} = \frac{M}{N} > \frac{1}{2}. \end{aligned}$$

Moreover, since $K > 1$, we have

$$\frac{1}{K}(1-F^K) \leq \frac{1}{2}(1-F^K) \leq \frac{1}{2}.$$

Hence, it holds that $w^K - \frac{1}{K}(1-F^K) > 0$.

Next, we note that $[\mu_a^1 - \mu] > 0$ because F has full support and, by assumption, $z > 0$. Thus, we arrive at the following expression:

$$\frac{w^1-1+F}{F} \geq \frac{w^K - \frac{1}{K}(1-F^K)}{1-\frac{1}{K}(1-F^K)}.$$

Rewriting this inequality yields

$$1 - w^1 \leq \frac{F}{1 - \frac{1}{K}(1 - F^K)}[1 - w^K].$$

Now, Albrecht et al. (2010) provide an alternative expression for the weights as a function of the probability that some member approves some candidate; they rely on the Gaussian hypergeometric function as well as the Euler integral.[37] We apply those expressions to the weights w^1 and w^K. In order to simplify the notation, let A^1 and A^K be the probability of approving some candidate k if there are one or K candidates respectively. In other words, define

$$\begin{aligned} A^1(z) &:= 1 - F, \text{ as well as} \\ A^K(z) &:= \frac{1}{K}(1 - F^K). \end{aligned}$$

Making use of this notation, the expressions in Albrecht et al. (2010) read as follows:[38]

$$\begin{aligned} w^1 &= A^1 + \frac{M}{N}(1 - A^1)\{\int_0^1 [1 + \frac{A^1}{1 - A^1}(1 - y^{\frac{1}{M}})]^{N-M} dy\}^{-1} \text{ and} \\ w^K &= A^K + \frac{M}{N}(1 - A^K)\{\int_0^1 [1 + \frac{A^K}{1 - A^K}(1 - y^{\frac{1}{M}})]^{N-M} dy\}^{-1}. \end{aligned}$$

Therefore, we obtain

$$\begin{aligned} 1 - w^1 &= 1 - A^1 - \frac{M}{N}(1 - A^1)\{\int_0^1 [1 + \frac{A^1}{1 - A^1}(1 - y^{\frac{1}{M}})]^{N-M} dy\}^{-1} \\ &= [1 - A^1] \cdot [1 - \frac{M}{N}\{\int_0^1 [1 + \frac{A^1}{1 - A^1}(1 - y^{\frac{1}{M}})]^{N-M} dy\}^{-1}] \\ &= F \cdot [1 - \frac{M}{N}\{\int_0^1 [1 + \frac{A^1}{1 - A^1}(1 - y^{\frac{1}{M}})]^{N-M} dy\}^{-1}], \end{aligned}$$

[37] See for example Abramowitz and Stegun (1965).
[38] The derivation can be found on pages 1403 f. in Albrecht et al. (2010).

as well as

$$
\begin{aligned}
1-w^K &= 1-A^K-\frac{M}{N}(1-A^K)\{\int_0^1[1+\frac{A^K}{1-A^K}(1-y^{\frac{1}{M}})]^{N-M}dy\}^{-1}\\
&=[1-A^K]\cdot[1-\frac{M}{N}\{\int_0^1[1+\frac{A^K}{1-A^K}(1-y^{\frac{1}{M}})]^{N-M}dy\}^{-1}]\\
&=[1-\frac{1}{K}(1-F^K)]\cdot[1-\frac{M}{N}\{\int_0^1[1+\frac{A^K}{1-A^K}(1-y^{\frac{1}{M}})]^{N-M}dy\}^{-1}].
\end{aligned}
$$

Then, the inequality $1-w^1 \leq \frac{F}{1-\frac{1}{K}(1-F^K)}[1-w^K]$ becomes

$$
\begin{aligned}
&F\cdot[1-\frac{M}{N}\{\int_0^1[1+\frac{A^1}{1-A^1}(1-y^{\frac{1}{M}})]^{N-M}dy\}^{-1}]\\
\leq&\frac{F}{1-\frac{1}{K}(1-F^K)}\cdot[1-\frac{1}{K}(1-F^K)]\\
&\cdot[1-\frac{M}{N}\{\int_0^1[1+\frac{A^K}{1-A^K}(1-y^{\frac{1}{M}})]^{N-M}dy\}^{-1}].
\end{aligned}
$$

