Investment Committee Voting and the Financing of Innovation*

ANDREY MALENKO
University of Michigan

RAMANA NANDA
Harvard Business School

MATT RHODES-KROPF
MIT Sloan

SAVITAR SUNDARESAN
Imperial College London

July 2020

Abstract

We provide novel evidence on voting practices used by the investment committees of prominent venture capital investors in the US. A substantial share of these VCs use a voting rule for seed and early stage investments where a single 'champion' is sufficient for the entire partnership to make an investment, even if other members are not as favorable. However, the same VCs migrate to more conventional 'majority' or 'unanimous' voting rules for their later stage investments. We show theoretically that a 'champions' model can emerge as the optimal voting rule under information environments that resemble those of early stage VC, but also requires that partners have sufficiently common objectives to prevent strategic overchampioning for pet projects. More traditional voting rules are robust to strategic voting but are more likely to systematically miss the best early stage investments. Our model can rationalize (i) A 'champions' voting rule in early stage VC (ii) 'majority' and 'unanimous' voting rules in late stage VC and (iii) an expectation that environments where strategic voting is a concern will systematically miss out on selecting best 'outlier' innovations.

*Malenko: amalenko@umich.edu; Nanda: RNanda@hbs.edu; Rhodes-Kropf: mattrk@mit.edu; Sundaresan: s.sundaresan@imperial.ac.uk. During the 2019-2021 academic years, Nanda is a Visiting Professor at Imperial College, London. Rhodes-Kropf is an advisor to, and investor in, Correlation Ventures, which provided some of the data. We are grateful to Patrick Bolton and Will Gornall and Jerry Green for helpful discussions. Nanda thanks the Division of Research and Faculty Development at Harvard Business School for financial support. All errors are our own.

Some VCs have all their partners score a deal's potential. We've learnt that those aggregate scores don't correlate strongly with ultimate returns. With that approach, you get the mush in the middle, with no big flaws but no great strengths.

– Marc Andreessen, co-founder of VC firm Andreessen Horowitz[1]

1 Introduction

One of the central elements of investment decisions, whether made by financial intermediaries or large corporations, is that they are often made by an *investment committee* – a group of people tasked with the go/no-go investment decision, who typically each vote their view, given the information signal they get on the prospective investment.

Most academic work in corporate finance abstracts away from the fact that a committee of individuals makes investment decisions. The unspoken assumption is that the committee effectively aggregates information into a decision with expected positive net 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)). Such voting practices also fit conventional wisdom, where voting is often considered valuable as a way to 'trim outliers' and emphasize the wisdom of the majority.

In this paper, we study the voting practices at investment committees of some of the largest venture capital investors in the U.S. and document an interesting result: nearly all the VCs we surveyed employ some version of a 'champions' rule when voting on whether to fund startups at their earliest ("seed" and "early") stages of financing. Specifically, both the formal and informal voting practices used by the investment committees at these VC

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

firms allow for a single committee member's strong positive signal to over-ride a majority of individuals who did not receive as positive a signal about the investment opportunity. We further document that these same VC investors change their voting practice for later stage investments, using either a 'majority rule' or 'unanimous agreement' voting model when deciding whether to make a late stage investment in a startup. This *within* VC change in the voting rule strongly suggests that the use of a 'champions model' in early stage investing is related to the stage of the startups being funded, as opposed to anything systematic about the VC investors who might focus on one stage or another.

Conventional wisdom and a large body of theoretical work suggests that an investment committee that aggregates the information of all members should systematically outperform decision making that stems from information signals of any single individual as would be the case with a champions voting model. So why would VC investors use a champions voting model when making certain investments? Moreover, given the fact that VCs rely on champions voting primarily for seed and early stage investments but not others, could it be that such an approach to aggregating information signals may even be optimal in the contexts it is used?

We are not aware of any academic work that derives the champions rule as an optimal voting rule,[2] so we next examine theoretically whether contexts that fit the early stage VC setting, in which returns are believed to be disproportionately *driven* by outliers, may require a different approach to aggregating information signals. For example, 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

[2]Several existing papers provide arguments in favor of the unanimity rule, which is the opposite of the champions rule, in various settings. As we discuss in Section 3, these arguments do not seem to explain the empirical evidence documented here.

for technological 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).

As with standard models of information aggregation, our model is based on the assumption that committee members receive signals with (at least some) different information. For example, one could think of investment success as stemming from different components such as team, product, market (Kaplan, Sensoy, and Stromberg 2009; Bernstein, Korteweg, and Laws 2017) and each committee member as having expertise in evaluating some but not all elements. The total expected value of the project is a sum of signals that committee members observe, in addition to a number of signals that they may not observe.

A key insight of our model is that if information signals come from subexponential (heavy tailed) distributions that correspond to the outcomes we see from innovative early stage investments, then the optimal voting rule can in fact be equivalent to a ‘champions’ voting model observed among VC investors.[3]

The intuition for this result comes from a combination of two effects. First, note that voting rules that require many affirmative votes for investment (such as majority or unanimous agreement) result in the funding of ventures that tend to be good on many dimensions. Importantly, they are likely to miss projects that are *exceptional* on few dimensions but are mediocre on many other dimensions. Conversely, the champions rule results in the acceptance of projects that have one superstar characteristic but miss projects that are quite good on many dimensions without being superstar on any one of them. The reason this is relevant for whether information signals come from subexpo-

[3]Subexponential distributions are a subclass of heavy-tailed distributions to which most commonly-used heavy-tailed distributions (including power law distributions) belong and is used frequently in the analysis of insurance claims and rare events.

nential distributions is because of an important property of such distributions, known as the "catastrophe principle". In our context, this property of subexponential distributions 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.* This property of superstar ventures is also consistent with an observation made by famed entrepreneur and venture capital investor, Marc Andreessen, that *"Google, Facebook, eBay and Oracle all had massive flaws as early-stage ventures, but they also had overpowering strengths"* (Eisenmann and Kind 2014). Interestingly, in such a setting, the average committee member will likely receive a mediocre signal even for superstar project, which is consistent with the relative low correlations between the average score given by investors and the ultimate outcome of ventures noted by Andreessen in the quote above, and also documented in Kerr, Nanda, and Rhodes-Kropf (2014).

