Movers and Shakers

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April 6, 2015

Abstract

Most projects, in most walks of life, require the participation of multiple parties. While it is difficult to unite people in a common endeavor, some people, whom we call "movers and shakers," seem able to do it. The paper specifically examines moving and shaking of an investment project. We analyze a model with a large number of *ex ante* identical agents. Agents form social connections, bid to buy ownership and cashflow rights to an asset that is necessary for undertaking a project, and acquire private *iid* signals of the project's quality, which they can communicate, at a cost, to those with whom they are linked. Finally, agents choose whether to invest in the project whose returns are a function both of its underlying quality and aggregate investment. We characterize the equilibrium of this game, including the endogenously formed network structure, information flows, and payoffs. We show that a single agent emerges as most connected; these connections confer the ability to increase aggregate investment (i.e., move and shake the project); he consequently earns a rent. In extensions, we move away from the assumption of *ex ante* identical agents to highlight various forces that lead one agent or another to become a mover and shaker. Finally, we explore various applications, including: anchor investors, funds management, and insider trading.

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1 Introduction

Most projects – in business, politics, sports, and academia – require the participation of *multiple parties*. In business, they usually involve, among other things, raising capital from disparate sources. Many projects fail – or do not even get off the ground – because of the difficulty of bringing together the relevant parties. While it is not easy to unite individuals in a common endeavor, some people – often called "movers and shakers" – seem able to do it. This paper develops an equilibrium theory regarding who these movers and shakers will be and why they receive outsize compensation for their endeavors.

Perhaps contrary to intuition, movers and shakers need not be better informed than their peers. Superior information does facilitate "moving and shaking." With superior information, it is possible to increase participation by convincing prospects of a project's underlying quality. But another attribute – social connectedness – can also make someone a mover and shaker. Even without superior information, someone who is well connected can raise participation by convincing prospects of others' willingness to participate. Expressed differently, they can affect the higher-order beliefs of agents, and in so doing help to create "common knowledge" of the underlying state.

In our baseline model, we consider a setting in which agents are equally well informed. Agents also start out equally well connected (in fact, they initially have no social connections). There is a tendency, however, for one agent to become better connected and thus emerge as a mover and shaker.

We consider a game with a large number of identical agents and an investment project. The game has three stages. In stage 1, agents form social connections. We assume, for simplicity, agents can link with just one other agent. In stage 2, agents bid to buy an asset. The asset is necessary for undertaking the project and entitles the owner to the project's returns. For instance, if the project were the construction of a shopping mall, the asset might be the plot of land on which the mall is to be built. In stage 3, agents acquire private *iid* signals of the project's quality, which they can communicate, at a cost, to those with whom they are linked. Agents then choose whether to invest capital in the project (i.e., whether to *participate*). The project yields a return that is a function both of its underlying quality and the amount of capital raised (i.e., the *rate of*

participation).

While the agents are identical *ex ante*, in equilibrium, one of them becomes a mover and shaker. In stage 1, the agents all link to one particular agent, thus forming a star network. Because of his position, the agent at the center of the network, whom we may refer to as agent M, is most able to move and shake. This ability allows M to outbid others for the asset in stage 2 and earn rents from control of the project. Agents' private signals of the project's quality – which we can think of as their "views" of the project – are equally good (they are *iid*). Nonetheless, agent M's view has a larger effect than other agents' on how much capital is raised and the ultimate outcome of the project.

One of the agents emerges, in equilibrium, as a mover and shaker because there is a preference, in stage 1, to link to the most connected agent. Observe that the value of linking to an agent is the possibility of learning his signal (or "view") in stage 3. There are two reasons to link to the most connected agent. First, he will outbid others for the project in stage 2, and in consequence, has more incentive than other agents to communicate his view in stage 3. Second, and more importantly, his view conveys more information than those of other agents. While all players' views are equally informative about the project's quality, the most connected agent's view conveys more information about the likelihood others will invest/participate in the project. In more technical terms, when the agents are deciding whether to invest, they are engaged in a global game; the most connected agent's signal is most worth learning because his signal is the most public.

We consider several extensions to the basic model, from which we obtain additional predictions. In our baseline model, all agents possess the same amount of capital. As one extension, we consider a case where some possess more capital than others. As in the baseline model, a mover and shaker emerges in equilibrium. In contrast to the baseline model, the mover and shaker need not be the project owner. It might be a potential investor with a large block of capital. In stage 3, the project owner offers agents with blocks of capital more attractive terms for investing in the project. The reason is that such agents, if they choose to invest, draw in other investors. They are compensated not just for the capital they personally provide but also for the additional capital their investment helps attract.

In our baseline model, any agent can emerge as a mover and shaker. Our extensions draw out some of the characteristics that make it more likely someone will become a mover and shaker: (1) ability at forming social connections, (2) better information, (3) talent as a communicator; and, (4) a large block of capital.

We also show in an extension that movers and shakers can become well informed through their connections. The information they acquire may be an additional source of rents.

It is helpful, in thinking about movers and shakers, to have a concrete example in mind. To that end, consider William Zeckendorf, who was, in the 1950s and 60s, the United States' preeminent real estate developer. He undertook a variety of ambitious projects including Mile High Center in downtown Denver, Place Ville-Marie in Montreal, and L'Enfant Plaza in Washington, D.C. He was also famous for his role in bringing the United Nations to New York.[1] Key to Zeckendorf's success (and his ability to move and shake) were his social connections, as he recognized himself: "the greater the number of...groups...one could interconnect...the greater the profit." He knew all the important real estate brokers, bankers, and insurance men; he served on numerous corporate boards; and he was a fixture of New York society. Zeckendorf also owned a nightclub, the Monte Carlo, where he would hold court several nights a week, entertaining friends and business acquaintances.

His Montreal project, Place Ville-Marie, provides an excellent example of his talents as a mover and shaker. Since the 1920s, the Canadian National Railway (CNR) had been attempting, without success, to develop a 22-acre site in downtown Montreal, adjacent to the main train station: "a great, soot-stained, angry-looking, open cut where railway tracks ran out of a three-mile tunnel." While the site had enormous potential, Canadian developers shied away, considering the challenges too daunting. Desperate, CNR approached Zeckendorf in 1955. He was immediately enthusiastic, appreciating that: "a sort of Rockefeller Center-cum-Grand Central Station could create a new center of gravity and focal point for the city." But, making this vision a reality would require the participation of two constituencies. First, he would need to raise large sums from

[1] Upon learning of the United Nations' difficulty finding a suitable New York site – and their intention, in consequence, to locate in Philadelphia – he realized he could help. He offered them a site he had assembled on the East River for a massive development.

investors: one hundred million dollars for the tower he proposed to build as the site's centerpiece. Second, and even more vexing, was the challenge of leasing office space. Every major company had its offices on St. James Street. "The very idea of a shift to center-town offices struck many as dangerously radical." Zeckendorf initially faced a freeze, unable to get anyone to lease space. As he put it, "nobody..believed we would ever put up a project as big as we said we would." His big break came when he managed to convince the Royal Bank of Canada to move into the new building. He had been introduced to James Muir, the CEO, by his good friend John McCloy, chairman of Chase. He set out to woo Muir, making him his Canadian banker. He offered extremely attractive terms, redesigned the tower around RBC's needs, and proposed naming it the Royal Bank Tower. With RBC lined up, he managed, with considerable pressing, to obtain a fifty million dollar loan from Met Life – half of what he needed. Also with considerable pressing, he lined up a second big tenant: Aluminium Limited. At that point, the freeze began to thaw. Realizing that the project would indeed become a reality, other companies – which had previously turned him down – agreed to take space, and he was able to obtain the additional capital he needed.

Our results shed light on a range of empirical phenomena. For instance, anchor investors and anchor tenants (such as the Royal Bank of Canada in the above example) typically receive attractive terms. This finding comports with the returns in our model to investing a block of capital. The model also provides a novel explanation for why certain private equity and venture capital fund managers consistently outperform the market and obtain large rents.

Our paper relates to a number of different literatures. At a formal level, the problem we analyze is a global game and thus relates to the now large literature pioneered by Carlsson and van Damme (1993) and Morris and Shin (1998). More specifically, it is the role of public information that plays a central role in our model – a phenomenon that has been studied in a variety of global games settings (see Morris and Shin (2003), section 3 for an overview).

The model we analyze relates to large theoretical and empirical literatures in finance. A natural benchmark for thinking about investments and returns is, of course,

Q-theory.[2] Investors, in Q-theory, earn the same rate of return whether they invest one dollar or one million. By contrast, investment is lumpy in our model. Agents invest in projects; projects yield a poor rate of return unless they are well capitalized. One consequence is that agents with large blocks of capital can earn higher rates of return. Even more importantly, our model suggests that the rate of return to a project/asset will depend upon the social network that exists among investors. We predict, moreover, that agents with a privileged position in the network will earn outsize returns, because they can move and shake contributions from others.[3] Our model is, to the best of our knowledge, the first to emphasize the importance of network structure for investment. This network view has two important implications. First, when thinking about asset prices, the appropriate unit of analysis is not the asset, as is customary, but the asset-network pair: asset prices can only be understood with reference to market participants. Second, even without possessing privileged knowledge of a project's underlying quality, an agent can earn an outsize return. A privileged position in the network – or, for that matter, privileged *knowledge about the network* – yields a return. This has implications for what it means to have "inside information," or the formal legal notion of "material nonpublic information" in SEC Rule 10b5-1, the use of which is a violation of the Securities Exchange Act of 1934. We return to these issues later in the paper.

Our model relates to the economic literature on leadership: since a mover and shaker is arguably a type of leader. It particularly relates to work examining how leaders persuade followers. Several papers consider signaling by leaders as a means of persuasion (see, for instance, Prendergast and Stole (1996), Hermalin (1998), and Majumdar and Mukand (2004)). There is also work on leaders creating cascades to influence followers (see Caillaud and Tirole (2007)). Our paper examines a third type of persuasion. The

[2]A host of papers have documented departures from Q-theory and highlighted the implications of such departures. Liquidity constraints are important (see among others: Fazzari et al. (1988), Hoshi et al. (1991), Blanchard et al. (1994), Kashyap et al. (1994), Sharpe (1994), Chevalier (1995), Kaplan and Zingales (1997), Lamont (1997), Peek and Rosengren (1997), Almeida et al. (2004), Bertrand and Schoar (2006)); as are short-term biases (Stein (1988, 1989)). Moreover, there is compelling evidence that there are real consequences of such inefficiencies (see, for instance, Morck et al. (1988) and the large ensuing literature on the equity channel of investment).

