Catching Outliers: Committee Voting and the Limits of Consensus when Financing Innovation[*]

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Abstract

We provide novel evidence that a substantial share of venture capital investors in the US use a voting model where a single partner 'championing' an early stage investment is sufficient for an investment committee to do the deal, even if other partners are not as enthusiastic. Their stated reason for this voting rule is to 'catch outliers'. The same VCs also tend towards more conventional 'majority' or 'unaninimity' rules for later stage investments. We analyze this evidence through the lens of several conventional models of information aggregation in committees, and conclude that it points to a model in which different voting partners get signals about different aspects of the project and superstar projects are the ones that excel on some dimensions even if potentially flawed on others. In this case, if the distribution of investment returns is sufficiently heavy-tailed, a champions rule is optimal, while for less heavy-tailed distributions, more consensus is optimal. We then show empirically that the distribution of early stage returns have significantly heavier tails than late stage returns, validating the model. In a quantitative example, we find that a majority voting rule in early stage investing reduces the chances of finding the best investments by up to 70% relative to a 'champions' model.

1

1 Introduction

Corporate decisions, whether they are about hiring, R&D financing or investment, are almost always made by a committee. When the outcome of those decisions is ex-ante uncertain, the goal of the committee is to effectively aggregate information into a decision with a positive expected present value. Theoretical work on information aggregation in voting, going back to the famous Condorcet's jury theorem, has provided compelling evidence of the benefits of the 'majority voting rule' (Condorcet (1785); Ladha (1992); Feddersen and Pesendorfer (1997), Feddersen and Pesendorfer (1998)), or more generally, requiring some consensus to change the status quo decision. Using venture capital committee investing as a laboratory, this paper places bounds on the benefits of consensus in committee decisions. VC investments have substantial implications for economic growth[1] and as such, understanding their decision making process is of first-order importance.

Using new evidence from a survey of the 50 largest U.S. venture capital (VC) investors, we show that while all use an investment committee to make decisions, a majority of these VC firms use a voting rule (either formal or informal) where the investment committee agrees to undertake the investment as long as at least one partner champions the deal (even if others are not bullish on the investment). This 'champions voting rule' is used primarily in seed and early stage investments, while in later stage investments, VC firms tend to move to more consensus based voting rules. Even if the goal in seed and early stage investing is to 'move quickly' or 'spray and pray', it is significant that the selection rule for investments does not prioritise options where multiple partners' quick reaction was positive, and instead allows for emphatic support by just one partner.

In a followup survey we sought to understand the reasons for the use of the champi-

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[1]As (Lerner and Nanda 2020) show, VC backed firms account for 89 percent of recorded R&D, and almost half of all non-financial IPOs in the past 20 years.

ons rule in early stage investments. We offered three possible explanations for the use of champions voting rule for seed and early-stage investments but not for later-stage investments. These explanations are motivated by theory and were suggested to us by either academics or VC practitioners. The first explanation is that the champions voting rule is used because it is better at 'catching outliers' than the alternative decision rules. The second explanation is that early-stage deals require more specialized expertise that only few partners possess, so it makes sense to listen to whether the person with the most experise in a particular project type champions for the deal or not. Finally, the third explanation is related to effort: earlier-stage deals are smaller in the amount of investment, so the partnership may want to have only one or few partners spend effort on diligence; in addition, the voting champion 'owns' the decision and thus has stronger incentives to ensure its success. We asked VC firms to evaluate the importance of each explanation. While all three explanations received some support, the overwhelming response was that firms use the rule to 'catch outliers', stating that the best early stage investments are outstanding on some but flawed on many other dimensions and requiring more consensus risks missing the best investments as many partners would focus on the flaws. This evidence flies directly in the face of conventional wisdom, where voting is often considered valuable as a way to 'trim outliers' and emphasize the wisdom of the majority. These surveys raise a natural question: under what circumstances is too much consensus a bad thing?

To better understand the conditions under which the 'champions voting rule' arises as an optimal way to catch outliers and maximize expected returns for a committee, we evaluate our survey evidence through the lense of several canonical models of information aggregation. It is not a general implication of information aggregation models that the champions voting rule is optimal, even if catching right-tail outliers drives value. Thus,

3

the survey evidence is helpful at differentiating between different canonical models of information aggregation in committees. We show that the survey evidence is inconsistent with models with binary project types as well as with models with infinitely many project types in which each committee member's signal equals the true value of the project plus i.i.d. Normal error term, which has been a workhorse model of information aggregation in many settings.[2] In particular, in this model the champions voting rule does similarly well at catching projects from the right tail as the majority voting rule, and even if the tail of the distribution of project values is very fat, we do not find the champions voting rule to dominate the majority voting rule. Instead, we argue that the survey evidence is more consistent with the model in which the fundamental value of a project is determined by a number of dimensions, the quality of each dimension is relatively independent from the other dimensions, and each partner gets an informative signal about one dimension but not the others.

A key implication of this model is that the degree to which a voting rule with more or less consensus is optimal depends on the tail behavior of the distribution from which fundamentals are drawn. When the fundamentals observed by committee members are drawn from a subexponential – fat right-tailed – distribution, the champions rule 'catches an outlier' with a higher probability than any other voting rule, and when the distribution tails are sufficiently fat, it emerges as the optimal voting rule to maximize expected returns. In contrast, when fundamentals are distributed with thinner right tails, majority voting rules can be optimal.

The intuition here stems from two key attributes of fat right-tailed distributions: first,

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[2]This is a classic setting to study information aggregation in financial markets (e.g., Hellwig (1980), Verrecchia (1982), Goldstein and Yang (2017)). It has also been used to study information aggregation in committees (Sah and Stiglitz (1986), Csaszar and Eggers (2013)), and the optimal extent of experimentation in innovation (Azevedo et al. (2020)).

the fact that the distribution of project payoffs exhibits fat right tails implies that much of the potential value from investment comes from maximizing the probability of finding a superstar project. This makes it much more important to reduce false negatives than to reduce false positives – lowering the benefits of consensus in the tradeoff described above. Second, voting rules that require many affirmative votes (such as majority or unanimous agreement) result in the undertaking of projects that tend to be good on many dimensions but are likely to miss those that are *exceptional* on few dimensions but are mediocre elsewhere. An important property of subexponential distributions – known as the 'catastrophe principle' implies that *a superstar venture is more likely to driven by one exceptional characteristic and many mediocre ones rather than by many very good characteristics.* Together these two effects – the importance of getting decisions on superstar projects correct and the fact that a superstar project is likely to be driven by one superstar characteristic rather than many good ones – implies that the champions rule dominates other voting rules in contexts where the distribution of information and returns have heavy right tails. Other decision rules, such a majority rule or unanimous agreement would vote down superstar projects with a high positive probability – because it is possible and even likely that they have many weak characteristics.

In Appendix D, we provide quotes from the VC investors we surveyed suggestive of these mechanisms. Here we note two by Marc Andreessen, co-founder of VC firm Andreessen Horowitz, which show how VCs think about early stage investments[3]:

> *Google, Facebook, eBay and Oracle all had massive flaws as early-stage ventures, but they also had overpowering strengths.*

and

> *Aggregate scores [from all partners] don't correlate strongly with ultimate returns. With that approach, you get the mush in the middle, with no big flaws*

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[3]Eisenmann and Kind (2014), page 8.

but no great strengths.

For VCs, significant flaws are not deal-breakers, as strong negative components in valuation can be compensated for by even stronger positives. Therefore, requiring consensus when every partner cannot see all the positives or negatives themselves, can result in rejecting the best deals.

Having discovered that the benefits from using a champions voting rule are related to the tail behavior of the fundamentals, we next turn to analyzing whether this relation is consistent with the results of our surveys. While finding the fundamental distributions is out of reach, we can find the ex-post realizations of investments by round. We use novel data on venture capital return multiples at the level of each startup's round of financing to calculate the distribution of return multiples for different investment stages. We are therefore able to directly corroborate the intuition that returns of late stage investments are substantially less skewed than 'seed' and 'early stage' investments. Our estimates of the tail index show that the distribution of returns of seed-round investing are significantly more heavy-tailed than those of any of the other rounds, while the returns of late-round investing are significantly less so.[4] To the extent that the *ex ante* valuations for these stages are distributed in a manner similar to the *ex post* returns, this would provide a rationale for why venture capital investors use the champions model primarily in the seed and early stage investments and migrate to more traditional voting models for later stage investments. This is consistent with the literature on the topic: as documented by Hall and Woodward (2010) and Kerr, Nanda, and Rhodes-Kropf (2014), over half of startups receiving VC investment fail completely while a few generate enormous returns. Scherer and Harhoff (2000) provide evidence that returns in venture capital, and for technological

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[4]We use Hill's estimator of tail indices with 20%, 10%, and 5% cutoffs, as well as a log-log rank size regression model. A more complete description is in section 4 while the full results are in Section A.

innovation more generally have 'heavy right tails' and there have been explicit suggestions among practitioners that early stage VC returns follow a power law (Pareto) distribution (Thiel and Masters 2014).

Lastly, we evaluate the quantitative importance of using a champions model instead of traditional voting in contexts such as seed and early stage venture capital, by analyzing a numerical example of the model whose inputs fit the VC context. We consider a fund with 5 partners that make 25 investments and assume that the distribution of fundamentals has a similar tail index to the estimate of the tail index for seed investments. In our numerical example, the model-implied probability that the VC will be able to "catch a unicorn" (specifically, have at least one of the investments deliver a multiple that is 10X or more) is 2.7 times higher for the champions rule than a majority rule, and 3.7 times higher than a unanimity rule.

The theory provides an explanation for the use of a champions model. And our data on returns provides support for the underlying assumptions of the model. However, the correlations in the data could come from reverse causality – the voting rule itself causes skewed outcomes – and the voting rule could stem from other reasons. While we have no way to rule out every other possible explanation, the follow up survey mentioned earlier asked the VC's why they use the champions rule. The overwhelming response was that firms use the rule to 'catch outliers', stating that the best early stage investments are outstanding on some but flawed on many other dimensions and requiring more consensus risks missing the best investments as many partners would focus on the flaws. This evidence supports our theory and flies directly in the face of conventional wisdom, where voting is often considered valuable as a way to 'trim outliers' and emphasize the wisdom of the majority.

The lower chance of selecting exceptional ideas in early stage settings when the cham-

pions model is not used is useful to put into context, because the dominance of the champions model for subexponential distributions is only true when conflicts of interest between committee members, resulting in strategic championing, are not too extreme. If individual committee members have private benefits (e.g. Scharfstein and Stein (2000)), then the cost of 'over championing' poor projects can over-ride the potential benefits from selecting outlier projects. In such an instance, more traditional voting models are likely to be second best alternative, providing a potential rationale for the limited observed use of this type of voting – which we document for venture capital but does not appear to be widely used when selecting between potential projects within corporate R&D of large companies. Additionally, while there might be other factors affecting VC voting, such as disagreement, non-rational expectations, or inefficiencies in decision-making, we believe the simplified setting we consider in the model shows the power of belief distributions on optimal voting behavior. However, we do consider a version of the model with behavioral biases in the appendix.

Literature Review

The paper is primarily related to a large literature on decision making in committees whose members have dispersed information, surveyed in Gerling et al. (2005). Most of the literature on committee decision making and voting focus attention on the setting with binary states and signals. Sah and Stiglitz (1988) present a theory of optimal committee voting rules in this environment, building on their earlier insights in Sah and Stiglitz (1986). In this framework, the problem of finding the optimal voting rule reduces to a statistical problem of finding the number of positive signals at which the committee is just indifferent between investing and not investing. While this setting can generate the optimality of requiring no consensus, it does not capture the intuition that the champions

model is better at 'catching outliers', while the majority rule results in 'mush in the middle' projects.

Two other strands of the literature on committee decision-making are related. First, several papers analyze models with the same information structure that we find most consistent with our survey evidence: the value of a project is a linear function of multiple independent signals, and each committee member learns one of them (Moldovanu and Shi (2013); Malenko (2014); Name-Correa and Yildirim (2019)). In particular, Section 5.3 of Name-Correa and Yildirim (2019) studies optimal voting rules in this model when the distribution of signals is an interval and the uninformed decision-maker is indifferent between the two actions. The element that we focus on is the relation between the tail behavior of the state and signal distributions and the optimal voting rule.

Second, several existing papers establish the optimality of the unanimity rule in various environments (Coughlan (2000); Bond and Eraslan (2010); Jackson and Tan (2013); Chan et al. (2018)). In Coughlan (2000), unanimity can be optimal if committee members can communicate all information prior to the vote and they have similar preferences. In Bond and Eraslan (2010), the unanimity rule is beneficial because it incentivizes the proposer to make a proposal that is attractive to the rest of the group. In Jackson and Tan (2013), the unanimity rule is beneficial because it encourages committee members to disclose verifiable information prior to the vote. Finally, in Chan et al. (2018), the unanimity rule can be beneficial because in an environment with committee members with heterogeneous discount factors unanimity makes makes patient members pivotal, leading to more information acquisition and more precise decisions. However, since the unanimity rule is the opposite of the champions model, the forces highlighted in these papers work against explaining the use of the champions model by VC investment committees.

Our work also builds on a long literature that has examined venture capital's role

in financing innovation. In particular, this research has fleshed out many of the tools venture capital investors use to improve the outcome of the startups they back, such as staged financing (Gompers 1995; Bergemann and Hege 1998), securities that have state-contingent cash flow and control rights (Hellmann 1998; Cornelli and Yosha 2003; Kaplan and Strömberg 2003) and the active role of venture capital investors on boards of portfolio companies (Hellmann and Puri 2000, 2002; Lerner 1995). Our work builds on the nascent literature on understanding decision making in venture capital partnerships including how venture capital investors select investments (Kaplan, Sensoy, and Stromberg 2009; Gompers et al. 2020), which is an important element to understanding the role of venture capital investors in financing innovation (Lerner and Nanda 2020). This work is related to the broader literature on the incentive, agency and organizational frictions among intermediaries financing innovation (Manso 2011), the role this can play in surfacing transformational ideas (Bloom et al. 2020) and the fact that radical innovations that upend existing firms often arise from venture capital despite the much larger R&D expenditure directed towards the financing of innovation in large companies across the world (Kortum and Lerner 2000).