Simplifying and rearranging this inequality yields

$$\int_0^1[1+\frac{A^1}{1-A^1}(1-y^{\frac{1}{M}})]^{N-M}dy \leq \int_0^1[1+\frac{A^K}{1-A^K}(1-y^{\frac{1}{M}})]^{N-M}dy.$$

In the following, we claim that, for all $y\in[0,1)$,

$$[1+\frac{A^1}{1-A^1}(1-y^{\frac{1}{M}})]^{N-M} > [1+\frac{A^K}{1-A^K}(1-y^{\frac{1}{M}})]^{N-M},$$

which implies that the former inequality cannot be true.
To begin with, note that $A^1 = A^1(z) > A^K(z) = A^K$ since $z \neq \overline{x}$. Now, take any

$y \in [0, 1)$ and observe that

$$\begin{aligned}
& A_1 > A_K \\
\Leftrightarrow \quad & \frac{A^1}{1 - A^1} > \frac{A^K}{1 - A^K} \\
\Leftrightarrow \quad & 1 + \frac{A^1}{1 - A^1}(1 - y^{\frac{1}{M}}) > 1 + \frac{A^K}{1 - A^K}(1 - y^{\frac{1}{M}}) \\
\Leftrightarrow \quad & [1 + \frac{A^1}{1 - A^1}(1 - y^{\frac{1}{M}})]^{N-M} > [1 + \frac{A^K}{1 - A^K}(1 - y^{\frac{1}{M}})]^{N-M}.
\end{aligned}$$

This establishes the claim yielding the desired contradiction. Therefore, overall, we conclude that $S^1(z, N, M) < S^K(z, N, M)$ for all $z \in (0, \bar{x})$.
Finally, it remains to tackle the case of $z = 0$. Here, observe that $S^1(0, N, M) = \mu$. Suppose towards a contradiction that $\mu = S^1(0, N, M) \geq S^k(0, N, M)$. By the law of total expectation, we obtain

$$\begin{aligned}
& [\frac{1}{K}(1 - [F(0)]^K)]\mu_a^K + [1 - \frac{1}{K}(1 - [F(0)]^K)]\mu_r^K = \mu \\
& \geq S^k(0, N, M) = \mu_a^K w^K + \mu_r^K[1 - w^K].
\end{aligned}$$

Rearranging this inequality yields

$$0 \geq [\mu_a^K - \mu_r^K][w^K - \frac{1}{K}].$$

However, we have that

$$0 \geq [\mu_a^K - \mu_r^K][w^K - \frac{1}{K}] > 0,$$

because $\mu_a^K - \mu_r^K > 0$ as well as $w^K - \frac{1}{K}(1 - F^K) > 0$ as established in the first part of this proof. Hence, we arrive at the desired contradiction. □

Proof of Proposition 5.
Suppose, by contradiction, that there exists $K > 1$ such that for all $\bar{c}_K > 0$ there exists $c < \bar{c}_K$ such that $v_1 \geq v_K$. Without loss of generality, restrict attention to sufficiently small values of c such that the equilibria under both procedures are interior. Let z_1 and z_K denote the equilibrium cutoffs corresponding to single-

option as well as multi-option sequential search with K candidates, respectively. These cutoffs solve the respective equilibrium equations

$$\begin{aligned} S^1(z_1, N, M) - z_1 &= \frac{c \cdot h(1)}{1 - Q^1(z_1, N, M)} \\ S^K(z_K, N, M) - z_K &= \frac{c \cdot h(k)}{K[1 - Q^K(z_K, N, M)]} = \frac{c\frac{h(K)}{K}}{1 - Q^K(z_K, N, M)}, \end{aligned}$$

and they coincide with welfare: $z_1 = v_1$ as well as $z_K = v_K$. Thus, by assumption, $z_1 \geq z_K$. Lemma 1 implies that $\frac{d[S^1(z,N,M)-z]}{dz} \leq 0$ for all $z \in [0, \bar{x})$. Making use of this property and employing the equilibrium equations as well as $z_1 \geq z_K$, we obtain

$$\begin{aligned} \frac{c \cdot h(1)}{1 - Q^1(z_1, N, M)} &= S^1(z_1, N, M) - z_1 \\ &\leq S^1(z_K, N, M) - z_K \\ &= S^1(z_K, N, M) + \frac{c\frac{h(K)}{K}}{1 - Q^K(z_K, N, M)} - S^K(z_K, N, M). \end{aligned}$$

Rearranging this inequality yields

$$S^K(z_K, N, M) - S^1(z_K, N, M) \leq \frac{c\frac{h(K)}{K}}{1 - Q^K(z_K, N, M)} - \frac{c \cdot h(1)}{1 - Q^1(z_1, N, M)}.$$

Now, we claim that there exists $B < \bar{x}$ such that for all $c > 0$, it holds $z_K < B$ and $z_1 < B$.