[3]Another, quite distinct, form of "lumpiness" has been well studied: adjustment costs (see Uzawa (1969), Lucas and Prescott (1971), Hayashi (1982), and for a recent dynamic analysis, Miao and Wang (2014)). It is well known that such lumpiness can have significant macroeconomic implications (see, for instance, Lucas (1967); Prescott (1986); Caballero et al. (1995)).

mover and shaker persuades agents by publicizing his view of the project, which coordinates higher-order beliefs. This feature of our model is shared by Dewan and Myatt (2007, 2008), who have explored how speeches by politicians can influence followers. There is also work on the use of authority by leaders in settings where agents, as in our model, have a desire to coordinate. For instance, Bolton et al. (2013) argue that resoluteness is an important quality in a leader because a leader who is overly responsive to new information can undermine coordination.

While our focus is an investment setting, we also relate to a literature on communication and attention within organizations (see especially Dessein (2002), Dessein and Santos (2006), Alonso et al. (2008), Rantakari (2008), and Calvo-Armengol et al. (2014), Dessein and Santos (2014), and Dessein et al. (2014)). Agents in these models, as in our own, wish to coordinate their actions. One related paper is Calvo-Armengol et al. (2014). They construct a model in which agents decide how much effort to put into listening to other agents and how much effort to put into communicating with other agents. In their model, there are neither increasing costs nor decreasing benefits of listening to multiple agents.[4] A consequence is that agents' attention is dispersed, in contrast to our own model, in which it is concentrated on a mover and shaker. While agents decide whom to pay attention to in Calvo-Armengol et al. (2014) and in our own model, two recent papers (Dessein and Santos (2014) and Dessein et al. (2014)) consider a setting in which a principal decides the allocation of attention. They find that it is optimal for there to be some concentration of attention, since it aids coordination. Although attention is also concentrated in our model, it is not necessarily optimally placed. In particular, we obtain equilibria in which the mover and shaker is better or worse informed, resulting respectively in higher or lower welfare.[5] Another related paper, Hellwig and Veldkamp (2009), examines attention in a trading rather than an organizational setting. Somewhat analogous to the coordination of attention in our setting, they find traders may coordinate

[4]Formally, these features arise in Calvo-Armengol et al. (2014) because they assume additive separability (and a strict form of continuity) of the listening cost function.

[5]Intuitively, agents coordinate on the views of certain players (movers and shakers), whose views may be better or worse. This finding suggests the possibility of constructing a mover-and-shaker model, similar to our own, in which there are persistent performance differences across firms. Some firms get stuck paying attention to the wrong people (or, more generally, focus on the wrong issues/things). Persistent performance differences have been shown to be ubiquitous (see Gibbons and Henderson (2012)). There is considerable interest in understanding what drives these productivity differences (see Gibbons (2006), Chassang (2010), and Ellison and Holden (2014)).

attention on one piece of information or another.

Our paper also connects to the literature in economics on networks – especially work on communication in endogenous networks. Several papers (Calvo-Armengol et al. (2014), Dessein et al. (2014), and Dessein and Santos (2014)) have already been mentioned. Hagenbach and Koessler (2010) examines network formation with cheap talk communication. Galeotti and Goyal (2010) predicts the emergence of star networks, as we do. Furthermore, a small number of agents are influential in equilibrium even though they are ex ante similar to others. But the logic underpinning their result is quite different from ours. In their paper, there are increasing (and concave) benefits from information, but linear costs of information acquisition, in addition to substitutability of information acquired by different individuals. It follows that any (strict) equilibrium must involve a concentrated number of information acquirers.[6]

We also relate to models of communication with exogenously given networks, such as Galeotti et al. (2013) and Calvo-Armengol and de Marti (2009). Calvo-Armengol and de Marti (2009), in particular, shares features with our model. They assume, like us, that agents have identical preferences and want to coordinate; agents also receive private signals in their model of a state of the world. Because their network is exogenous, however, the focus of their paper is different. Their main finding is that adding links to a network can reduce welfare. While agents are better informed when there are more links, it may be harder to coordinate.

Additionally, our paper captures a central notion in the sociological literature on networks, developed by Burt (1992, 2001, 2004). According to Burt, individuals who bridge "structural holes" in a network (i.e., who link disparate parties) have the "opportunity to broker the flow of information...and control the projects that bring together people from opposite sides of the hole."[7]

The paper proceeds as follows. Section 2 contains the setup of our model and the analysis of equilibrium, information flows and payoffs. In Section 3 we consider a number of extensions of the basic model analyzed in Section 2. Section 4 highlights a num-

[6]Several papers, studying contexts quite different from our own, have also predicted the emergence of star networks (see Jackson and Wolinksy (1996), Bala and Goyal (2000), Galeotti et al. (2006), Goyal and Vega-Redondo (2007), Feri (2007), Hojman and Szeidl (2007) and Bloch and Dutta (2009)).

[7]Burt 2001: 208.

ber of concrete settings that illustrate the properties of our model. Section 5 concludes. Proofs of all formal results are contained in the Appendix.

2 The model

2.1 Statement of the problem

The model is a multi-period game with a continuum of identical, risk-neutral players. The utility of player i ($i \in [0,1]$) is given by: $U_i = w_i - e_i^2$, where w_i denotes agent i's wealth at the end of the game and e_i denotes agent i's effort.

Between them, the players possess one unit of cash. This cash is uniformly distributed across the players, with each possessing only a negligible amount. We will denote by k the negligible quantity of cash possessed by player i.

Each player is also endowed with illiquid assets that yield w if held until the end of the game. These assets can be liquidated prior to the end of the game, but at a cost. We assume an agent receives only $\frac{x}{1+L}$ when he liquidates assets worth x if held to maturity. L is the cost of liquidation, which we assume is very large ($L >> 0$).

The game has five periods. We assume all of the choices made by players in the game are observable. In period 1, each player chooses one other agent to whom he will link.[8] These choices are made simultaneously. We assume, all else equal, players prefer to link to agents of lower index. Let l_i denote the agent to whom player i chooses to link. Let C_i denote the set of players connected to player i at the end of period 1. Player i is connected to players who link to him as well as the player to whom he links: $C_i = \{j : l_j = i\} \cup \{l_i\}$.

In period 2, players bid in a second-price auction to buy an asset, A, that is being sold by an outsider (O). The asset is needed to undertake a project, and entitles the owner to the project's return. The asset might, for instance, be a parcel of land; the project might be the construction of a building on that parcel. The project yields a return R at the end of the game that depends both upon the project's underlying quality (θ) and the amount

[8] We assume, for simplicity, an agent can link to only one other player. However, a version of the model in which agents can, at a cost, link to multiple players yields qualitatively similar results.

of capital raised for the project (K). More specifically, $R = \theta + (1 + g) \cdot K$, where $g > 0$ parameterizes the return to raising capital (i.e., the return to "moving and shaking"). The underlying quality of the project, θ, is unknown to the agents in period 2. They have a common prior that θ is distributed uniformly on $[0, \overline{\theta}]$, and we assume $\overline{\theta}$ is large. Let b_i denote player i's bid in the auction, let $b_{(2)}$ denote the second-highest bid, and let M denote the winning bidder. In the event multiple players place the highest bid, we assume, for simplicity, the player with the lowest index wins the auction.

After the auction, M acquires the asset and pays $b_{(2)}$ to the outsider O. Since players only have negligible cash-on-hand, M must liquidate some assets to pay off O. We assume agents have sufficient illiquid assets (w is sufficiently large) that they are not constrained in how much they can bid.

In period 3, players simultaneously decide how much effort to invest in their ability to communicate (e_i).

Since the project yields a higher return when it is better capitalized, the auction winner M may want to raise capital by selling equity. We assume that, in period 4, M decides the amount of equity he will offer to a player in exchange for his cash-on-hand (k). Let $\beta_M k$ denote the equity share offered to player i in exchange for cash k. We assume M cannot offer agents more than one hundred percent of the equity: that is, $\beta_M \leq 1$. [9]

Players then receive private signals of the project's quality: $x_i = \theta + \varepsilon_i$, where the ε_i's are distributed iid $N(0, \frac{1}{\tau})$, and we assume throughout τ is small. We will refer to x_i as agent i's "view" of the project. Agents connected to player i learn his view of the project with probability $p(e_i)$, where $p(\cdot)$ is strictly increasing, $p(0) = 0$, and $p(\infty) = 1$. Observe that, the greater i's communication effort, the greater the chance agents connected to him learn his view of the project. We further assume, for simplicity, the chances of two agents linked to player i learning his view are independent.

Finally, in period 5, the players simultaneously decide whether to invest their cash in the project, in exchange for equity shares. Let $a_i \in \{0, 1\}$ ($i \neq M$) denote i's decision whether to invest. We assume M uses the negligible cash he has to pay off O, and thus does not have an investment choice to make. The total capital raised for the project is

[9] We assume that the cost of liquidating assets, L, is sufficiently large that players will not liquidate assets to provide capital for the project.

$K = \overline{a}$, where $\overline{a}$ is the average value of a_i.

The project is then undertaken, and yields return $R = \theta + (1 + g) \cdot K$. Players who invested in the project receive their shares of the return, and M receives the remainder. We can write player i's payoff at the end of the game ($i \neq M$) as follows:

$$U_i = w - e_i^2 + [(1 - a_i) + a_i \beta_M R]k.$$

The first term is the return on player i's illiquid assets. The second-term is the cost of effort. The final term, which is of negligible size, is equal to k if player i does not invest in the project ($a_i = 0$); it is equal to $\beta_M Rk$ if player i does invest. We can write player M's payoff at the end of the game as follows:

$$U_M = (w - (1 + L)b_{(2)}) + (1 - \overline{a}\beta_M)R - e_M^2.$$

Again, the first term is the return on player M's illiquid assets (some of these assets are liquidated to pay off the outsider O). The second term is player M's share of the project's return. The final term is the cost of effort.

It is useful to summarize the timing of the game: (1) agents simultaneously choose to whom they wish to link (l_i); (2) agents simultaneously place bids for asset A (b_i) and the winning bidder (M) acquires the asset; (3) agents simultaneously decide how much to invest in communicating (e_i); (4) M offers equity shares ($\beta_M k$) to those who invest in the project; agents then acquire private signals – or "views" – of the project's quality, which are communicated, with probability $p(e_i)$, to those connected to them; (5) agents simultaneously choose whether to invest their cash in the project (a_i), after which the project is undertaken, its return R is realized, and each player who invested receives the share of the return due to him.

2.2 Discussion of the model

We now pause briefly to discuss a number of the modeling choices we have made.