Second, the fact that the distribution of signals and 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. In contrast, finding projects of low but positive NPV is of secondary importance. 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 sufficiently many weak characteristics. This is consistent with Marc Andreessen's comment above, that with those voting rules, *"you get the mush in the middle, with no big flaws but no great strengths".*

Another important insight from the model is that the optimal rule for aggregating information signals depends on the underlying signal distribution, F, from which information is received by the committee members. If F has light tails (e.g., is a Normal distribution), a superstar project will typically be driven by many characteristics that are very good rather than by one exceptionally good characteristic. In this case, the advantage of the champions rule over other decision making rules in identifying superstar projects is lost and more traditional voting rules dominate. In light of this insight, the declining use of 'champions' voting among the same VC investors in later stage investments could arise if information signals for early rounds of financing were heavy-tailed while those in later rounds were less so. Although we cannot directly validate this premise, 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. To the extent that the *ex ante* information signals 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.

In the final part of the paper, 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 and where we consider a fund with 5 partners that make 25 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 55.7% for the champions rule, 20.2% for the majority rule, and 15% for the unanimity rule.

The lower chance of selecting exceptional ideas in early stage settings when the champions model is not used is useful to put into context, because we also show theoretically that the dominance of the champions model for subexponential distributions is only true in our model 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 over-rides 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.

Our work 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 Sorensen, 2007 (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).

Our paper is also 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).

2 Empirical Evidence from Venture Capital

Venture capital provides a unique context within which to examine empirical patterns related to financing innovation 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 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 1 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 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 appear 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.[4]

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 2, 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 3, we further document that this pattern continues to exist in a very similar manner when one examines the informal voting practices within the investment commit-

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

tees. 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, 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.

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.

3 Can the existing literature explain our empirical findings?

The previous section documents a striking relation between the decision making rule of a VC partnership and the stage of investment considered. For a seed stage startup, VC partnerships tend to use the champions rule, where a single positive vote is sufficient for the partnership to go ahead with the investment. However, the same partnerships tend to move to the majority rule when analyzing later-stage investment decisions. It is natural to ask whether existing papers on committee decision making can explain this pattern.

Most of the literature on voting highlights the benefits of the majority voting rule, and extreme voting rules, such as unanimity and the champions rule, tend to be inferior relative to the majority rule (e.g., Feddersen and Pesendorfer (1997); Duggan and Martinelli (2001)). In fact, we are not aware of a paper that derives the champions rule as the optimal one in an environment that fits the VC setting.

While we are not aware of papers arguing for optimality of the champions rule, 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)). These results are related, because the unanimity rule is the opposite of the champions rule: the former requires unanimity to change the status-quo, while the latter requires unanimity to support the status-quo. It is thus natural to ask whether these results can also explain the use of the champions rule for making early-stage investments by VC partnerships. In what follows, we discuss these papers and conclude that they are unlikely to provide a plausible explanation for our empirical findings.

Coughlan (2000) shows that unanimity can be optimal if committee members can communicate prior to the vote and they have similar preferences. We think this is probably the reason why empirically we see small partnerships requiring unanimity for later-stage investment decisions. However, it is unclear why the voting rule changes with the type of investment considered, since both the ability to communicate and the partners' preferences should be the same.

Bond and Eraslan (2010) endogenize a proposal put for a vote when the proposer can have misaligned preferences from the other committee members. A voting rule in their setting affects both the proposal put for a vote and the likelihood of its approval over the status quo. The unanimity rule has a disciplining benefit on the proposer by inducing the proposer to make a proposal that is more attractive to the rest of the group. In the context of VC partnerships, a proposer is a partner bringing a potential investment for consideration to the rest of the partnership. However, this model would not give a plausible explanation for the use of the champions rule. If there is a conflict of interest between the proposing partner and the other partners, it is arguably in the direction of the proposing partner being biased in favor of investment. The champions rule would play the opposite of the disciplining role by giving the proposing partner an easy way to get her project approved.

Jackson and Tan (2013) consider a setting in which voters get advised by informed experts, who can withhold information from the committee members but cannot lie about it. They show that the majority rule can be dominated by the unanimity rule, because the latter can encourage more information revelation by the experts. Intuitively, the unanimity rule makes the pivotal voter most biased for the status quo, which induces experts biased for the status quo to reveal their signals even if they go against the status quo. In the context of the VC investment, it is natural to interpret a start-up founder as an expert in Jackson and Tan's model. Since the start-up founder should be extremely biased in the direction of getting her project funded, she will always reveal positive information and not reveal negative information about her project, irrespectively of the voting rule. Thus, we do not see that the champions model can be optimal via inducing more information revelation by the start-up founder.

Chan et al. (2018) consider a model of sequential information acquisition by a committee with heterogeneous discount factors. The benefit of requiring unanimity in this setting is that it makes patient members pivotal, leading to more information acquisition and precise decisions. In this setting, the champions model would make impatient members pivotal, leading to even less information acquisition than the majority rule. Thus, we do not think this theory can be used to explain the prevalence of the champions voting rule at early stage VC investments.

In light of this discussion, we attempt to rationalize the empirical findings by providing a different theory, which is based on the idea that the importance of tail events changes with the stage of the VC investment.