The remainder of the paper is organized as follows: Section 2 provides survey evidence on voting practices and justifications for VCs. Section 3 lays out a model of voting and shows conditions for the optimality of a champions voting rule. Section 4 Shows empirical evidence that the conditions from Section 3 are met in early stage VC investing, and provides a quantitative exercise to measure the size of the benefits. Section 5 concludes.

10

2 Survey Evidence on VC Voting Rules

Venture capital provides a unique context within which to examine empirical patterns related to committee decision making for several reasons. First, VC partnerships view project selection as among the most important determinants of their success (Gompers et al. (2020)) and in addition appear to exhibit substantial heterogeneity in the ways in which they make investment decisions. Second, it has been well-documented that venture capital returns are driven by a few outliers (e.g., Hall and Woodward (2010) and Scherer and Harhoff (2000)), often referred to as 'home runs' by practitioners. Indeed, there has even been explicit suggestions among practitioners that early stage VC returns follow a power law (Thiel and Masters 2014). We conducted two surveys, the key questions of which can be seen in Appendix D.

2.1 Evidence on Voting Rules

We follow the examples of Graham and Harvey (2001) and Gompers et al. (2020) to survey VC investors on their voting practices. While our empirical approach builds on and is most similar to Gompers et al. (2020), we note some key differences. Gompers et al. (2020) have an extensive survey of over 650 VC investors across a wide range of topics. Our approach focuses in more detail on voting practices within investment committees, and also aims to look at those who invest across multiple stages so as to get within-VC variation in voting practices across rounds. Since it is only larger VC funds that typically have the ability to invest across seed, early and late stage, we focus our survey on U.S based managing partners at 55 the largest VC firms that make investments into U.S startups. Our measure of size is based on the cumulative fund raising over the 2016-2018 period as calculated from Pitchbook. Figure 12 documents the key questions used for

this analysis as they were posed in the survey. As can be seen from the questions, we asked about both the formal voting process used in these VC firms as well as the informal process. We received responses from 35 of these 55 firms, implying a response rate of nearly two-thirds.

As noted above, the VC firms we targeted were larger investors. Despite our focus on a narrow sample of VCs, it is important to recognize that these investors are responsible for a disproportionate share of the dollars invested into VC-backed startups in U.S. and hence are more representative of VC investing than might be expected. For example, Lerner and Nanda (2020) examine fund raising by VC investors between 2014 and 2018 and find that the top 50 VCs (or approximately 5% of those who raised funds in that period) accounted for half of the total capital raised over that period.

The average investment committee at the VC firms we surveyed had 10.4 partners compared to an average of 4.8 partners in the VC firms surveyed by Gompers et al. (2020). Despite this difference and the fact that over half our sample comprised VCs investing from funds over $500 million, the partnership size in VCs remained relatively small. VC firms in the 75th percentile in our sample had 13 partners on their investment committee. In other words, the size of investment committees in VC firms appears not to scale proportionately to the size of the funds. This lack of scaling among the partners on investment committees is an interesting fact, one that seems different from partners at other professional service firms such as lawyers and management consultants.

Having documented the characteristics of the VC firms and the questions asked of the respondents, we turn next to outlining the key results. The charts report results broken down by the stage of the investment being considered when the partners are voting. The first bar corresponds to "Seed" stage investments, which are the earliest investments into startups and are believe to have the most skewed returns. The next bar corresponds to

"Early Stage" investments, typically considered to be Series A and at times, Series B investments. The final bar corresponds to later stage or "Growth Stage" investments, which are typically made into more mature startups which have already shown some degree or product market fit, are often generating some revenue and hence are the least skewed in terms of the profile of returns.[5]

Within each of these stages, we further break down the results by share of the firms that report using different types of voting rules. As can be seen from the bars in Figure 1, 60% of all VCs in our sample decide whether to deploy capital into a Seed stage startup by using a champions voting model in their investment committee, where a single partner can go ahead and do the deal regardless of what the others feel. A further 30% of VCs use a variant of the champions model, where a single champion can do the deal as long as there is no veto. For investments into early stage ventures, the share of VCs using champions voting falls to 20% and a much larger proportion of VCs use some form of majority or consensus to decide which investment to make. By the growth stage, this share has falls even further. It is worth emphasizing that since most of these VCs invest across all stages, a shift in the share of VCs voting using the champions model across the different stages is evidence of the same VCs changing their voting model across stages. This provides compelling evidence of voting models shifting by stage, as the variation being documented is "within VC" as opposed to "across VCs", the latter of which is much more subject to concerns about unobserved heterogeneity.

In Figure 2, we further document that this pattern continues to exist in a very similar manner when one examines the informal voting practices within the investment committees. At the Seed stage, an enthusiastic champion is sufficient for others to vote in favor of the deal in 90% of investment committees regardless of the formal voting model in place,

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[5]We use novel data to validate the difference in skew across rounds of financing in Section 4.

implying that in practice the veto is rarely used. However, this deference to the enthusiastic champion on the investment committee falls within the *same VC firm* by the Early stage, with a greater proportion of investment committees requiring either a majority of individuals to be enthusiastic, or all individuals to be enthusiastic. By the growth stage, the informal process reflects even less deference to an enthusiastic champion.

2.2   Evidence on Voting Reasons

We turn next to understanding why these different voting practices might be undertaken at VC firms, in particular the emphasis on champions voting when investing in extremely early stage startups.

The same set of 55 firms were sampled, and we received 19 responses, implying a response rate of a little over a third. The average investment committee at the responding firms had 12.8 partners. The most recent fund raised for 16 of the 19 respondents was at least $500 million, while the remaining three were between $150 million and $500 million.

We told the participants the results of our initial survey: that champions voting appears to be prevalent on early stage deals, and proposed three explanations, suggested to us by colleagues that we shared the results of our initial survey with. The first explanation was that "earlier-stage deals require[d] more specialized expertise than late-stage deals, so partnerships give people with expertise greater discretion in doing earlier-stage deals but not later-stage deals." Formally, only one or few partners get informative signals about early-stage deals, but more partners get informative signals about later-stage deals. The second explanation was that "the best early-stage investments can be extremely promising in some dimensions but flawed in others. Requiring too much consensus can therefore lead partnerships to pass on the best deals." The formal model that shows this logic is presented in the following section. The last explanation was that "VCs care less about

14

smaller deals, and don't want too many partners to spend effort on diligence. Leaving the decision to a champion for these smaller deals also incentivizes greater effort on the part of the champion." Formally, each partner needs to incur an effort cost to get an informative signal about the project. If there is a fixed cost of effort, it can be optimal to have only one partner acquire information.[6] If degree of signal precision is endogenous and one very precise signal is better than several moderately precise, then concentrating information production on one partner can result in a better decision.[7] For each explanation, the participants were asked if they "strongly agreed", "somewhat agreed", "neither agreed nor disagreed", "somewhat disagreed" or "strongly disagreed".

We present the key results in two figures. In the first, Figure 3, we show the percentage of respondents who agreed with the three explanations we offered. The first set of three bars shows the percentage who either "somewhat agreed" or "strongly agreed", while the second set shows the percentage who "strongly agreed". The dark blue bars correspond to the "catching outliers" explanation; the light blue bars correspond to the "expertise" explanation, while the grey bars correspond to the "effort" explanation. While all three enjoy at least some support, that support is clearly greatest for the "catching outliers" explanation, with over half (58%) of respondents strongly agreeing with it, and 84% at least somewhat agreeing.

The second, Figure 4 shows the percentage of the time one explanation was ranked more highly by respondents than others. The first set of three bars shows the fraction of the responses that had each explanation as the joint or outright leader; the second set shows the fraction of responses that had each explanation as the outright leader; the

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[6]See Yung (2005) for a model based on this logic that shows that underwriters benefit from restricting participation in an IPO.

[7]See Khanna and Mathews (2011) for a model in which herding on an initial decision in a multistage context can result in more informative and better outcomes due to a related intuition.

third set shows the fraction of responses that had each explanation dominated by at least one other. Again, "catching outliers" is most frequently the favorite explanation from respondents, dominating 84% of the time, while it is only dominated by another explanation in 16% of responses.

Given that VCs tend towards champions voting, and that their justification for doing so explicitly refers to catching outliers, we next set up and solve a model to find the conditions under which doing so would maximize expected value.

3   Interpreting Survey Evidence via Models of Information Aggregation in Committees

To sum up, the evidence from our surveys and the stated reasons why VC investment committees use certain voting rules can be summarized in the following way:

- Investment committees use the champions model for seed and sometimes for early-stage investment proposals. The same investment committees tend to shift to the majority rule when they evaluate potential investment in later-stage projects.

- When asked why they adopt the champions voting rule, the explanation that receives the most support is that the champions voting rule performs better at "catching outliers" than other voting rules.

- There is belief that requiring a lot of consensus results in "mush in the middle" investment decisions, with no big flaws but no great strenghts.

Our next goal is understand which models of committee decision-making are consistent with these facts. While "effort" and "expertise" expalantions received some support in

our second survey, they are not the explanation that received the most support. As a consequence, we abstract away from the issues of effort in information acquisition and from asymmetric expertise among committee members and focus on purely information aggregation models with symmetric committee members.

Specifically, suppose that there are N partners at a venture capital firm, who need to decide whether to accept $(a = 1)$ or reject $(a = 0)$ a project. The project has an upfront investment cost $I > 0$ and yields a payoff V upon success. Each partner gets a signal θ_i about payoff V. We consider voting mechanisms where every partner simultaneously submits a binary vote $v_i \in \{0, 1\}$. The project is deemed worthy of investment if and only if the total number of votes exceeds some cut-off k, i.e., $\sum_{i=1}^{N} v_i \geq k$. This voting mechanism captures as special cases the three following decision making rule:

1. Champions rule $(k = 1)$: The fund undertakes the investment if and only if there is at least one partner that votes ("champions") for it.

2. Simple majority rule $(k = \frac{N+1}{2})$: The fund undertakes the investment if and only if $\frac{N+1}{2}$ or more partners vote for it.

3. Unanimity rule $(k = N)$: The fund undertakes the investment if andonly if no partner objects to it.

This setup captures a general model of information aggregation in committees. The specific models differ in their assumptions about the joint distribution of project payoffs and signals $(V, \theta_1, ..., \theta_N)$. Ideally, one would estimate this joint distribution from the data. This, however, is not feasible. Instead, our approach is to analyze the empirical evidence through the lense of several canonical models of information aggregation, and conclude which ones of them, if any, is consistent with the empirical evidence.

3.1   Models with Binary Signals

Models with binary signals are probably the most common models used in the literature on information aggregation in voting and committee decision making.

A natural starting point to think about optimal voting rules in committees is Sah and Stiglitz (1988), who studied optimal voting rules in a committee when there are two kinds of projects (good and bad) and each committee member gets a binary signal about the project' type, independent conditionally on the project's type. In this case, the search for the optimal voting rule is equivalent to a statistical problem of finding the ratio of positive to negative signals at which the committee is indifferent between investing and not investing. The optimal voting rule is determined by the fraction of good projects in the pool and costs of Type I and Type II errors. The champions model is optimal if the cost of Type-II error is sufficiently higher than the cost of Type-I error and the prior probability that the project is good is sufficiently high. In the application to early stage VC investments, the first condition is very likely to be satisfied: The cost of missing on a good investment is much higher than the cost of making a bad investment. In contrast, the second condition is likely to be violated: VCs invest in a very small fraction of early stage investments they evaluate, so the prior probability that the project is good is very low. Nevertheless, if the first force is sufficiently powerful, the champions model can be optimal in this setting.

However, a model with two project types cannot distinguish between good projects and outstanding projects, so there are no notions of "passing on the best deals" and "the mush in the middle." So overall we conclude that these models do not do a very good job at capturing the empirical evidence on the behavior of VC investment committees.

3.2 Model with Signals Equal to State Plus i.i.d. Noise

We next consider a model in which each committee member i receives a signal that equals the true value of the project with i.i.d. noise:

$$\theta_i = V + \varepsilon_i,$$

where ε_i is an i.i.d. draw from some distribution $F(\cdot)$. When distribution of noise is Normal, this setup captures a workhorse model of information aggregation in financial markets (e.g., Hellwig (1980), Verrecchia (1982), Goldstein and Yang (2017)). In the case of aggregation of information in committees, this setup has been used in Sah and Stiglitz (1986) and Csaszar and Eggers (2013), among others. In the context of innovation, Azevedo et al. (2020) use this additive setup with normally distributed errors and value being drawn from a distribution with fat tails to study the optimal extent of experimentation. In equilibrium, each committee member i votes for the project if and only if her signal θ_i exceeds the threshold level θ_k^*, determined by

$$\mathbb{E}\left[V | \theta_1 = \theta_k^*; \theta_2, ..., \theta_k \geq \theta_k^*; \theta_{k+1}, ..., \theta_N \leq \theta_k^*\right] = I. \tag{1}$$

Intuitively, a committee member i knows her signal θ_i and anticipates that her vote only matters when the votes of others are split: $k-1$ other committee members vote for the project and $N-k$ committee members vote against the project. This event implies that $k-1$ signals are above the equilibrium threshold θ_k^* and $N-k$ signals are below θ_k^*. Condition (1) means that the committee member with signal θ_k^* is just indifferent between investing and not investing given this information.

Since this model does not admit analytic solutions, we analyze whether this model can

explain the empirical evidence on voting in venture capital committees by simulations. Specifically, we simulate draws of V from Pareto distribution with various degrees of scale and shape parameters. Our baseline case has $N = 5$ committee members, shape $\alpha = 1.7$ (corresponding to the empirical estimate in Section 4), the investment cost $I = 1$, the scale parameter $x_m = 0.25$, and the standard deviation of signal error of one, but we repeat the analysis for many other parameter values. After numerically calculating the equilibrium threshold θ_k^* for each decision rule k, we perform three analyses. First, we calculate the optimal decision rule, i.e., find the value of k at which the expected value from the investment decision is maximized. We do this for a range of different parameters. Second, for each decision rule k, we calculate the distribution of payoffs of accepted projects that are implied by each decision rule. Finally, for each decision rule we calculate the probability that a project with value V gets accepted, $p_k(V)$. The results of this analysis can be summarized as follows.

Observation 1. *The champions decision-making rule is not optimal regardless of shape α of distribution of V.*

For our baseline parameters, the optimal decision rule is simple majority ($k = 3$). In fact, keeping the other parameters constant, the majority rule is optimal for any shape α of distribution V. When the investment cost I is sufficiently high (or, equivalently, scale x_m is sufficiently low), we obtain that the optimal decision rule requires $k = 4$ positive votes out of $N = 5$.