First, our game has five stages and, at first inspection, might seem unwieldy in this respect. In fact, this is the simplest formulation that captures all the economics we wish

to convey. Network formation is a central part of our story. Without this there is no meaningful way of speaking about what a "mover and shaker" is – so we need time 1. It is also important to us to highlight that, in equilibrium, movers and shakers value assets more than other players. The simplest way to demonstrate this is through the auction we consider at time 2. Similarly, analyzing effort choices are indispensable to our story since this is what moving and shaking *is* – hence time 3. Finally, we need two periods to address investment since it necessarily involves the equity offer and the choice of whether to invest.

Second, we have assumed that there are a continuum of investors, each with zero mass. As with many other models, this simplifies the analysis. In this environment it means that deviations by agents, with the exception of agent M, have no effect on the outcome. This makes our analysis considerably easier. We believe, however, that our main results carry over to cases with a finite number of agents.[10]

Third, we model the project's return as increasing in the amount of capital invested. This simply helps us highlight the important role of strategic complementarities and hence higher-order beliefs, that are a key part of our story. It also leads to investment being "lumpy", as discussed in the introduction.

Fourth, in order to ensure the game that takes place at time 5, which is a global game, has a unique equilibrium, we have assumed players' signals are not too precise (τ is small) and their prior regarding θ is not too precise ($\overline{\theta}$ large).

Fifth, we have made some simplifying assumptions about the formation of network links. Indeed, we have made the stark assumption that agents can only link to one other player. This, however, is easy to generalize. The ingredient that is important for us is simply that there is a well-defined cost associated with forming links.

Sixth, we have included liquidation costs. This assumption allows us to have cash poor agents who, nonetheless, are unconstrained in how much they can bid in the auction. It is important that agents are not constrained in how much they can bid since we want the agent who values the project the most to acquire it in the auction. This is the

[10]Indeed, we worked at length with an alternative formulation with a finite number of agents. The main technical issue in conducting the analysis in that setting is adopting an equilibrium concept that deals appropriately with deviations. We feel that the continuum case best addresses the underlying economics of this.

simplest way to do this, and we believe it fits our applications well (e.g Zeckendorf). There are, however, other ways to do this: for instance, the mover-and-shaker, in addition to raising capital for the project, could also raise capital to buy the asset.

Seventh, at time 4 we consider a particular form of financial contracting: equity. This is not the most general contracting space one could consider, to be sure. However, we conjecture that our main results hold in more general contracting spaces, and we have considered some of those in detail.

Eighth, we have chosen to have effort and equity shares chosen before people learn their signals. The key reason for doing this is to eliminate signaling considerations from the game. Such considerations may be important, but we see them as distracting from – or at best orthogonal to – our main purposes. It is natural, however, to consider how the project owner might use the equity offers to signal x_M to his advantage. We return to this issue briefly in our concluding remarks.

Finally, we have made the assumption that, all else equal, players prefer to link to agents of lower index. This acts as an equilibrium refinement. It gets rid of equilibria in which agents fail to coordinate their linking choices, and consequently, no mover and shaker emerges. Our view of robustness of equilibria is that an arbitrarily small perturbation of players preferences should not lead to a discontinuous change in equilibrium. Lack of coordination is not robust in this sense for the following reason. Small differences between players propagate in our setup because agents have a preference to link to more connected players. Of course, if one does not share this view of robustness, then removing the "lower index" assumption merely admits additional equilibria involving lack of coordination.

2.3 Equilibrium

Our focus will be on Perfect Bayesian Equilibria, which henceforth, we will refer to simply as the equilibria of the game. Proposition 1 characterizes the equilibria. The proof is discussed in detail below.

Proposition 1. *Provided g is sufficiently large (i.e., the return to moving and shaking is sufficiently large), all equilibria have the following properties and, moreover, such equilibria exist:*

(1) All agents connect to one particular player, Y. That is, $l_i = Y$ for all $i \neq Y$. Y can be any player.

(2) Y wins the auction at time 2 (Y=M); Y exerts positive effort at time 3, while other agents exert zero effort; and Y receives a higher expected payoff than other agents.

(3) Y's view (x_Y) has more weight than those of other agents in the following sense: x_Y has a non-negligible effect on the amount of capital raised (K) and the project's return (R); other agents' views have a negligible effect.

In equilibrium, one player emerges as a "mover and shaker." Even though the players are identical ex ante, all agents choose to connect to one particular player (player Y) at time 1. These connections distinguish player Y, turning him into a mover and shaker. As we will see when we discuss the proof of the proposition, player Y values the project more than his peers because his connections make it easier to raise capital. He outbids other agents in the auction, in consequence; he puts effort into "moving and shaking" after winning the auction; and he earns a higher expected payoff. Player Y's view of the project (x_Y) also holds more weight than those of other agents: since his "moving and shaking" results in his view becoming public.

Proof of Proposition 1.

As a first step towards proving the proposition, we will state a lemma (Lemma 1) and show that Proposition 1 follows from the lemma. Subsequently, we will discuss the proof of Lemma 1.

Lemma 1. *Suppose players make linking choices l at time 1, and consider the resulting subgame. For any l, an equilibrium of the subgame has the following properties:*

(1) Provided g is sufficiently large, the auction winner is connected to a (weakly) larger fraction of the population than other players and he receives a (weakly) higher expected payoff. He receives a strictly higher expected payoff if he is connected to a strictly larger fraction of the population.

(2) The auction winner exerts zero effort at time 3 if he is only connected to a negligible fraction of the population. Provided g is sufficiently large, if the auction winner is connected to a non-negligible fraction of the population, he exerts positive effort at time 3.

(3) Players who do not win the auction exert zero effort at time 3.

The proof of Proposition 1 relies both upon Lemma 1 and upon the following observation. Agents prefer, all else equal, to link to players who exert more effort and players who are more connected. Agents prefer to link to players who exert more effort since there is a higher probability of learning their views. Agents prefer to link to more connected players for the following reason: while all players' views provide equally valuable information about the project's quality, θ, a more connected player's view, since it is more widely broadcast, provides superior information about other agents' likelihood of investing.

To prove Proposition 1, we need to show: (1) existence of the equilibria described in the proposition, and (2) uniqueness. We will suppose throughout the proof that g is large.

Existence. To prove existence, we need to show that players are best-responding in their linking choices at time 1. According to Lemma 1, if all players link to player Y at time 1, player Y will exert more effort than other players at time 3. Because player Y is more connected than other players and exerts more effort, agents have a preference to link to Y at time 1. Hence, players are indeed best-responding in their time 1 linking choices.

Uniqueness. First, suppose there is an equilibrium in which one of the players is connected to a non-negligible fraction of the population. Lemma 1 implies that, in such an equilibrium, the auction winner (M) will be weakly more connected than other players and will exert strictly more effort. Hence, at time 1, players strictly prefer to link to M. So, the equilibrium must be one in which all players link to M.

Now, let us show, by contradiction, that there there are no equilibria in which all players are connected to negligible fractions of the population. Suppose such an equilibrium does exist. It follows from Lemma 1 that no player exerts effort at time 3 (i.e., communicates his view). Recall that agents prefer, all else equal, to link to players of lower index. Since no player communicates his view, agents strictly prefer to link to player 0. But, this is a contradiction, since player 0 is only connected to a negligible fraction of the population. This proves uniqueness.

Proof of Lemma 1.

It is easy to show that players exert zero effort when they are outbid in the auction. Recall from our discussion of the model's setup that, if player i does not win the auction, he receives a payoff of $w - e_i^2 + [(1 - a_i) + a_i\beta_M R]k$. The final term is negligible, since k is negligible, so it is clearly optimal for player i to choose $e_i = 0$ (exert zero effort at time 3). Intuitively, since the share of the project offered to player i is of only negligible size, he has no reason to exert effort. Observe that this leaves player i with a payoff of w (ignoring the negligible component).

We showed in our discussion of the model's setup that, if player i wins the auction, he receives a payoff of $w - (1 + L)b_{(2)} + [(1 - \overline{a}\beta_i)R - e_i^2]$. The second term ($(1 + L)b_{(2)}$) is the amount player i pays to acquire asset A. The third term ($(1 - \overline{a}\beta_i)R - e_i^2$) is the payoff of the project to player i, net of effort. We can also think of the third term as the value of asset A to player i.

Let $V_i(l, e_i, \beta_i)$ denote the expected value of the third term – the expected value of asset A – when player i chooses e_i at time 3 and equity share β_i at time 4. Observe that player i will choose e_i and β_i so as to maximize V_i. Let $e_i^*(l, i = M)$ and $\beta_i^*(l, i = M)$ denote the optimal choices. In a slight abuse of notation, let $V_i(l)$ denote the expected value of the asset when e_i and β_i are optimally chosen (that is, $V_i(l) = V_i(l, e_i^*(l, i = M), \beta_i^*(l, i = M))$.

Let us consider how much player i will bid in the auction at time 2. The effective amount player i bids in the auction is $b_i \cdot (1 + L)$, since there is a cost of liquidating assets. Since it is a second-price auction, player i will place an effective bid equal to the expected value of the asset: $b_i \cdot (1 + L) = V_i(l)$. Hence, $b_i = \frac{V_i(l)}{1+L}$.

The remainder of the proof of Lemma 1 involves proving the following three claims (the lemma follows almost immediately from these claims):

1. If player i is connected to a larger fraction of the population than player j and exerts positive effort when he wins the auction ($e_i^*(l, i = M) > 0$), he values the asset strictly more than player j ($V_i(l) > V_j(l)$).

2. If two players, i and j, both exert zero effort when they win the auction ($e_i^*(l, i = M) = e_j^*(l, j = M) = 0$), they place the same value on the asset ($V_i(l) = V_j(l)$).

3. If player i is only connected to a negligible fraction of the population, he exerts zero effort when he wins the auction ($e_i^*(l, i = M) = 0$). Provided g is sufficiently large, player i exerts positive effort ($e_i^*(l, i = M) > 0$) whenever he is connected to a non-negligible fraction of the population.

First, consider claim (2). Suppose player i wins the auction, exerts zero effort, and offers equity share β. His payoff will be the same as player j's payoff if j wins the auction, exerts zero effort, and offers equity share β: $V_i(l, 0, \beta) = V_j(l, 0, \beta)$. The reason is that, in both cases, all players exert zero effort, so there is no asymmetry between i and j. This proves claim (2).

It is easy to prove the first part of claim (3). Suppose player i is connected to only a negligible fraction of the population and wins the auction. Clearly, his effort has at most a negligible effect on agents' investment decisions at time 5. Hence, player i's payoff from the project *excluding* the cost of effort ($V_i(l, e_i, \beta_i) + e_i^2$) is unchanging in e_i. Therefore, it is optimal for player i to exert zero effort: $e_i^*(l, i = M) = 0$.