First, towards a contradiction, suppose that for all $B^1 < \bar{x}$ there exist $c > 0$ such that $z_1 \geq B^1$. By the equilibrium equation and the monotonicity properties of the involved functions established in the proofs of Lemma 1 and Proposition 2, we have that z_1 is weakly decreasing in c. Thus, the previous assumption requires that $z_1 \to \bar{x}$ as $c \to 0$. Consider the following rearranged version of the equilibrium equation:

$$z_1 = S^1(z_1, N, M) - \frac{c \cdot h(1)}{1 - Q^1(z_1, N, M)}.$$

If we take the limit on both sides of the equation as $c \to 0$, we obtain

$$\begin{aligned}\bar{x} = \lim_{c \to 0}[z_1] &= \lim_{c \to 0}[S^1(z_1, N, M) - \frac{c \cdot h(1)}{1 - Q^1(z_1, N, M)}]\\ &\leq \lim_{c \to 0}[S^1(z_1, N, M)] = S^1(\bar{x}, N, M) < \bar{x},\end{aligned}$$

which constitutes the desired contradiction. Recalling the average representation of $S^1(\bar{x}, N, M)$, the final inequality holds since $w^1(\bar{x}) < 1$ and $\mu_r^1(\bar{x}) = \mu < \bar{x}$ due to $M < N$. Therefore, there exists $B^1 < \bar{x}$ such that for all $c > 0$, it holds that $z_1 < B^1$.

Second, applying the same argument in an analogous way to multi-option sequential search, we infer that there exists $B^K < \bar{x}$ such that for all $c > 0$, $z_K < B^K$. Consequently, setting $B := \max\{B^1, B^K\}$, we conclude that $z_K < B$ and $z_1 < B$ for all $c > 0$.

Making use of this feature, we obtain the following upper bound on the difference of expected search costs:

$$\begin{aligned}&\frac{c\frac{h(K)}{K}}{1 - Q^K(z_K, N, M)} - \frac{c \cdot h(1)}{1 - Q^1(z_1, N, M)}\\ &< \frac{c\frac{h(K)}{K}}{1 - Q^K(B, N, M)} - \frac{c \cdot h(1)}{1 - Q^1(0, N, M)}\\ &= \frac{c\frac{h(K)}{K}}{1 - Q^K(B, N, M)} - c \cdot h(1)\\ &= c[\frac{\frac{h(K)}{K}}{1 - Q^K(B, N, M)} - h(1)].\end{aligned}$$

Note that this upper bound does not depend on z_1 or z_K.

Let us perform a case distinction:

1) $\frac{\frac{h(K)}{K}}{[1 - Q^K(B,N,M)]} - h(1) \leq 0$

In this case, we obtain

$$S^K(z_K, N, M) - S^1(z_K, N, M) \leq 0,$$

which contradicts Lemma 3. Let $\bar{c}_K$ be the cost value such that for all $c < \bar{c}_K$, the unique equilibrium under both search procedures is interior. That is, set

$$\bar{c}_K := \min\{\frac{S^K(0,N,M)[1-Q^K(0,N,M)]}{\frac{h(K)}{K}}, \frac{\mu}{h(1)}\} > 0,$$

recalling the proofs of Propositions 1 and 2. Then, the established contradiction implies that, for all these levels of c, we have $v_1 < v_K$.