Observation 2. *The decision-making rule has little effect on the investment in superstar (very high V) projects and primarily changes investment decisions in marginal*

20

projects.

This effect can be seen in Table 5 and Figures 9 and 8. Figure 9 plots the distribution of values of accepted projects for the champions, majority, and unanimity decision-making rules, respectively. As one can see, different decision rules imply different return distributions on accepted projects that the partnership is getting. However, these differences do not occur for projects in the right tail. Intuitively, conditional on a project having extremely high fundamental value, it is very likely that each partner's signal will also be high, and so the project would receive support in any decision rule. The differences are pronounced among low-quality ($V < 1$) and medium quality ($V \in (1, 2)$) projects, where the majority rule achieves a better distribution of project returns (more high-quality and fewer low-quality projects) than the champions rule. Table 5 corroborates this evidence with quantile statistics. In particular, it shows that the right tail behavior of project payoffs is quite similar across the decision rules, but quite different for projects in the bottom 50% of values.

Figure 8 plots probabilities of a project with value V getting accepted for three decision rules for different values of V. It shows that projects from the right tail of the distribution of values get accepted with probability close to one regardless of the decision rule. Intuitively, for any distribution of noise, if V is sufficiently high, the probability that signal $V + \varepsilon_i$ exceeds the equilibrium voting cutoff is close to one. However, the majority rule is significantly more efficient at selecting moderately good projects (e.g., $V \in (1, 2)$) than either the champions or the unanimity rules. This result captures a common intuition that the majority rule is good at averaging out the noise and trimming outliers.

Overall, this model illustrates the intuition that the majority rule is good at trim-

ming outliers. However, the implications of this model are clearly inconsistent with our empirical evidence on decision-making in VC committees.

3.3 Model where State Equals the Sum of Characteristics

Finally, we consider another canonical model from the literature on decision-making in committees. In this model, the project is determined by the values of a set of M-many characteristics where $M \geq N$:

$$V = \theta_1 + \theta_2 + ... + \theta_M. \tag{2}$$

All M characteristics are independently distributed over $[-l, \infty)$ (for some constant $l \in \mathbb{R}$) according to a distribution function $F(\cdot)$ with density $f(\cdot)$. Let $G(\cdot)$ denote the implied distribution of V. Each partner i perfectly observes the value of characteristic i. Thus, partner i learns θ_i but only knows the distribution of the other characteristics. This model has been quite popular in the literature on decision-making in committees and organizations more generally, in particular, because it leads to tractable solutions. Variations of this model have been studied by Moldovanu and Shi (2013), Malenko (2014), Name-Correa and Yildirim (2019), Harris and Raviv (2005), and Harris and Raviv (2008). As we will argue below, this model is most consistent with our empirical evidence on decision-making in VC committees.

Independence of characteristics is a strong assumption, but is used in this case to highlight the value of additional information that each partner brings; also note that as characteristics become perfectly correlated then voting is no longer needed. One can more generally interpret θ_i as the portion of partner i's information about residual uncertainty of the project's value. For example, if the value of each characteristic were a sum of

the common factor Z and an idiosyncratic factor and each partner learned the values of both, the model becomes similar, as we can simply subtract the common factor from the investment cost. Intuitively, the idea behind (2) is that different partners at a firm might have different, and orthogonal areas of expertise in assessing a companies value, and will be better placed to assess the values of those characteristics. For example, one partner can be an expert in assessing the technology, another partner can be an expert in assessing potential demand for the product, while the third partner can be an expert in assessing the quality of managerial team of the start-up.

The assumption $\mathbb{E}[V] \leq I$ in this case is equivalent to $M\mathbb{E}[\theta] \leq I$. In the context of early stage investment, it is natural to model F as having heavy tails. As we show in the next section, this assumption fits the empirical evidence: heavy tails of the characteristic distributions imply in the model heavy tails of the return distribution, which is strongly supported by the data, especially for early-stage investments. Further, venture capital firms find it very important to "catch the unicorn" (i.e., find and invest in projects with very high Vs). In contrast, in later stage investments, it is natural to expect that the distribution of valuations has thinner tails: a project is unlikely to be superstar if it does not already have high profile by then.

3.3.1 Optimality of the Champions Rule when Tails are Sufficiently Fat

We next solve for the optimal committee rule k. In particular, we are interested in the conditions under which the champions rule ($k = 1$) arises as the optimal one.

Consider a voting model that requires k positive votes for approval of the project. Under this model, each partner will vote for the project if and only if her characteristic's value exceeds some cut-off $\hat{\theta}_k$. $\hat{\theta}_k$ is the value such that each partner is exactly indifferent between investing and not investing, given her characteristic and the fact that her vote is

pivotal:

$$\hat{\theta}_k + (k-1)\,\mathbb{E}\left[\theta|\theta \geq \hat{\theta}_k\right] + (N-k)\,\mathbb{E}\left[\theta|\theta \leq \hat{\theta}_k\right] + (M-N)\,\mathbb{E}\left[\theta\right] = I. \qquad (3)$$

Equation (3) pins down the voting threshold $\hat{\theta}_k$. It satisfies the intuitive property that $\hat{\theta}_k$ is decreasing in k. This follows from monotonicity of $\mathbb{E}\left[\theta|\theta \geq \hat{\theta}\right]$ and $\mathbb{E}\left[\theta|\theta \leq \hat{\theta}\right]$ in $\hat{\theta}$. Intuitively, each partner is more aggressive about voting for the project if more votes are needed to approve the project.

From (3), it is easy to see the pros and cons of the champions model and more conventional voting rules, such as simple majority. On the one hand, a good project but with only few "superstar" characteristics will be rejected by the majority rule, if its other characteristics are weak. In contrast, the committee will invest in this project under the champions model, because the partner with a very strong characteristic will champion for it. On the other hand, a good project with many good characteristics will not be invested in under the champions model, if none of its characteristics are of superstar quality. Since these two types of projects potentially result in very different return profiles, the choice of the information aggregation rule is akin to the choice of the return profile implied by each rule.

Our first proposition shows that the champions model does particularly well in picking "superstar" projects if the distribution of characteristics has sufficiently heavy tails (formally, it is subexponential):

Proposition 1. *Suppose that F is subexponential. Then, the champions rule accepts a project with $V \rightarrow \infty$ with probability $\frac{N}{M}$. In contrast, any $k \geq 2$ rule rejects such a project with a strictly higher probability.*

Subexponential distributions is a subclass of heavy-tailed distributions whose tails

decrease slower than any exponential tail. Almost all commonly-used heavy-tailed distributions are subexponential: for example, Pareto (power law), Weibull (with $\alpha < 1$), and lognormal distributions. This class of distributions is used frequently in the analysis of insurance claims and rare events. The reason for Proposition 1 comes from an important property of subexponential distributions called the "catastrophe principle." The catastrophe principle says that the distribution of a sum of N subexponential random variables in the tail is similar to the distribution of the maximum element in the sum. Informally, it means that a superstar project is much more likely to be driven by one superstar characteristic and many mediocre ones rather than by all very high characteristics. This property is consistent with the fact that Facebook, Google, eBay, and other superstar companies all had many flaws as early-stage ventures but also some overpowering strengths, as Marc Andreessen's quote above asserted. Note that the fact that F is subexponential is an important condition for Proposition 1. Specifically, if F has light tails (e.g., Normal), a superstar project is typically driven by many characteristics that are pretty good rather than by one superstar characteristic. In this case, the advantage of the champions rule over other decision making rules in identifying superstar projects is lost.

While Proposition 1 implies that the champions model is more likely to identify projects with superstar payoffs than any other voting rule if the distribution of characteristics is subexponential, it does not imply that it leads to a higher expected payoff because it may be more likely to miss non-superstar good projects, and a typical project is the latter. However, as the next two propositions show, this will be the case if the right tail of the characteristic distribution[8] are sufficiently important.

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[8]And consequently, of the return distribution, since for subexponential distributions, the tail distributions of the characteristic and the sum coincide.

Proposition 2. *Suppose that F is subexponential and projects in the upper tail of the distribution are sufficiently important: $\frac{\lim_{\hat{V} \to \infty} \int_{\hat{V}}^{\infty} V d(G(V))}{\int_{0}^{\infty} V d(G(V))} \geq C$, where constant C is defined in the appendix. Then the champions rule has a higher expected value than any other voting rule.*

The intuition for Proposition 2 naturally follows from Proposition 1. Recall that Proposition 1 shows that when the distribution of characteristics has heavy tails, the champions model is better at identifying superstar projects than any other decision making rule. Proposition 2 shows that if identifying projects in the tail is sufficiently important, then the advantage of the champions rule outweighs the advantage of other decision making rules.

While Proposition 2 helps at showing the intuition, it relies on a strong condition that sufficient value comes from projects with infinite payoffs. The next result shows that this strong condition is not needed. Specializing to the case of Pareto (power law) distribution, which is a popular distribution to depict returns on venture capital investments, it obtains a specific cut-off $\hat{\alpha}$ on the spare parameter, such that the champions model is optimal for any $\alpha \leq \hat{\alpha}$.

Proposition 3. *Suppose that θs are distributed according to the Pareto Type 1 distribution with shape parameter α. For any fixed and finite mean level of the characteristic $E[\theta]$, there exists cut-off shape parameter $\hat{\alpha}$, such that the champions voting model is optimal for any $\alpha \leq \hat{\alpha}$.*

The argument for Proposition 3 is related to Proposition 2, but more involved, since under Pareto distribution the part of value that comes from projects with infinite returns is equal to zero even for distributions with low α, unless α is so low that the mean does not exist. Nevertheless, the broad intuition remains the same. If the tails of the

distribution are sufficiently fat (i.e., α is sufficiently low), then (1) correctly identifying projects with very high payoffs is a bigger driver of value than correctly identifying projects with moderately high payoffs; and (2) these projects are more likely to be driven by one very high realization of θ rather than by multiple moderately high ones.

3.3.2 Illustration and Comparisons

Figure 5 illustrates Proposition 3. Here, under the assumption that characteristics are distributed according to a Pareto distribution with shape parameter α, we plot the optimal value of k as a function of α and the number of investors N. It is clear to see that the champions rule (dark blue color) is often the optimal rule for even moderate values of α, but that, more pertinently, for every values of N, there is a threshold α below which champions rule is always optimal.

By analogy with Figures 10 and 11 and Table 5, we show the analogous statistics for the model in which the true value of the project equals the sum of independent project characteristics, and each partner learns one of them. Figure 11 plots the distribution of values of accepted projects for the additive model for the champions, majority, and unanimity decision-making rules, respectively. Similarly to Figure 9, different decision rules imply different return distributions on accepted projects. However, unlike in the case of Figure 9, now different decision rules imply very different return distributions in the right tail. Specifically, projects in the right tail are much more common for the champions rule than for majority and unanimity rules. Table 5 illustrates this point via quantile statistics. For example, the 99th percentile of the payoff of accepted projects is 7.8 for the champions rule, but 3.6 for the majority rule and 1.6 for the unanimity rule. In contrast, projects around the zero-NPV threshold are more common for majority and unanimity decision rules than for the champions rule. In this respect, the majority rule

selects "the mush in the middle." Figure 10 plots probabilities of a project with value V getting selected for the three decision rules. The champions rule is much more likely to accept any project, both good and bad, than other decision rules, but the difference is especially pronounced for projects with values in the right tail.[9]

Overall, this model is more consistent with our empirical evidence than the alternatives. In particular, it captures three motivating pieces of empirical evidence. First, the champions rule is optimal for seed projects but not for later-stage investments. This is because the distribution of payoffs (and, thus, signals) has significantly fatter tails for seed projects than for later-stage investments. Second, the reason why the champions rule is optimal in the model is consistent with the explanation provided by the VC committees that the champions rule performs better at "catching outliers." Finally, this model predicts that decision rules that require more consensus result in "mush in the middle" projects.

Finally, it is worth contrasting the case in which superstar projects are driven by few superstar characteristics with the opposite case in which for a project to be successful, all its characteristics must be of sufficiently high quality. Specifically, suppose that the mapping of project characteristics into project value is not additive, as in (2), but rather $V = \min \{\theta_1, ..., \theta_M\}$. In other words, the value of each project is determined by its worst characteristic. This specification can be motivated in the same way as the O-ring theory of economic development (Kremer (1993)): one bad component can make an otherwise successful project fail, as in the case of the O-ring imperfection leading to a collapse of the space shuttle Challenger. The next proposition shows that the consensus rule is optimal for projects of this type:

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[9]We expect the reality to be not as extreme as illustrated in Figure X2 for two reasons. First, in reality the values of different characteristics are likely positively correlated, rather than uncorrelated. Second, in reality some of the information gets aggregated in pre-vote communication.

Proposition 4. *Suppose that $V = \min\{\theta_1, ..., \theta_M\}$. Then, regardless of the distribution of characteristics, the optimal voting rule is consensus ($k = N$).*

Intuitively, unlike any other decision rule, the consensus rule ensures that all characteristics are above a certain bar, which is very valuable when the value of the project is determined by its weakest characteristic.

3.4 Extensions

Til now we have precluded agents from communicating with each other prior to voting. Such an assumption is required to set up any voting model - if agents could perfectly communicate, there would be no need to vote, as they would always perfectly agree on the correct course of action. However, we can also accommodate partial communication in our framework. Specifically we consider two extensions to the model in which the value equals the sum of signals. In the first every agent i can noisily communicate their private θ_i to their colleagues. In the second, every agent has a positive but non-guaranteed probability of perfectly communicating their private θ_i to their colleagues.