Now, consider the second part of claim (3). We leave the formal proof for the Appendix, but we will consider the basic logic. Suppose player i is connected to a non-negligible fraction of the population and wins the auction. We formally prove in the Appendix that, for g large, player i's payoff from the project excluding the cost of effort ($V_i(l, e_i, \beta_i) + e_i^2$) is increasing in e_i. Since the marginal cost of exerting effort is zero at $e_i = 0$, it follows that player i will exert positive effort.

The logic behind the proof is as follows. Player i's effort has two effects on the time 5 game. First, it affects the expected level of investment. We prove in the Appendix that the expected level of investment is increasing in e_i when $\beta_i > \overline{\beta}$, where $\overline{\beta} = \frac{2}{\bar{\theta}+(1+g)}$; the expected level of investment is decreasing in e_i when $\beta_i < \overline{\beta}$. Intuitively, player i's effort increases the likelihood his signal is broadcast. The broadcasting of his signal has a positive effect on investment when he is likely to be broadcasting good news; his effort has a negative effect on investment when he is likely to be broadcasting bad news. When β_i is higher, more news is interpreted as good news, since investing pays off for lower values of θ. $\overline{\beta}$ converges to zero as g increases. So, for g sufficiently large, $\beta_i^*(l, i = M) > \overline{\beta}$ for all values of l. We therefore conclude that, for g sufficiently large, effort increases the expected level of investment. Clearly, player i's payoff is greater

when there is more investment.

The second effect of an increase in e_i is that it makes investment at time 5 more correlated with player i's signal (x_i) and less correlated with the project's actual quality (θ). Player i's expected payoff is higher when investment is less correlated with the project's underlying quality.

Finally, consider claim (1). Suppose player i is connected to a larger fraction of the population than player j and exerts positive effort when he wins the auction. Since player i finds it optimal to broadcast his signal when he wins ($e_i^*(l, i = M) > 0$) and player j is unable to broadcast his signal as widely, since he is less connected, it is clear that player j must value the asset strictly less than player i ($V_i(l) > V_j(l)$). This completes our discussion of the proof of Lemma 1 and also completes our discussion of the baseline model.

3 Extensions

We will consider several extensions, from which we obtain additional predictions. In the baseline model, all agents are equally likely to emerge as movers and shakers. The extensions identify several characteristics that make it more likely an agent will emerge as a mover and shaker: (1) ability at forming social connections; (2) better information; (3) talent as a communicator; and (4) a large block of capital.

In addition to showing that owning a block of capital helps an agent become a mover and shaker, we will show another important benefit. We find that the project owner offers agents with blocks of capital more attractive terms for investing in the project.

Finally, we show movers and shakers can become well informed through their connections. The information they acquire may be an additional source of rents.

Extension 1: different abilities to form social connections.

In the baseline model, we assumed the cost of linking to any agent was the same. A natural case to consider is one in which it is more costly to link to some agents than to others. Proposition 2, stated below, extends the baseline model by assuming there is a

cost c_i of linking to agent i.[11]

One can think of an agent with a low c_i as one who has a high ability to form social connections. An agent's personality might affect c_i. A particularly extroverted or gregarious agent might have a high ability to form connections. c_i might also be affected by an agent's gender, ethnicity, socioeconomic status, etc. For instance, if the population of agents (i.e., potential investors) consists largely of men, a woman might have a particularly high c_i (a low ability to connect).

According to Proposition 2, a mover and shaker emerges in equilibrium, just as in the baseline model. The mover and shaker can be any of a number of agents, but an agent whose ability to socially connect is sufficiently low relative to other agents cannot emerge as a mover and shaker.

Note that we can show, for this case, the existence of equilibria in which all agents link to the mover and shaker. However, we cannot rule out the existence of equilibria in which only a fraction link to the mover and shaker.

Proposition 2. *Suppose, in contrast to the baseline model, there is a cost c_i associated with linking to player i. Suppose these linking costs are uniformly distributed on $[\underline{c}, \overline{c}]$. Provided g (the return to moving and shaking) is sufficiently large:*

(1) In equilibrium, a majority of agents link to one particular player, Y. Y wins the auction at time 2 (Y=M); Y exerts positive effort at time 3, while other agents exert zero effort; and Y receives a weakly higher expected payoff than other agents.

(2) Y cannot be a player with a low ability to form social connections (a player i for whom $c_i - \underline{c}$ is sufficiently large).

(3) Provided player i's ability to form connections is sufficiently high ($\overline{c} - c_i$ is sufficiently small), an equilibrium exists in which all agents link to player i.

Extension 2: different quality information.

All agents' signals – or "views" – were of the same quality in the baseline model. More specifically, we assumed agent i received a signal $x_i = \theta + \varepsilon_i$, where ε_i was normally distributed, with precision τ. What happens if some agents' signals/views are more

[11] We assume agents must form a link. If we gave agents the option not to form a link, provided $c_i \leq 0$ for some i, the results would be the same.

precise that others (i.e., ε_i is distributed normally with precision τ_i)? In particular, will it still be the case that any agent can emerge as a mover and shaker?

Proposition 3, stated below, assumes agents signals/views differ in their precision. It also assumes, in contrast to the baseline model, an agent linked to player i learns player i's view with probability $p(e_i+\gamma)$. Observe that $\gamma > 0$ means there is a chance of learning a player's view even if he exerts no effort. Proposition 3 shows that, when $\gamma > 0$, agents with low quality signals/views cannot emerge as movers and shakers.

The reason we need $\gamma > 0$ to obtain this result is as follows. Imagine all agents link to a player i whose signal is of low quality. Agents will not find it profitable to deviate when $\gamma = 0$, since when $\gamma = 0$, agents can only learn the views of players who exert positive effort; player i is the only player who does exert positive effort. On the other hand, if $\gamma > 0$, a player might deviate, since there is a chance, in deviating, of learning the view of a better informed player.

Note that, for this case as well, we can show existence of equilibria in which all agents link to the mover and shaker. But, we cannot rule out existence of equilibria in which only a fraction link to the mover and shaker.

Proposition 3. *Suppose, in contrast to the baseline model, players' views differ in their precision: $x_i = \theta + \varepsilon_i$, where ε_i is distributed $N(0, \frac{1}{\tau_i})$. Suppose the τ_i's are uniformly distributed on $[\underline{\tau}, \overline{\tau}]$. Additionally, suppose agents connected to player i learn his signal with probability $p(e_i + \gamma)$, where γ is a positive constant. Provided g (the return to moving and shaking) is sufficiently large:*

(1) In equilibrium, a positive fraction of agents link to one particular player, Y. Y wins the auction at time 2 (Y=M); Y exerts positive effort at time 3, while other agents exert zero effort; and Y receives a weakly higher expected payoff than other agents.

(2) Y cannot be a player with low quality information (a player i for whom $\overline{\tau} - \tau_i$ is sufficiently large).

(3) Provided player i's information is of sufficiently high quality ($\overline{\tau} - \tau_i$ is sufficiently small), an equilibrium exists in which all agents link to player i.

Observe that, while the proposition rules out players becoming movers and shakers when their signals/views are of extremely low quality, the mover and shaker need not

be the player with the most precise signal. Indeed, it is possible that an agent with low quality information will become a mover and shaker. Notably, in such an equilibrium, the views of the poorly informed mover and shaker hold more weight than those of better informed peers.

There are two distinct ways in which players benefit from having higher quality information. First, fixing players' social connections, an agent is more able to move and shake if he has superior information, since it helps an agent convince potential investors of a project's underlying quality. More precisely, $V_i(l)$ (the value to player i of owning the asset) is increasing in τ_i (the precision of player i's signal). Second, Proposition 3 identifies what may be an even more important benefit of having high quality information. Players with more precise signals are more likely to become socially connected; a player's social connectedness critically affects his ability to move and shake.

Extension 3: different ability to communicate.

We assumed in the baseline model that all players have the same ability to communicate. More precisely, we assumed that if agents exerted the same effort, they had the same probability of successfully communicating their views. What happens if some agents are better communicators than others?

Proposition 4 considers an extension to the baseline model in which player i's view is communicated with probability $p(\alpha_i \cdot (e_i + \gamma))$. A high α_i reflects a high ability to communicate. Proposition 4 shows that, provided $\gamma > 0$, agents who are poor communicators cannot emerge as movers and shakers. As in Proposition 3, $\gamma > 0$ is needed to ensure there is some probability of learning the signal/view of a player who exerts zero effort.

Note that, once again, we can show existence of equilibria in which all agents link to the mover and shaker. But, we cannot rule out existence of equilibria in which only a fraction link to the mover and shaker.

Proposition 4. *Suppose, in contrast to the baseline model, agents differ in their ability to communicate their views. More precisely, suppose the probability agents connected to player i learn his view is $p(\alpha_i \cdot (e_i + \gamma))$, where γ is a positive constant. Suppose the α_i's are uniformly distributed on $[\underline{\alpha}, \overline{\alpha}]$. Provided g (the return to moving and shaking) is sufficiently large:*

(1) In equilibrium, a positive fraction of agents link to one particular player, Y. Y wins the auction at time 2 (Y=M); Y exerts positive effort at time 3, while other agents exert zero effort; and Y receives a weakly higher expected payoff than other agents.

(2) Y cannot be a player with low ability to communicate (a player i for whom $\overline{\alpha} - \alpha_i$ is sufficiently large).

(3) Provided player i's ability to communicate is sufficiently high ($\overline{\alpha} - \alpha_i$ is sufficiently small), an equilibrium exists in which all agents link to player i.

Just as players benefitted in two distinct ways from having high quality information, there are two distinct ways in which players benefit from being skilled communicators. First, there is a direct effect. Fixing players' social connections, an agent values ownership of the asset more when he is a more skilled communicator ($V_i(l)$ is increasing in α_i). The reason is that an ability to communicate helps an agent move and shake. Second, Proposition 4 identifies an indirect effect, that is perhaps even more important. Players who are better communicators are more likely to become socially connected; a player's social connectedness affects his ability to move and shake.

We model a player's skill as a communicator in a non-behavioral way. One could imagine a behavioral model in which players not only have skill at imparting information but also skill at convincing/manipulating other agents. It is worth noting that skill at manipulating other agents would also make it more likely a player would emerge as a mover and shaker.[12]

Extension 4: blocks of capital.

In the baseline model, all agents have negligible amounts of capital. What happens when some agents possess non-negligible amounts of capital?