4 A Simple Model of Investment

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. The payoff of the project is determined by the values of a set of M-many characteristics where $M \geq N$. Specifically, we assume that

$$V = \theta_1 + \theta_2 + ... + \theta_M. \tag{1}$$

All M characteristics are independently distributed over $[-l, \infty)$ (where $l > 0$) according to a distribution function $F(\cdot)$ with density $f(\cdot)$. Assume that F and f are such that $E[\theta_i] = 0$ for all i. Let $G(\cdot)$ denote the implied distribution of V. We assume that each partner i receives a perfectly informative signal about the value of characteristic i. Partner i learns θ_i but only knows the distribution of other characteristics. Independence of characteristics is a stark assumption, but is used in this case as adding some positive correlation would add complication without adding insight; also note that as signals become perfectly correlated then voting is no longer needed. 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. In the context of early stage investment, it is natural to model F as having heavy tails: as we show in section 2 this assumption fits the empirical evidence. Further, venture capital firms find it very important to "catch the unicorn" (i.e., find and invest in projects with very high Vs).

The status quo (uninformed) decision in this case is to not invest: because $\mathbb{E}[V] =$

$M\mathbb{E}[\theta] = 0 < I$. In contrast, in later stage investments, it is natural to expect that the distribution of valuations has thin tails: a project is unlikely to be superstar if it does not already have high profile by then. Each partner has linear utility from investment and all partners share the common objective of maximizing the value of an investment. Specifically, utility is given by:

$$U_i = U = V - I \tag{2}$$

Under this setting, if partners could communicate, they would reveal their signals truthfully to each other, obviating the need for a voting mechanism. While we consider the implications of settings with imperfect revelation in subsequent sections, we first lay out the simplest version of the model, assuming that a voting mechanism is already in place. 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 models:

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

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

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

The questions we ask are: What is the optimal k is and how does it vary with the characteristics of the project (the signal distribution F). We are particularly interested in the conditions under which the champions model is optimal.

4.1 Simple Model solution

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 signal 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 signal and the fact that her vote is pivotal:

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

Equation (3) pins down the voting threshold $\hat{\theta}_k$. Equation (3) defines the voting rule as partners with information signals above theta hat sub k will have a positive expected value and for for, while those with information below theta hat sub k will have a negative expected value. 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. When all partners share common objectives, the voting strategy is quite sensitive to the information that each partner learns from the fact that her vote is pivotal. In contrast, if objectives are very different, each partner either wants her project to go through (if the signal exceeds $\frac{I}{N}$) or fail (if the signal is below $\frac{I}{N}$), regardless of what she learns about the signals of others. In this case, the voting strategy is not sensitive to the voting 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 $V \to \infty$ with probability one, if $M = N$, and with probability $\frac{N}{M}$, if $N < M$. 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 intuition for Proposition 1 comes from an important property of subexponential distributions called the "catastrophe principle." The catastrophe principal 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, a superstar project is much more likely 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 flaws as early-stage ventures but also some overpowering strengths.

The champions model does a particularly good job at identifying projects with one superstar characteristic. In contrast, any other decision rule, such a majority rule, votes such projects down with a positive probability, because it is possible that they have sufficiently many other weak characteristics. Note that the fact that F is subexponential is an important property. 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. The next result leverages Proposition 1 to show that if identifying projects in tails is sufficiently important (formally, a sufficiently high mass of value comes from the tail), then the champions rule dominates any other voting rule:

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. This comes at a cost, however: The champions model is bad at identifying projects that are moderately good on many dimensions (and, hence, are positive-NPV investments) but are not superstar on any of them. Decision making rules that require more consensus, such as the majority rule, are better at identifying such projects. 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.

5 Empirical Evidence and Quantitative Importance

5.1 Empirical Evidence

Our model suggests that the champions model dominates other voting models, but only in settings where the distribution of information signals has heavy right tails. The model can therefore also rationalize the fact 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 signals 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 information signals received by partners, 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 information signals for these investments are potentially also less skewed.

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, which 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 4. 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 5 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.

Our results on the round level returns therefore provide suggestive evidence that is consistent with early stage – and in particular seed stage – information signals being much more skewed than those at later (Series C and beyond) stages. Under the assumption that information signals 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.

5.2 Quantitative Importance

While the pros and cons of the champions decision making rule are quite general, theoretical results about its optimality rely on the limit case and may lead to questions about applicability beyond the limit case. To address this concern as well as to more generally 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 signals are driven from Pareto (power law) distribution with tail parameter 1.7. 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 signals 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 signals with probability 50%. Overall, this distribution means that a typical project considered by the committee is clearly bad, but a very small fraction of projects are exceptionally promising. We keep the assumption that signals of partners are independent.[5] 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

[5]The assumption of independent signals exaggerates the difference between the champions rule. We are currently working on incorporating positive correlation of signals in this example.

unanimity rules. Projects funded under the champions rule have significantly higher average payoffs, variance, and more skewed. 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,[6] is 3.2% for the champions rule, 0.9% for 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.

[6]Assuming a 5-year investment horizon and the discount rate of 12%, this implies the adjusted multiple of 6.2.

6 Extension: 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 is only dominant if there is no strategic voting.

Suppose now that partners have utility functions that weight their own signal differently than those of their colleagues. Specifically, let the utility function of partner i be given by:

$$\begin{aligned} U_i &= \alpha\theta_i + \left(1 - \frac{\alpha - 1}{N - 1}\right) \sum_{j \neq i} \theta_j - I \\ &= V - I + (\alpha - 1)\,\frac{N\theta_i - V}{N - 1} \end{aligned} \tag{4}$$

where $\alpha \in [1, N]$. There are a few possible interpretations of α:

1. Expertise/Salience: Partner i has developed a level of expertise in a particular dimension, or perhaps has had past experience that has caused a particular dimension to be particularly salient to him/her. As a result, partner i's estimate of firm value is tilted towards that dimension.

2. Information/Confidence: Each partner i could know that they have seen their dimension θ_i completely accurately. However, the degree to which they believe that their colleagues have seen their dimensions accurately could be less than 1. The degree to which it is less than one would be reflected by α.