3.4.1 Voting with Noisy Communication

Suppose that agents are allowed communicate with their partners, but can only do so noisily. As before, assume that $V = \theta_1 + ... + \theta_M$, and that agent i sees θ_i perfectly. For simplicity, assume that there are as many agents as dimensions of valuation ($N = M$).[10] Each θ_i is distributed independently over $[-l, \infty)$ with $l > 0$ as before, with distribution function $H(\cdot)$ and density $h(\cdot)$, such that $E[\theta_i] = 0$ for all i. Each agent i communicates a signal t_i about θ_i to all of her colleagues. Signals have distribution function $S(\cdot)$ and

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[10]Relaxing this assumption will change nothing besides some notation.

density $s(\cdot)$, where $E_s[t_i] = \theta_i$. The signal is common to all of her partners - which is to say that communication is not bilateral, but public. Therefore, all agents $j \neq i$ will have posterior beliefs about θ_i that can expressed with the distribution $F(\cdot)$ and density $f(\cdot)$, where

$$f(\cdot) = p(\theta_i|t_i)$$

The important assumptions here are distributional: we assume that F and H are both subexponential.[11] Call the posterior expectation of θ_i by any agent j, $\tilde{\theta}_i$ - this posterior expectation is common to all agents other than agent i herself. We continue to hold that under the prior H, an agent j will have common beliefs over all θ_i where $i \neq j$, $E_{Hj}[\theta_i] = 0$. However, after communication, it can be the case that $E_{Fj}[\theta_i] \equiv \tilde{\theta}_i \neq 0$. Therefore, before communication, $E_i[V] = \theta_i$ for all i, while afterwards $E_i[V] = \tilde{\theta}_1 + ... + \tilde{\theta}_{i-1} + \theta_i + \tilde{\theta}_{i+1} + ... + \tilde{\theta}_M = \sum_j \tilde{\theta}_j + (\theta_i - \tilde{\theta}_i) \equiv \tilde{V} + \epsilon_i$.

Put differently, we can reframe posterior expectations such that the common value to all voters is not the unconditional expectation $E_H[V] = 0$, but the expectation conditional on communication $\tilde{V} = \sum_j \tilde{\theta}_j$. Then each agent i's private information is not their signal θ_i, but the *uncommunicated* part of that signal $\epsilon_i = \theta_i - \tilde{\theta}_i$. $\epsilon_i|\theta_i$ is distributed subexponentially, which means that the propositions of the baseline model will continue to hold. Therefore, noisy communication in our baseline could be thought of as an unmodeled first stage interaction between agents without altering the conclusions of the model.

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[11] one way to satisfy this condition is if F and S are both Pareto distributions

3.4.2 Voting with Imperfect Communication

Another way to think of communication is to instead assume that each agent i, with some probability p_i, is able to perfectly communicate the value of θ_i to her colleagues. With probability $1 - p_i$, agent i communicates nothing, and her colleagues maintain their prior beliefs about θ_i. Therefore, after communication of all agents, some subset $S \subset \{1, ..., N\}$ of agents will have communicated their beliefs perfectly, (where $|S| = n$) while the remaining subset $T = \{1, ..., N\} - S$ have failed to communicate at all. Therefore, for each agent $i \in S$, their estimate of the value V will be:

$$E_i[V] = \sum_{j \in S} \theta_j$$

While for each agent $i \notin S$, their estimate of the value V will be:

$$E_i[V] = \theta_i + \sum_{j \in S} \theta_j$$

We next argue that Proposition 1 extends to this model. Again, we focus on the case $M = N$. Consider a project with $V \to \infty$. Since $F(\cdot)$ is subexponential, the distribution of V in the right tail coincides with the distribution of $Z = \max\{\theta_1, ..., \theta_n\}$. There are two possible cases. With probability $\bar{p} = \sum_{i=1}^{N} \frac{1}{N} p_i$, $\theta_k : \theta_k = \max\{\theta_1, ..., \theta_n\}$ is communicated successfully prior to voting. With probability $1 - \bar{p}$, it is not communicated prior to voting.[12] In the former case, the project is accepted with certainty under any voting rule. In the latter case, the project is accepted with certainty under the champions model ($k = 1$), but with probability strictly below one for any $k > 1$. This follows directly from the proof of Proposition 1 and the fact that no signal is communicated with strictly

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[12]Here $\bar{p} = \sum_{i=1}^{N} \frac{1}{N} p_i$, because each agent's signal is equally likely to be the highest and agent i's signal is communicated with probability p_i.

positive probability. Thus, the result of Proposition 1 also holds in this model.

Next, to show that Proposition 2 also holds in this model, note that rule $k = 2$ rejects a tail project $(V \to \infty)$ with probability exceeding $F\left(\hat{\theta}_2\right)^{n-1} \Pi_{i=1}^{n} (1 - p_i)$. Applying the same argument as in the proof of Proposition 2, a sufficient condition for $k = 1$ dominating $k = 2$ is

$$\lim_{\hat{V} \to \infty} V d\left(G\left(V\right)\right) \geq \frac{\int_{I}^{N\hat{\theta}_1} V dG\left(V\right)}{F\left(\hat{\theta}_2\right)^{n-1} \Pi_{i=1}^{n} (1 - p_i)}.$$

These two extensions should reassure the reader that communication does not negate the fundamental conclusions of our model. Next we provide empirical evidence that the conditions for champions voting are satisfied by the returns of early stage VC investments.

4   Empirical Evidence and Quantitative Importance

4.1   Empirical Evidence

Our model suggests that the champions model dominates other voting models, but only in settings where the distributions of fundamental characteristics has heavy right tails. The model can therefore also rationalize the survey evidence that VCs start with a champions model for early stage investments and migrate to more conventional voting models for later stage investments. This would be the model's prediction if the distribution of characteristics for early stage had heavy right tails, but that this was not as true for late stage investments.

While it is not possible to validate the distribution of individual characteristics of a startup, we are able to examine the *ex post returns* across a wide cross section of venture

capital investments. If we find that the returns of later stage investments are less skewed, this would certainly be consistent with the premise the fundamental characteristics for these investments are potentially also less skewed. In the model, if characteristics are subexponentially distributed, then the return distribution is also subexponential with the same tail as the characteristic distribution. Thus, the empirical evidence on the return distribution across different stages will be consistent with the premise of the model.

Systematic data on returns at the investment level is not available from standard datasets. We received anonymized data on round level returns from Correlation Ventures, a venture capital firm that collects and makes investments in venture capital startups based on quantitative investment strategies. As such, they have a strong incentive to collect, improve and validate the quality of the data they get from standard commercial databases.

The data filter used for the analysis was to first select startups whose headquarters were in the US and had received at least one round of institutional venture capital financing between January 1 2006 and December 31, 2015, and had a realized exit by December 31, 2019. We were provided data on 19,882 rounds of financing in this period with labels corresponding to whether the round of financing was "Seed", "Series A", "Series B", "Series C" or "Series D+". In other words, while there were slightly more than 19,882 rounds of financing, the rounds including Series D and beyond were aggregated together. Correlation Ventures imputes multiples where these are missing, but for the analysis we conduct, we focus on the subset of 8,603 rounds of financing where the multiple is not missing.

For these rounds, we show the distribution of multiples in Figure 6. As can be seen, nearly 50% of all (non-imputed) returns at the round-level are zero, consistent with the very high failure rates reported in Kerr, Nanda, and Rhodes-Kropf (2014). Table 1 breaks

the returns by round, further aggregating those that are in Series C and beyond into a "Series C+" bucket. As can be seen from this, the Seed rounds (and to some extent Series A) stands apart from the other rounds in terms of the skewness of returns. While the median round in the later stages returns a gross return multiple of 0.3, the gross return for even the 75th percentile Seed round is zero. On the other hand, looking at the 99th percentile shows that which the 99th percentile Series C+ investment returns a gross return of 20, the 99th percentile gross return of a Seed round of financing in the data is 125.

In Figure 7 we compare the distributions of return multiples for each round of financing. For a given point (percentile) in the distribution, we divide the return multiple for each round at that percentile by the return multiple for the overall dataset at the same percentile. We then plot these ratios for all points in the distribution. If the resulting curve for a round has a positive slope, it is because that round has a fatter right tail than the overall distribution. If the resulting curve has a negative slope, it is because that round has a thinner right tail than the overall distribution. The level of the curves (as opposed to the slope) indicate the average return multiple of the round as compared to the overall distribution, and center around 1. We find that Seed is the steepest upward sloping, followed by Series A, while the slopes of Series B and Series C+ are decreasing - indicating that the distribution of returns has the fattest tail at the earliest stage and is less so as the rounds progress.

We also empirically test the return data to estimate the tail index of their respective

distributions. The first estimate we use is the truncated Hill's estimate.[13] It is defined as

$$\hat{\alpha}_{Hill} \equiv \frac{n}{\sum_{k=1}^{n} \log(X_k) - \log(X_n)}$$

where n is the number of observations in the truncated distribution (we truncate the distribution of each return at the highest 5%, 10%, and 20% of returns), and X_k is the return of observation k. These coefficients are plotted in Table 2. The estimated tail indices for the Seed round are statistically significantly lower than any of the other rounds for all three cutoffs chosen, indicating that the seed round return distribution is the heaviest-tailed of the four. The other three distributions are ranked by stage (later stages have higher coefficients) though the results are not always statistically significant. We also use the method (and Matlab code) of Huisman et al. (2001) to account for the potential of small sample issues in these estimates, and we attain qualitatively similar outcomes as shown in Table 3.

The second estimate we use is the coefficient from a log-log rank-size regression. Here we order the observed returns by size, truncate each distribution to restrict to only positive returns and sort observations by returns. We then estimate the following regression:

$$\log(k) \approx A - \alpha \log(X_k)$$

where k is the rank of a return X_k. The results here are reported in Table 4. Again the estimated αs increase in the stage of the investment, where the seed stage has the lowest estimated α by a statistically significant margin, while the $C+$ round has the highest estimated α.

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[13]For implementation guidance and advice for these tests, we are grateful to Rustam Ibragimov and Ibragimov, Ibragimov, and Walden (2015).

Our results on the round level returns therefore provide suggestive evidence that is consistent with early stage – and in particular seed stage – fundamental characteristics being much more skewed than those at later (Series C and beyond) stages. Under the assumption that characteristics follow a similar relative pattern, our model can rationalize the use of champions model for seed and early stage investments as well as a shift towards majority or unanimous voting models for later stage investments. We can compare the estimates of α we come up with from ex-post realizations of returns against the predictions of the model based on ex-ante distributions of outcomes. Figure 5 makes it clear that for all the estimates of α in the seed round, the champions rule is optimal for committees of up to 40 members and more.

4.2 Quantitative Example

To assess quantitative importance of alternative decision making rules, we analyze a numerical example of the model, whose inputs fit the VC context reasonably well. Specifically, we assume that individual characteristics are driven from Pareto (power law) distribution with tail parameter 1.7, which is close to our estimate of the Hill's tail index for seed investments of 1.62. This implies that the right tail of the return distribution also follows Pareto (power law) distribution with the same tail parameter 1.7. The committee consists of five members. The total number of relevant characteristics is 20, which implies that at most the committee can learn a quarter of the value-relevant information about the project. The other parameter of the Pareto distribution is calibrated so that under the champions rule 1% of projects are accepted on average. Regardless of its quality, each project is assumed to fail with probability 50% returning zero payoff and to return a non-zero payoff equal to the sum of characteristics with probability 50%. Overall, this distribution means that a typical project considered by the committee is clearly bad, but a

36

very small fraction of projects are exceptionally promising. We keep the assumption that characteristics observed by partners are independent.[14] Three decision rules are compared in this setting: (1) champions (one positive vote out of five is needed for investment); (2) majority (three out five); (3) unanimity (five out of five).

This example produces the following results. In this example, the champions rule is optimal, yielding higher values to the partnership than the alternatives. More interestingly, it leads to investment in projects with a very different profile than the majority and unanimity rules. Projects funded under the champions rule have significantly higher average payoffs, higher variance, and higher skewness. For example, the standard deviation of payoffs (conditional on the payoff being above zero) for the champions, majority, and unanimity rules are 6.36, 1.73, and 1.37 per dollar of investment, respectively. Skewness (also normalized per dollar of investment) are 42.1, 15.5, and 11.5, respectively. The 95th quantile of the realized per-investment multiple is 4.96 for the champions rule, 3.19 for majority, and 2.97 for unanimity. The corresponding numbers for the 99th quantile are 11.1, 5.74, and 5.1, respectively. In other words, the payoff distribution is right-skewed under any decision rule, which is simply due to the nature of investments, but it is significantly more right-skewed under the champions rule. Different project profile implies that the probability of "catching a unicorn" is significantly higher for the champions rule than the alternatives. The model-implied probability of getting a realized payoff per investment exceeding multiple 10x, adjusted for the time value of money, is 1.18% for the champions rule, 0.29% for the majority rule, and 0.2% for the unanimity rule. The model-implied probability of getting a realized payoff per investment exceeding multiple 10x, unadjusted for the time value of money,[15] is 3.2% for the champions rule, 0.9% for

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[14]The assumption of independent characteristics exaggerates the difference between the champions rule.

[15]Assuming a 5-year investment horizon and the discount rate of 12%, this implies the adjusted multiple

37

the majority rule, and 0.65% for the unanimity rule. For example, if we consider a fund with 25 investments, then the probability that it least one of these investments will deliver such a multiple is 55.7% for the champions rule, 20.2% for the majority rule, and 15% for the unanimity rule.

5 Conclusion

We provide novel empirical evidence on the voting practices of venture capital investors in the US, showing that investors use different voting rules for different types of investments, and importantly different voting rules than would appear to be optimal based on received wisdom. For early stage investments, they tend to favor champion voting rules, where one partner can unilaterally make the decision to invest, while for later stage investments, their strategies shift towards more consensus based models, like majority or unanimity. When asked why they do it, venture capital investors overwhelmingly say that the champion voting rule maximizes the chances of 'catching outliers'. We next analyze this survey evidence through the prism of existing canonical models of information aggregation in committees. We conclude that the model that is most consistent with the survey evidence is one in which the value of the project depends on multiple project attributes, an extremely strong attribute can overcompensate for the presence of other weak attributes, and each partner gets a signal about one attribute but not the others. In this model, distributions with fat right tails (similar to the distribution of early-stage investments) are ones where a champions voting model is optimal. In contrast, later stage investments where distributions have significantly less fat tails imply that 'majority' or 'unanimous' voting rules are optimal. We then confirm that these conditions, which justify champions

of 6.2.

voting rules, are satisfied by the ex-post returns of early stage investments, while they are not by later stage investments, thus validating the voting rules seen in practice.

While venture capital provides a useful empirical setting in which to test and validate the model, the implications of the paper are more wide-ranging: effectively any decision made by a group could benefit from lower levels of consensus if the options being considered satisfy a few conditions: first, that they are not ex-ante perfectly observable; second that the members of the group cannot perfectly communicate their information to one another; third that the ex-ante distribution of outcomes for each option has a sufficiently large right tail. This type of setting could be applicable to hiring decisions, research and development, innovation, financial investment, and more.