Proposition 5, stated below, considers a case in which there are two agents with blocks of capital. One agent, whom we will refer to as Mr. Big, is endowed with k_{big} in cash. Another agent, whom we will refer to as Mr. Medium, is endowed with

[12]Skill at manipulating other agents clearly helps a project owner "move and shake" naive, manipulable agents. Such skill also makes sophisticated agents more inclined to invest: while they cannot be manipulated, they are more inclined to invest because of the project owner's ability to get naive agents to invest.

$k_{med} < k_{big}$. The other agents collectively possess k_{med} in cash; this cash is equally distributed amongst them, with each possessing only a negligible amount. We denote this negligible amount by k_{small}. We assume, for simplicity, that $k_{big} \leq \frac{\overline{\theta}}{2}$, which ensures all agents bid more than their cash-on-hand in the auction.

Observe that an agent with more cash can buy asset A at a lower cost, since it is not necessary to liquidate as many assets. Since we assumed the cost of liquidating assets is very large, we find that the agent with the most cash, Mr. Big, will win the auction.

As in the baseline model, an equilibrium exists in which all agents link to the project owner – Mr. Big – and Mr. Big moves and shakes the project. In contrast to the baseline model, there is also an equilibrium in which all agents link to Mr. Medium, and Mr. Medium – rather than Mr. Big – moves and shakes the project. Additionally, we cannot rule out existence of equilibria in which some agents link to Mr. Big and some link to Mr. Medium, in which case both move and shake the project.

The reason Mr. Medium can emerge as a mover and shaker is as follows. In the baseline model, since players only had negligible amounts of capital to invest, there was no reason for a player to exert effort – to move and shake the project – unless he happened to own the project. In contrast, since Mr. Medium has a non-negligible amount of capital, he has an incentive to exert effort – to move and shake the project – even though he is outbid in the auction by Mr. Big.

Thus, one finding concerns who will emerge as mover and shaker. A second finding concerns the amount of equity Mr. Big offers players in exchange for investing in the project. Proposition 5 assumes that, at time 4, the auction winner (M) offers a player with cash k an equity share $\beta_M(k) \cdot k$ in exchange for investing. Under this assumption, the equity share need not simply be proportional to k.

We find that, in equilibrium, $\beta_M(k_{small}) < \beta_M(k_{medium})$. Hence, the small players are offered less total equity than Mr. Medium, even though they collectively have the same amount of capital as Mr. Medium. The reason is as follows. Mr. Medium is given more attractive terms because, if Mr. Medium is expected to invest, other players will be more inclined to invest. Put differently, Mr. Medium is compensated not just for the capital he personally provides but also for the additional capital his investment helps attract.

Proposition 5. *Suppose, in contrast to the baseline model, agents are endowed with different*

amounts of cash. Player 0, whom we will refer to as Mr. Big, has k_{big} in cash; player 1, whom we will refer to as Mr. Medium, has k_{med}; the other players, whom we will refer to as small, only have negligible cash (k_{small}). Between them, the small players have k_{med} in cash. We assume $0 < k_{med} < k_{big} \leq \frac{\overline{\theta}}{2}$. We further assume M offers an equity share that is a function of the amount of cash an agent possesses: more precisely, to an agent with capital k, he offers a share $\beta_M(k) \cdot k$. Provided g (the return to moving and shaking) is sufficiently large:

(1) In equilibrium, Mr. Big wins the auction. A fraction of agents link to Mr. Big; the remainder link to Mr. Medium. Mr. Big (Mr. Medium) exerts effort to move and shake the project if he is connected to a non-negligible fraction of the population.

(2) An equilibrium exists in which all agents link to Mr. Big. An equilibrium also exists in which all agents link to Mr. Medium.

(3) The equity offered to Mr. Medium is greater than the total amount offered to small agents: $\beta_M(k_{med}) > \beta_M(k_{small})$.

Extension 5: information aggregation.

Proposition 6, stated below, shows that movers and shakers may acquire valuable information as the result of being well connected.

It extends the baseline model in two ways. First, it assumes that the auction winner M makes a decision d_M at time 5; the project's return depends upon the quality of this decision. More specifically, $R = \theta + (1+g) \cdot K + \Psi(|\theta - d_M|)$, where $\Psi(|\theta - d_M|)$ is greater when d_M is closer to θ ($|\theta - d_M|$ is smaller). Second, Proposition 6 assumes an agent linked to player i learns player i's view with probability $p(e_i + \gamma)$, where $\gamma > 0$.

As in the baseline model, a mover and shaker emerges in equilibrium, to whom all players link. In contrast to the baseline model, the mover and shaker learns the signals of a positive fraction (a fraction $p(\gamma)$) of the population and thus becomes perfectly informed regarding θ. This information is valuable since it results in a better decision (d_M) being made. Consequently, the mover and shaker earns an *information rent* in addition to a moving and shaking rent.

Proposition 6. *Suppose, in contrast to the baseline model, the project yields a return: $R = \theta + (1+g) \cdot K + \Psi(|\theta - d_M|)$, where M chooses $d_M \in [0, \overline{\theta}]$ at time 5, Ψ is continuous, $\Psi'(x) < 0$, $\Psi(0) > 0$, and $\Psi(\infty) = 0$. Additionally, suppose agents connected to player i learn*

his signal with probability $p(e_i + \gamma)$, where γ is a positive constant. Provided g (the return to moving and shaking) is sufficiently large:

(1) All agents connect to one particular player, Y. Y can be any player. Y wins the auction at time 2 (Y=M); and Y exerts positive effort at time 3, while other agents exert zero effort.

(2) $d_M = \theta$ with probability 1.

(3) Player Y earns a higher expected return than other agents, which reflects both a moving and shaking rent and an information rent.

Recall that, in extension 2, a mover and shaker could be poorly informed. In this extension, the mover and shaker becomes well informed through his position at the center of the network. We see both as distinct possibilities.

Notice Proposition 6 assumes player i communicates his own signal (x_i) only. One could imagine amending the model further, so that players are able to communicate signals they learn from other players, in addition to their own. This would result in other agents besides the mover and shaker becoming well informed regarding θ.

4 Illustrations

In this section we highlight a number of practical environments where our theory explains observed patterns and contrasts, to some degree, with standard accounts of those environments.

4.1 Anchor investors in funds

A common difficulty in raising private equity or venture capital funds is convincing enough limited partners that the fund will be successfully raised. Put differently, potential investors' willingness to invest depends upon whether they believe other potential investors intend to participate. This raises the possibility that a large investor could act as a cornerstone, causing a fund to be successfully raised, and earn rents (say, through preferential fees or capital allocations) for playing that role. We have in mind, here, extension 4 from section 3, above, where "Mr. Medium" receives preferential terms be-

cause of his block of capital.

This seems to be precisely the role the Prudential Insurance Company played in the establishment of the Blackstone Group's first private equity fund in 1987.[13] Blackstone co-founder Steve Schwarzman described the difficulty in raising the first fund this way to the Financial Times[14]:

> "Oh my gosh, that was hard!...Our first 19 best prospects turned us down one after another; 488 potential investors turned us down. There were some crowning moments of embarrassment...We were on the road for a long time and it was hard to be told 'no' by a lot of our friends." Then came a breakthrough. "Garnett Keith [Prudential Insurance Company's vice-chairman] was eating a tuna salad sandwich. It was a Friday in Newark and I was not expecting success," says Mr Schwarzman. "He took a bite out of his sandwich and said, 'I will give you $100m.' I was shocked into silence: I was so grateful, so appreciative...I knew others would follow."

For its role, Prudential received favorable terms, as in our theory. One account (Carey and Morris (2010)) puts it this way:

> As an anchor investor, Prudential drove a hard bargain...Prudential insisted that Blackstone not collect a dime of the profits until Prudential and other investors had earned a 9 percent compounded annual return on every dollar they'd pledged to the fund. This concept of a "hurdle return"...would eventually become a standard term in buyout partnership agreements. Prudential also insisted that Blackstone pay investors in the fund 25 percent on the net revenue...from its M&A advisor work, even on deals not connected to the fund...In the end, these were small prices to pay for the credibility the Pru's backing would give Blackstone."

One naturally wonders whether, at least in this instance, a (positive) information cascade occurred. The details that Schwarzman cites about the ordering of prospects

[13] Blackstone now has around $30 billion in funds under management and more than 1500 employees.

[14] Smith, Peter, "Reliance on contacts and a preference for corporate partnering," *The Financial Times* 24 April 2007, Retrieved from `http://www.ft.com`.

suggest otherwise. Schwarzman points to having been turned down by their "19 best prospects". We know from Bikhchandani et al. (1992) that a reversal of a negative cascade into a positive one is very unlikely. What is more plausible is that Prudential's investment increased the likelihood the fund would successfully be raised and hence made others more inclined to invest.

We should mention that there is an existing literature on anchor stores. For instance, Gould et al. (2005) demonstrate empirically that shopping mall store contracts are written to take account of the positive externality that "national brand" stores generate in driving traffic to smaller stores. Bernstein and Winter (2012) derive the structure of the optimal contract in the presence of heterogeneous externalities. Our theory, adapted to such a setting, also predicts that anchor stores receive preferable terms, but for rather different reasons than that strand of literature.[15]

4.2 Returns to venture capital and private equity

According to Kaplan and Schoar (2005), private equity and venture capital funds, on average, yield roughly the same return, net of fees, as the S&P 500; however, certain fund managers consistently outperform the market, achieving higher risk-adjusted returns.

The standard interpretation of this finding is that these fund managers are particularly skilled at originating investment ideas. While this is a possibility, the model suggests a novel explanation. Such fund managers might instead be skilled movers and shakers.

We have already mentioned that raising private equity or venture capital funds involves convincing potential investors of other investors' willingness to participate. An anchor investor – like Prudential in the case of Blackstone – can help in this regard. But, even in the absence of a Prudential, a fund manager who is well connected may be able to raise funds by coordinating the beliefs of potential investors (i.e., by moving

[15]This strand of literature typically assumes that only the anchor store imposes (positive) externalities on other stores. By contrast, our model (as applied to stores), involves all stores imposing externalities on one another; these externalities being proportional to size. The argument in, say, Gould et al. (2005) or Bernstein and Winter (2012) as to why there should be a better rental rate for a large store does not apply in our environment. We nonetheless predict that anchor stores obtain a better rate. Our story is that it is easier to move and shake a big store (Mr. Medium in extension 4) than a collection of small stores (the small agents in extension 4), so a big store should obtain a better rate.

and shaking). In fact, while Prudential was critical to Blackstone's ability to raise funds, there is an argument that Blackstone's founders, Steve Schwarzman and Pete Peterson, nonetheless played a moving and shaking role. Peterson, in particular – a former secretary of commerce and CEO of Lehman Brothers – had valuable connections. According to Carey and Morris: "Peterson, with his entrée to executive suites around the country, would get Blackstone in the door and Schwarzman...would make the deal happen."[16,17]

Relative to our model, one can think of asset A as an investment idea; the original owner of the asset as the originator of the idea; the mover and shaker as a skilled fund manager; and the other agents as potential investors in the fund. Under this interpretation, the skilled fund manager outperforms the market by purchasing – rather than originating – good investment ideas. He chooses to purchase these ideas because he has a particular talent for raising capital.