3. Agency or career concerns: partners might want to overweigh their signals to make

their opinions seem more relevant, which might increase their chances of advancement or promotion.

On one extreme, if $\alpha = 1$, 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 $\alpha = N$, then all partners have private values with each partner caring about her signal alone and ignoring the signals of others. All partners, however, do want to maximize the value of an investment. The presence of this behavioral bias implies that agents will not share their signals truthfully with each other, which, in turn necessitates a voting mechanism.

Lemma 1. *Consider a game in which all partners simultaneously send reports $\hat{\theta}_i$ to an uninformed decision maker, who invests if and only if $\mathbb{E}\left[V|\hat{\theta}_i, i = 1, ..., N\right] \geq I$. If $\alpha > 1$, truthful reporting is not an equilibrium in this game. Every equilibrium has an interval partition structure in which partner i reports that her signal is in a certain interval $\left[\tilde{\theta}_k, \tilde{\theta}_{k+1}\right]$. The lowest number of intervals in equilibrium is one. The highest number of intervals in equilibrium is some finite K.*

Lemma 1 means that the partners will not perfectly exchange their information due to communication frictions. Furthermore, the message that each partner is able to send is akin to a discrete score. For example, in equilibrium with two intervals, a discrete score is equivalent to a positive or negative vote on the investment proposal. Now that a voting mechanism is necessary, we first show that the results of the previous section are preserved, and then show the additional predictions that arise from the lack of truthful revelation discussed in the lemma.

6.1 Model solution

Under this model, each partner will vote for the project if and only if her signal exceeds some cut-off $\hat{\theta}_k(\alpha)$. Cut-off $\hat{\theta}_k$ is implicitly defined by the following equation:

$$\alpha\hat{\theta}_k + \left(1 - \frac{\alpha - 1}{N - 1}\right)\left((k-1)\,\mathbb{E}\left[\theta_i|\theta_i \geq \hat{\theta}_k\right] + (N-k)\,\mathbb{E}\left[\theta_i|\theta_i \leq \hat{\theta}_k\right]\right) = I \qquad (5)$$

We have that α is the same for all partners, and that θ is i.i.d. for all dimensions. The cutoff $\hat{\theta}_k$ is defined for the cases when partner k is the pivotal vote. If partner k votes yes, that increases her utility by $\alpha\hat{\theta}_k$, and if voting yes pushes agent k's valuation above the investment level IIn that setting, the investment will be taken up. $k-1$ many of the partners have received signals moving them to vote in favor of investing (their signals are above the cutoff), and the remaining $N-k$ partners have received signals moving them to vote against investing (their signals are below the cutoff). Voting strategy (5) satisfies two intuitive properties. As before, $\hat{\theta}_k$ is decreasing in k, which 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. Second, $\hat{\theta}_k$ is less sensitive to k if α is higher. For example, in the limit case of $\alpha = N$, $\hat{\theta}_k = \frac{I}{N}$ regardless of k.

Proposition 1 continues to hold for all values of α, while Proposition 2 holds for sufficiently small values of α. Our next proposition shows that the dominance of the champions rule is not robust to committees with high agency conflicts. Intuitively, committee members will overchampion for their projects. Decision making rules that require more consensus among committee members are better in this case, because they curb overchampioning:

Proposition 3. $NE[\theta] = 0 < I$ *(i.e., the uninformed decision is to not invest). If* α *is* *sufficiently close to N, the champions model will have a lower expected value than some $k > 1$ model.*

As each partner becomes more enamored of their own dimension of valuation $\alpha \to N$, they may suboptimally push for investments in projects that no longer pass muster.

7 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. 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. We rationalize this behavior by showing that a committee can choose different voting models based on the distribution of the valuation of the underlying investment opportunity. Distributions with fat right tails (similar to the distribution of early-stage investments) are ones where a champions voting model is optimal, while later stage investments where distributions have significantly less fat tails imply that 'majority' or 'unanimous' voting rules are optimal.

A second insight from our model is that the dominance of the champions model for fat right tailed distributions is only true when strategic voting is not too extreme. If individual committee members have private benefits (Scharfstein and Stein, 2000), then the cost of 'over championing' poor projects over-rides the potential benefits from selecting outlier projects. In such an instance, more traditional voting models are likely to be second best alternatives, providing a rationale both for the limited observed use of this type of voting, and perhaps the small size of investment committees among VC firms that do use such models.

More generally, we show that optimal rules for information aggregation in the financing of innovation might need to be systematically different because of stark differences in the information environment for early stage, highly innovative projects.

References

Bergemann, Dirk and Ulrich Hege. 1998. "Venture capital financing, moral hazard, and learning." *Journal of Banking & Finance* 22 (6-8):703–735.

Bernstein, Shai, Arthur Korteweg, and Kevin Laws. 2017. "Attracting early stage investors: Evidence from a randomized field experiment." *Journal of Finance* 72:509–538.

Bloom, Nicholas, Charles I. Jones, John Van Reenen, and Michael Webb. 2020. "Are Ideas Getting Harder to Find?" *American Economic Review* 110:1104–1144.

Bond, Philip and Hülya Eraslan. 2010. "Strategic voting over strategic proposals." *The Review of Economic Studies* 77 (2):459–490.

Chan, Jimmy, Alessandro Lizzeri, Wing Suen, and Leeat Yariv. 2018. "Deliberating collective decisions." *The Review of Economic Studies* 85 (2):929–963.

Condorcet, Marquis de. 1785. "Essay on the Application of Analysis to the Probability of Majority Decisions." *Paris: Imprimerie Royale* .

Cornelli, Francesca and Oved Yosha. 2003. "Stage financing and the role of convertible securities." *Review of Economic Studies* 70 (2):1–32.