2) $\frac{\frac{h(K)}{K}}{[1-Q^K(B,N,M)]} - h(1) > 0$

To begin with, define

$$r := \min_{s\in[0,B]}[S^K(s,N,M) - S^1(s,N,M)].$$

Observe that r is well-defined because the involved minimum exists due to the extreme value theorem. Also, it does not depend on z_1, z_K or c. Lemma 3 implies that $r > 0$ and, moreover, we have

$$S^K(z_K,N,M) - S^1(z_K,N,M) \geq r.$$

Taking the upper bound on the cost difference together with this lower bound on the difference in terms of expected quality, we arrive at the following inequality:

$$r < c[\frac{\frac{h(K)}{K}}{1-Q^K(B,N,M)} - h(1)].$$

Now, set

$$\bar{c}_K := \frac{r}{\frac{\frac{h(K)}{K}}{[1-Q^K(B,N,M)]} - h(1)}.$$

Note that $\bar{c}_K > 0$ since $\frac{\frac{h(K)}{K}}{[1-Q^K(B,N,M)]} - h(1) > 0$ by assumption and, again, $r > 0$

because of Lemma 3. Then, for all $c < \bar{c}_K$, we have that

$$\begin{aligned} r &< c[\frac{\frac{h(K)}{K}}{[1 - Q^K(B, N, M)]} - h(1)] \\ &< \frac{r}{\frac{\frac{h(K)}{K}}{[1-Q^K(B,N,M)]} - h(1)} \cdot [\frac{\frac{h(K)}{K}}{[1 - Q^K(B, N, M)]} - h(1)] \\ &= r. \end{aligned}$$

This constitutes the desired contradiction. □

Appendix B Derivations

B.1 Expected Value Conditional on Stopping

First, we derive the expression for the value quality of some candidate $k \in \mathcal{K}$ for some member $i \in \mathcal{N}$ conditional on stopping:

$$
\begin{aligned}
S^K(z,N,M) &= \mathbb{E}[X_i^k|\text{candidate } k \text{ hired}]\\
&= \sum_{l=M}^{N} \Pr(\#k\ supporters = l|k\ hired)\mathbb{E}[X_i^k|k\ hired \text{ and } \#k\ supporters = l]\\
&= \sum_{l=M}^{N} \frac{q^K(z,N,l)}{1-Q^K(z,N,M)}\mathbb{E}[X_i^k|\#k\ supporters = l]\\
&= \sum_{l=M}^{N} \frac{q^K(z,N,l)}{1-Q^K(z,N,M)}\cdot\\
&\{\Pr(voter\ i\ supports\ k|\#k\ supporters = l)\mathbb{E}[X_i^k|voter\ i\ supports\ k]\\
&+ \Pr(voter\ i\ rejects\ k|\#k\ supporters = l)\mathbb{E}[X_i^k|voter\ i\ rejects\ k]\}\\
&= \sum_{l=M}^{N} \frac{q^K(z,N,l)}{1-Q^K(z,N,M)}[\frac{l}{N}\mu_a^K(z) + \frac{N-l}{N}\mu_r^K(z)]\\
&= w^K(z)\mu_a^K(z) + [1-w^K(z)]\mu_r^K(z),
\end{aligned}
$$

where $w^K(z)$ is defined as

$$w^K(z) := \sum_{l=M}^{N} \frac{q^K(z,N,l)}{1-Q^K(z,N,M)}\frac{l}{N}.$$

B.2 Probability of Acceptance

Second, we derive the expression for the probability that some member $i \in \mathcal{N}$ votes in favor of some candidate $k \in \mathcal{K}$ as a function of K, F and the employed cutoff z:

$$
\begin{aligned}
&\Pr(X_i^k \geq \max_{l\neq k} X_i^l, X_i^k \geq z) \\
&= \int_0^{\overline{x}} \Pr(X_i^k \geq s, X_i^k \geq z) \Pr(\max_{l\neq k} X_i^l = s) ds \\
&= \int_0^{\overline{x}} \Pr(X_i^k \geq \max\{s, z\}) \Pr(\max_{l\neq k} X_i^l = s) ds \\
&= \int_0^{z} \Pr(X_i^k \geq z) \Pr(\max_{l\neq k} X_i^l = s) ds + \int_z^{\overline{x}} \Pr(X_i^k \geq s) \Pr(\max_{l\neq k} X_i^l = s) ds \\
&= [1 - F(z)] \int_0^{z} \frac{dF(s)^{K-1}}{ds} ds + \int_z^{\overline{x}} [1 - F(s)](K-1)F(s)^{K-2} f(s) ds \\
&= [1 - F(z)]F(z)^{K-1} + \int_z^{\overline{x}} (K-1)F(s)^{K-2} f(s) ds \\
&- \int_z^{\overline{x}} (K-1)F(s)^{K-1} f(s) ds \\
&= [1 - F(z)]F(z)^{K-1} + \int_z^{\overline{x}} \frac{dF(s)^{K-1}}{ds} ds - \int_z^{\overline{x}} \frac{d[\frac{K-1}{K}F(s)^K]}{ds} ds \\
&= [1 - F(z)]F(z)^{K-1} + [1 - F(z)^{K-1}] - \frac{K-1}{K} + \frac{K-1}{K} F(z)^K \\
&= F(z)^{K-1} - F(z)^K + 1 - F(z)^{K-1} - 1 + \frac{1}{K} + F(z)^K - \frac{1}{K} F(z)^K \\
&= \frac{1}{K}[1 - F(z)^K].
\end{aligned}
$$