As highlighted by Proposition 1, the initial owner of the asset (the idea originator) receives a return, but does not capture all of the surplus from the project. The role played by the mover and shaker (the fund manager) is also important and leads him to earn a rent as well. Furthermore, our extensions highlight some of the qualities one would expect to see in successful fund managers if they indeed play a moving and shaking role: ability to form social connections, ability as communicators, and better information regarding the quality of investment ideas/strategies.

4.3 Insider trading

Insider trading is prohibited in the United States and is regulated by SEC Rule 10b5-1 and the Securities Exchange Act of 1934. We will not go into the long legal history of the regulation of insider trading here, but note that the two most salient parts of Rule

[16]Carey and Morris (2010), p. 47.

[17]Carey and Morris say that Lehman Brothers hired Peterson specifically as a "rainmaker." He had no experience in finance, but Lehman suspected the connections he developed as commerce secretary would help the firm bring in investors. There is a long history of financial firms hiring government officials for this reason. Most recently, KKR has hired David Petraeus. According to the *New York Times*, "Mr. Petraeus runs what is described as a small research division...but private equity experts said his real value was his Rolodex. 'Petraeus is a kind of door-opener,' said one friend of Mr. Kravis...'If Petraeus helps Henry find a way to $100 million in investments...it's a good deal for both of them.'" (Stolberg, Sheryl Gay, "After Scandal, Petraeus Stays Under Radar but Not Out of the Spotlight," *The New York Times* 27 February 2015, Retrieved from `http://www.nytimes.com`.)

10b5-1 concern the definition of insider trading (clarifying the so-called "misappropriation theory") and clarifying the distinction between "possession" and "use" of inside information. Regarding the former, it states:

> The "manipulative and deceptive devices" prohibited by Section 10(b) of the Act and Rule 10b-5 thereunder include, among other things, the purchase or sale of a security of any issuer, on the basis of material nonpublic information about that security or issuer, in breach of a duty of trust or confidence that is owed directly, indirectly, or derivatively, to the issuer of that security or the shareholders of that issuer, or to any other person who is the source of the material nonpublic information.

Regarding the latter, it states:

> Subject to the affirmative defenses in paragraph (c) of this section, a purchase or sale of a security of an issuer is "on the basis of" material nonpublic information about that security or issuer if the person making the purchase or sale was aware of the material nonpublic information when the person made the purchase or sale.

Our theory raises a completely separate set of issues to those in cases such as United States v. O'Hagan (521 U.S. 642) that led to the current SEC Rule. The most recent legal issues have largely surrounded what kind of person owes a fiduciary duty. O'Hagan was a law firm partner with privileged knowledge of a takeover (Pillsbury) who traded on that inside information. By contrast, Vincent Chiarella (see Chiarella v. United States, 445 U.S. 222 (1980)) was an employee at a financial printing firm who used his inside information about takeovers to also profit through securities transactions. He was found *not* to have violated section 10(b) of the Securities Exchange Act.

Put simply, to determine whether a breach has occurred one must know: (a) what information a person has; and (b) who that person is. For a fairly long time, legal scholars and the Court itself have been focused on the latter: who the person in possession of inside information is, what duties they owe, and what harm they might have caused. Our theory, by contrast, shifts focus back to the former inquiry: the nature of the information

the person possesses. Yet it also shows that, in an important sense, the two inquiries are inextricably linked. The information a person has – and more importantly, how it is transmitted in equilibrium – depends crucially on who they are in the sense of their connections and communication abilities.

In our setting, a privileged position in the network – or even knowledge of the structure of the network – is valuable. Additionally, the structure of the network is crucial in determining the quality of information available to members of the network. In a sense, trades by highly connected members of the network are partially self-fulfilling. Is someone who is highly connected who buys a large block of stock in the face of takeover rumors – thereby propagating that information around the network – guilty of insider trading? Is knowledge of the network structure "material nonpublic information"?

To a significant degree, regulation of insider trading is concerned with preserving market liquidity and stems from economic concerns about the chilling effects of the perceived presence of better-informed traders. Our theory suggests that network structure and higher-order beliefs play an important role in such settings, which suggests that there is a *prima facie* case for them being included in rules governing insider trading.

5 Concluding remarks

We have analyzed a model in which agents form social connections, bid to buy an asset that is necessary for undertaking a project, acquire private *iid* signals of the project's quality, which they can communicate, at a cost, to those with whom they are linked, and choose whether to invest in the project whose returns are a function both of its underlying quality and aggregate investment.

In our baseline formulation all agents are *ex ante* identical, yet a single player emerges, in equilibrium, as the "mover and shaker". That is, a star network forms because, in equilibrium, agents want to link to the most connected agent. This is because he will outbid others for the project in stage 2, and thus has more incentive than other agents to communicate his view in stage 3. Moreover, his view conveys more information than those of other agents. Even though all players' views are equally informative about the state of nature, the most connected agent's view conveys more information about the

likelihood others will invest in the project. This global-games aspect is central to our story.

We also considered various elaborations of our baseline model to highlight certain characteristics that make it more likely an agent will emerge as a mover and shaker: (1) ability at forming social connections; (2) better information; (3) talent as a communicator; and (4) a large block of capital. These are useful in making our theory predictive and operational, as the illustrations in Section 4 highlight.

We remarked in section 2.2 that we have abstracted from signaling considerations in our formulation. It is natural to consider a different timing of the game, where β is chosen after the x_i's are learned. One wonders whether M could use β to signal x_M.

To this question we have two responses. First, although one can certainly encode a message into β, this kind of soft information contrasts with the hard information that we assume gets transmitted in the communication phase. Second, an announced β is really a reduced form for some more complicated bargaining process. That is, players only learn β if they are sufficiently keen to invest that they start negotiating with the project owner. It may be fruitful to consider such additional complexity, but one would need to guard against such an augmented model boiling down to one in which the only people who can ever invest in a project are those connected to the project owner (M). In our setting we want people to be somewhat aware there is a project, even if they don't know M, as this is the key information transmission mechanism that we highlight.

In addition to this, there are other implications of our theory, and potential avenues for future work. Here, we briefly sketch three.

One notable feature of our model is that rents that are earned by agents do not correspond to their "marginal product" – at least not in the conventional usage of that term. In our setting, rents are derived from social position. The mover and shaker is socially useful, to be sure, but can derive "outsize" rewards. Since the model predicts that the views of a mover and shaker hold a lot of weight, the model also suggests that it is easy to misattribute a mover and shaker's success to the quality of his ideas. In fact, a mover and shaker may succeed in spite of – rather than because of – his ideas. The broad debate about rising inequality (see Piketty (2014) for a notable recent contribution) has focused to a large degree on returns to capital versus labor, but relatively little on what

might be termed "returns to social position." Our theory differs from existing accounts of the drivers of inequality because technological factors play a secondary role. Empirical tests of the relative importance of network position versus marginal product may be informed by the structure of our model.

Second, political campaigns have many of the features of our model. They are "projects"; people make contributions (financial and non-financial); and there are strong complementarities. Moreover, beliefs about what others will do seem to matter a lot. Donors often worry about what other donors are contributing, and it is common wisdom that voters typically like to vote for winning candidates. The strong momentum effects in, for example, US Presidential Primaries (see Knight and Schiff (2010) for persuasive empirical evidence) may be explained, in part, by considerations present in our theory.

Third, there is a burgeoning literature on persistent performance differences in organizations. Most models seeking to rationalize differences among otherwise identical organizations involve some kind of equilibrium theory where *ex ante* identical organizations end up in different positions ex post. In, for example, Chassang (2010) and Ellison and Holden (2014) this wedge is due to dynamics. In our theory, agents coordinate on the views of movers and shakers, whose views may be better or worse, which suggests an alternative explanation for persistent performance differences. This explanation does not involve dynamics but does emphasize higher-order beliefs.

Finally, our approach to solving the game makes a technical contribution that may be of independent interest. Many global games models consider settings in which there is a public signal. But, to our knowledge, existing models do not explore the effects of how public a signal is on the rate of participation. In this paper, we have offered conditions under which publicizing a signal increases or decreases the expected participation level. Remarkably, we also find a cutoff point (for β) where the publicness of signals has *no* effect on the expected participation level. This is a useful technical device, and it also demonstrates the somewhat nuanced relationship between publicness of signals and participation levels.

6 Appendix

Proof of Lemma 1. Most of the proof of the lemma is given in Section 2.3. But, two things remain to be shown: (i) the expected level of investment is increasing in e_M (the auction winner's effort) when $\beta > \overline{\beta}$, and decreasing in e_M when $\beta < \overline{\beta}$. (ii) the expected level of investment is less correlated with θ when e_M is higher.

First, let us prove claim (i), which is the more involved of the two. The game played at time 5 is a global game. It is a global game in which all agents receive private signals (x_i) and a fraction $\zeta(e_M)$ of agents also receive a signal x_M. $\zeta(e_M)$ is increasing in e_M. It is well know that, if players' priors are relatively dispersed (which is true, since we assumed $\overline{\theta}$ is relatively large) and players' signals are not too precise (which is true, since we assumed τ is relatively low), such a game has a unique equilibrium in which players follow cutoff rules (see Morris and Shin (2003)). A player i who does not observe x_M has a cutoff rule which takes the following form: invest if $x_i > \kappa_1$. A player i who observes x_M receives a combined signal of $\frac{x_i+x_M}{2}$ and invests if the combined signal exceeds a cutoff: $\frac{x_i+x_M}{2} > \kappa_2(x_M)$. Note that the combined signal is a simple average since x_i and x_M have the same precision.

We will now consider what the cutoffs (κ_1 and κ_2) look like when $\beta = \overline{\beta} = \frac{2}{\overline{\theta}+(1+g)}$.

We will endeavor to show that: (1) $\kappa_1 = \frac{\overline{\theta}}{2}$ and (2) $\kappa_2(\frac{\overline{\theta}}{2}+z) + \kappa_2(\frac{\overline{\theta}}{2}-z) = \overline{\theta}$ for all z.