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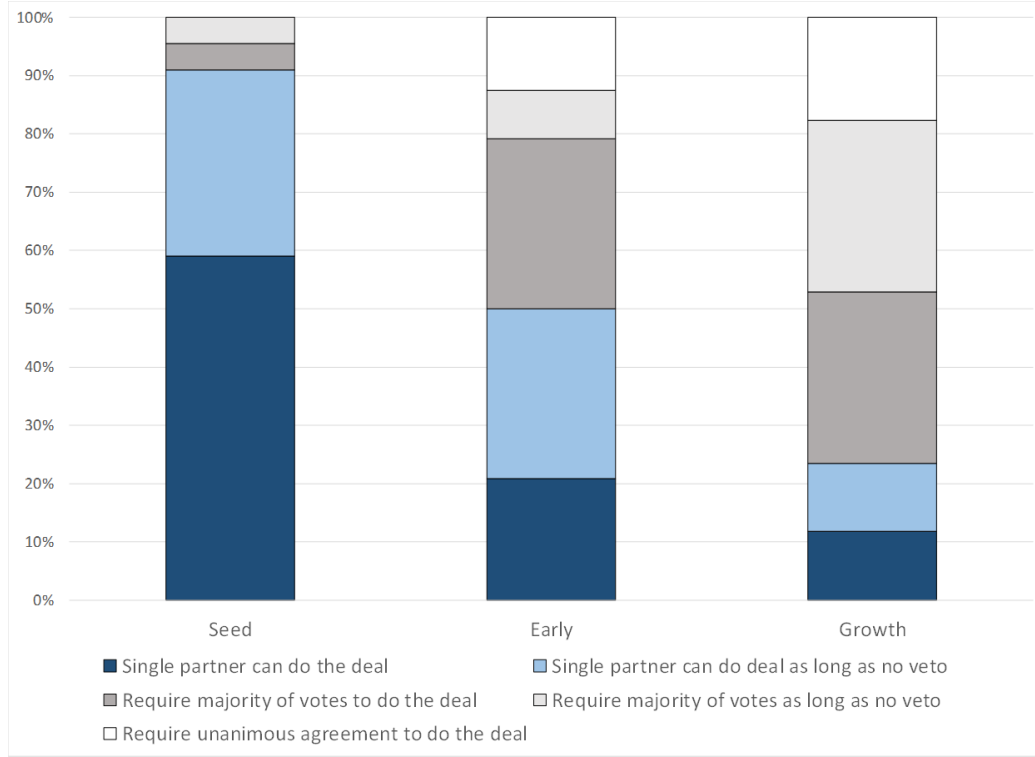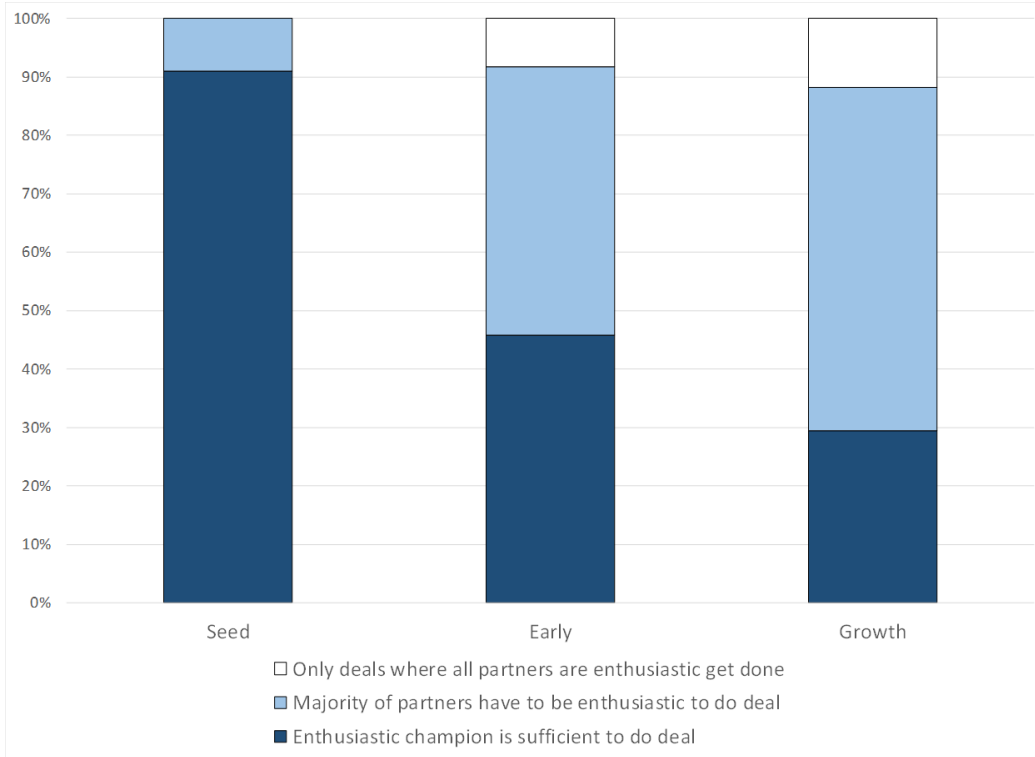
A Figures and Tables

Figure 1: Breakdown of Formal Voting by stage of investment: This figure shows the results from survey question 3 from Figure 12. The three bars correspond, for left to right, to the voting rules for seed, early and growth investment rounds. The bars all add up to 100% and are broken down into different voting rules.

	Percentile					
	25th	50th	75th	90th	95th	99th
Seed	0.00	0.00	0.00	3.25	8.81	124.58
Series A	0.00	0.00	2.56	8.80	20.15	77.65
Series B	0.00	0.26	2.56	6.56	11.14	36.10
Series C+	0.00	0.30	1.87	4.01	6.23	19.76
Total Sample	0.00	0.00	2.13	5.98	11.21	49.71

Table 1: Return multiple percentiles for overall data, as well as by round of financing.

Figure 2: Breakdown of Informal Voting by stage of investment: This figure shows the results from survey question 4 from Figure 12. The three bars correspond, for left to right, to the voting rules for seed, early and growth investment rounds. The bars all add up to 100% and are broken down into different voting rules.

	Hill's Tail Index Estimate			
	Seed Round	Series A	Series B	Series C+
20% Cutoff Estimate	0.62	2.00	2.64	3.12
	(0.055)	(0.09)	(0.11)	(0.13)
10% Cutoff Estimate	1.53	2.24	3.01	3.26
	(0.19)	(0.15)	(0.18)	(0.20)
5% Cutoff Estimate	1.62	2.76	3.03	3.04
	(0.29)	(0.26)	(0.25)	(0.18)

Table 2: This table shows the Hill estimator of the tail index for each round, along with standard errors for each round.
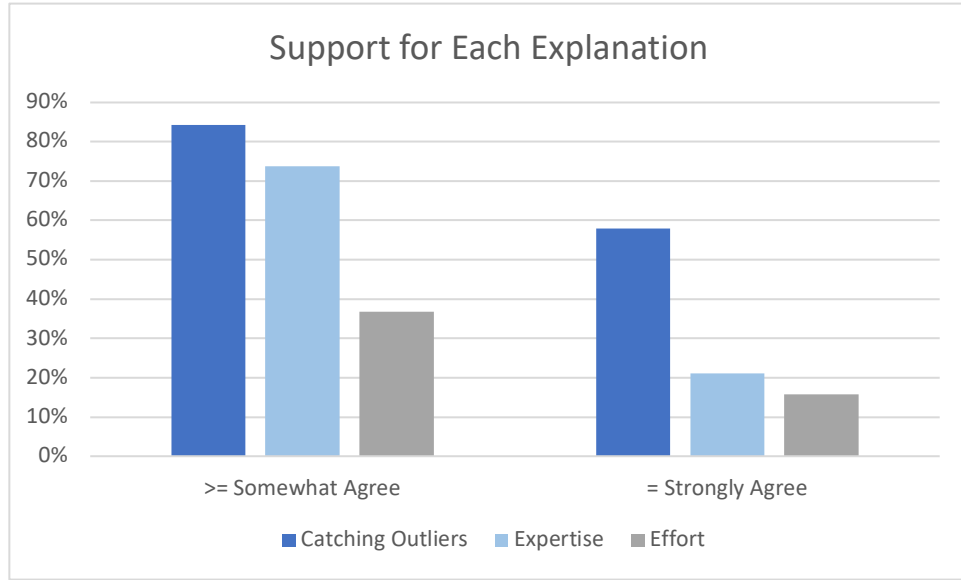
Figure 3: This figure shows the support for each suggested explanation for champions rule voting. The left hand bars correspond to the fraction of respondents who gave each explanation their highest (possibly joint highest) rating. The right hand bars correspond to the fraction of respondents who gave each explanation their strongest, exclusive support.

	Small Sample Tail-Index Estimate			
	Seed Round	Series A	Series B	Series C+
Small Sample Estimate	0.1978	0.7718	0.6901	0.7380
	(0.0128)	(0.0007)	(0.0006)	(0.0006)

Table 3: This table shows the Tail-index estimate in small samples of Huisman et al. (2001), using a 20.7% cutoff.

	Log-Log Tail Index Estimate			
	Seed Round	Series A	Series B	Series C+
Coefficient Estimate	0.35	0.49	0.49	0.61
	(0.02)	(0.009)	(0.009)	(0.01)

Table 4: This table shows the coefficients from the log-log rank-size regressions for each round, along with standard errors for each round.
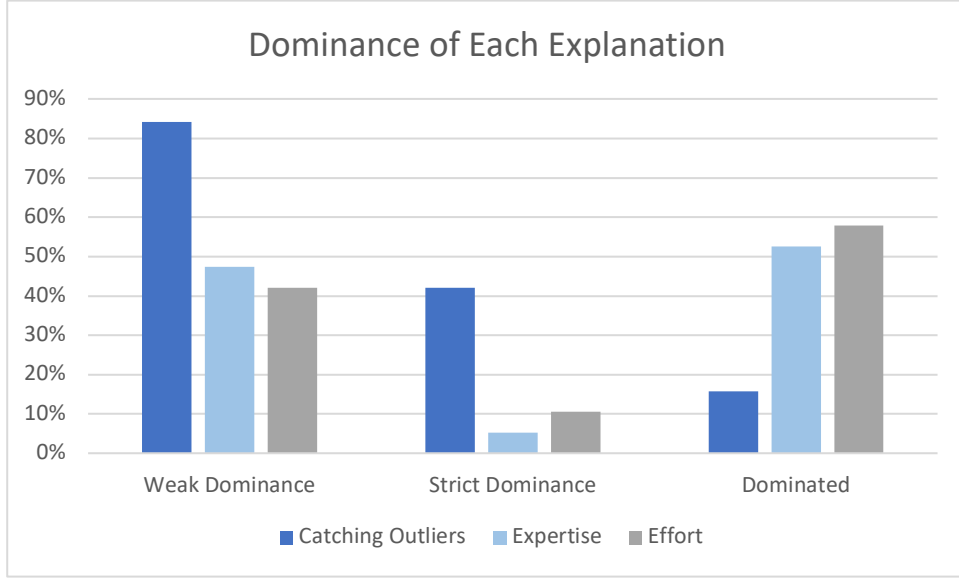
Figure 4: This figure shows the relative dominance for each suggested explanation for champions rule voting. The first set of bars correspond to the fraction of respondents that rated no other explanation more highly; the second set of bars correspond to the fraction of respondents that rated no other explanation as highly; the last set of bars correspond to the fraction of respondents that rated other explanations more highly.
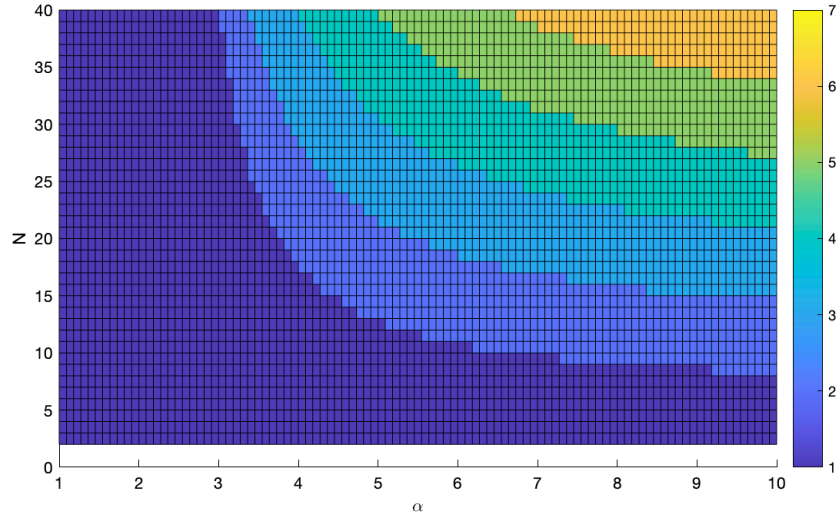