References

Abramowitz, M. and I. Stegun (1965). *"Handbook of Mathematical Functions: With Formulas, Graphs, and Mathematical Tables"*. Dover Publications, New York.

Albrecht, J., A. Anderson, and S. Vroman (2010). "Search by Committee". *Journal of Economic Theory 145*(4), 1386–1407.

Bagnoli, M. and T. Bergstrom (2005). "Log-concave Probability and its Applications". *Economic Theory 26*(2), 445–469.

Benedict XVI (2013). "Motu proprio Normas nonnullas". The Holy See. http://www.vatican.va/content/benedict-xvi/en/motu_proprio/documents/hf_ben-xvi_motu-proprio_20130222_normas-nonnullas.html [Accessed: 12 December 2019].

Bundesrepublik Deutschland (2019). "Grundgesetz für die Bundesrepublik Deutschland - Art 54". https://www.gesetze-im-internet.de/gg/art_54.html [Accessed: 29 January 2020].

Burdett, K. and K. L. Judd (1983). "Equilibrium Price Dispersion". *Econometrica 51*(4), 955–969.

Cao, X. and Y. Zhu (2019). "Group Search Strategy". *Available at SSRN 3437993*. Working Paper New York University and Massachusetts Institute of Technology.

Casella, G. and R. L. Berger (2002). *"Statistical Inference"* (2 ed.). Duxbury advanced series in statistics and decision sciences. Duxbury Thomson Learning, Pacific Grove.

Columbia University in the City of New York (2016). "Guide to Best Practices in Faculty Search and Hiring". https://provost.columbia.edu/sites/default/files/content/BestPracticesFacultySearchHiring.pdf [Accessed: 18 October 2019].

Compte, O. and P. Jehiel (2010). "Bargaining and Majority Rules: A Collective Search Perspective". *Journal of Political Economy 118*(2), 189–221.

Deutscher Caritasverband e.V. (2018). "Satzung des Deutschen Caritasverbandes e.V.". https://www.caritas.de/cms/contents/caritas.de/medien/dokumente/dcv-zentrale/verbandsordnungen/satzung-des-deutsche/dcv-satzung_fassung_16-10-18.pdf?d=a&f=pdf [Accessed: 27 May 2020].

Li, H. and W. Suen (2009). "Decision-Making in Committees". *Canadian Journal of Economics 42*(2), 359–392.

Manning, R. and P. Morgan (1985). "Optimal Search". *Econometrica 53*(4), 923–944.

McCall, J. J. (1970). "Economics of Information and Job Search". *Quarterly Journal of Economics 84*(1), 113–126.

Moldovanu, B. and X. Shi (2013). "Specialization and Partisanship in Committee Search". *Theoretical Economics 8*(3), 751–774.

Morgan, P. (1983). "Search and Optimal Sample Sizes". *Review of Economic Studies 50*(4), 659–675.

Prékopa, A. (1973). "On Logarithmic Concave Measures and Functions". *Acta Scientiarum Mathematicarum 34*, 335–343.

Rothschild, M. (1974). "Searching for the Lowest Price When the Distribution of Prices Is Unknown". *Journal of Political Economy 82*(4), 689–711.

Stigler, G. J. (1961). "The Economics of Information". *Journal of Political Economy 69*(3), 213–225.

The University of Arizona (2019). "Guide to Successful Searches". https://hr.arizona.edu/supervisors/recruitment-hiring/guide-successful-searches [Accessed: 18 October 2019].

The University of California, Berkeley (2019). "Academic Job Search - The Hiring Process From The Other Side". https://career.berkeley.edu/PhDs/PhDhiring [Accessed: 18 October 2019].

Wang, R. (1993). "Auctions versus Posted-Price Selling". *American Economic Review 83*(4), 838–851.