Coughlan, Peter J. 2000. "In defense of unanimous jury verdicts: Mistrials, communication, and strategic voting." *American Political science review* :375–393.

Duggan, John and César Martinelli. 2001. "A Bayesian model of voting in juries." *Games and Economic Behavior* 37 (2):259–294.

Eisenmann, Thomas and Liz Kind. 2014. “Andreessen Horowitz.” *Harvard Business School Case* 814-060.

Feddersen, Timothy and Wolfgang Pesendorfer. 1997. “Voting behavior and information aggregation in elections with private information.” *Econometrica: Journal of the Econometric Society* :1029–1058.

———. 1998. “Convicting the innocent: The inferiority of unanimous jury verdicts under strategic voting.” *American Political science review* :23–35.

Gompers, Paul. 1995. “Optimal Investment, monitoring, and the staging of venture capital.” *Journal of Finance* 50:1461–1490.

Gompers, Paul, William Gornall, Steven Kaplan, and Ilya Strebulaev. 2020. “How do venture capitalists make decisions?” *Journal of Financial Economics* 135 (1):169–190.

Graham, John and Campbell Harvey. 2001. “The theory and practice of corporate finance: evidence from the field.” *Journal of Financial Economics* 60:187–243.

Hall, Robert E and Susan E Woodward. 2010. “The Burden of the Nondiversifiable Risk of Entrepreneurship.” *American Economic Review* 100 (3):1163–1194.

Hellmann, Thomas. 1998. “The allocation of control rights in venture capital contracts.” *RAND Journal of Economics* 29:57–76.

Hellmann, Thomas and Manju Puri. 2000. “The interaction between product market and financing strategy: The role of venture capital.” *Review of Financial Studies* 13:959–984.

———. 2002. “Venture capital and the professionalization of start-up firms: Empirical evidence.” *Journal of Finance* 57:169–197.

Jackson, Matthew O and Xu Tan. 2013. "Deliberation, disclosure of information, and voting." *Journal of Economic Theory* 148 (1):2–30.

Kaplan, Steven N, Berk Sensoy, and Per Stromberg. 2009. "Should Investors Bet on the Jockey or the Horse? Evidence from the Evolution of Firms from Early Business Plans to Public Companies." *Journal of Finance* 61 (4):75–115.

Kaplan, Steven N and Per Strömberg. 2003. "Financial contracting theory meets the real world: An empirical analysis of venture capital contracts." *The review of economic studies* 70 (2):281–315.

Kerr, William R, Ramana Nanda, and Matthew Rhodes-Kropf. 2014. "Entrepreneurship as experimentation." *The Journal of Economic Perspectives* 28 (3):25–48.

Kortum, Samuel and Josh Lerner. 2000. "Assessing the Contribution of Venture Capital to Innovation." *The RAND Journal of Economics* 31 (4):674–692.

Ladha, Krishna K. 1992. "The Condorcet jury theorem, free speech, and correlated votes." *American Journal of Political Science* :617–634.

Lerner, Josh. 1995. "Venture Capital's Role in Financing Innovation: What We Know and How Much We Still Need to Learn." *Journal of Finance* 50:301–318.

Lerner, Josh and Ramana Nanda. 2020. "Venture Capital's Role in Financing Innovation: What We Know and How Much We Still Need to Learn." *Journal of Economic Perspectives* 34 (3).

Manso, Gustavo. 2011. "Motivating Innovation." *Journal of Finance* 66 (5):1823–1860.

Scharfstein, David and Jeremy Stein. 2000. "The Dark Side of Internal Capital Markets: Divisional Rent-Seeking and Inefficient Investment." *The Journal of Finance* 55 (5):2537–2564.

Scherer, F. M. and Dietmar Harhoff. 2000. "Technology policy for a world of skew-distributed outcomes." *Research Policy* 29 (4-5):559–566.

Thiel, Peter and Blake Masters. 2014. *Zero to One.* Crown Business.

8 Figures and Tables

Figure 1: Key Survey Questions used in Analysis

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 2: Breakdown of Formal Voting by stage of investment