Figure 5: This figure shows the optimal voting rule k as a function of the number of investors/characteristics N, under the assumption that the characteristics are distributed according to a Pareto distribution with shape parameter α. Darker colors correspond to lower values of k (the dark blue corresponds to champions rule, while lighter colors correspond to higher values of k.
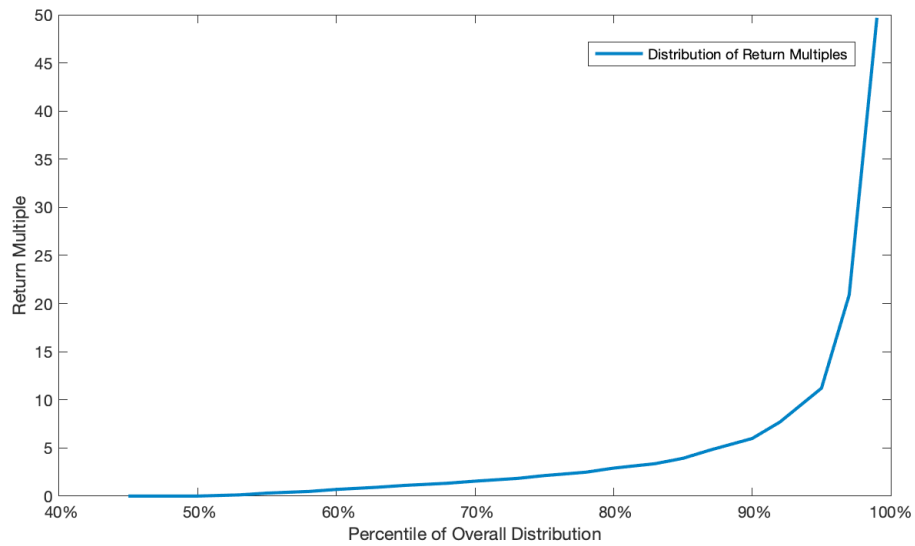
Figure 6: This figure shows the distribution of return multiples for the total sample of investments.
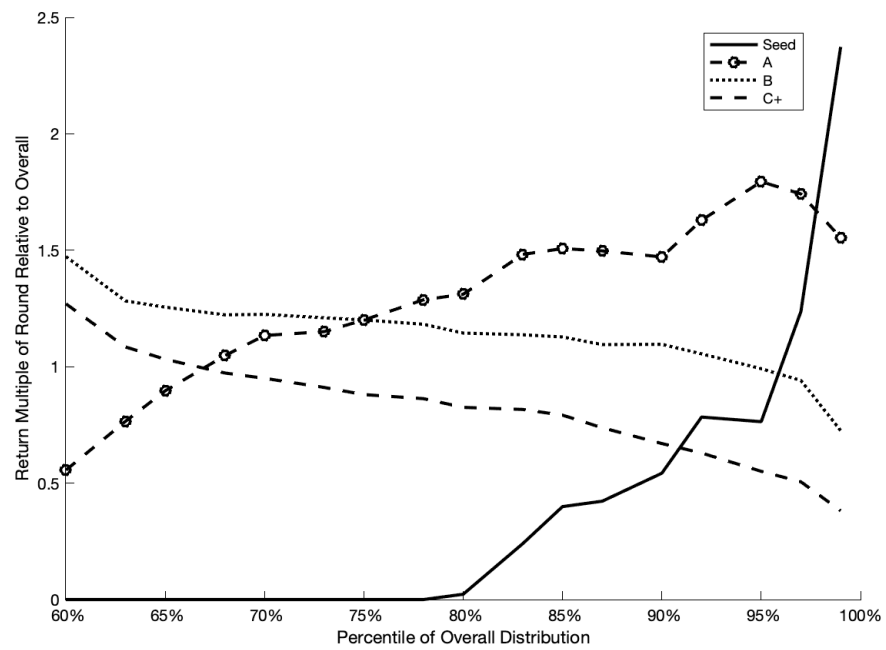

Figure 7: This figure shows the ratio of return multiples for a given round to the total sample of investments.
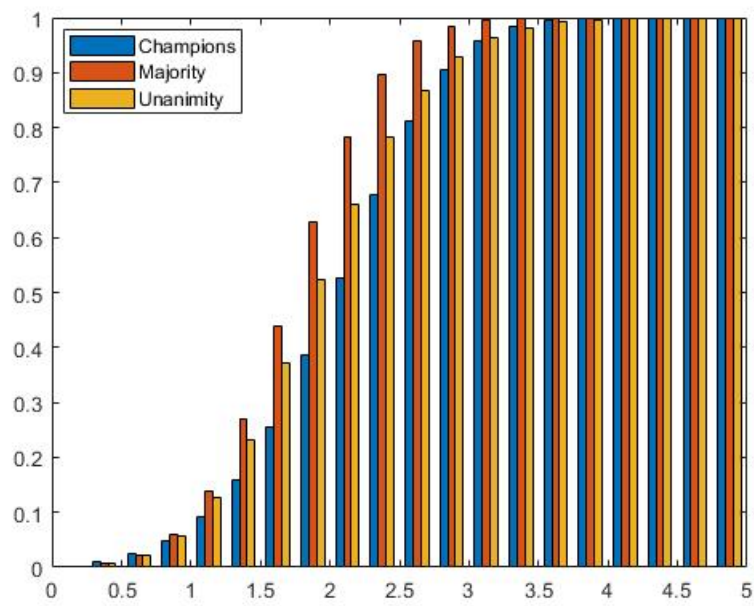
Figure 8: This figure shows the distribution of the probability of accepting different projects under three different voting rules, when the information setup is truth plus noise.
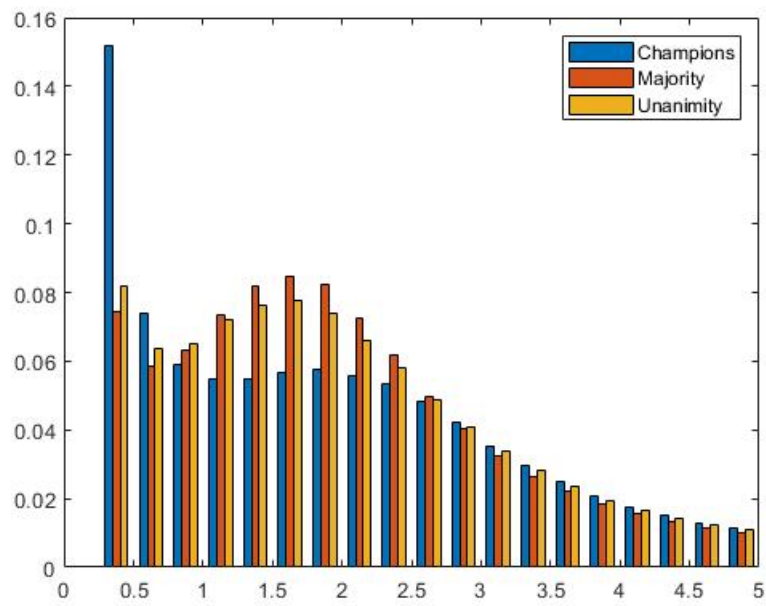
Figure 9: This figure shows the distribution of ex-post returns of projects under three different voting rules, when the information setup is truth plus noise.
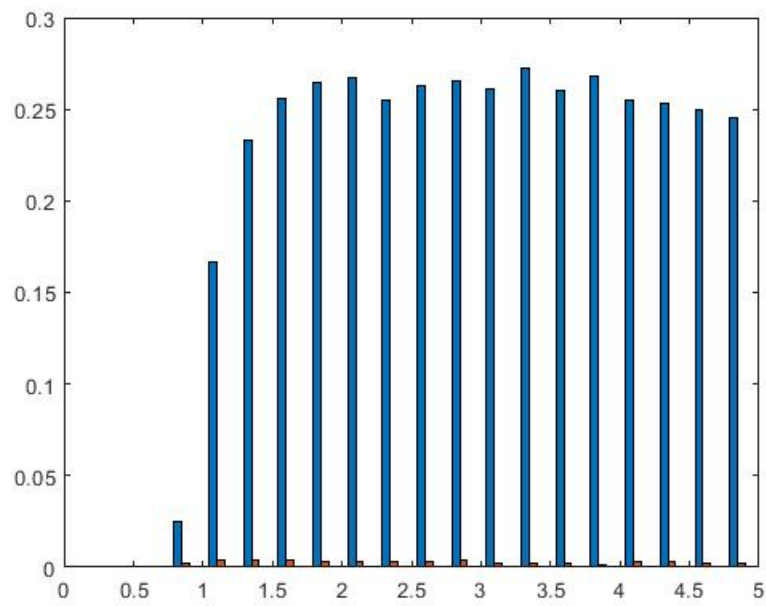
Figure 10: This figure shows the distribution of the probability of accepting different projects under three different voting rules, when the information setup is the sum of signals.
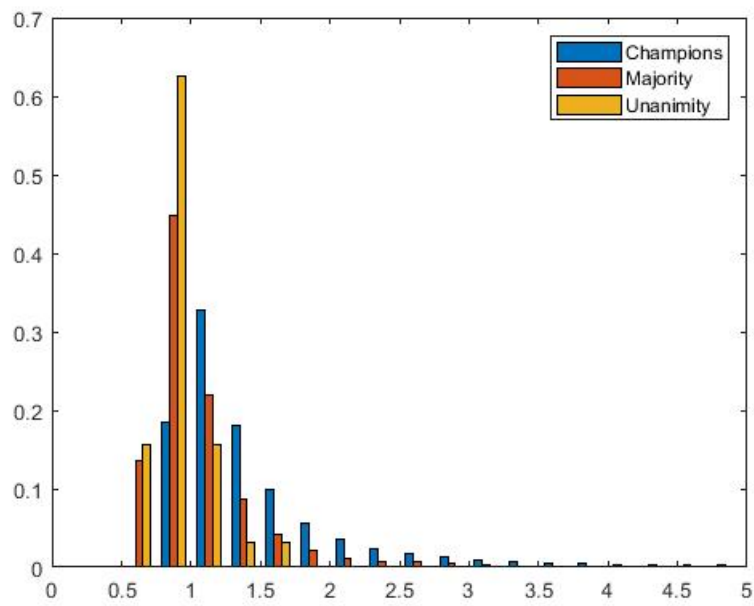
Figure 11: This figure shows the distribution of ex-post returns of projects under three different voting rules, when the information setup is the sum of signals.

Truth + Noise Setup			
percentile	Champions	Majority	Unanimity
25th	104%	81%	78%
50th	124%	95%	89%
75th	163%	117%	95%
90th	239%	155%	112%
95th	333%	195%	127%
99th	779%	365%	162%
Additive Signals Setup			
percentile	Champions	Majority	Unanimity
25th	85%	119%	114%
50th	196%	194%	196%
75th	330%	305%	319%
90th	568%	525%	550%
95th	855%	790%	827%
99th	2209%	2050%	2142%

Table 5: This table shows the quantiles of payoff distributions for different voting rules under two different informational setups.

B Appendix

B.1 Proofs

Proof of Proposition 1 Assume, without loss of generality, that the N partners receive signals about the first $N < M$ characteristics. That is, that partner i learns about characteristic i, and for all $j > M$ characteristic j is unlearned. Because F is subexponential, it satisfies the catastrophe principle:

$$\frac{\Pr\{\max(\theta_1, \theta_2, ..., \theta_M) > t\}}{\Pr(\theta_1 + \theta_2 + ... + \theta_M > t)} \rightarrow 1$$

$$\Pr(\max(\theta_1, \theta_2, ..., \theta_M) > t | \theta_1 + \theta_2 + ... + \theta_M > t) \rightarrow 1$$

as $t \rightarrow \infty$. Two cases are possible: either $\max_{i \in \{1,...,M\}} \theta_i = \max_{i \in \{1,...,N\}} \theta_i$ or $\max_{i \in \{1,...,M\}} \theta_i > \max_{i \in \{1,...,N\}} \theta_i$. Since draws of θ_i are i.i.d., the first case occurs with probability $\frac{N}{M}$, and the second case occurs with probability $\frac{M-N}{M}$. Consider the first case:

$$\frac{\Pr\{\max(\theta_1, \theta_2, ..., \theta_N) > t\}}{\Pr(\theta_1 + \theta_2 + ... + \theta_M > t)} = \Pr(\max(\theta_1, \theta_2, ..., \theta_M) = \max(\theta_1, \theta_2, ..., \theta_N)) \times$$

$$\frac{\Pr\{\max(\theta_1, \theta_2, ..., \theta_M) > t\}}{\Pr(\theta_1 + \theta_2 + ... + \theta_M > t)}$$

$$\rightarrow \frac{N}{M}$$

$$\Pr(\max(\theta_1, \theta_2, ..., \theta_N) > t | \theta_1 + \theta_2 + ... + \theta_M > t) \rightarrow \frac{N}{M}$$

Therefore:

$$\int_{\hat{t}}^{\infty} V \, dF(V | V = \theta_1 + \theta_2 + ... + \theta_M) \approx \frac{N}{M} \int_{\hat{t}}^{\infty} V \, d\Pr(\max(\theta, \theta_2, ..., \theta_N) > t)$$

$$= \frac{N}{M} \int_{\hat{t}}^{\infty} \max(\theta_1, \theta_2, ..., \theta_N) \, dF(\max(\theta_1, \theta_2, ..., \theta_N))$$

when $\hat{t}$ is large. Let $Z \equiv \max(\theta_1, \theta_2, ..., \theta_N)$. Then, $\Pr(Z \leq z) = \Pr(X_i \leq z)^N = F(z)^N$.

Hence, the above integral is equal to:

$$\frac{N}{M} \int_{\hat{t}}^{\infty} zd\left(F(z)^N\right) = \frac{N}{M} \int_{\hat{t}}^{\infty} zNF(z)^{N-1} f(z) \, dz$$

For any decision-making rule D, let $p_D(V)$ denote the probability of investment in a project of value $V = \theta_1 + \theta_2 + ... + \theta_M$. The expected value of decision rule D is therefore:

$$\int_0^{\infty} p_D(V)(V - I) \, dG(V)$$

which is less than the expected values of the first best decision rule $\int_I^{\infty}(V - I) \, dG(V)$. Consider a very high valuation Z. Its distribution is similar to $\max(\theta_1, \theta_2, ..., \theta_M)$. Let us consider two cases, one where the max is learned about, and one where it is not. In the first instance, without loss of generality suppose $\max\{\theta_1, ..., \theta_M\} = \max\{\theta_1, ..., \theta_N\} = \theta_1$. This instance occurs with probability $\frac{N}{M}$. Then, the conditional distribution of any other θ_i is F truncated at Z. Given a voting rule k, the probability that this project gets rejected is:

$$C_{N-1}^{N-k+1} \left(\frac{F\left(\hat{\theta}_k\right)}{F(Z)}\right)^{N-k+1} \left(1 - \frac{F\left(\hat{\theta}_k\right)}{F(Z)}\right)^{k-2}$$

namely, that there are $N - k + 1$ many signals that are below the threshold for acceptance. The probability of rejection is zero when $k = 1$ and strictly positive when $k > 1$. Therefore, conditional on the maximum characteristic being learned about (which occurs with probability $\frac{N}{M}$), the champions rule never rejects high value projects, while other voting rules will reject with some positive probability.

Consider the second case and assume without loss of generality that $\max\{\theta_1, ..., \theta_M\} = \theta_M$. The instance occurs with probability $\frac{M-N}{M}$. θ_M is distributed similarly to Z, and θ_M is not learned about. Then, the conditional distribution of any other θ_i is F truncated at Z, and given

a voting rule k, the probability that the project gets rejected is:

$$C_{N-1}^{N-k+1} \left(\frac{F\left(\hat{\theta}_k\right)}{F\left(Z\right)} \right)^{N-k+1} \left(1 - \frac{F\left(\hat{\theta}_k\right)}{F\left(Z\right)} \right)^{k-2}$$

This is strictly positive for all values of k and increasing in k. Therefore, the champions rule rejects high value projects strictly less than any other rule.