First, consider statement (1). We need to show that a player i who does not learn x_M is indifferent between investing and not if $\kappa_1 = \tilde{\theta}_i = \frac{\overline{\theta}}{2}$. Again, the payoff to not investing is k. If player i does invest, his expected payoff is $\overline{\beta}\cdot(E(\theta|x_i = \frac{\overline{\theta}}{2}) + (1+g)E(K|x_i = \frac{\overline{\theta}}{2}))\cdot k = \overline{\beta}\cdot(\frac{\overline{\theta}}{2} + (1+g)E(K|x_i = \frac{\overline{\theta}}{2}))\cdot k$. Player i's expectation of K will be: $E(K) = (1-\zeta)\Pr(x_j > \kappa_1 = \frac{\overline{\theta}}{2})|x_i = \frac{\overline{\theta}}{2}) + \zeta\cdot\Pr(\frac{x_j+x_M}{2} > \kappa_1(x_M)|x_i = \frac{\overline{\theta}}{2})$. This expression is a weighted average of the probabilities that agents who do not learn x_M and agents who do learn x_M will invest. It is clear that the probability player i assigns to an agent who does not learn x_M investing is $\frac{1}{2}$: $Pr(x_j > \kappa_1 = \frac{\overline{\theta}}{2})|x_i = \frac{\overline{\theta}}{2}) = \frac{1}{2}$. Statement (2) tells us that $\kappa_1(\frac{\overline{\theta}}{2}) = \frac{\overline{\theta}}{2}$. More generally, since player i believes x_M is distributed symmetrically about $\frac{\overline{\theta}}{2}$, statement (2) says that player i believes $\kappa_1(x_M)$ will also be distributed symmetrically about $\frac{\overline{\theta}}{2}$. It follows that the probability player i assigns to an agent who learns x_M investing is $\frac{1}{2}$: $\Pr(\frac{x_j+x_M}{2} > \kappa_1(x_M)|x_i = \frac{\overline{\theta}}{2}) = \frac{1}{2}$. We thus conclude that $E(K) = \frac{1}{2}$, and player i's payoff

from investing is $\overline{\beta} \cdot (\frac{\overline{\theta}}{2} + (1+g)\frac{1}{2}) \cdot k = k$. This shows player i is indeed indifferent between investing and not, and hence establishes statement (1).

Now, let us show statement (2). Suppose player i learns x_M. His payoff if he does not invest is k. His expected payoff if he does invest is $\overline{\beta} \cdot (E(\theta|x_i, x_M) + (1+g)E(K|x_i, x_M)) \cdot k$. We can write $E(\theta|x_i, x_M)$ as $\tilde{\theta}(\frac{x_i+x_M}{2})$. $E(K|x_i, x_M) = (1-\zeta)\Pr(x_j > \kappa_1|x_i, x_M) + \zeta \cdot \Pr(\frac{x_j+x_M}{2} > \kappa_2(x_M)|x_i, x_M) = (1-\zeta)\Pr(x_j - \tilde{\theta}(\frac{x_i+x_M}{2}) > \kappa_1 - \tilde{\theta}(\frac{x_i+x_M}{2})|x_i, x_M) + \zeta \cdot \Pr(x_j - \tilde{\theta}(\frac{x_i+x_M}{2}) > 2\kappa_2(x_M) - x_M - \tilde{\theta}(\frac{x_i+x_M}{2})|x_i, x_M) = (1-\zeta)(1 - F(\kappa_1 - \tilde{\theta}(\frac{x_i+x_M}{2})) + \zeta \cdot (1 - F(2\kappa_2(x_M) - x_M - \tilde{\theta}(\frac{x_i+x_M}{2})))$, where F is the cdf of a distribution that is symmetric about 0. When $\frac{x_i+x_M}{2} = \kappa_2(x_M)$, player i should be indifferent between investing and not. This gives us the following equation: $k = \overline{\beta} \cdot (\tilde{\theta}(\kappa_2(x_M)) + (1+g)[(1-\zeta)(1 - F(\kappa_1 - \tilde{\theta}(\kappa_2(x_M)))) + \zeta \cdot (1 - F(2\kappa_2(x_M) - x_M - \tilde{\theta}(\kappa_2(x_M))))] \cdot k$.

Simplifying the equation slightly, we find: $\frac{\overline{\theta}}{2} = \tilde{\theta}(\kappa_2(x_M)) + (1+g)[\frac{1}{2} - (1-\zeta) \cdot F(\frac{\overline{\theta}}{2} - \tilde{\theta}(\kappa_2(x_M))) - \zeta \cdot F(2\kappa_2(x_M) - x_M - \tilde{\theta}(\kappa_2(x_M)))]$. If we substitute $\frac{\overline{\theta}}{2} + z$ for x_M, we obtain the following:

(i) $\frac{\overline{\theta}}{2} = \tilde{\theta}(\kappa_2(\frac{\overline{\theta}}{2} + z)) + (1+g)[\frac{1}{2} - (1-\zeta) \cdot F(\frac{\overline{\theta}}{2} - \tilde{\theta}(\kappa_2(\frac{\overline{\theta}}{2} + z))) - \zeta \cdot F(2\kappa_2(\frac{\overline{\theta}}{2} + z) - (\frac{\overline{\theta}}{2} + z) - \tilde{\theta}(\kappa_2(\frac{\overline{\theta}}{2} + z)))]$.

We can also substitute $\frac{\overline{\theta}}{2} - z$ for x_M, in which case we obtain the following:

(ii) $\frac{\overline{\theta}}{2} = \tilde{\theta}(\kappa_2(\frac{\overline{\theta}}{2} - z)) + (1+g)[\frac{1}{2} - (1-\zeta) \cdot F(\frac{\overline{\theta}}{2} - \tilde{\theta}(\kappa_2(\frac{\overline{\theta}}{2} - z))) - \zeta \cdot F(2\kappa_2(\frac{\overline{\theta}}{2} - z) - (\frac{\overline{\theta}}{2} - z) - \tilde{\theta}(\kappa_2(\frac{\overline{\theta}}{2} - z)))]$.

Observe that $F(x) = 1 - F(-x)$ since distribution F is symmetric about 0. Observe, also, that $\tilde{\theta}(x) = \overline{\theta} - \tilde{\theta}(\overline{\theta} - x)$ since $\tilde{\theta}(\cdot)$ is symmetric about $\frac{\overline{\theta}}{2}$. If we apply both the rule regarding F and the rule regarding $\tilde{\theta}$ to (ii) and then rearrange terms, we obtain the following:

(iii) $\frac{\overline{\theta}}{2} = \tilde{\theta}(\overline{\theta} - \kappa_2(\frac{\overline{\theta}}{2} - z)) + (1+g)[\frac{1}{2} - (1-\zeta) \cdot F(\frac{\overline{\theta}}{2} - \tilde{\theta}(\overline{\theta} - \kappa_2(\frac{\overline{\theta}}{2} - z))) - \zeta \cdot F(2(\overline{\theta} - \kappa_2(\frac{\overline{\theta}}{2} - z)) - (\frac{\overline{\theta}}{2} + z) - \tilde{\theta}(\overline{\theta} - \kappa_2(\frac{\overline{\theta}}{2} - z)))]$.

Equation (iii) exactly mirrors equation (i), with $(\overline{\theta} - \kappa_2(\frac{\overline{\theta}}{2} - z))$ substituted for $\kappa_2(\frac{\overline{\theta}}{2} + z)$. In order for both equations to hold, it must be the case that: $(\overline{\theta} - \kappa_2(\frac{\overline{\theta}}{2} - z)) = \kappa_2(\frac{\overline{\theta}}{2} + z)$, or $\kappa_2(\frac{\overline{\theta}}{2} + z) + \kappa_2(\frac{\overline{\theta}}{2} - z)) = \overline{\theta}$. This proves statement (2).

So, we conclude agents who do not learn x_M invest if and only if $x_i > \frac{\overline{\theta}}{2}$, or with probability $\frac{1}{2}$. Agents who do learn x_M invest if and only if $\frac{x_i+x_M}{2} > \kappa_2(x_M)$. By state-

ment (2), $\kappa_2(x_M)$ is distributed symmetrically about $\frac{\overline{\theta}}{2}$, which means these agents also invest with probability $\frac{1}{2}$.

We conclude that, when $\beta = \overline{\beta}$, the expected level of investment is $\frac{1}{2}$ regardless of how much effort player M chooses to exert. As we mentioned in the text, it is clear that more news will be treated as "good news" when β is higher: since the project does not need to be as high quality for investment to be profitable. It follows that, when $\beta > \overline{\beta}$, effort increases the expectation of K; when $\beta < \overline{\beta}$, effort decreases the expectation of K. This completes the proof of claim (i).

We turn now to the second claim to be proven: that an increase in e_M (the auction winner's effort) makes investment at time 5 more correlated with player M's signal (x_M) and less correlated with the project's quality (θ). Consider what happens when $e_M = 0$, so that x_M is not broadcast to any agents. Clearly, in that case, no signal has more than a negligible effect on the level of investment. So, the level of investment will depend upon the underlying quality of the project (θ), but not upon any player's noisy signal of θ. In contrast, when $e_M > 0$, so that x_M is broadcast, a non-negligible fraction of the population bases it's investment decision on x_M. So, the noisy signal x_M – and not just θ – will affect the level of investment.

As noted in the text, it increases M's expected payoff if investment is less correlated with the project's quality (θ). This completes the proof of Lemma 1.

□

Proof of Proposition 2. We will assume throughout the proof that g is large.

Notice that Lemma 1 holds even under the amended assumptions of Proposition 2: since the subgame resulting from linking choices l is the same as in the baseline model. We will use Lemma 1 in the proof.

First, let us show part (1) of the proposition. We can prove, by contradiction, that there is no equilibrium in which all players are connected to negligible fractions of the population. Suppose such an equilibrium does exist. It follows from Lemma 1 that no player exerts effort at time 3 (i.e., communicates his view). Since players never communicate their views, agents have a strict preference to link to the player with the lowest linking cost (the player i for whom $c_i = \underline{c}$). But, this is a contradiction, since player i is

only connected to a negligible fraction of the population.

So, there must be a player connected to a non-negligible fraction of the population in equilibrium. It follows from Lemma 1 that the auction winner (M) will be the most connected player and will exert positive effort, while other players exert zero effort. If $c_M = \underline{c}$, all agents must strictly prefer to link to M: since M is the only player who puts effort into communicating and M has the lowest linking cost. Hence, if $c_M = \underline{c}$, all players must link to M in equilibrium.