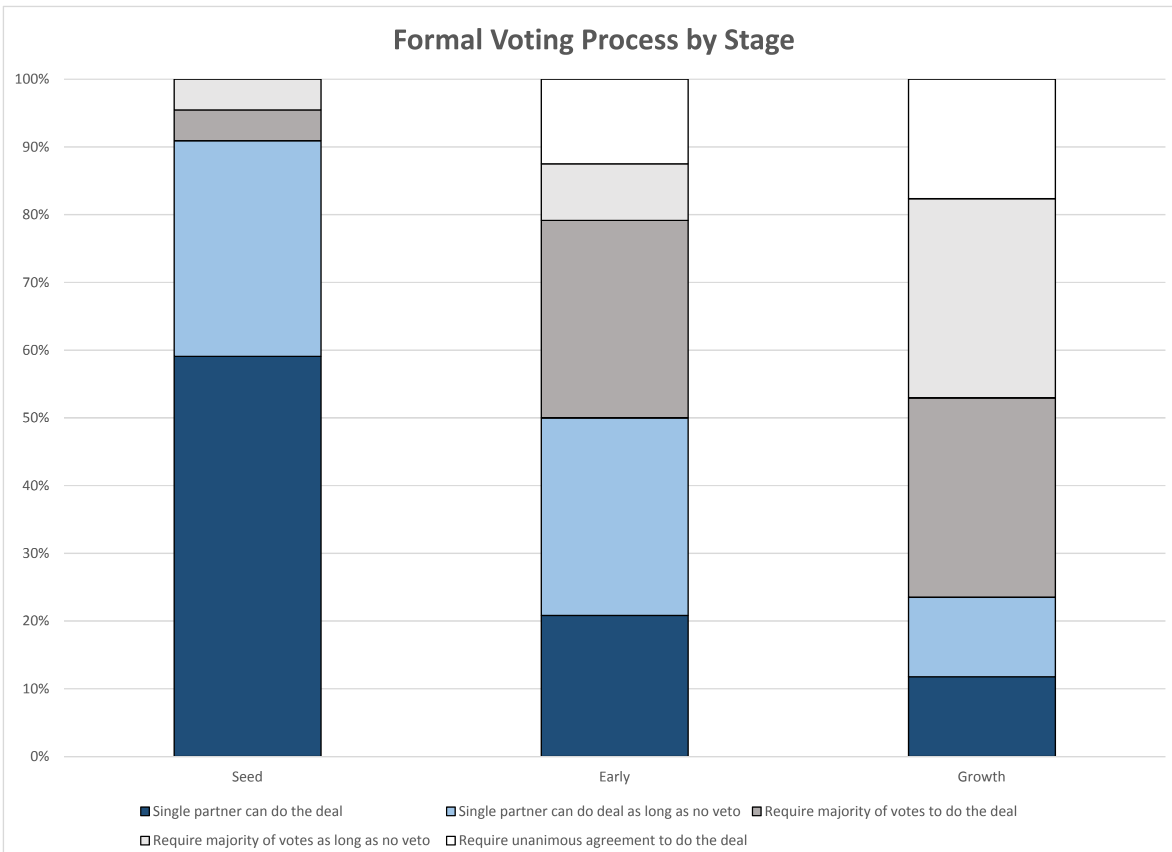


Figure 3: Breakdown of Informal Voting by stage of investment

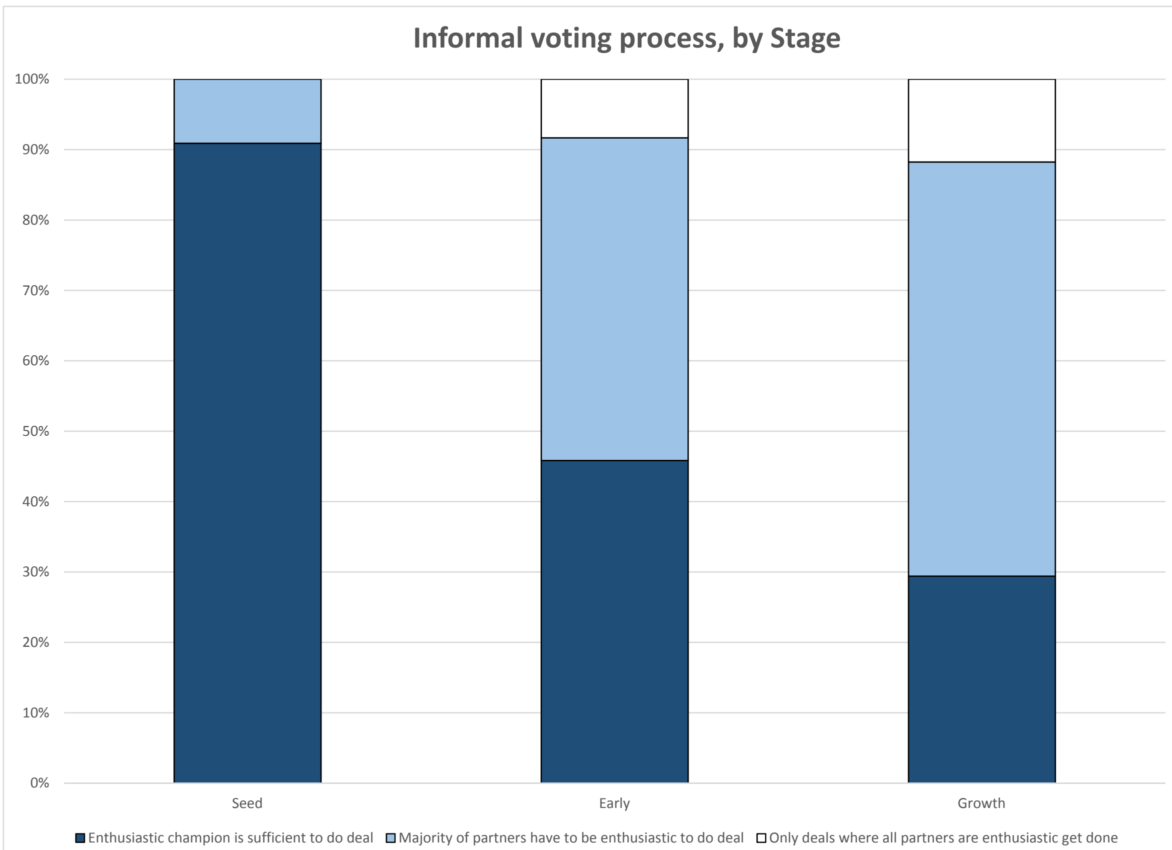


Figure 4: Distribution of Return Multiples for Overall Sample

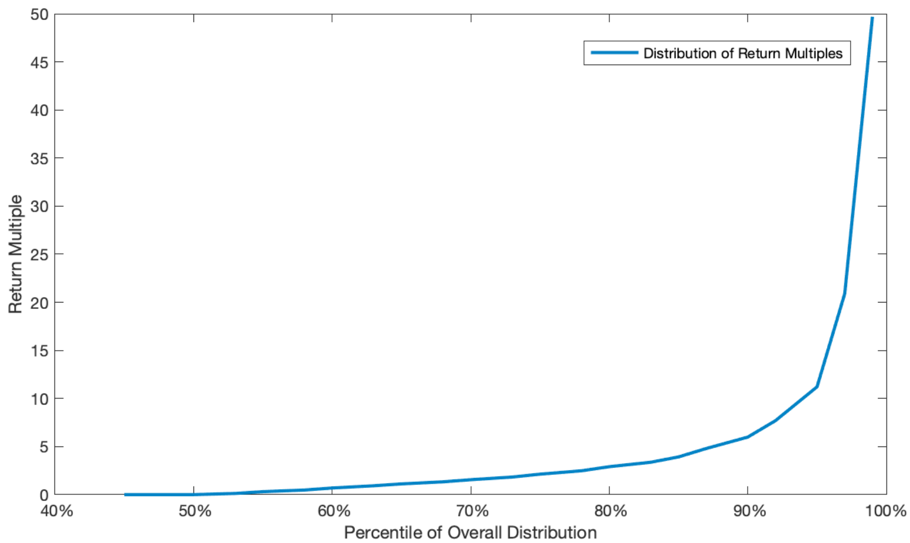
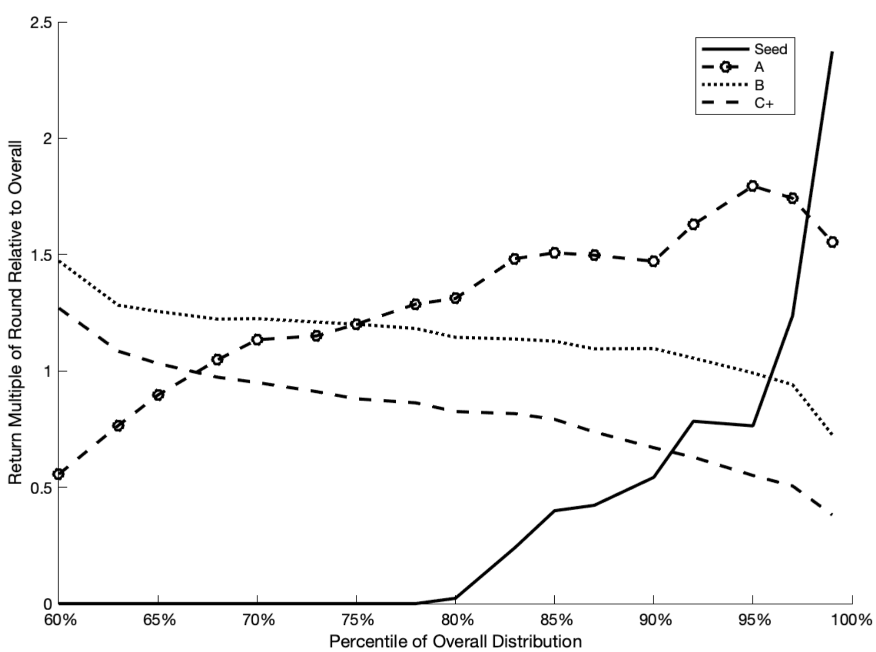


Figure 5: Ratio of round-level distribution to overall



	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.

9 Appendix

9.1 Proofs

Proof of Lemma 1. Follows the argument of Crawford and Sobel (1982).

Proof of Proposition 1 We prove the proposition for $M = N$. The case of $M > N$ can be proven analogously. Because F is subexponential, it satisfies a famous catastrophe principle:

$$\begin{aligned}
\frac{\Pr\{\max(\theta_1, \theta_2, ..., \theta_n) > t\}}{\Pr(\theta_1 + \theta_2 + ... + \theta_n > t)} &\to 1 \\
\Pr(\max(\theta_1, \theta_2, ..., \theta_n) > t | \theta_1 + \theta_2 + ... + \theta_n > t) &\to 1
\end{aligned}$$

as $t \to \infty$. Therefore:

$$\begin{aligned}
\int_{\hat{t}}^{\infty} V dF(V | V = \theta_1 + \theta_2 + ... + \theta_n) &\approx \int_{\hat{t}}^{\infty} V d \Pr(\max(\theta, \theta_2, ..., \theta_n) > t) \\
&= \int_{\hat{t}}^{\infty} \max(\theta_1, \theta_2, ..., \theta_n) dF(\max(\theta_1, \theta_2, ..., \theta_n))
\end{aligned}$$

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:

$$\int_{\hat{t}}^{\infty} Zd(F(z)^n) = \int_{\hat{t}}^{\infty} ZnF(z)^{n-1} f(z) dz$$

For any decision-making rule D, let $p_D(V)$ denote the probability of investment in a project of value $V = \theta_1 + \theta_2 + ... + \theta_n$. 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 $\max(\theta_1, \theta_2, ..., \theta_n)$. Without loss of generality suppose $\max\{\theta\} = \theta_1 = Z$. 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:

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

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 $k>1$.

Proof of Proposition 2. 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 $\max\left\{\theta_1,...,\theta_n\right\}\in\left[\hat{\theta}_2,\hat{\theta}_1\right]$ 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

$$\hat{\theta}_2+\mathbb{E}\left[\theta_i|\theta_i\geq\hat{\theta}_2\right]+(N-2)\,\mathbb{E}\left[\theta_i|\theta_i\leq\hat{\theta}_2\right]=I. \tag{6}$$

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

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

Therefore, if

$$\lim_{\hat{V}\to\infty}\int_{\hat{V}}^{\infty}Vd\left(G\left(V\right)\right)\geq\frac{\int_{I}^{N\hat{\theta}_1}VdG\left(V\right)}{F\left(\hat{\theta}_2\right)^{n-1}},$$

then the champions model dominates $k = 2$.