Proof of Proposition 2. We start by showing that the model with $M > N$ is equivalent to the model with $M = N$ and a modified investment cost. Then, given this result, it is sufficient to prove this and the subsequent propositions for the case of $M = N$ only.

Let us decompose the value of the project into a potentially learned part and an unknown part:

$$V = V_1 + V_2 - I,$$

where $V_1 = \sum_{i=1}^{N} \theta_i$ and $V_2 = \sum_{i=N+1}^{M} \theta_i$. By independence of θ_i, the expected value of any decision rule k is equal to the expected value of the same decision rule if each project's value is given by

$$\tilde{V} = V_1 - \tilde{I},$$

where $\tilde{I} = I - (M - N) E\left[\theta\right]$ is the investment cost modified by the expected value of the unlearned characteristics. Indeed:

$$\mathbb{E}\left[\left(\sum_{i=1}^{M} \theta_i - I \right) \mathcal{D}\left(\theta_1, ..., \theta_N\right) \right]$$
$$= \mathbb{E}\left[\mathbb{E}\left[\left(\sum_{i=1}^{M} \theta_i - I \right) \mathcal{D}\left(\theta_1, ..., \theta_N\right) | \theta_1, ..., \theta_N \right] \right]$$
$$= \mathbb{E}\left[\left(\sum_{i=1}^{N} \theta_i - \tilde{I} \right) \mathcal{D}\left(\theta_1, ..., \theta_N\right) \right].$$

Given this result, without loss of generality, consider the case $M = N$. In the proof we will

show that $k = 1$ dominates $k = 2$ under the conditions of the proposition. The proof that $k = 1$ dominates any $k > 2$ is analogous. As shown in the proof of Proposition 1, the champions model accepts tail projects ($V \to \infty$) with certainty, while $k = 2$ model rejects them with probability exceeding $F\left(\hat{\theta}_2\right)^{N-1}$. Suppose hypothetically that $k = 2$ accepts all positive NPV projects with $\max\{\theta_1, ..., \theta_N\} \in \left[\hat{\theta}_2, \hat{\theta}_1\right]$ and no negative NPV project, where $\hat{\theta}_1$ is given by

$$(N - 1)\, \mathbb{E}\left[\theta_i | \theta_i \leq \hat{\theta}_1\right] + \hat{\theta}_1 = I.$$

Clearly, the payoff from the actual $k = 2$ rule is lower. $\hat{\theta}_2$ is given by

$$\hat{\theta}_2 + \mathbb{E}\left[\theta_i | \theta_i \geq \hat{\theta}_2\right] + (N - 2)\, \mathbb{E}\left[\theta_i | \theta_i \leq \hat{\theta}_2\right] = I. \tag{4}$$

Then, the difference between the expected payoffs under $k = 1$ and under $k = 2$ is at least:

$$F\left(\hat{\theta}_2\right)^{N-1} \lim_{\hat{V} \to \infty} \int_{\hat{V}}^{\infty} V\, d\left(G\left(V\right)\right) - \int_{I}^{N\hat{\theta}_1} V\, dG\left(V\right).$$

Therefore, if
$$\lim_{\hat{V} \to \infty} \int_{\hat{V}}^{\infty} V\, d\left(G\left(V\right)\right) \geq \frac{\int_{I}^{N\hat{\theta}_1} V\, dG\left(V\right)}{F\left(\hat{\theta}_2\right)^{N-1}},$$

then the champions model dominates $k = 2$.

Proof of Proposition 3. By the result at the beginning of the proof of the previous proposition, it is sufficient to consider the case of $M = N$.

Let $U\left(k, \hat{\theta}\right)$ be the expected value from a decision rule that requires k approval votes for investment, if each if each partner votes for if and only if her signal exceeds $\hat{\theta}$. We can re-write

it as:

$$
\begin{aligned}
U\left(k,\hat{\theta}\right) &= \sum_{m=k}^{N} C_N^m \left(1 - F\left(\hat{\theta}\right)\right)^m F\left(\hat{\theta}\right)^{N-m} \left(m\mathbb{E}\left[\theta|\theta \geq \hat{\theta}\right] + (N-m)\mathbb{E}\left[\theta|\theta < \hat{\theta}\right] - I\right) \\
&= \sum_{m=k}^{N} \left(1 - F\left(\hat{\theta}\right)\right)^m F\left(\hat{\theta}\right)^{N-m} \\
&\quad \times \left(\frac{N!}{(m-1)!\,(N-m)!}\frac{\int_{\hat{\theta}}^{\infty}\left(\theta - \frac{I}{N}\right)dF\left(\theta\right)}{1 - F\left(\hat{\theta}\right)} + \frac{N!}{m!\,(N-m-1)!}\frac{\int_0^{\hat{\theta}}\left(\theta - \frac{I}{N}\right)dF\left(\theta\right)}{F\left(\hat{\theta}\right)}\right) \\
&= (N\mathbb{E}\left[\theta\right] - I)\left(1 - I_{F(\hat{\theta})}\left(N - k, k\right)\right) + C_{N-1}^{k-1}\left(1 - F\left(\hat{\theta}\right)\right)^{k-1} F\left(\hat{\theta}\right)^{N-k}\left(\int_{\hat{\theta}}^{\infty}(N\theta - I)\,dF\left(\theta\right)\right),
\end{aligned}
$$

where $C_N^m = N!/\left(m!\left(N-m\right)!\right)$ and $I_x\left(a,b\right)$ is the regularized incomplete beta function. Let $U^*\left(k\right)$ be the equilibrium value of the project under decision rule k, i.e., $U\left(k,\hat{\theta}\right)$ evaluated at the equilibrium voting cut-off $\hat{\theta}$. Since all committee members have the same utility functions, this is the game of common interest, and thus $\hat{\theta}$ that maximizes $U\left(k,\hat{\theta}\right)$ constitutes an equilibrium ((McLennan 1998)). Thus,

$$
U^*\left(k\right) = \max_{\hat{\theta}} U\left(k,\hat{\theta}\right) = \max_p \bar{U}\left(k,p\right), \tag{5}
$$

where

$$
\begin{aligned}
\bar{U}\left(k,p\right) &= (N\mathbb{E}\left[\theta\right] - I)\left(1 - I_{1-p}\left(N - k, k\right)\right) + C_{N-1}^{k-1}p^{k-1}\left(1 - p\right)^{N-k}\left(\int_{1-p}^{1}(Nu\left(z\right) - I)\,dz\right) \tag{6} \\
u\left(z\right) &= F^{-1}\left(z\right),
\end{aligned}
$$

(for convenience, we introduced changes in variables). Intuitively, $p = 1 - F\left(\hat{\theta}\right)$ is the probability that a committee member votes for the project, implied by threshold $\hat{\theta}$, and $u\left(z\right)$ is the value of a characteristic in the zth quantile.

Under Pareto distribution with shape α, $\int_{1-p}^{1}(Nu\left(z\right) - I)\,dz = N\frac{\alpha}{\alpha-1}x_m p^{1-\frac{1}{\alpha}} - Ip$, where

$x_m = -l$. Hence, (6) simplifies to

$$\bar{U}(k,p) = (N\mathbb{E}[\theta] - I)(1 - I_{1-p}(N - k, k)) + C_{N-1}^{k-1} p^{k-1} (1-p)^{N-k} \left(N\frac{\alpha}{\alpha-1} x_m p^{1-\frac{1}{\alpha}} - Ip \right).$$

(7)

We first consider the case in which the project is ex-ante zero-NPV ($N\mathbb{E}[\theta] = I$), and then consider the more realistic case in which it is negative NPV ($N\mathbb{E}[\theta] < I$).

Case 1: $N\mathbb{E}[\theta] = I$. In this case, the first term in (7) equals zero, so (5) simplifies to

$$U^*(k) = C_{N-1}^{k-1} \max_p p^{k-1} (1-p)^{N-k} \left(N\frac{\alpha}{\alpha-1} x_m p^{1-\frac{1}{\alpha}} - Ip \right)$$

The zero-NPV condition implies $Nx_m = \frac{\alpha-1}{\alpha} I$. Therefore, $I = N\frac{\alpha}{\alpha-1} x_m$. Hence,

$$U^*(k) = C_{N-1}^{k-1} \max_p p^{k-1} (1-p)^{N-k} \left(\frac{\alpha}{\alpha-1} p^{1-\frac{1}{\alpha}} - \frac{\alpha}{\alpha-1} p \right) Nx_m.$$

Consider the ratio of $U^*(k+1)$ to $U^*(k)$:

$$\frac{U^*(k+1)}{U^*(k)} = \frac{N-k}{k} \frac{\max_p p^k (1-p)^{N-k-1} \left(\frac{\alpha}{\alpha-1} p^{1-\frac{1}{\alpha}} - \frac{\alpha}{\alpha-1} p \right)}{\max_p p^{k-1} (1-p)^{N-k} \left(\frac{\alpha}{\alpha-1} p^{1-\frac{1}{\alpha}} - \frac{\alpha}{\alpha-1} p \right)}$$

$$= \frac{N-k}{k} \frac{\max_p p^k (1-p)^{N-k-1} \left(p^{1-\frac{1}{\alpha}} - p \right)}{\max_p p^{k-1} (1-p)^{N-k} \left(p^{1-\frac{1}{\alpha}} - p \right)}$$

We will show that $\frac{U^*(k+1)}{U^*(k)}$ for all $k \in \{1, ..., N-1\}$ for $\alpha \to 1$. Notice that

$$\lim_{\alpha \to 1} \left(p^{1-\frac{1}{\alpha}} - p \right) = 1 - p \ \forall p \in (0, 1).$$

Therefore,

$$
\begin{aligned}
\lim_{\alpha \to 1} \frac{U^* (k+1)}{U^* (k)} &= \frac{N-k}{k} \frac{\max_p p^k (1-p)^{N-k}}{\max_p p^{k-1} (1-p)^{N-k+1}} = \frac{N-k}{k} \frac{k^k (N-k)^{N-k}}{(k-1)^{k-1} (N-k+1)^{N-k+1}} \\
&= \frac{k^{k-1} (N-k)^{N-k+1}}{(k-1)^{k-1} (N-k+1)^{N-k+1}} = \left(\frac{k}{k-1} \right)^{k-1} \left(\frac{N-k}{N-k+1} \right)^{N-k+1}
\end{aligned}
$$

Taking a natural logarithm, $\lim_{\alpha \to 1} \frac{U^* (k+1)}{U^* (k)} < 1$ is equivalent to

$$
(k-1) (\ln (k) - \ln (k-1)) + (N-k+1) (\ln (N-k) - \ln (N-k+1)) < 0
$$

Consider $f(x) = x \ln \left(1 + \frac{1}{x} \right)$.

$$
\begin{aligned}
f'(x) &= \ln \left(1 + \frac{1}{x} \right) - \frac{\frac{1}{x}}{1 + \frac{1}{x}} = \ln \left(1 + \frac{1}{x} \right) - \frac{1}{x+1} \\
\lim_{x \to 0} f'(x) &= \infty \\
f''(x) &= -\frac{x}{x+1} \left(\frac{1}{x^2} \right) + \frac{1}{(x+1)^2} \\
&= \frac{1}{(x+1)^2} - \frac{1}{x(x+1)} = \frac{x - (x+1)}{x(x+1)^2} < 0 \\
\lim_{x \to \infty} f'(x) &= \lim_{x \to \infty} \left(\ln \left(1 + \frac{1}{x} \right) - \frac{1}{x+1} \right) = 0
\end{aligned}
$$

Hence, $f'(x)$ is strictly decreasing in x starting from infinity for $x \to 0$ to zero for $x \to \infty$.

Hence, $f'(x) > 0$ for all x. Therefore, $f(x) = x \ln \left(1 + \frac{1}{x} \right)$ is maximized at $x \to \infty$, in which case

$$
\lim_{x \to \infty} x \ln \left(1 + \frac{1}{x} \right) = 1
$$

Consider $g(x) = (x+1)\ln\left(1 + \frac{1}{x}\right)$:

$$
\begin{aligned}
g'(x) &= \ln\left(1 + \frac{1}{x}\right) - (x+1)\frac{\frac{1}{x^2}}{1 + \frac{1}{x}} \\
&= \ln\left(1 + \frac{1}{x}\right) - \frac{x+1}{x^2 + x} = \ln\left(1 + \frac{1}{x}\right) - \frac{1}{x} \\
g''(x) &= -\frac{\frac{1}{x^2}}{1 + \frac{1}{x}} + \frac{1}{x^2} = \frac{1}{x^2}\left(1 - \frac{1}{1 + \frac{1}{x}}\right) > 0
\end{aligned}
$$

For $x = 1$: $g'(x) = \ln(2) - 1 < 0$, and for $x \to \infty$: $\lim_{x\to\infty}\left(\ln\left(1 + \frac{1}{x}\right) - \frac{1}{x}\right) = 0$. Since $g'(x)$ is strictly increasing in x, we have that it must be the case that $g'(x) < 0 \; \forall x$. Hence, the minimum of $g(x)$ is reached at $x \to \infty$, in which case it is:

$$
\lim_{x\to\infty} (x+1)\ln\left(1 + \frac{1}{x}\right) = 1.
$$

Combining:

$$
\begin{aligned}
&(k-1)(\ln(k) - \ln(k-1)) - (N-k+1)(\ln(N-k+1) - \ln(N-k)) \\
&= (k-1)\ln\left(1 + \frac{1}{k-1}\right) - (N-k+1)\ln\left(1 + \frac{1}{N-k}\right) \\
&< \max_x\left\{x\ln\left(1 + \frac{1}{x}\right)\right\} - \min_x\left\{(x+1)\ln\left(1 + \frac{1}{x}\right)\right\} = 1 - 1 = 0.
\end{aligned}
$$

Therefore, $\frac{U^*(k+1)}{U^*(k)} < 1$ for $\alpha \to 1$, and by continuity for all α sufficiently close to one. Since $U^*(k)$ is strictly decreasing in k in this case, $k = 1$ is optimal.