Now, suppose $c_M \neq \underline{c}$. If agents link to a player besides M, observe that it must be the player i with the lowest linking cost ($c_i = \underline{c}$). So, the equilibrium must be one in which a fraction $f \geq \frac{1}{2}$ of players link to M (f possibly equal to 1) and the remainder link to player i.

Finally, we need to show that the auction winner (M) receives a higher expected payoff than other agents. Since M is weakly more connected than other players ($f \geq \frac{1}{2}$), he values the asset weakly more. Thus, his expected payoff from the auction is nonnegative (and it is strictly positive if $f > \frac{1}{2}$). We also need to consider the possibility that M's rent from the auction could be dissipated if M pays a higher linking cost than other agents. M will link to the agent for whom c_i is lowest ($i \neq M$). Hence, the only way in which player M could have a higher linking cost than other agents is if c_M is non-negligibly lower than any other c_i. Our assumption that the linking costs are uniformly distributed rules out this possibility. This completes the proof of part (1).

Now, let us prove part (2). Suppose an agent linked to player Y deviates and links instead to the player i for whom the linking cost is lowest ($c_i = \underline{c}$). If he deviates, he will not learn Y's signal which contains valuable information (this is the cost of the deviation); the benefit is he pays a lower linking cost ($\underline{c}$ rather than c_Y). Clearly, the deviation will be profitable if $c_Y - \underline{c}$ is sufficiently large. Hence, player Y cannot be a player for whom the linking cost is sufficiently large relative to $\underline{c}$.

To prove part (3), suppose all agents link to player i at time 1, where $c_i = \underline{c}$. Lemma 1 implies that player i will win the auction and exert effort, while other players will exert zero effort. Since player i exerts more effort than other players, is more connected, and has the lowest linking cost, agents clearly have a strict preference to link to player i at time 1. Hence, such an equilibrium exists. Observe that we can apply the same

argument to show existence of an equilibrium in which all agents link to a player i for whom c_i is slightly greater than $\underline{c}$. This proves part (3).

□

Proof of Proposition 3. Again, we assume throughout the proof that g is large.

First, let us show part (1) of the proposition. We can prove, by contradiction, that there is no equilibrium in which all players are connected to negligible fractions of the population. Suppose such an equilibrium does exist. By a similar logic to that given in the proof of Lemma 1, it follows that no player exerts effort at time 3. Since players never exert effort, agents have a strict preference to link to the player whose signal is most precise (the player i for whom $\tau_i = \overline{\tau}$). But, this is a contradiction, since player i is only connected to a negligible fraction of the population.

So, there must a player connected to a non-negligible fraction of the population in equilibrium. By a logic similar to that given in the proof of Lemma 1, we can show that players who are connected to non-negligible fractions of the population value the asset more than players connected to negligible fractions of the population. Hence, the auction winner M will be connected to a non-negligible fraction of the population. We can also show, by a logic similar to that given in the proof of Lemma 1, that the auction winner exerts strictly positive effort at time 3 while other players exert zero effort at time 3. Finally, it is clear that the auction winner receives a weakly higher payoff than other agents, since he values the asset weakly more. This completes the proof of part (1).

Now, let us prove part (2). Suppose an agent linked to player Y deviates and, instead, links to the player i whose signal is most precise ($\tau_i = \overline{\tau}$). He will not learn Y's signal, which contains valuable information (this is the cost of the deviation); but, the benefit is he learns i's signal with some probability. Clearly, the deviation will be profitable if $\overline{\tau} - \tau_Y$ is sufficiently large. Hence, Y cannot be a player whose signal has sufficiently low precision relative to $\overline{\tau}$.

Finally, let us prove part (3). Suppose all agents link to player i at time 1, where $\tau_i = \overline{\tau}$. Since player i is the only connected player, he values the asset more than other players. Hence, he will win the auction and exert effort. Other players will exert zero effort. Since player i exerts more effort than other players, is more connected, and has the highest quality signal, agents clearly have a strict preference to link to player i at

time 1. Hence, an equilibrium indeed exists in which all agents link to player i. Observe that we can apply the same argument to show existence of an equilibrium in which all agents link to a player i for whom τ_i is slightly less than $\overline{\tau}$. This proves part (3).

□

Proof of Proposition 4. The proof closely resembles to proof of Proposition 3. Once again, we assume g is large throughout the proof.

First, let us show part (1) of the proposition. We can prove, by contradiction, that there is no equilibrium in which all players are connected to negligible fractions of the population. Suppose such an equilibrium does exist. By a similar logic to that given in the proof of Lemma 1, it follows that no player exerts effort at time 3. Since players never exert effort, agents have a strict preference to link to the player who is the best communicator (the player i for whom $\alpha_i = \overline{\alpha}$). But, this is a contradiction, since player i is only connected to a negligible fraction of the population.

So, there must a player connected to a non-negligible fraction of the population in equilibrium. By a logic similar to that given in the proof of Lemma 1, we can show that players who are connected to non-negligible fractions of the population value the asset more than players connected to negligible fractions of the population. Hence, the auction winner M will be connected to a non-negligible fraction of the population. We can also show, by a logic similar to that given in the proof of Lemma 1, that the auction winner exerts strictly positive effort at time 3 while other players exert zero effort at time 3. Finally, it is clear that the auction winner receives a weakly higher payoff than other agents, since he values the asset weakly more. This completes the proof of part (1).

Now, let us prove part (2). Suppose an agent linked to player Y deviates and, instead, links to the player i who is the best communicator ($\alpha_i = \overline{\alpha}$). He will not learn Y's signal, which contains valuable information (this is the cost of the deviation); but, the benefit is he learns i's signal with some probability. Clearly, the deviation will be profitable if $\overline{\alpha} - \alpha_Y$ is sufficiently large. Hence, Y cannot be a player whose signal has sufficiently low precision relative to $\overline{\alpha}$.

Finally, let us prove part (3). Suppose all agents link to player i at time 1, where $\alpha_i = \overline{\alpha}$. Since player i is the only connected player, he values the asset more than other players. Hence, he will win the auction and exert effort. Other players will exert zero

effort. Since player i exerts more effort than other players, is more connected, and is the best communicator, agents clearly have a strict preference to link to player i at time 1. Hence, an equilibrium indeed exists in which all agents link to player i. Observe that we can apply the same argument to show existence of an equilibrium in which all agents link to a player i for whom α_i is slightly less than $\overline{\alpha}$. This proves part (3).

□

Proof of Proposition 5. We will assume throughout the proof that g is large.

First, let us prove part (1) of the proposition. Observe that $V_i(l) \geq \frac{\overline{\theta}}{2}$ for all i and l. The reason is that, all players can choose to exert zero effort and offer other agents zero equity. This clearly results in no investment ($K = 0$), but the project still yields an expected return – and expected payoff to M – of $\frac{\overline{\theta}}{2}$. Hence, $\frac{\overline{\theta}}{2}$ is a lower bound on $V_i(l)$.

Since, $V_i(l) \geq \frac{\overline{\theta}}{2}$, all players (with the possible exception of Mr. Big) value the asset at more than their cash-on-hand. Thus, players (with the possible exception of Mr. Big) will be forced to liquidate assets to acquire the asset. But Mr. Big has more cash-on-hand than other agents, and so can acquire the asset without liquidating as many assets as other players. Given our assumption that the liquidation cost L is very large, it follows that Mr. Big will always win the auction.

We can prove, by contradiction, that there is no equilibrium in which both Mr. Big and Mr. Medium are connected to negligible fractions of the population. Suppose such an equilibrium does exist. Players who are small do not win the auction and only have negligible capital to invest. So, by a logic similar to that given in the proof of Lemma 1, small players exert zero effort. Hence, an agent linked to a small player has no chance of learning that player's view. Hence, an agent receives at least as a high an expected payoff if he links to Mr. Big. Additionally, Mr. Big (who is player 0) has a lower index. Since agents have a marginal preference to link to players of lower index, we conclude that the agent linked to the small player has a profitable deviation.

As a brief aside: notice that the argument just given relies upon agents having a preference, all else equal, to link to Mr. Big. In fact, all we need to make the argument is that a non-negligible fraction of agents has a preference, all else equal, to link to Mr. Big or Mr. Medium.

Hence, Mr. Big or Mr. Medium is connected to a non-negligible fraction of the population in equilibrium. Mr. Big exerts positive effort if he is connected to a non-negligible fraction of the population (since he is the project owner). Mr. Medium also exerts positive effort if he is connected to a non-negligible fraction of the population (since he has a non-negligible amount of capital available to invest in the project). We conclude that either Mr. Big or Mr. Medium exerts positive effort in equilibrium. Since agents strictly prefer to link to players who exert positive effort, it follows agents cannot link to a small players in equilibrium. This proves part (1) of the proposition.

Now, let us show part (2). If all players link to Mr. Big, clearly Mr. Big will exert positive effort while other players will exert zero effort. Since Mr. Big is the only player who exerts positive effort, all agents will indeed have a preference to link to him. This shows existence of an equilibrium in which all players link to Mr. Big.

Suppose all players link to Mr. Medium. Clearly, Mr. Medium will exert positive effort while other players will exert zero effort. Since Mr. Medium is the only player who exerts positive effort, all agents will indeed have a preference to link to him. This shows existence of an equilibrium in which all players link to Mr. Medium.

Now, consider part (3) of the proposition. It is perhaps easiest to see the logic for this result in the following way. Suppose we allow Mr. Big more freedom in the equity offers he can make. Suppose we allow him to tailor his equity offers to each small player: with small player i being offered equity $\beta(i) \cdot k_{small}$. It is clear that it is optimal to set $\beta(k_{medium}) > \beta(i)$. The only reason to offer player i equity is to obtain capital from player i. In contrast, since Mr. Medium's investment increases the inclination of small players to invest, there are two reasons to offer Mr. Medium equity: (1) to obtain Mr. Medium's investment, and (2) to make investment more attractive for small players. Observe that, by symmetry, all small players will be offered the same equity share, so Mr. Big will not, in fact, use the additional freedom we allowed him to tailor small players' equity offers. This shows that $\beta(k_{medium}) > \beta(k_{small})$. This completes the proof. □

Proof of Proposition 6. Under the assumptions of Proposition 6, it turns out Lemma 1 still holds.

Lemma 1 holds because, just as in the baseline model, players who are more connected value the asset more. They value the asset more because they are more able to

move and shake. They *also* value the asset more because, through their connections, they acquire better information about θ; this allows them to make better decisions (d_M) when they win the project.

An identical logic to that given in the proof of Proposition 1 shows that all agents link to one player (Y) in equilibrium. Y earns a rent from being the agent most able to move and shake the project; additionally, he earns a rent from being better informed. □

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