Proof of Proposition 3. Because F is subexponential, it satisfies a famous catastrophe principle:

$$\begin{aligned}
\frac{\Pr\{\min(\theta_1, \theta_2, ..., \theta_n) < t\}}{\Pr(\theta_1 + \theta_2 + ... + \theta_n < t)} &\to 1 \\
\Pr(\min(\theta_1, \theta_2, ..., \theta_n) < t | \theta_1 + \theta_2 + ... + \theta_n < t) &\to 1
\end{aligned}$$

as $t \to -\infty$. Therefore:

$$\begin{aligned}
\int_{-\infty}^{\hat{t}} V dF(V | V = \theta_1 + \theta_2 + ... + \theta_n) &\approx \int_{-\infty}^{\hat{t}} V \, d\Pr(\max(\theta, \theta_2, ..., \theta_n) < t) \\
&= \int_{-\infty}^{\hat{t}} \min(\theta_1, \theta_2, ..., \theta_n) \, d(1 - F(\min(\theta_1, \theta_2, ..., \theta_n)))
\end{aligned}$$

when $\hat{t}$ is small. Let $Z \equiv \min(\theta_1, \theta_2, ..., \theta_n)$. Then, $\Pr(Z \geq z) = \Pr(X_i \geq z)^n = (1 - F(z))^n$. Hence, the above integral is equal to:

$$\int_{\hat{t}}^{\infty} Z d((1 - F(z))^n) = -\int_{\hat{t}}^{\infty} Zn(1 - F(z)^{n-1}) f(z) \, dz$$

Consider a very low valuation Z. Its distribution is similar to $\min(\theta_1, \theta_2, ..., \theta_n)$. Without loss of generality suppose $\min\{\theta\} = \theta_1 = Z$. Then, the conditional distribution of any other θ_i is $1 - F$ truncated at Z. Given a voting rule k, the probability that this project gets accepted is:

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

namely, that there are $n - k + 1$ many signals that are above the threshold for rejection. The probability of acceptance is zero when $k = N$ and strictly positive when $k < N$.

Proof of Proposition 4. For any decision making model K and voting threshold $\hat{\theta}$, we can write the expected value from investment as

$$
\begin{aligned}
& \sum_{k=K}^{N} C_N^k \left(1-F\left(\hat{\theta}\right)\right)^k F\left(\hat{\theta}\right)^{N-k} \left(k\frac{\int_{\hat{\theta}}^{\infty}\left(\theta-\frac{I}{N}\right)dF\left(\theta\right)}{1-F\left(\hat{\theta}\right)} + \left(N-k\right)\frac{\int_{0}^{\hat{\theta}}\left(\theta-\frac{I}{N}\right)dF\left(\theta\right)}{F\left(\hat{\theta}\right)}\right) \\
= & \; N\sum_{k=K}^{N}\frac{(N-1)!}{(k-1)!\,(N-k)!}\left(1-F\left(\hat{\theta}\right)\right)^{k-1}F\left(\hat{\theta}\right)^{N-k}\int_{\hat{\theta}}^{\infty}\left(\theta-\frac{I}{N}\right)dF\left(\theta\right) \\
& +N\sum_{k=K}^{N-1}\frac{(N-1)!}{k!\,(N-k-1)!}\left(1-F\left(\hat{\theta}\right)\right)^{k}F\left(\hat{\theta}\right)^{N-k-1}\int_{0}^{\hat{\theta}}\left(\theta-\frac{I}{N}\right)dF\left(\theta\right) \\
= & \; N\sum_{k=K}^{N}P\left(1-F\left(\hat{\theta}\right),k-1,N-1\right)\int_{\hat{\theta}}^{\infty}\left(\theta-\frac{I}{N}\right)dF\left(\theta\right) \\
& +N\sum_{k=K}^{N-1}P\left(1-F\left(\hat{\theta}\right),k,N-1\right)\int_{0}^{\hat{\theta}}\left(\theta-\frac{I}{N}\right)dF\left(\theta\right) \\
= & \left(\int_{\hat{\theta}}^{\infty}\left(N\theta-I\right)dF\left(\theta\right)\right)\left(\sum_{k=K-1}^{N-1}P\left(1-F\left(\hat{\theta}\right),k,N-1\right)\right) \\
& +\left(\int_{0}^{\hat{\theta}}\left(N\theta-I\right)dF\left(\theta\right)\right)\left(\sum_{k=K}^{N-1}P\left(1-F\left(\hat{\theta}\right),k,N-1\right)\right) \\
= & \left(\sum_{k=K}^{N-1}P\left(1-F\left(\hat{\theta}\right),k,N-1\right)\right)\left(\int_{0}^{\infty}\left(N\theta-I\right)dF\left(\theta\right)\right) \\
& +P\left(1-F\left(\hat{\theta}\right),K-1,N-1\right)\int_{\hat{\theta}}^{\infty}\left(N\theta-I\right)dF\left(\theta\right)
\end{aligned}
$$

Consider the limit case $\alpha \to N$. In this case, $\hat{\theta}_k \to \frac{I}{N}$ for any k. The expected payoff from decision making rule k in this case is:

$$
\begin{aligned}
& \left(\sum_{k=K}^{N-1}P\left(1-F\left(\frac{I}{N}\right),k,N-1\right)\right)\left(\int_{0}^{\infty}\left(N\theta-I\right)dF\left(\theta\right)\right) \\
& +P\left(1-F\left(\frac{I}{N}\right),K-1,N-1\right)\int_{\frac{I}{N}}^{\infty}\left(N\theta-I\right)dF\left(\theta\right)
\end{aligned}
$$

It is clear that $K=1$ is not the solution to maximizing this expression over K. To see this, denote the second term of the above expression by $S(K)$ and consider

$$\frac{S(K+1)}{S(K)} = \frac{P\left(1-F\left(\frac{I}{N}\right), K, N-1\right)}{P\left(1-F\left(\frac{I}{N}\right), K-1, N-1\right)} = \frac{(N-K)\left(1-F\left(\frac{I}{N}\right)\right)}{KF\left(\frac{I}{N}\right)} \geq 1$$
$$\text{iff } N\left(1-F\left(\frac{I}{N}\right)\right) \geq K.$$

which is the case for low K. In addition, increasing K from $K=1$ reduces the first term because $\int_0^\infty (N\theta - I)\, dF(\theta) < 0$. Hence, $K=1$ is not the optimal voting rule if agency conflicts are sufficiently important.

9.2 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 4. *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.