Case 2: $N\mathbb{E}[\theta] < I$. In this case, the first term in (7) is negative. We first show that the equilibrium probability of the affirmative vote in the champions model, $p_1^* \equiv \arg\max_p \bar{U}(k, p)$, approaches zero, i.e., the same value as in the zero-NPV case. Denoting $NPV_0 \equiv N\mathbb{E}[\theta] - I$,

Pareto distribution implies $N x_m = (I + NPV_0) \frac{\alpha - 1}{\alpha}$. Thus,

$$
\begin{aligned}
p_1^* &= \arg\max_p NPV_0 \left(1 - (1-p)^{N-1} \right) + (1-p)^{N-1} \left(N \frac{\alpha}{\alpha - 1} x_m p^{1 - \frac{1}{\alpha}} - Ip \right) \\
&= \arg\max_p (1-p)^{N-1} \left(N \frac{\alpha}{\alpha - 1} x_m p^{1 - \frac{1}{\alpha}} - Ip - NPV_0 \right) \\
&= \arg\max_p (1-p)^{N-1} \left((I + NPV_0) p^{1 - \frac{1}{\alpha}} - Ip - NPV_0 \right)
\end{aligned}
$$

When $\alpha \to 1$, $p^{1 - \frac{1}{\alpha}} \to 1$ for any $p \in (0, 1)$, so

$$
p_1^* \to \arg\max_p (1-p)^N = 0.
$$

Next, re-write (5) as

$$
U^* (k) = U_1^* (k) + U_2^* (k),
$$

where

$$
\begin{aligned}
U_1^* (k) &= NPV_0 \left(1 - I_{1 - p_k^*} (N - k, k) \right), \\
U_2^* (k) &= C_{N-1}^{k-1} (p_k^*)^{k-1} (1 - p_k^*)^{N-k} \left(\int_{p_k^*}^1 (Nu(z) - I) \, dz \right),
\end{aligned}
$$

where $p_k^* \equiv \arg\max_p \bar{U}(k, p)$. We will show that in the limit $\alpha \to 1$, $U_2^* (1) > U_2^* (k)$ and $U_1^* (1) > U_1^* (k) \ \forall k > 1$.

The proof of $U_2^* (1) > U_2^* (k) \ \forall k > 1$ is as follows:

$$
\begin{aligned}
\lim_{\alpha \to 1} U_2^* (1) &= \lim_{\alpha \to 1} \max_p (1-p)^{N-1} \left(\frac{\alpha}{\alpha - 1} p^{1 - \frac{1}{\alpha}} - \frac{\alpha}{\alpha - 1} p \right) N x_m \\
&> \lim_{\alpha \to 1} \max_p C_{N-1}^{k-1} p^{k-1} (1-p)^{N-k} \left(\frac{\alpha}{\alpha - 1} p^{1 - \frac{1}{\alpha}} - \frac{\alpha}{\alpha - 1} p \right) N x_m \\
&\geq \lim_{\alpha \to 1} U_2^* (k)
\end{aligned}
$$

for all $k > 1$. Here, the first equality is from the fact that $p_1^* \to 0$ for both the negative-NPV

case and the zero-NPV case; the first inequality is from the fact that

$$\lim_{\alpha \to 1} \max_p C_{N-1}^{k-1} \max_p p^{k-1} (1-p)^{N-k} \left(\frac{\alpha}{\alpha-1} p^{1-\frac{1}{\alpha}} - \frac{\alpha}{\alpha-1} p \right) N x_m$$

is strictly decreasing in k, established in the proof of the zero-NPV case; and the second inequality is from the fact that $U_2^*(k)$ cannot exceed the point at which

$$C_{N-1}^{k-1} p^{k-1} (1-p)^{N-k} \left(\frac{\alpha}{\alpha-1} p^{1-\frac{1}{\alpha}} - \frac{\alpha}{\alpha-1} p \right) N x_m$$

is maximized over p.

The proof of $U_1^*(1) > U_1^*(k) \ \forall k > 1$ is as follows. Note that $\lim_{\alpha \to 1} U_1^*(1) = 0$, since $\lim_{\alpha \to 1} p_1^* = 0$. In contrast, for any $k > 1$, $\lim_{\alpha \to 1} U_1^*(k) < 0$, since $NPV_0 < 0$ and $p_k^* > 0$.

Since $U_2^*(1) > U_2^*(k)$ and $U_1^*(1) > U_1^*(k) \ \forall k > 1$, $U^*(1) > U^*(k)$ for any $k > 1$. Therefore, $k = 1$ is optimal.

Proof of Proposition 4

Consider the problem of the informed, but constrained planner who observes all N signals and decides on the investment decision. Let us define $X \equiv E[\min \{\theta_{N+1}, ..., \theta_M\}]$ to be the expectation of the minimum of the unseen factors. If $X < I$, the constrained planner will not invest, and the optimal voting rule is irrelevant. If $X > I$, then the constrained optimal decision is to invest if and only if $\min \{\theta_1, ..., \theta_N\} \geq I$. Next, let us show that the decision-making rule $k = N$ implements this constrained first-best investment decision. To do this, we show that voting threshold $\hat{\theta} = I$ corresponds to a Nash equilibrium in the voting game when $k = N$. Consider member i with signal θ_i. Her vote is pivotal if and only if all $N - 1$ committee members vote for the project, which implies that all of their signals exceed $\hat{\theta}$. Consider member i's forecast of V, conditional on her signal θ_i and on the information that her vote is pivotal. If $\theta_i \leq \hat{\theta}$, then

$$\mathbb{E}[V|\theta_i, Piv_i] = \mathbb{E}\left[\min \{\theta_1, ..., \theta_N\} | \theta_i, \theta_j \geq \hat{\theta} \ \forall j \neq i\right] = \theta_i \leq \hat{\theta}.$$

If $\theta_i > \hat{\theta}$, then

$$\mathbb{E}\left[V|\theta_i, Piv_i\right] > \theta_i > \hat{\theta}.$$

We can see that the strategy profile with voting threshold $\hat{\theta} = I$ constitutes a Nash equilibrium. Indeed, if $\hat{\theta} = I$ and $\theta_i < I$, player i is better off voting against the project since $\mathbb{E}\left[V|\theta_i, Piv_i\right] = \theta_i < I$; if $\hat{\theta} = I$ and $\theta_i > I$, player i is better off voting for the project since $\mathbb{E}\left[V|\theta_i, Piv_i\right] > \theta_i > I$. Since the consensus decision rule implements the first-best action, no other decision can improve on it. Further for any other voting threshold $k < M$, there is a positive probability that they will invest in a project where $\min\{\theta_1, ..., \theta_N\} < I$. Therefore $k = N$ must be optimal.

C Extensions

C.1 Model with Heterogeneous Preferences

Given the apparent value to investors using the champions models in such contexts, it seems interesting that this practice is observed in VC but has not been noted in other contexts such as corporate R&D. In this extension of the model, we provide one potential explanation: the fact that the champions model loses its value if each committee member may prefer to vote for the project for a private, rather than common, reason.

Consider the following variation of the baseline model. Suppose that with probability π each partner wants to either do the project or not do a project (with equal probabilities) for a private reason irrespectively of its quality (i.e., the project is a private benefit or private cost project). This may be due to agency conflicts or due to career concerns in the organization. In contrast, with probability $1 - \pi$, the partner is unbiased and wants to maximize the expected value. Suppose that the realizations of whether the project is partner i's private benefit project are independent across partners.

On one extreme, if $\pi = 0$, then all partners have common objectives of maximizing the value of the project - which reverts to the model of the previous section. On the other extreme, if $\pi = 1$, then all partners have private values.

Under this model, each partner will vote for the project in two scenarios. First, she will vote for the project with probability $\frac{1}{2}\pi$, irrespectively of the realization of her signal. Second, with probability $1 - \pi$, she will vote for the project if and only if it exceeds some cut-off $\hat{\theta}_k(\pi)$. Cut-off $\hat{\theta}_k$ is implicitly defined by the following equation:

$$\hat{\theta}_k + ((k-1)\,\mathbb{E}\left[\theta_i | i \text{ votes for}\right] + (N-k)\,\mathbb{E}\left[\theta_i | i \text{ votes against}\right]) = I \qquad (8)$$

To see the role of private benefits, consider what happens in the extreme case of $\pi \to 1$. In this case, the vote of each other partner is determined fully by private benefits (or costs) of

the project. Thus, these votes are uninformative about the partners' signals, so the equilibrium cut-off of the benevolent partner will be $\hat{\theta}_k = I - (N-1)\,\mathbb{E}[\theta]$. In particular, her voting strategy is independent of the rule k. Consider $k = 1$. Compared to the case of $\pi = 0$, each partner will now overchampion for the project for two reasons. First, she will overchampion if she wants to do the project for a private benefit reason, since the probability of approval vote in this case $(\frac{1}{2})$ exceeds that of p_1 in Proposition 3 (below $\frac{1}{N}$ for any α). Second, and more interestingly, she will overchampion even if she is benevolent: This will happen because the negative votes of others do not reveal negative information about other characteristics of the project when the votes occur primarily for private benefit reasons.

It is easy to see why the champions model will be suboptimal for a sufficiently high π in this case. While the champions model is still useful at identifying tail projects if the champion happens to be benevolent, most projects get championed for private benefit reasons. Since ex-ante an average project has negative NPV, it is optimal to increase k to reduce the probability of investment for private benefit reasons. Decision making rules that require more consensus among committee members are better in this case, because they curb overchampioning.

C.2 Fat Left Tails

The model can be symmetrically applied to study investments in projects with fat left tails. We can turn the parameters of the model of the previous sections on their head to analyze this question. Suppose now that, as before, the valuation of the company is as before: $V = \theta_1 + \theta_2 + ... + \theta_M$, but now suppose that each of the M characteristics is distributed independently over $[-\infty, r)$ (where $r > 0$) according to a distribution function $H(\cdot)$ with density $h(\cdot)$. Further assume, as before that G and g are such that $E[\theta_i] = 0$ for all i. This distribution is meant to capture the shape of late stage investment decisions (or, alternatively, the payoff profile of debt contracts as opposed to equity contracts). Under this profile, the conclusions of the previous section reverse:

Proposition 5. *Suppose that H is subexponential. Then, the unanimity rule rejects a project with $V \to -\infty$ with probability one. In contrast, any $k < N$ rule accepts such a project with a strictly positive probability.*

The intuition of this proposition is very similar to that of proposition 1: unanimity and champions rules are two sides of the same coin. Under unanimity only one partner needs to object to the project to reject it; under the champions rule only one partner needs to support the project to accept it.

D Survey Questions and Quotations

D.1 Survey Questions

3. Please indicate the formal process that best describes your investments in (a) seed stage, (b) early stage, and (c) later/growth stage.

	Seed	Early stage	Later/growth stage
Not applicable (don't make this kind of investment)	○	○	○
Require unanimous agreement to do the deal	○	○	○
Require majority of votes to do the deal	○	○	○
Require majority of votes as long as no veto	○	○	○
A single partner can do the deal	○	○	○
A single partner can do the detail as long as no veto	○	○	○

4. Leaving aside your formal investment process, what is the culture you feel best describes your partnership?

	Seed	Early stage	Later/growth stage
Not applicable (don't make this kind of investment)	○	○	○
An enthusiastic champion is usually sufficient for others to vote 'yes'	○	○	○
Majority of the partners have to be enthusiastic to do the deal	○	○	○
Only deals where *all* partners are enthusiastic get done	○	○	○
Other (please describe below)	○	○	○

If you selected "other" above, please describe in the box below.

Figure 12: Key Survey Questions used in Analysis: This figure is a screenshot of two of the survey questions asked to VC investors about the formal and informal voting processes their firms use to make decisions.

3. A prior study has documented that many VC partnerships use a champions voting rule where a single partner can decide whether or not to do a deal, even if the majority of partners is not supportive. These VCs often use champions voting *for seed and early investments* but *not for later-stage investments*. How much do you agree with the following possible explanations?

Expertise: VCs use champions voting for seed and early investments but not for later-stage investments because earlier-stage deals require more specialized expertise than late-stage deals, so partnerships give people with expertise greater discretion in doing earlier-stage deals but not later-stage deals.

Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
○	○	○	○	○

Catching Outliers: VCs use champions voting for seed and early investments but not for later-stage investments because the best early-stage investments can be extremely promising in some dimensions but flawed in others. Requiring too much consensus can therefore lead partnerships to pass on the best deals.

Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
○	○	○	○	○

Effort: VCs use champions voting for seed and early investments but not for later-stage investments because they care less about smaller deals, and don't want too many partners to spend effort on diligence. Leaving the decision to a champion for these smaller deals also incentivizes greater effort on the part of the champion.

Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
○	○	○	○	○

Figure 13: Key Survey Questions used in Analysis: This figure is a screenshot of the survey question asked to VC investors about the reasons for champions voting processes their firms use to make decisions.

70

D.2 Quotations

Here we provide some quotations from the anonymous participants in our surveys:

We use champion voting. The primary reason is that successful early-stage VC requires people to "think differently" from the pack (either by being early to a trend or literally interpreting the same fact set differently). Requiring consensus risks cautious investments that regress to the mean. [One investment] is a great example of a "Think Differently" investment that yielded a big return for us but was unpopular in the partnership initially.

At least in our firm we recognize that most of our alpha comes from early-stage conviction, but that this conviction requires often a deep up close study of a trend or prospect, and that knowledge can be hard to communicate to a larger group. So we leave early stage dealmakers alone on early stage decisions worried that if we provide too much feedback they'll lose that conviction on the deals that matter. It should also be noted that some of the best investments are both weird/different and can be at valuations that don't always completely compensate for this weirdness (because there's momentum) - and so the early stage conviction of the champions can be fragile if they hear lots of pushback from their partners. We have many examples of an investor building conviction early in their career on a future potential fund moving deal only to have that conviction shattered by an errant comment by an "old dog" investor.

It's mostly because in early stages neither the trend nor the metrics are obvious and committee decisions can result in the firm losing out on outliers

We care more about early stage deals since we can get more ownership at a lower price, but have a partner conviction model since our partners each have different areas of expertise. Our partner conviction model also stands for later stage deals, but more people are involved in diligence to help the partner make a better decision.

In practice, there is 1-2 partners who are responsible for ongoing support for the portfolio. It is more important to have strong support from 1 partner, vs. lukewarm support from multiple partners. In the latter case no one will truly assume responsibility for post investment support.